LARGE GROUNDWATER WITHDRAWAL PERMIT APPLICATION NOTIFICATION FORM

NOTICE OF SUBMITTAL TO THE NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

PROJECT LOCATION

Site Name and Owner (if different than Applicant)	Angle Pond Woods Condominium Association, Inc.
Address	Odd Fellows Road, Hampstead, New Hampshire
Tax Map/Lot Number/PID	000011000031000000
Municipality(s) in Potential Impact Area	Hampstead, Sandown, Danville, Kingston
Community Water Supplier(s) in Potential Impact Area	Hampstead Area Water Company, Cotton Farms MHP

APPLICANT

Name	Hampstead Area Water Company, Inc. – Contact: Harold Morse
Affiliation	
Mailing Address	54 Sawyer Avenue, Atkinson, NH 03811
Phone Number	603-362-5333
Email Address	Harold@lewisbuilders.com

APPLICATION PREPARER (provide imprint of professional license stamp)

Name	Dan Tinkham, P.G.
Company Name	Emery & Garrett Groundwater Investigations, a Division of GZA
Mailing Address	PO Box 1578, 56 Main Street, Meredith, NH 03253
Phone Number	603-279-4425
Email Address	Daniel.Tinkham@gza.com

*Notice to application preparer: Provide copies of certified mail receipts to NHDES immediately following each submittal.

For additional information contact Mr. Stephen Roy at (603) 271-3918 or stephen.roy@des.nh.gov.

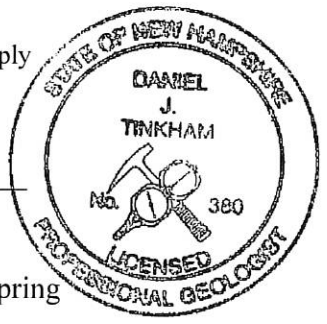
SUBMITTAL INFORMATION

SUBMITTAL TYPE **DATED: 12/13/17**

_X_ Preliminary Application
___ Preliminary Application - Supplemental Information
___ Final Report
___
___ Final Report – Supplemental Information
___ Permit Renewal Application
Other: _____

PROJECT TYPE

X Public Water Supply
___ Bottled/Bulk Water Supply
___ Irrigation Water Supply
___
___ Process Water Supply
___ Other: _____



1. Type of proposed water source: __X__ Bedrock well(s), Overburden well(s), ____ Spring
2. Number of proposed water sources: __1_____
3. Proposed cumulative withdrawal volume in gallons per day: ____230,400_____

Project Summary: (please provide a brief description of your proposed project in the space below)
A new bedrock groundwater supply well has been developed to meet the needs of the Angle Pond Water System, to meet growing water supply demands of the Hampstead Area Water Company, Inc. (HAWC), and to offset decreases in production capacity of exiting HAWC production wells.

NOTE: Per RSA 485C:21, the deadline to request a public hearing for this project is fifteen (15) days following receipt of the Preliminary Application or Final Report. See the attached NHDES fact sheet WDDWGB2215 regarding the permitting process.

PRELIMINARY HYDROGEOLOGIC INVESTIGATION
GROUNDWATER DEVELOPMENT
ANGLE POND PRODUCTION WELL #3

HAMPSTEAD AREA WATER COMPANY, INC.
HAMPSTEAD, NEW HAMPSHIRE

"Preliminary Report" in Accordance with New Hampshire Regulations RSA 485-C:21, NH Env-Dw 302, and NH Env-Wq 403

August 2018

Presented to:
Mr. Stephen Roy
NH Department of
Environmental Services

EMERY & GARRETT GROUNDWATER INVESTIGATIONS, A DIVISION OF GZA
56 Main Street • P.O. Box 1578
Meredith, New Hampshire 03253

New England **Mid-Atlantic** **South Atlantic**

Emery & Garrett Groundwater Investigations,
A Division of GZA
56 Main Street • P.O. Box 1578
Meredith, New Hampshire 03253
(603) 279-4425 *www.eggi.com* *Fax (603) 279-8717*

August 13, 2018

Mr. Stephen Roy
New Hampshire Department of Environmental Services
Drinking Water and Groundwater Bureau
P.O. Box 95
29 Hazen Drive
Concord, NH 03301

Dear Mr. Roy,

Please find enclosed a copy of Emery & Garrett Groundwater Investigations, A Division of GZA (EGGI's) report entitled, "Preliminary Hydrogeologic Investigation, Groundwater Development, Production Well #3, Hampstead Area Water Company, Inc., Hampstead, New Hampshire", which has been prepared in accordance with RSA 485-C:21, NH Env-Dw 302, and NH Env-Wq 403 New Hampshire regulations.

The Hampstead Area Water Company, Inc. (HAWC) would like to develop additional water resources to provide additional water to the Angle Pond Water System to meet the growing demand of the HAWC water system, and to offset decreases in the productivity of existing HAWC production wells. Therefore, the HAWC seeks to gain approval to develop a maximum of 160 gpm (230,400 gpd) from proposed Angle Pond Production Well #3.

I hope you find the information contained herein responsive to your needs. If you have any questions, please do not hesitate to contact me.

Sincerely,

Daniel J. Tinkham, P.G.
Senior Consultant

Emery & Garrett Groundwater Investigations,
A Division of GZA
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PRELIMINARY HYDROGEOLOGIC INVESTIGATION GROUNDWATER DEVELOPMENT PRODUCTION WELL HWT #3

HAMPSTEAD WATER COMPANY, INC. ANGLE POND WATER SYSTEM HAMPSTEAD, NEW HAMPSHIRE

"Preliminary Report" in Accordance with New Hampshire Regulations RSA 485-C:21, NH Env-Dw 302, and NH Env-Wq 403

August 2018

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PRELIMINARY HYDROGEOLOGIC INVESTIGATION GROUNDWATER DEVELOPMENT PRODUCTION WELL #3

HAMPSTEAD AREA WATER COMPANY, INC. ANGLE POND WATER SYSTEM HAMPSTEAD, NEW HAMPSHIRE

"Preliminary Report" in Accordance with New Hampshire Regulations RSA 485-C:21, NH Env-Dw 302, and NH Env-Wq 403

August 2018

I. INTRODUCTION

A new groundwater supply well is being permitted within the Angle Pond Well Field to supply water resources to the existing Angle Pond Water System, which is operated by the Hampstead Area Water Company, Inc. (HAWC). The new well, identified as Production Well #3, is located on property owned by the Angle Pond Woods Condominium Association, Inc. in Hampstead, New Hampshire. The property lies west of Route 121A and south of Odd Fellows/Pillsbury Road (Figures 1 and 2).

Emery & Garrett Groundwater Investigations (EGGI), a Division of GZA was retained by the HAWC to complete hydrogeologic analyses required to permit the new groundwater well in compliance with New Hampshire RSA 485-C:21 and Administrative Rules for Large Production Wells and Wells for Large Community Water Systems (Env-Dw 302) and Large Groundwater Withdrawals (Env-Wq 403).

This report presents the findings and recommendations resulting from EGGI's hydrogeologic analyses of: a) existing hydrogeologic data; b) data collected during field mapping; c) earlier drilling events; and d) preliminary water quality analyses. Based on the results of these hydrogeologic analyses, the HAWC is requesting that the New Hampshire Department of Environmental Services (NHDES) approve the use of Production Well #3 as a public groundwater supply well. This bedrock Production Well is estimated to be capable of producing groundwater at a sustainable capacity of up to 160 gallons per minute (gpm) (230,400 gallons per day [gpd]).

The following report includes information required in the State Statutes and Rules noted above for permitting a Large Groundwater Withdrawal. A certain degree of overlap exists between these sets of regulations. Therefore, the required information has been combined into common sections within the report to avoid repetition.

II. PROJECT MANAGEMENT INFORMATION

A. Name of Project

Hampstead Area Water Company – Angle Pond Production Well #3

B. Name and Address of Owner of the Water System

Hampstead Area Water Company
Attn: Mr. Harold Morse, President
54 Sawyer Ave.
Hampstead, NH 03811
(1603) 362-5333
harold@lewisbuilders.com

C. Name and Address of Owner of the Property

Angle Pond Woods Condominium Association, Inc.
Tax Parcel PIN# 000011000031000000
Mike McNeal – 978-314-1482

D. Name and Address of Groundwater Consultant

Emery & Garrett Groundwater Investigations, LLC
Daniel J. Tinkham, PG, Project Manager
56 Main Street/P.O. Box 1578
Meredith, NH 03253
(1603) 279-4425
djtinkham@eggi.com

E. Water Volume Required for the Project

The Angle Pond Water System serves 121 service connections, but the local System is also tied into a regional water distribution system. Therefore, Well #3 will provide water to connections beyond the Angle Pond System. Typical water demand for a domestic service connection is on the order of 0.5 gpm per unit, the total water demand for the Angle Pond Water System will be approximately 61 gpm. In 2017, groundwater withdrawals from the Angle Pond Well Field totaled 8.87 million gallons or 24,300 gallons per day (gpd) (16.9 gallons per minute), which is equivalent to 28% of the total estimated water demand. In addition to serving the Angle Pond Water System, HAWC would like to utilize excess water from Well #3 to provide water resources to its regional water system to help offset decreases in the productivity of existing

HAWC production wells. Therefore, the HAWC seeks to gain approval to develop a maximum of 160 gpm (230,400 gpd) from Production Well #3. This is the discharge rate maintained during the initial testing of Production Well #3 which is the rate considered to be sustainable.

III. HYDROGEOLOGIC CONCEPTUAL MODEL

A. Introduction

A hydrogeologic conceptual model was created through the compilation of data from existing databases, regional and local groundwater investigations, published geologic studies, and previous investigations conducted by EGGI. *Regional* data sources and published maps provided valuable insights into the surficial and bedrock geologic settings of the Hampstead area (Bennett et al, 2005; Bennett et al., 2006; Gephart ,1987; Lyons and others, 1997). GIS databases of hydrogeologic data, contaminant threat inventories, and water resources inventories obtained from the New Hampshire GRANIT online website (http://www.granit.unh.edu/) provided additional background information for the project area.

The preliminary conceptual hydrogeologic model of the bedrock aquifer was systemically created by:

- Compiling and analyzing available public and proprietary hydrogeologic data;
- Investigating the bedrock geologic setting (including bedrock type and distribution, lineament analysis, fracture-fabric analysis);
- Investigating the surficial geologic setting;
- Investigating the Regional Hydrologic Setting; and,
- Evaluating the Local Water Budget.

The conceptual model of groundwater flow developed during the project was used to establish *preliminary* estimates of the Zone of Influence (ZOI), Wellhead Protection Area (WHPA), and the Potential Impact Area (PIA). The following sections describe the information used to help develop the conceptual model of groundwater flow.

B. Geologic Setting

1) Methods of Groundwater Assessment and Sources of Geologic Information

EGGI's investigation of the hydrogeology of the area proximal to Well #3 included:

- A background review of existing surficial and bedrock geology maps.
- Field mapping of bedrock exposures.
- Lineament and bedrock fracture fabric analyses.
- Review and analysis of available well information.
- Review of hydrogeologic data previously collected for the Production Well.

2) Results of Geologic Assessment

The bedrock geology of the area proximal to Well #3 was documented through a program of geologic field mapping to provide insights into the spatial variation of those factors that are most influential to the hydrogeology of the area. Bedrock outcrops in the area were identified and evaluated by EGGI geologists. The geologic map presented on Figure 3 combines the published bedrock geologic maps of the area proximal to Production Well #3 with the specific rock type identified at available exposures identified during EGGI's on-site mapping for this project.

The existing geologic maps indicate that the Study Area proximal to Production Well #3 is underlain primarily by the Berwick Formation, and to a much lesser extent, the Elliot Formation (Figure 3). The Berwick Formation is comprised of metamorphic rocks that developed from sediments such as those found on modern continental shelves (e.g., sands, silt, and clay). These metamorphic rocks are variably calcareous, fine- to medium-grained, quartz, feldspar granofels to schist.

The Elliot Formation is primarily composed of phyllite, a fine-grained metamorphic rock with a characteristic alignment of muscovite grains that results in a distinctive sheen.

EGGI's mapping revealed several exposures of the Berwick Formation (Figure 3). All of the exposures shown on Figure 3 consisted primarily of granofels, with occasional thin schistose layering. Granofels outcrops examined by EGGI ranged in composition from biotite-muscovite-quartz to quartzo-feldspathic granofels with limited mica and trace garnets. Layering in the rocks generally trended northerly, with moderate to steep dips towards the east. The Elliot Formation was not observed in outcrop in the study area.

The surficial sediments within the area proximal to the Production Well are mapped as till, a formation comprised of poorly-sorted silt to boulders (Gephart,1987; Figure 4). The map also shows glacial stream deposits comprised of sand and gravel approximately 1,000 feet to the east and 3,000 feet to the west of the Production Well. Observations in the immediate area of the Production Well #3 suggests that remnants of similar glacial stream deposits are present in close proximity to the Well, but they are discontinuous in nature and represent a relatively thin layer on top of dense glacial till (hardpan). Available well information shows that the unconsolidated overburden overlying competent bedrock is typically 10 to 40 feet thick, generally getting thicker from east to west in the area of the Well. Competent bedrock was intercepted at a depth of 18 feet below ground during the installation of the Production Well #3 (Appendix A).

3) *Lineament and Fracture Fabric Analyses*

a) Introduction

EGGI's geologic mapping of the area proximal to the Angle Pond Water System demonstrated that the water-bearing capacity of the bedrock units underlying the subdivision is dependent upon the presence of secondary discontinuities such as fractures, fracture zones, and faults. EGGI used a two-fold approach in investigating the water-bearing potential of such brittle discontinuities:

1) Remote sensing (i.e., lineament) analysis of the site using multiple scales and types of aerial imagery; and,
2) Measurement of bedrock fracture characteristics at bedrock exposures present in the project area.

Both methods individually provided insights into the groundwater development potential of the bedrock underlying the Angle Pond Water System. In addition, the correlation of remote sensing data with the bedrock fracture information observed in bedrock exposures allowed the extrapolation of bedrock characteristics into areas where bedrock is not exposed.

b) Remote Sensing Analysis (Lineament Analysis)

Lineaments were defined on Digital Elevation Models (DEMs) and were digitally processed from two different data sets, including high-resolution Light Detection and Ranging (LiDAR) (see Table below). In addition, lineaments were drawn on a color infra-red aerial image.

LINEAMENT PLATFORMS EVALUATED

Scale	Image ID	Image Type	Number of Observational Trials	Total Number
1:20,000	Aerial Image	Color Infrared Aerial Images	2	184
1:30,000	Digital Elevation Model	Digital Elevation Model Computer Images	2	115
1:15,000	LiDAR Image Digital Elevation Model	High Resolution LiDAR	2	314
		TOTALS:	6	613

A total of 613 lineaments were identified during this investigation. The raw lineaments were processed to produce a rose diagram illustrating the distribution of lineament trends and highlighting the dominant "families" of lineaments (Figure 3). The major lineament families are oriented at (in order of decreasing significance) 39°, 97°, 63°, 170°, 154°, 136°, and 15°.

The analysis of the lineament data also provided the location of coincident lineaments[1], some of which are fracture-supported[2] (Figure 3). Discontinuities in the rock that potentially possess enhanced water-bearing properties can underlie coincident lineaments and lineament intersections. Because of this, the presence of such lineaments was used to provide insights into potential anisotropies in the hydraulic characteristics of the bedrock aquifer proximal to the Angle Pond Water System. The orientations of lineaments proximal to the Production Well suggest that pumping-induced water level responses during the pumping of Well #3 *may* be greater in northeast/southwest and south-southeast/north-northwest directions than in other orientations.

c) Bedrock Fracture Fabric Analysis

Detailed field measurements of fractures were made on outcrops in the general area of the Production Well. Analysis focused on the potential identification and characterization of structural features known to influence groundwater movement, such as fractures, brittle faults, and other structural discontinuities. As can be seen on Figure 3, the three dominant fracture sets measured are oriented 4°, 20°, and 42°. Three subordinate fracture sets trend 108°, 145°, and 84°. Two of the fracture families (20° and 42°) have similar orientations to the lineament families that trend 15° and 39°, respectively.

d) Drilling of Angle Pond Production Well #3

Viera Artesian Well, LLC (VAW) completed the drilling of Production Well #3 on December 29, 2017[3]. The Well Completion Report submitted to the State of New Hampshire Water Well Board by VAW indicates that the total depth of the Well is 600 feet (Appendix A). The diameter of the well is eight inches from the ground surface to the full depth of 600 feet.

Till and/or clay/silt was intercepted in the borehole from the ground surface to a depth of 18 feet. The bedrock was reported as "granite", but the rock was most likely Berwick Formation, as drill cuttings of both may appear similar.

The final airlift[4] yield reported by VAW was 275 gallons per minute (gpm) coming from four known water-bearing zones at 75' (20 gpm), 320' (70 gpm), 460' (50 gpm), and 580' (100 total gpm).

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[1] Lineaments observed on images at different scales that have a similar trend (±5°) and similar location (±2 mm at the scale of the image) are referred to as coincident lineaments (Mabee, and others, 1994). The use of such coincident lineaments helps to remove the inherent subjectivity of lineament analysis (Wise, 1982) and facilitates the confident use of lineament mapping as a groundwater exploration tool.

[2] Reduction of raw lineament data to coincident lineaments and fracture-supported coincident lineaments follows the method described in Mabee and others (1994).

[3] Personnel from EGGI were not present during the drilling of the Production Well.

[4] An airlift measurement is taken during drilling while the drilling rig is injecting high pressure air into the borehole and lifting the groundwater to the surface. This provides a preliminary measurement of the rate of water produced from the well. An accurate determination of the pumping capacity of the pumping well is determined by conducting a long-term pumping test.

A sample of unfiltered groundwater obtained from the Production Well at the end of drilling was submitted to Nelson Analytical Lab for analyses of common drinking water quality parameters (Appendix A). The results of the analyses show that iron and manganese are the only parameters that exceed their respective Secondary Maximum Contaminant Levels (SMCL). Because the groundwater sample was not filtered, the iron and manganese concentrations were likely impacted by the presence of undissolved (suspended) particles that contained iron and manganese. Further pumping/development of the Well will likely eliminate *undissolved* iron and manganese, thereby reducing the concentration of these two parameters.

C. Regional Hydrologic Setting

Production Well #3 was installed within the upper reaches of the greater Powwow River watershed (Figure 5). The closest stream to Well #3 is an unnamed tributary stream that flows northward into Angle Pond, which subsequently drains into Bartlett Brook, and finally Colby Brook before contributing its flow to the Powwow River. It is approximately 2,000 feet from Well #3 to the nearest watershed divide with the neighboring Little River watershed (Figure 5).

The local surface water drainage consists of a widespread network of low-gradient streams and scabby wetlands with occasional ponds, all of which drain to Angle Pond, approximately 2,000 feet north of Well #3. The closest pond to the Well is approximately 80 feet away and is thought to exist as a result of a former gravel mining operation which likely removed sand and gravel from beneath the water table either creating a new pond or expanding an existing pond. The pond covers 4.3 acres.

D. Water Budget Calculations

Recharge to deep bedrock aquifers is typically derived from precipitation or is induced from local surface water bodies. The primary source of recharge to Well #3 will be precipitation as there is no evidence of hydraulic connection with nearby surface water bodies. The pond immediately adjacent to the Well is estimated to hold just 14 million gallons of water (4.3 acre pond approximately 10 feet deep). Other nearby surface water is contained in shallow, scabby wetlands and is likely isolated from a direct hydraulic connection with the underlying bedrock fractures by the low permeability wetland sediments and the till substrate. Therefore, recharge to the bedrock fracture system will rely on leakage from the overburden and into the dispersed bedrock fracture network over a large area.

The USGS StreamStats program indicates that approximately 45 inches of annual precipitation occurs in the watersheds surrounding the Production Well (Appendix B). Of that precipitation, up to 23.6 inches of precipitation is available as groundwater recharge in the average year. However, given the thin unconsolidated deposits and relatively low permeability of many of the local surficial deposits (till), runoff can be enhanced, and recharge can be reduced. Therefore, EGGI estimates that approximately nine to twelve inches of groundwater recharge is a reasonable and conservative estimate of precipitation serving as groundwater recharge from the watersheds located proximal to the Production Well.

A radius of 3,000-feet has been estimated to be the maximum potential Zone of Influence (ZOI) around Well #3 (see Section IV C) . At a rate of nine inches per year, 434,1600 gpd (or 302 gpm) of recharge would be available within such a 3,000-foot radius. At a rate of 12 inches per year and 579,136 gpd (402gpm) of recharging would be available. Therefore, approximately 1.9 to 2.5 times the requested permitted production volume of 160 gpm is potentially available as groundwater recharge within the ZOI.

E. Summary of Conceptual Hydrogeologic Model

The results of the background data compilation and EGGI's geologic and hydrologic data collection and analyses provided the basis for developing the following hydrogeologic model for the contributing recharge area to Well #3. This hydrogeologic model forms the foundation for defining future work to be completed in preparation for submitting the final groundwater withdrawal permit application for the Production Well.

The Production Well is located within an area that is underlain by metamorphosed sedimentary rocks that are covered by a generally thin layer of glacial till. Small, discontinuous areas underlain by glacial stream deposits of sand and gravel also can be found in the area. The Well is located within a bedrock aquifer comprised of intersecting structural discontinuities such as fracture, fracture zones, and/or faults. Groundwater flow and storage within the bedrock aquifer will be dependent on the degree to which such structural discontinuities are developed and interconnected.

EGGI lineament analyses and fracture fabric measurements suggest that fracture supported coincident lineaments in the area trend northeast/southwest to south-southeast/north-northwest northwest to southeast (Figure 3). Pumping-induced water level impacts *may* occur preferentially in those directions.

Previous hydrogeologic investigations in similar geologic settings suggest pumping-induced water level impacts could occur out to a distance of approximately 3,000 feet from the Well. To be conservative, a circular Zone of Influence was defined using a ***"radius"*** that equals the maximum anticipated extent of pumping-induced water level impacts rather than assuming water level impacts will only occur out to a distance of 3,000 in the directions of the local coincident lineaments and fractures.

It is anticipated that recharge to Well #3 will be derived almost exclusively from precipitation within the contributing watershed to the Production Well. The proposed hydrogeologic evaluation of the Production Well will include an assessment of whether the adjacent pond and local wetlands provide potential additional recharge to the Well.

The preliminary results of water quality sampling following drilling show that the groundwater from Well #3 is suitable for use as a public water supply, but could need treatment for iron and manganese. Additional water quality analyses collected during the long-term pumping test will provide insights into whether groundwater withdrawn from the Well will comply with New Hampshire Primary or Secondary Drinking Water Standards for community supply wells.

F. Identification of Data Gaps in the Conceptual Hydrogeologic Model

The following components of the conceptual hydrogeologic model will require additional information to enhance our conceptual understanding of groundwater flow within the bedrock aquifer(s) surrounding Production Well #3. The long-term testing program will be designed to address the following questions:

- What is the contributing recharge area surrounding Production Well #3 when pumped for extended intervals at 160 gpm?
- Is the Zone of Influence strongly defined by dominant northeast/southwest to south-southeast/ north-northwest trending bedrock heterogeneities?
- How much recharge will be derived from infiltration from surface water bodies, such as the nearby pond and wetlands?
- Will the long-term pumping of the Production Well impact local water resource users, including domestic wells and other public water supply wells?
- How will water quality change during prolonged pumping?

IV. LOCATION OF WELL #3 RELATIVE TO SURFACE WATER, SANITARY PROTECTIVE AREA, PRELIMINARY WELLHEAD PROTECTION AREA, AND POTENTIAL IMPACT AREA

A. Well Location Relative to Surface Water and Floodplains

Production Well #3 is approximately 80 feet from nearby pond and at least 100 feet from the closest wetlands (Figure 6).

In addition, FEMA floodplain maps[5] show that Well #3 is located outside of any defined 100-year floodplain limits (Figure 6).

B. Sanitary Protective Area

The Permitted Production Volume (PPV) for Well #3 is being requested to be 230,400 gpd (160 gpm). Therefore, the Sanitary Protective Area (SPA) for the Well is defined as a circle with a 400-foot radius, per specifications set forth in Env-Dw 302 regulations. Properties located within the SPA of the Production Well are shown on Figure 6.

[5] Firmette map obtained on website http://fema.maps.arcgis.com/home/webmap/viewer.html?webmap=cbe088e7c8704464aa0fc34eb99e7f30&extent=-71.15131987770098,42.83489412571914,-71.142178909379,42.8374903879131604

The SPA for Well #3 lies completely within the same lot (PID: 000011000031000000) as the two existing Angle Pond Water System Wells, #15 and #16. The lot is owned by the Angle Pond Woods Condominium Association, Inc. and HAWC owns the right to develop water within the lot (Appendix C). Although the SPA remains on the same property, the 400-foot radius reaches the nearest condominium unit on Linden Drive and incorporates a small portion of the lawn (to the northeast) (Figure 6). Septic/leach field areas within the Subdivision will be located greater than 400 feet from the Well. However, the SPA, defined by Administrative Rule, cannot contain land uses unrelated to the water withdrawal. Therefore, HAWC is petitioning NHDES for a waiver of the rules for that portion of the property containing other land uses (approximately 0.11 acres or 4,950 square feet or 0.98% of the SPA). The request for a waiver has been included as Appendix D).

C. Preliminary Zone of Influence and Wellhead Protection Area

The objective of defining a Wellhead Protection Area (WHPA) is to help protect the groundwater resources derived from the Production Well under long-term pumping conditions. For this Preliminary Application, the Preliminary Zone of Influence[6] (PZOI) needed to be estimated to help determine the area where the natural groundwater table will experience pumping-induced impacts. Once an estimation of the PZOI is made, the extent of the Preliminary WHPA is delineated to define that area from which groundwater will be captured by the Production Well. Therefore, the Preliminary WHPA provides a limit of the search area used during the collection of background data, such as contaminant threat information (as presented in later Sections of this report).

Until the final pumping test is performed, the exact extent of the Zone of Influence (ZOI) will remain unknown. However, HAWC did perform a preliminary pumping test on Well #3, pumping at 160 gpm for a period of just over three days (Figures 7 and 8). Water level responses in the pumping well were highly favorable during the pumping test, with gradual flattening of the pumping response curve. Total drawdown during the three-day test was 79.61 feet, resulting in a final specific capacity of 2.0 gallons per minute per foot of induced drawdown. Water levels were also recorded in the two existing Production Wells (#15 and #16). Well #15 is 620 feet from Well #3 and began responding to pumping several hours into the pumping test, eventually responding with a total of 5.22 feet of drawdown. No drawdown was noted in Well #16 during the pumping test.

Graphical projection of the pumping test data for both Production Well #3 and Well #15 suggests drawdown after 180 days of continuous pumping at 160 gpm would result in drawdown of approximately 91 and 15 feet, respectively. By plotting those drawdowns versus logarithmic distance, it is estimated that the ZOI around Well #3 would project out to approximately 2,600 feet. Therefore, for the purposes of the delineation of the Preliminary WHPA, it is conservatively assumed that the PZOI projects to 3,000 feet in all directions (Figure 9). However, southwest of Well #3, the 3,000-foot radius intercepts the topographic divide between the Little River and Powwow River watersheds. Because the 3,000-foot radius is considered highly conservative and the watershed divide represents a hydraulic divide, the PZOI was

[6] The area where groundwater drawdown is induced in response to pumping.

truncated along the watershed divide (Figure 9). The total area encompassed by the PZOI is 593 acres (0.93 square miles).

Once the PZOI was defined, the Preliminary WHPA was then defined as the entire PZOI plus the topographic area draining to the PZOI (Figure 9). The Preliminary WHPA encompasses an area of 742 acres (1.16 square miles). Nine inches of recharge over the Preliminary WHPA provides a rate of groundwater recharge equal to 345 gpm (or 497,400 gpd), approximately 2.9 times the proposed PPV of 160 gpm (230,400 gpd). Monitoring of other water resources within the PZOI, such as domestic wells and other public water supply wells, will be conducted to determine the actual ZOI and WHPA around the Angle Pond Production Well #3.

D. Potential Impact Area Delineation

The Potential Impact Area (PIA) is defined by New Hampshire Statute and its delineation is intended to define that area within which other water users could potentially be impacted by the removal of groundwater resources from Well #3. It generally includes the Preliminary WHPA and those areas hydraulically down gradient to a point where either the flow of the trunk stream is ten times greater than the groundwater withdrawal or the land area encompassed is ten times greater than the Preliminary WHPA. In the case of Well #3, the down gradient watershed of concern is that of the Powwow River, and specifically the sub-watersheds of Bartlett Brook, which drains Angle Pond, and Colby Brook (Figure 10).

The PIA for Well #3 was extended down gradient to the confluence of Colby Brook with Country Pond (Figure 10). The USGS StreamStats Website[7] was used to delineate the watershed up-gradient of Country Pond and to calculate the estimated streamflow characteristics for each watershed defined (Appendix B). The total area of the PIA is approximately 10.2 square miles, which is approximately nine times larger than the 1.16 square mile area of the Preliminary WHPA defined for Production Well #3.

The Preliminary WHPA and PIA fall within the Towns of Hampstead, Sandown, Kingston, and Danville (Figure 10).

V. PRELIMINARY WATER RESOURCE AND WATER USE INVENTORY FOR THE PRELIMINARY WELLHEAD PROTECTION AREA AND POTENTIAL IMPACT AREA

Water resources and uses that occur within the estimated Preliminary WHPA and the Potential Impact Area are presented on Figure 10. This map was created using databases from the NHDES, including those for public water supplies, registered water users, private water wells, and wetlands.

[7] https://water.usgs.gov/osw/streamstats/

A. Permitted Public Water Supplies

Data from the NHDES PWS GIS database show that there are permitted public water supply wells within the Preliminary WHPA for Production Well #3, besides the other two Production Wells in the Angle Pond Well Field (Figure 10 and Appendix E). The permitted public supply wells include the following:

- Angle Pond Grove operates two "Transient" supply wells about 1,800 feet from Well #3, in the Town of Sandown.
- Hampstead Village Preschool has a supply well about 1,300 feet east of Well #3, but NHDES records show that system as being inactive.
- RAM Printing utilizes a Non-Community, Non-Transient well for its supply approximately 2,700 feet to the east.
- Squire Roberts Tavern has a "Transient" supply well 3,700 to the southeast of Well #3, but it also listed as being inactive.
- Finally, HAWC operates another public supply well on Tanglewood Drive, approximately 3,400 feet south-southeast of Well #3.

Thirty-four public water supply wells are present within the PIA of Well #3 but are outside of the Preliminary WHPA (Figure 10 and Appendix E). Only 21 of the 34 public wells are classified as "Community Supply Wells" and seven of those wells are owned or operated by HAWC. Five more of the Community Supply Wells, plus the Woodland Pond System, are classified as inactive (Appendix E).

B. Registered Water Users

Data obtained from the NHDES GIS database of Registered Water Users that withdraw more than 20,000 gpd indicate that ten Registered Water Users, besides the Angle Pond Wells, are located within the preliminary PIA (Figure 10 and Appendix E). Two of the Registered Water Users are part of the Cotton Farms System and the remaining are all owned by HAWC.

C. Private Groundwater Supply Wells

A water user inventory (including domestic wells) was carried out in accordance with Administrative Rule Env-Dw 302.12. This inventory showed that 14 lots with potential domestic wells occur within 1,000 feet *of the Production Well* (Figures 2 and 9; Appendix F). The owners of all lots within the 1,000-foot buffer *of the PZOI* will be sent a request for well information and permission to monitor wells on their properties during the pumping test program, as required per Env Dw-302.14. Requests for well owners within 1,000 feet of the Production Well will be honored to the most reasonable extent possible.

In accordance with those same rules, *"the owners of representative wells within 1,000 feet of the estimated cone of depression"* will be sent letters requesting permission to monitor their wells during the pumping test program. Monitoring requests for representative domestic wells will be selected based on such factors as: a) the location of the domestic well relative to the

Production Well; b) location of the domestic well relative to other available monitoring locations; c) the type of well; and d) the condition of the well. We anticipate monitoring 10 to 15 domestic wells on lots that are more than 1,000 feet from the Production Well.

When the ***"Request for Permission to Monitor"*** letters are sent to property owners, each owner will also be provided the opportunity to have groundwater samples collected from their respective wells prior to EGGI installing monitoring equipment and after the equipment is removed. These samples will be analyzed by an approved laboratory for Total Coliform and E. Coliform bacteria using an appropriate laboratory method that provides Most Probable Number (MPN) data.

D. Wetlands

Field observations, wetland surveys conducted for the Angle Pond Water System, and the NHDES National Wetland Inventory (NWI) databases show the location of jurisdictional wetlands that occur locally to Well #3 (Figures 4 and 6). None of the four towns incorporated into the PIA have designated Prime Wetlands.

E. Natural Heritage Inventory

The NH Division of Forests and Lands, Natural Heritage Bureau (NHB) indicates that there may potentially be endangered (Blanding's) or threatened (Spotted) turtles, as well as a species of Special Concern (Eastern Pond Mussel) within the PIA, but not within the preliminary WHPA. The NHB report is included in Appendix G.

VI. PRELIMINARY INVENTORY OF CONTAMINATION SOURCES

A. Contaminant Threats Inventory

An important component of any groundwater development program is the assessment of the potential for groundwater contamination resulting from past, present, or projected future land uses. EGGI investigated potential threats to groundwater quality through a review of available State contaminant threat databases and through field inspection of current land uses and activities.

Overview information from the State GIS database was compiled in GIS format to provide known locations of *potential* threats to groundwater quality. "Windshield" surveys and the evaluation of high resolution aerial imagery were completed as part of this Study to confirm the site locations listed in the State databases and to highlight additional land uses that could potentially diminish groundwater quality (Figure 11).

B. Summary of Contaminant Threat Potential for Well #3

The Production Well site is generally well-protected against potential contaminant threats to groundwater quality. Current and historical land uses within the SPA (a 400-foot radius) and in the immediate area of the Production Well have been restricted to woodlands and sand and

gravel mining for at least the last 50 years. Multiple subdivisions and individual homes have been constructed in the area over the past 20 years.

Potential threats to groundwater quality from land uses were inventoried for the preliminary WHPA and for the 1,000-foot buffer around the estimated cone of depression.

Existing land uses within the 1,000-foot buffer around the PZOI are *generally* limited to wooded residential, woodlands, and wetlands. The nearest commercial activities are located within 1,400 feet to the south of Well #3, along Route 111 and Sandown Street (Figure 11).

According to the NHDES OneStop Database, the types of classified threats to groundwater quality that are present within 1,000 feet of the PZOI and PWHPA include the following (Figure 11 and Appendix H):

- **Underground Storage Tank Facilities (ustsite):** The closest UST (1,700 feet from Well #3) is present at the Store N More gasoline station on Sandown Road. It is to be noted that the presence of underground storage tanks does not indicate that there has been a release of a contaminant into the groundwater. If a leak has occurred, it would show up on the Site Remediation database.
- **RCRA Hazardous Waste Generators (rsite):** These are sites the USEPA has deemed to be potential threats to groundwater quality because of the presence of hazardous chemicals that could be released. Once again, these locations are not releases of hazardous waste, just potential locations of such releases.
- **Site Remediation and Groundwater Hazards Inventory (csite):** These are the locations where known or suspected releases have occurred. Twelve "csites" occur within the 1,000-foot buffer around the PZOI. Five of the sites are registrations of underground injection controls (floor drains), one of which is for the HAWC pump house at the Angle Pond Well Field. Four of the sites involved petroleum spills. Seven of the 12 sites have been "closed" by NHDES and are thought to present no threat of groundwater contamination.

Some of the future land uses within the contributing area to the Angle Pond Well Field may pose a potential threat to groundwater quality, including the following: the application of fertilizers or pesticides around the houses nearest to the Production Well, the storage of fertilizers, pesticides, petroleum products, etc. in the condominiums, or potential oil or gas spills on the roads proximal to the Production Well. The condominium association will need to establish best management practices (BMPs) for the control of potential contaminants within the final Zone of Contribution to the Production Well.

VII. PROPOSED PUMPING TEST AND WATER QUALITY SAMPLING

A. Pumping Test Design

A long-term (seven-day), constant rate pumping test will follow the approval of the Preliminary Report by the NHDES. The objectives of the long-term pumping test program are as follows:

1) Refine the Preliminary Wellhead Protection Area (WHPA) and Zone of Influence (ZOI)

The response of the bedrock aquifer to long-term pumping will provide the basis for developing a technically defensible delineation of the WHPA and ZOI to Angle Pond Production Well #3. An accurate determination of the WHPA will provide the justification for a well-planned and effective contaminant source control program.

2) Determine the Permitted Production Volume

NHDES approval for the Permitted Production Volume (PPV) will be based on the results of the long-term pumping test. It is proposed to develop a groundwater withdrawal of 160 gpm (230,400 gpd) from Well #3. The ability of the Well to sustain a given pumping rate will be determined by conducting the long-term pumping test at a constant rate. Furthermore, projection of the pumping response data to 180 days of pumping with no recharge will be done to ensure water levels are not projected to decline below major water-bearing zones.

3) Provide Background Data Necessary to Address Issues Related to Groundwater Resource Development

The pumping test data will be used to gain a better understanding of the bedrock aquifer hydrogeology. The results of the conceptual and/or analytical modeling will provide insights into potential impacts to water resources proximal to the Production Well and the nature of recharge to the bedrock aquifer system.

In addition, each of the data gaps listed at the conclusion of Section III, G regarding the conceptual model of the Aquifer will be further investigated during the extended pumping program.

B. Monitoring Well Requirements for the Pumping Test

Water levels within the local bedrock aquifer and wetlands surrounding Well #3 will be monitored using:

- **Angle Pond Production Well #3**
- **Existing Angle Pond Production Wells #15 and #16:**
- **Existing Domestic Wells:** Figure 9 shows the distribution of 447 tax parcels that may contain domestic monitoring locations. Requests to Monitor will be sent to a representative sample of this total list of property owners (Appendix F). A representative sampling of wells will be selected for monitoring based on the responses. It is expected that between 12 and 15 domestic wells will be monitored during the pumping test.
- **Shallow Piezometers:** Three shallow piezometers are proposed for installation near Well #3. Piezometer HAP-P1 will be installed along the shore of the small pond nearby, approximately 80 feet from Well #3. The second, HAP-P2, will be installed

along the north shore of the same pond, approximately 350 feet to the west. Finally, the third piezometer, HAP-P3, will be installed in the closest wetlands to the north of Production Well #3 (Figure 6). These will be hand-driven drive points with the screened portions installed within the shallow water table.

- **Surface Water Stations:** Surface Water Station HAP-SW1 will provide water level measurements in the nearby pond (Figure 6). Station HAP-SW2 will be established at the outflow of the small pond and only monitored if the pond is overflowing, in an effort to measure surface water flow before, during, and following the pumping test. This data will help establish the nature of natural recharge to the pond and discharge from the pond and its relationship with the pumping well.

All wells and piezometers to be used for monitoring will be tested to ensure that they are hydraulically connected to the surrounding groundwater. Well HWK-4, an idle test well in Atkinson, New Hampshire, west of the Angle Pond Water System, will be used to monitor ambient water level conditions.

C. Discharge Measurement and Permitting

Discharge measurements of the water pumped from Production Well #3 will be conducted with in-line flow meters and/or orifice weirs. Documentation concerning the calibration of the flow meters and orifice weirs will be provided to the NHDES in the Final Report. In addition, volumetric measurements will be made periodically during the pumping test to calibrate the flow meters and orifice weirs.

Discharge water will be prevented from infiltrating the ground surface and conveyed approximately 400 feet to the tributary draining the nearby pond. The discharge point will be down-gradient of Surface Water Station SW-2 (Figure 6).

A Temporary Surface Water Discharge Permit describing discharge into the tributary will be obtained from the NHDES prior to the pumping of Well #3.

D. Long-term Constant Rate Pumping Test

A constant rate pumping test will be performed on Well #3 at a rate of 160 gpm. The discharge rate will be maintained at 160 gpm (~3%) for the duration of the seven-day pumping test.

All of the administrative rules stated in Env-Dw 302.14 for the design and operation of pumping tests will be followed throughout the pumping test program. All water levels and discharge measurements will be made using appropriate measuring devices.

Water levels at all locations will be measured for a minimum period of seven days prior to pumping and throughout the pumping period. Recovery of water levels will be monitored for a minimum period of seven days after the end of the pumping period.

Water level measurements will be taken at 30-minute intervals in all background or ambient monitoring wells. During the pumping test, Production Well #3 and existing Production Well #15 will be monitored at time intervals chosen on a logarithmic scale (at least 10 measurements per log cycle) at the start of pumping and recovery. Table I shows the monitoring schedule for measuring water levels for the Production Well, observation wells, piezometers, and surface water stations during the long-term pumping test.

Climatic conditions (precipitation and barometric changes) will be monitored throughout the 21-day pumping test program.

E. Water Quality Sampling

In accordance with the requirements of Env-Dw 302.15, water samples will be collected from Production Well #3 at the following intervals during the pumping test program:

- Between the first and fifth hour of the pumping test.
- Midway through the pumping period.
- Within the last three hours of the pumping period.

The first and second water samples from Production Well #3 will be analyzed for volatile organic compounds (VOCs), iron, manganese, pH, specific conductance, hardness, chloride, sodium, and nitrate. The final round of samples from the Well will be analyzed for a complete suite of Primary and Secondary Drinking Water Standards (as listed in the NHDES Publication "Analytical Requirements for Community Public Water Systems, 2016[8]). In addition, during the final day of pumping, samples for 1,4-Dioxane (low level), radon, and Per- and Poly-fluorinated Alkyl Substances (PFAS) will be collected.

In addition to the above parameters, field chemistry meters will be used to monitor discharge water from the Production Well on a daily basis for specific conductance, temperature, dissolved oxygen, and pH throughout the pumping period. The surface water in the nearby pond (or its overflow at Station SW-2) will be monitored for these three parameters at the same frequency.

Production Well #3 is located within 200 feet of surface water; therefore, a Microscopic Particulate Analysis (MPA) will be performed on the discharging groundwater, in accordance with the Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (USEPA, 1992). The MPA testing will be performed within the last two days of the pumping interval and will follow the protocol outlined in Env-Dw 302.15(f).

[8] https://www.des.nh.gov/organization/divisions/water/dwgb/documents/sdwalist.pdf

VIII. PROPOSED METHODOLOGY FOR REFINING THE PRELIMINARY WELLHEAD PROTECTION AREA

A. Analytical Modeling

Evaluation of the pumping test data using analytical models provides insights into the conceptual understanding of the bedrock Aquifer proximal to the Production Well. Corrections to the raw pumping test data will include ambient groundwater level conditions, variations due to rainfall events, and surface water level variations, if deemed appropriate. Final corrected water level data will be representative of water level variations attributable to pumping impacts only and will not be substantially impacted by other outside influences.

The most appropriate analytical models will be used to calculate aquifer coefficients and to enhance the conceptual model of groundwater flow in the Aquifer. However, because most analytical models were developed for application in aquifers approximating porous-media conditions, they may not be suited for the interpretation of bedrock aquifer responses. In addition to analytical models, the WHPA will be delineated by graphically projecting the corrected pumping-induced drawdown out in time to 180 days of pumping with no recharge. The projected drawdown will be subtracted from the pre-pumping groundwater contour map to create a resultant groundwater flow net that can be used to delineate the WHPA (contributing area) to the Production Well.

B. Predicting the Bedrock Aquifer Response During Extended Dry Periods

EGGI will attempt to schedule the long-term pumping test of Well #3 during a period of low precipitation. If unseasonably wet conditions exist around the proposed start date, then the test may need to be re-scheduled. Antecedent monitoring of groundwater levels and ambient monitoring during the seven-day pumping test will provide a means to assess non-pumping variations in the water table. Corrections to the pumping test response can be applied to account for wet conditions, such that more conservative 180-day drawdown can be estimated.

C. Determining the Impacts to the Nearby Pond and Adjacent Wetlands

Several methods will be employed to monitor impacts on the local surface water and adjacent wetlands. This will include:

- Installing shallow piezometers adjacent to the nearby pond (with screened intervals below the pond bottom) and within the closest wetlands within 400 feet of the Production Well to evaluate/observe potential pumping influences.
- Monitoring ambient streamflow conditions in the nearby pond's drainage channel will be accomplished by measuring surface water flow before, during, and after the pumping test. A rating curve will then be developed to estimate flow rates based on water levels.
- Water levels in the nearby pond will be monitored to help assess losses and gains under natural and pumping conditions.

- Water quality monitoring will be performed at the pumping well and in the tributary draining the pond to compare the physical and chemical characteristics of each, in an effort to assess the potential for surface water infiltration to directly influence groundwater quality.

D. Estimate of Effects on Water Resources and Uses in the Study Area

It is anticipated that the presence of the silt/clay-rich sediments beneath and within the wetlands will provide a hydraulic barrier between the nearby wetlands and the underlying bedrock aquifers. Potential impacts to the wetlands will be evaluated through the water level measurements obtained in the piezometer installed within the wetlands, as noted above. However, the nearby pond appears to have been excavated during previous mining activity and may lack fine-grained bottom sediments. Therefore, water level variations in the pond during the pumping test will be important to determine if a hydraulic connection exists between the pond and the deep bedrock aquifer.

Potential impacts to existing domestic wells and to the nearby public supply wells will be evaluated by monitoring water levels within selected domestic wells. It is anticipated that domestic wells will be monitored continuously for a period of three to four weeks at half-hour intervals. The analysis of water level data collected from these wells will help to determine potential impacts in the selected domestic wells, to neighboring wells, and to other existing production wells.

IX. WATER CONSERVATION RULES

Rule Env-Wq 2101 requires that the approval of any new public water supply source triggers adherence with the Water Conservation Rules. The HAWC's approved water conservation plan is presented on the following website:
https://www.des.nh.gov/organization/divisions/water/dwgb/water_conservation/documents/hawc_walnutridge.pdf

X. PUBLIC NOTIFICATION AND REPORT SUBMITTALS

NHDES rules Env-Dw 302 and Env-Wq 403 require public notification as follows:

Env-Dw 302

302.16(b)(3) – Complete Notification Requirements of RSA 485-C:21.

RSA 485-C:21

- Send a copy of the Preliminary Report using Certified Mail to the Governing bodies of each municipality and each supplier of water within the Potential Impact Area (PIA) of the proposed withdrawal as defined in RSA 485-C:21, V-e.

Env-Wq 403

403.05 - Send a copy of Preliminary Permit Application to the following:
- Each Municipality located within the PIA; and
- Each Public Water Supplier located within the PIA.

A copy of this Preliminary Hydrogeologic Report will, therefore, be sent via Certified Mail to four towns plus a single public community water system:

Town of Hampstead
Town Clerk
11 Main Street
Hampstead, NH 03841

Town of Sandown
Town Clerk
320 Main Street
Sandown, NH 03873

Town of Danville
Town Clerk
210 Main Street
Danville, NH 03819

Town of Kingston
Town Clerk
163 Main Street
Kingston, NH 03848

Active Public Water Community Supplier: Cotton Farms MHP of Danville, New Hampshire

All the other systems within the PIA are owned and operated by the Hampstead Area Water Company (HAWC).

Signed Certificates of Mailing will be forwarded to the NHDES upon receipt by EGGI.

XI. LIMITATIONS

EGGI has collected and evaluated the available technical data according to professionally accepted scientific standards. The recommendations provided herein represent EGGI's professional opinion based upon the hydrogeologic data collected and do not constitute a warranty written or implied.

XII. REFERENCES

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Gephart, G.D. ,1987, Surficial Geologic Map of the Sandown Quadrangle, Rockingham County, New Hampshire. State of New Hampshire Department of Resources and Economic Development, Office of State Geologist, Map SG-5.

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