TOWNS AT POINT SEANNA

Spotsylvania County, Virginia

Water System Preliminary Engineering Report

January 16, 2015

Project No. 6996-01-001

Bowman Consulting Group, Ltd.

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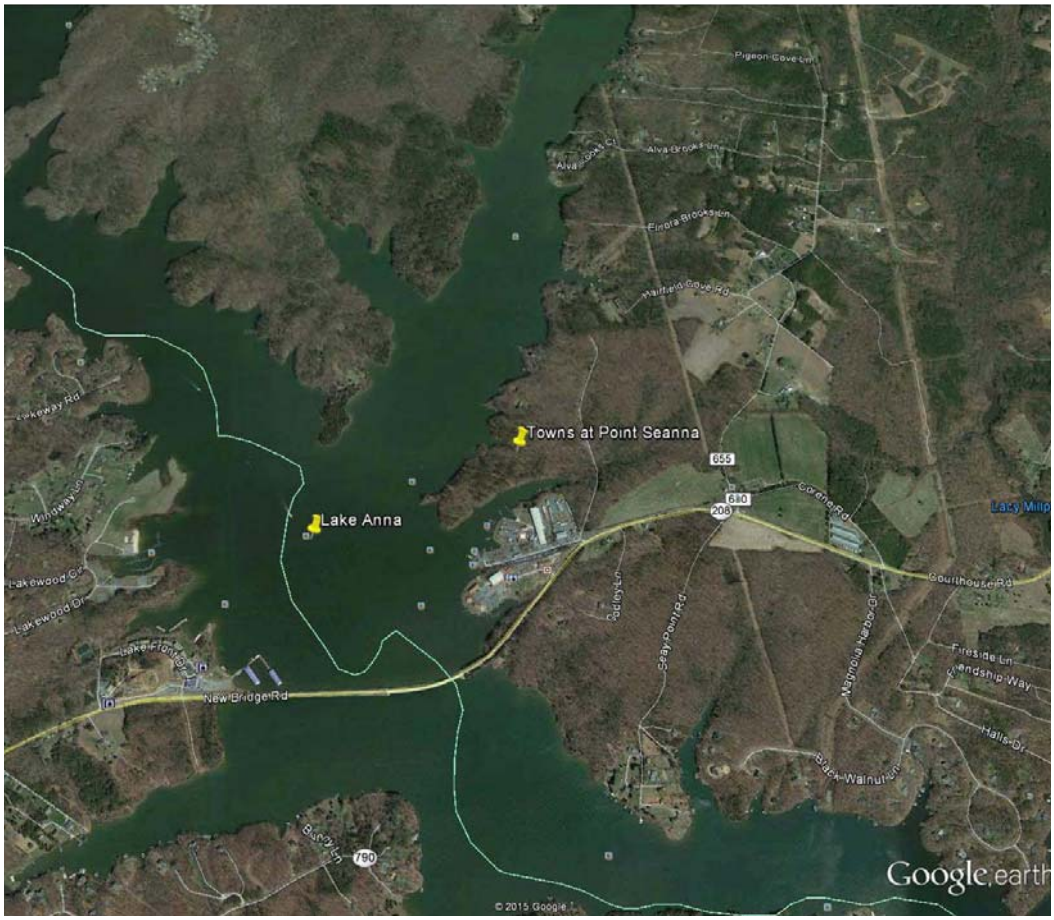
I. INTRODUCTION

The purpose of this preliminary engineering report is to support the design of a water system to serve the proposed Towns at Point Seanna subdivision in Spotsylvania County, Virginia. The system will serve approximately 81 residential townhomes. The development is located off of Courthouse Road (Route 208) in Spotsylvania County. The property is bordered by Lake Anna (Pigeon Run) on the western side and Shaffers Cove on the southern side (see **Figure I-1: Project Vicinity Map**). Since public water is not available, a new water supply, treatment, and pumping system is required to serve the development.

A preliminary hydrogeologic report conducted for this project indicated that it is highly likely that there is sufficient groundwater available to serve the proposed development. Design of any treatment for the water system will be contingent upon water quality data, however, based on information related to other wells in the area, we have assumed that the wells will require disinfection as well as iron and manganese removal.

The proposed water system will consist of two drilled groundwater wells, an atmospheric storage tank, booster pumps, hydropneumatic tank, a chlorine disinfection system and an iron and manganese filter.

The system will be privately owned and operated. The design for the water system is based on the Virginia Department of Health (VDH) standards for public water systems.



TOWNS AT POINT SEANNA WATER SYSTEM SPOTSYLVANIA COUNTY, VIRGINIA **FIGURE I-1: PROJECT VICINITY MAP**	BOWMAN CONSULTING GROUP, LTD. 460 McLAWS CIRCLE, SUITE 120 WILLIAMSBURG, VIRGINIA 23185 (757) 229-1776 FAX: (757) 229-4683

II. PRELIMINARY HYDROGEOLOGIC REPORT

A preliminary hydrogeologic report, included as Appendix A, was prepared by Maeville Energy, dated December 8, 2014. The report evaluated the site for water supply potential based on existing information and a brief site visit. The results of the evaluation indicated that the site is considered favorable for producing the required volumes of water to meet the demands.

A more detailed study, including remote sensing and a fracture trace analysis, as well as on site geographical surveying, will need to be prepared to identify the exact drilling sites. Once the well sites have been selected, test wells will need to be installed in order to determine well yields and water quality.

Based on similar water quality data in the region, it is assumed that water treatment for the system will include iron and manganese removal as well as disinfection.

III. DESIGN CRITERIA

A. AVERAGE FLOW RATES AND WELL PUMP CAPACITY

The water system will serve 81 units, each with 4 bedrooms. Based on a water demand of 90 gpd/bedroom, the water system will be designed based on the following average flow rate:

81 units x 4 bedroom/unit x 90 gpd/bedroom = 29,160 gpd = 20.3 gpm

VDH regulations require that wells produce a minimum of 0.5 gpm per unit. Therefore, the minimum well flow rate is:

81 units x 0.5 gpm/unit = 40.5 gpm

The proposed system will provide domestic water service only. Fire flows will be provided for the development by dry hydrants that draw non-potable water from Lake Anna.

B. IRON AND MANGANESE REMOVAL

The proposed iron and manganese removal system will include two Greensand Filters. The filter controls will be automated, and backwashing will occur automatically based on either time controls or differential pressure. Backwashing can also be manually initiated. Potassium permanganate and sodium hypochlorite will be fed continuously to the raw water prior to the filter. Each greensand filter will be sized for the minimum well flow rate of 40.5 gpm.

The greensand filters are sized based on a loading rate of 3 gpm/sf. Therefore, the

minimum required greensand filter surface area is 13.4 square feet (40.5 gpm / 3 gpm/sf = 13.4 sf), resulting in the need for two 48" diameter filter units.

The filters will be backwashed at a rate of approximately 15 gpm/sf for approximately 15 minutes. A backwash holding tank will be provided to store the backwash water before disposal. The tank will be sized for one backwash event, which is approximately 3,015 gallons. A 5,000 gallon storage tank is proposed. There are two alternatives for disposal of the backwash water. Backwash can either be pumped back into the lake, which would require a Virginia Pollutant Discharge Elimination System (VPDES) permit from Virginia Department of Environmental Quality (DEQ), or it can be disposed of through underground injection, which requires an Underground Injection Control (UIC) permit from the EPA.

C. ATMOSPHERIC STORAGE TANK

VDH requires a storage volume of 200 gallons per housing unit. Therefore, total storage required for the system is:

81 units x 200 gallon/unit = 16,200 gallons

The proposed atmospheric storage tank has a capacity of 20,000 gallons.

D. BOOSTER PUMPS

VDH requires a minimum pump capacity of $Q = 11.4\ n^{.544}$, where n equals the number of equivalent residential connections. This equates to a minimum pumping capacity of approximately 124 GPM based on 81 ERC's.
Two (2) pumps are provided in primary/backup configuration with each pump

capable of providing 124 GPM at a sufficient pressure to maintain the minimum distribution system pressure. The booster pumps will also be used to backwash the iron and manganese filters.

E. HYDROPNEUMATIC TANK

A 5,000 gallon hydropneumatic tank will be provided. An air compressor and the booster pumps will maintain pressure in the tank between approximately 50 and 60 psi.

F. SODIUM HYPOCHLORITE

Sodium hypochlorite will be fed to the raw water to maintain minimum chlorine residual in the atmospheric storage tank and distribution system. The assumed design feed concentration is 2 ppm. The following calculations are based on the well design flow rate of 40.5 gpm:

Flow: 40.5 gpm = 58,320 gpd x 8.34 lbs/gal = 486,389 lbs/day

$$\frac{X \text{ lb/day} CL_2}{486{,}389 \text{ lb/day} H_2O} = \frac{2 \text{ lb/day } CL_2}{1{,}000{,}000 \text{ lb/day} H_2O}$$

X = 1.0 lb/day CL_2

Using a 12.5% solution (Standard Sodium Hypochlorite Solution)

$$\frac{1.0 \text{ lb/day } CL_2}{0.125 \text{ lb/day } CL_2 \text{ solution}}$$

= 7.8 lb/day solution

= 0.9 gal/day = 0.04 gph

Two chemical feed pumps (one wall mounted, one spare) will be provided to pump the chemical into the well piping. The pumps will be capable of pumping 0.2 GPD @ 100 PSI with maximum pumping capacity of 3 GPD.

G. POTASSIUM PERMANGANATE SOLUTION

Potassium permanganate solution will be fed to the raw water prior to entering the filter in order to remove iron and manganese. The amount of potassium permanganate required will depend on the results of the water quality analysis.

H. SODIUM CARBONATE (SODA ASH) SOLUTION

If it is determined that pH adjustment is required, soda ash will be fed prior to the raw water entering the filter. Jar testing will be performed to determine the exact soda ash feed rate.

I. BUILDING AND SITE

The water system will be located within a pre-cast concrete building with approximate dimensions of 20’ by 24’. The wells will be remotely located from the building and will supply groundwater through 3” transmission mains from the wells to the treatment facility. We have assumed that the system will be equipped with an emergency generator to allow the system to continue to operate in the event of a power outage. However, as an alternative, it could be configured to allow the connection of a portable generator, if the Owner so

chooses.

The total water treatment plant site is estimated to be approximately 60’ by 100’, or 0.14 acres. The site requires an access drive with a turn around and a chain link fence.

An overall site plan showing potential sites for the wells and treatment facility, as well as an overall site plan for the treatment plant, are provided in Appendix C.

IV. SYSTEM OPERATION

The starting and stopping of the well pumps will be based on the water level in the atmospheric storage tank. When the water level drops to the "Well Pump On" elevation, the well pump will energize. When the water level reaches the "Well Pump Off" elevation, the well pump will be stopped. The two well pumps will automatically alternate operation. There will also be a "Low Water Level Lockout" set point in the storage tank that will prevent the booster pumps from operating if the storage tank is near empty.

The booster pumps and an air compressor will operate to maintain the pressure in the hydropneumatic tank and distribution system between 50 and 60 psi. When the water level in the hydropneumatic tank drops to the set elevation, the booster pumps will be energized. The booster pumps will be turned off when the water level has once again reached the desired level. The air compressor will be controlled based on the pressure in the hydropneumatic tank.

The greensand filters will have the capability to automatically backwash based on a set time period, by a pressure differential setpoint, or when manually initiated. Backwashing will be achieved by the booster pumps pulling water from the atmospheric storage tank.

The chlorine and potassium permanganate feed systems will be controlled so that when the well pumps are operating, the chemicals will be injected into the raw water.

V. PRELIMINARY COST ESTIMATE

We have prepared a preliminary cost estimate of the water system, excluding the cost to drill the wells and installation of the distribution system. We have made assumptions of how far the wells are from the treatment facility. We estimate that the construction cost for the facility is $675,625. A detailed cost estimate is provided in Appendix D.

VI. CONCLUSION AND RECOMMENDATIONS

The proposed water system will consist of two drilled groundwater wells, each with a minimum capacity of 40.5 gpm. The well pumps will transfer raw water to the water treatment facility, which will be housed inside a pre-cast concrete building. Upon entering the facility, chlorine and potassium permanganate will be added to the raw water. After chemical injection, the raw water will pass through one of two parallel greensand filters for iron and manganese removal. After treatment, the water will be held in the atmospheric storage tank. Booster pumps and a hydropneumatic tank will pressurize the distribution system and maintain system pressure between 50 and 60 psi. An emergency generator will provide backup power to the facility upon a power failure.

A process schematic for the system is provided in Appendix B and preliminary site and mechanical layouts are provided in Appendix C. A preliminary construction cost estimate was prepared and is included in Appendix D. The total estimated construction cost for the water facility is $675,625.

In order for the project to move forward, the next step is conducting the detailed hydrogeologic study. The hydrogeologic study will identify the proposed well sites and provide well testing data to include stabilized well yields and water quality data.

APPENDICIES

APPENDIX A – PRELIMINARY HYDROGEOLOGIC REPORT

December 8, 2014

Mr. Ken Baybutt
Bowman Consulting
460 McLaws Cir, Suite 120
Williamsburg, VA 23185

Re: Corsair Terrace Project, Spotsylvania County, Virginia
Via email to Ken Baybutt <kbaybutt@bowmanconsulting.com>

Dear Mr. Baybutt,

Maevelle Energy, LLC (ME) is pleased to provide you with this report concerning our preliminary evaluation of the Corsair Terrace Properties site in Spotsylvania County, Virginia. We evaluated the site for water supply potential based on existing information and a brief site visit. The property in question is located along the northeastern shore of the northwest-southeast trending Lake Anna. The site is just to the north of Courthouse Road (State Route 208), and straddles a small private road named Corsair Terrace which ends a few hundred yards past the site to the north. A majority of the site consists a peninsula jutting into Lake Anna to the west of Corsair Terrace road; bounded by Shaffer's Cove to the south and Pigeons Run to the north. A portion of the site also lies to the east of Corsair Terrace road. The site is 46.97 acres and includes Spotsylvania County lots 69-5-A5 and 69-5-B.

An 81 unit housing development is proposed for the property which would be served by a public water system fed by at least two water wells. The average day demand for the project based on design flows of 360 gal/day/unit is 29,160 gal/day, or 20.25 gal/min over a 24 hour period. Using a typical peaking factor of two, as is often done when designing a new public water system with no record of flow monitoring, a total yield of around 40 gpm should be planned to meet peak demands. State of Virginia regulations call for at least 0.5 gpm of flow for each unit, so this would also translate into a required total yield of 40.5 gpm. A minimum of two wells are planned to supply this total demand, providing some redundancy in the system, and satisfying requirements that a system of this size be served by two wells.

Our preliminary evaluation consisted of a non-stereoscopic fracture trace analysis, examination of existing geologic mapping, a review of a previous studies in the area, an analysis of nearby well information using federal databases, and a site visit. Based on this information, the site has a strong likelihood of finding sufficient water to meet demands, although there is of course no guarantee of that. I have identified several areas where wells might be promising. Depending on site plans, access, and other factors, these areas should be further investigated to determine

exact drilling locations. This would include a more detailed study of nearby wells, additional remote sensing and fracture trace analysis, and most importantly **on-site geophysical surveying**, to identify exact drilling sites.

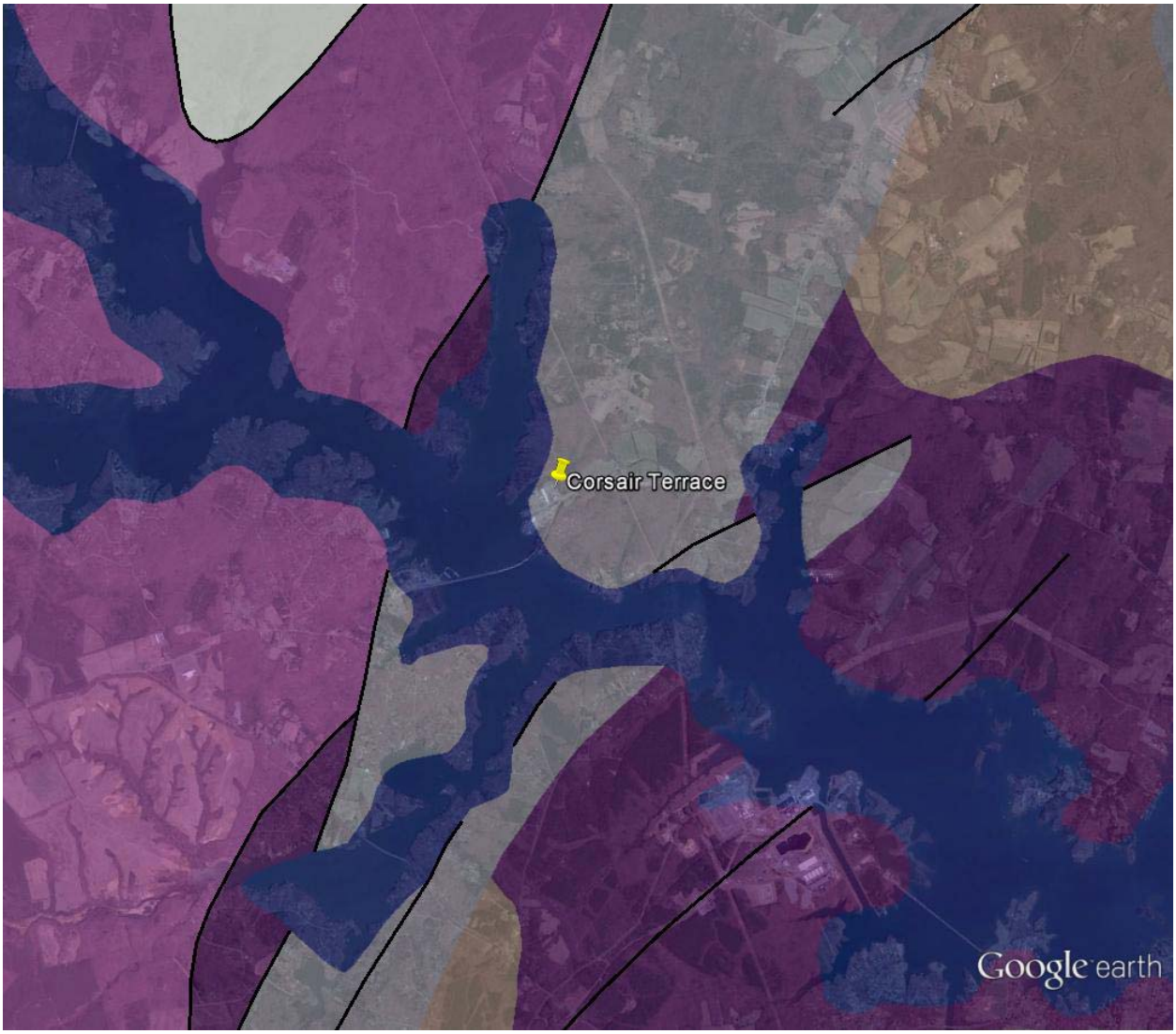
The site is considered to be favorable for producing the required volumes of water based on the following findings.

1. Existing Geologic Mapping

The review of existing geologic mapping shows the site to be underlain by the Quantico Formation, a slate or porphyroblastic schist, locally containing felsic metatuff, metagreywacke, with micaceous quartzite interbeds. (Digital Representation of the 1993 Geologic Map of Virginia", 2003). This is a metamorphic rock, where water is transmitted through faults and fractures in the rock. The rock type itself is somewhat favorable for the formation of fractures, with the quartzite interbeds being particularly suited to fracturing. Some of the largest yielding wells in the area are drilled into this formation, including those serving the Village of Mineral. Locating high yielding wells in this unit (or any type of crystalline metamorphic rock) requires locating major fracture zones or faults; these being the zones transmitting large volumes of water.

In addition to favorable rock type, the contacts between the Quantico formation and the adjacent geologic units are mapped as major faults (prime areas for groundwater movement). There are several major faults passing through the Quantico formation, the site being situated between two of these mapped major faults, and on strike with a third to the north. Because of this, it is possible that the fault to the north extends under the site, and/or that smaller unmapped faults might exist on the property. Faults, and the areas near them, are usually the best areas for drilling in metamorphic rocks, and they can often be detected using geophysical methods.

Figure 1 Quantico Formation (grey) and nearby faults (black lines)

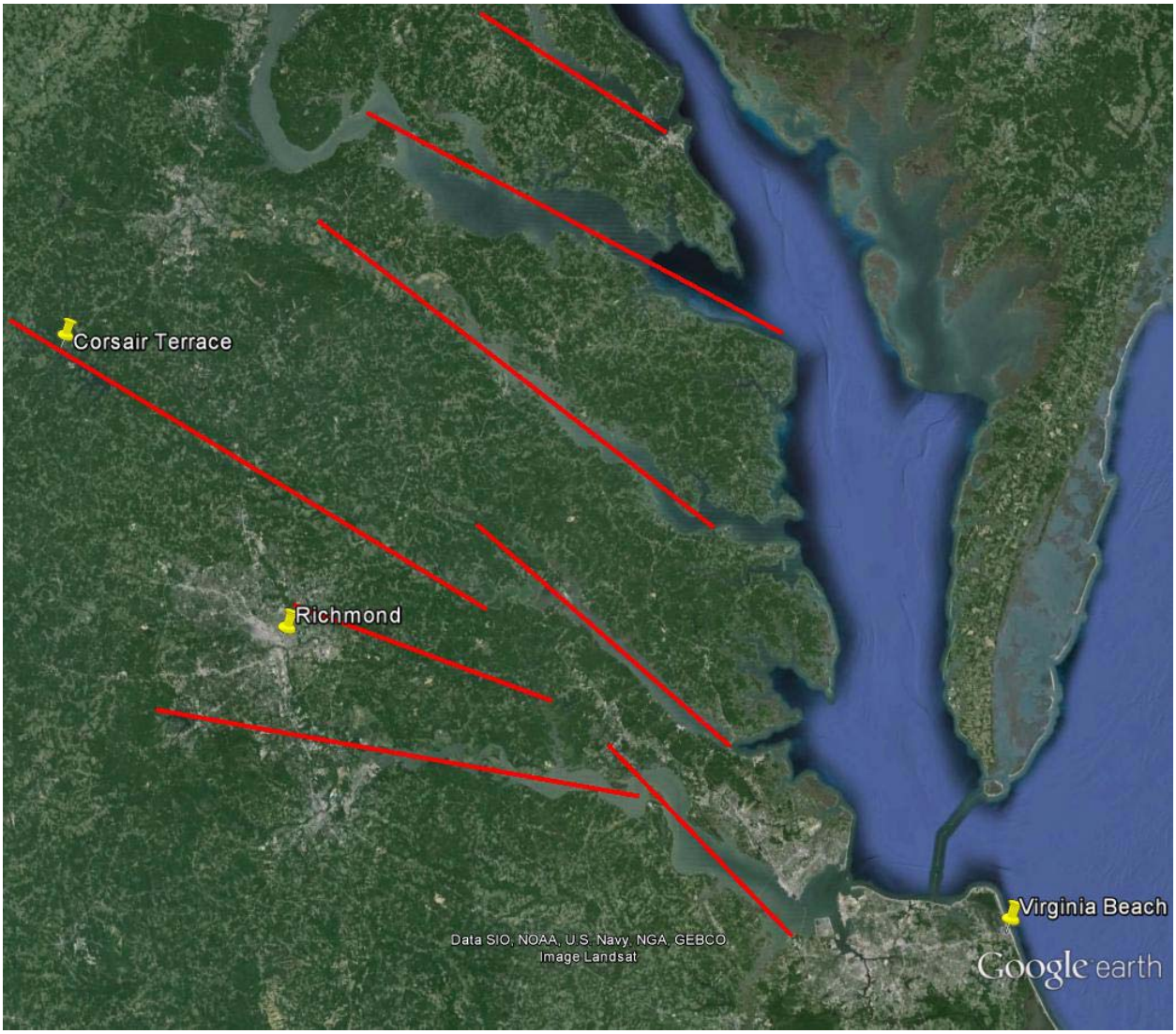


2. Fracture Trace Analysis

Because groundwater flows in fractures in this type of rock, a very limited analysis of fracture patterns was undertaken using Google Earth imagery. The analysis first looks at very large, regional patterns. Lineaments were mapped and are shown below in Figure 2. The long axis of Lake Anna is observed to follow a major lineament; one that is consistent with other large scale lineaments in the region controlling major drainage basins. This major lineament passes very close to (or perhaps even under) the site. It is

a very favorable location for drilling, in fact the most favorable in the area. In general, the closer to this lineament one drills, the higher the probability of success.

Figure 2: Regional Fracture Pattern



Closer examination of the areas surrounding Lake Anna reveals a more detailed pattern of fractures, Figures 3 and 4 below, indicating the site as being in a very favorable location at the intersection of several significant lineaments. Note the very large lineament trending almost east west and passing near and perhaps through the site. Several large yielding wells are a located along the trace of this lineament, which controls the orientation of the east trending branch of the North Anna River as it forks to the northwest of the site. This east west lineament intersects the 'Lake Anna Lineament' in the vicinity of the site as well as another north south trending lineament in the area;

which passes along the eastern side of Lake Anna State Park (which also has a good yielding well) and to the west of our site. This north south lineament controls the orientation of Pigeons Run.

Figure 3: Local Fracture Pattern

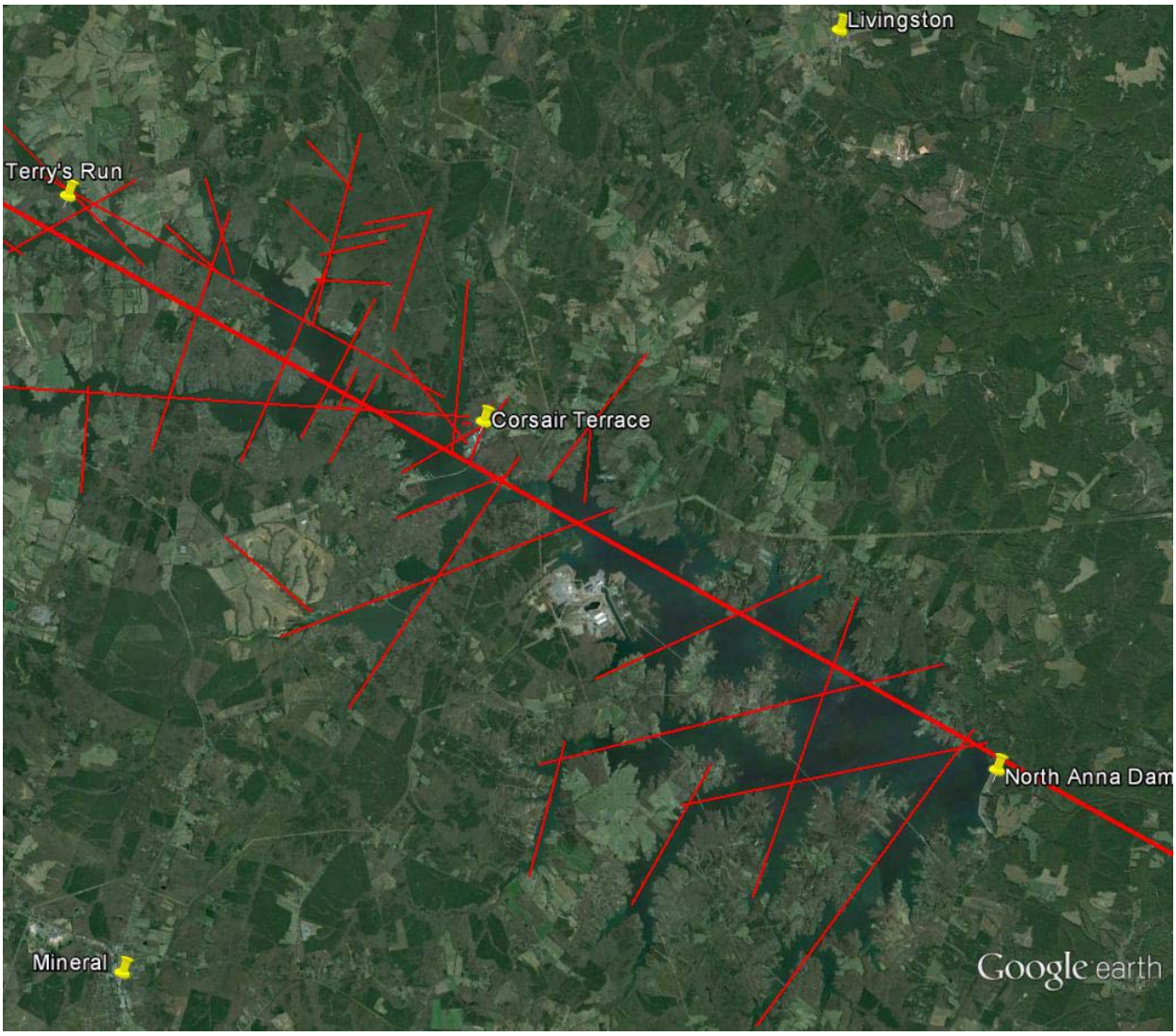
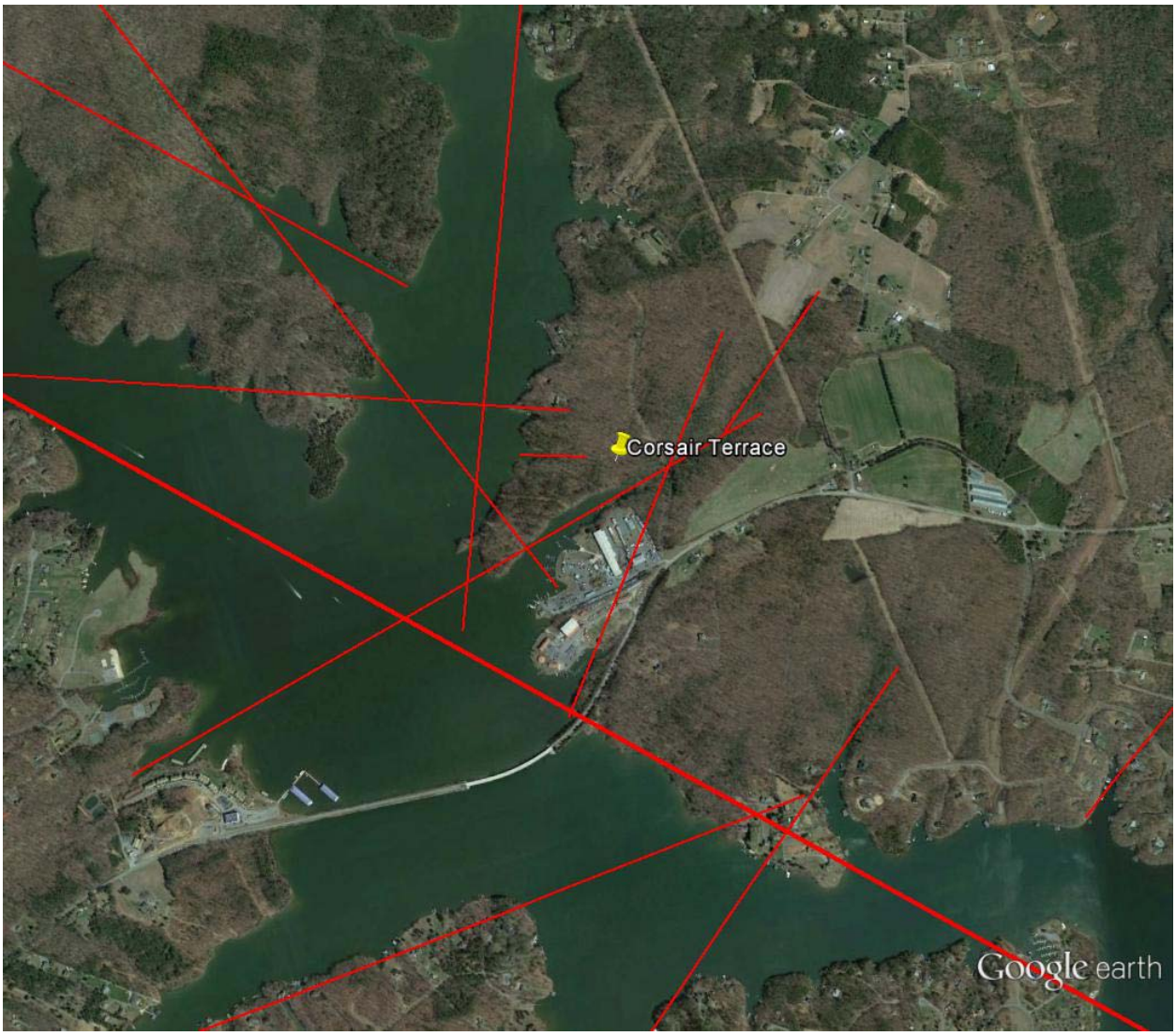
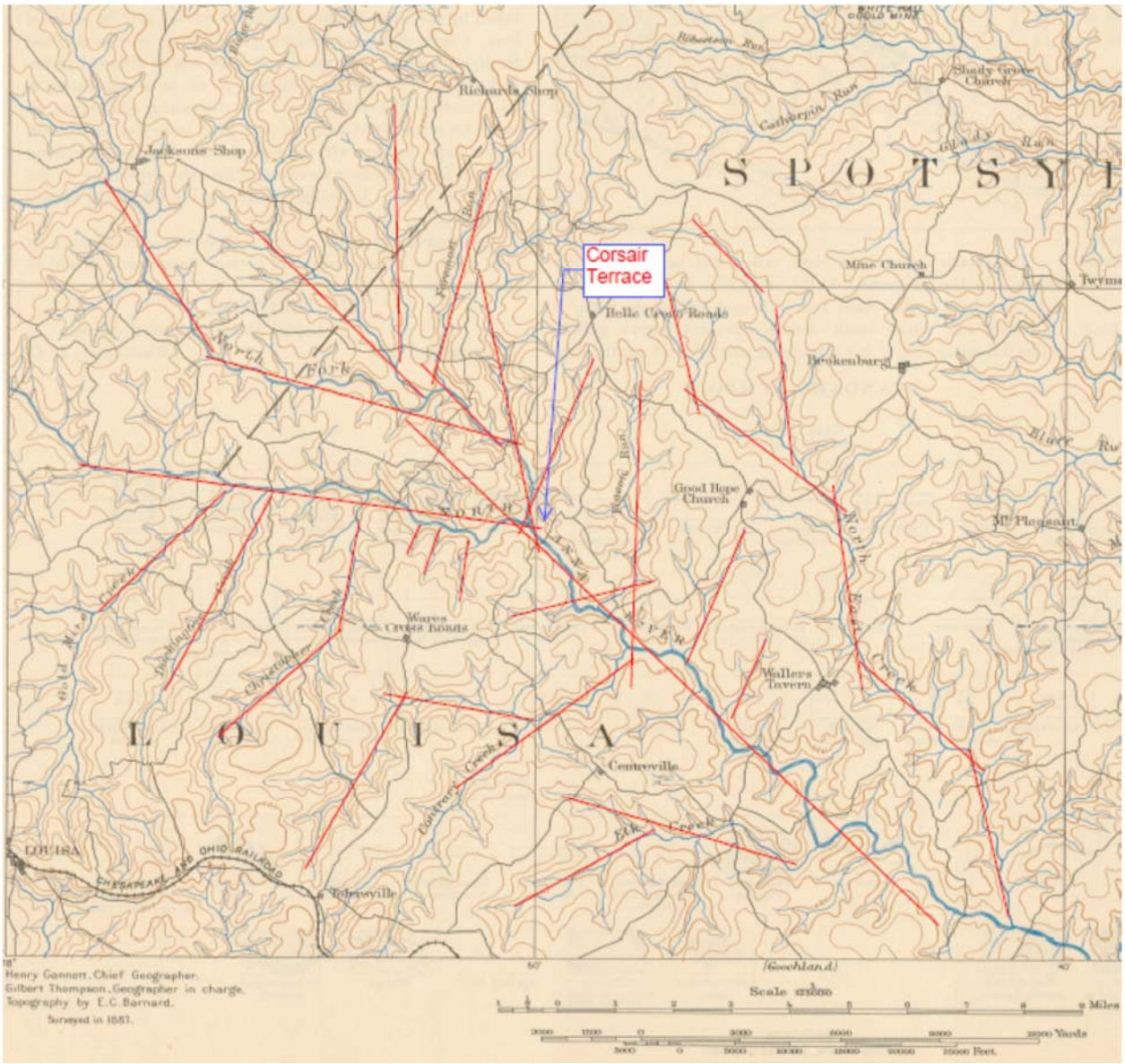


Figure 4 Site Fracture Pattern



Further analysis was conducted on historical USGS Topographic maps. These 1892 maps reveal the natural topography before Lake Anna was created, and before the landscape was modified by modern transportation or buildings. Fracture patterns plotted on this map reveal the intersection of several major fractures in the vicinity of the site, a very favorable finding relative to the prospect of finding water.

Fig 5 Historical Map Fracture Pattern



3. True North Environmental Report

A “Limited Groundwater Assessment Study”, August 23, 2012, was prepared regarding the Terry’s Run property, located about 5.5 miles upriver along Lake Anna, and situated in almost the same position geologically with respect to the “Lake Anna Lineament” although in a different rock type (granite instead of schist), see Figure 3 above. The report concluded the site is suitable for the development of drinking water supplies to serve a ten lot subdivision without undue adverse impact

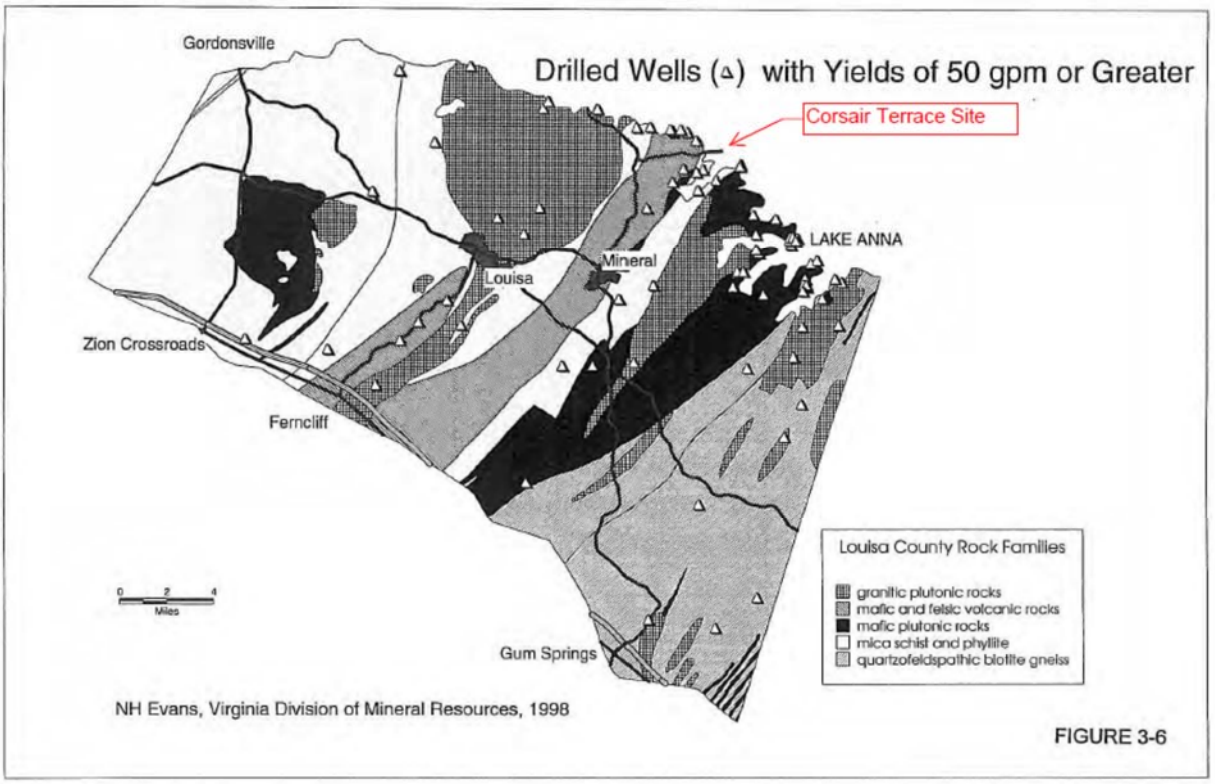
to nearby wells. Private and public well records presented in this report to support this conclusion include several high yielding public wells that are in fact very near our site (High Point Marina, Anna Point Marina) and still other public wells also near our site that have had high yields documented via pumping tests (Lake Anna State Park, Duke's Creek Marina). Some of these wells are very close to, almost abutting our site, indicating that high yields are possible on our site.

4. 1998 Well Study

The County of Louisa Water Quality Management Plan and Groundwater Study (unpublished by Nick Evans) 1998 includes a review of all the wells in Louisa County. There are three significant findings from that report, relevant to our site. First, that report shows a correlation between high yield wells and proximity to Lake Anna, the closer to the lake, the greater likelihood of high yield. That study showed 82 high yield wells (50gpm+) with 50 wells (61%) located in the immediate vicinity of Lake Anna. For this reason alone, the site is in a favorable location. This is likely a result of the major lineament discussed above.

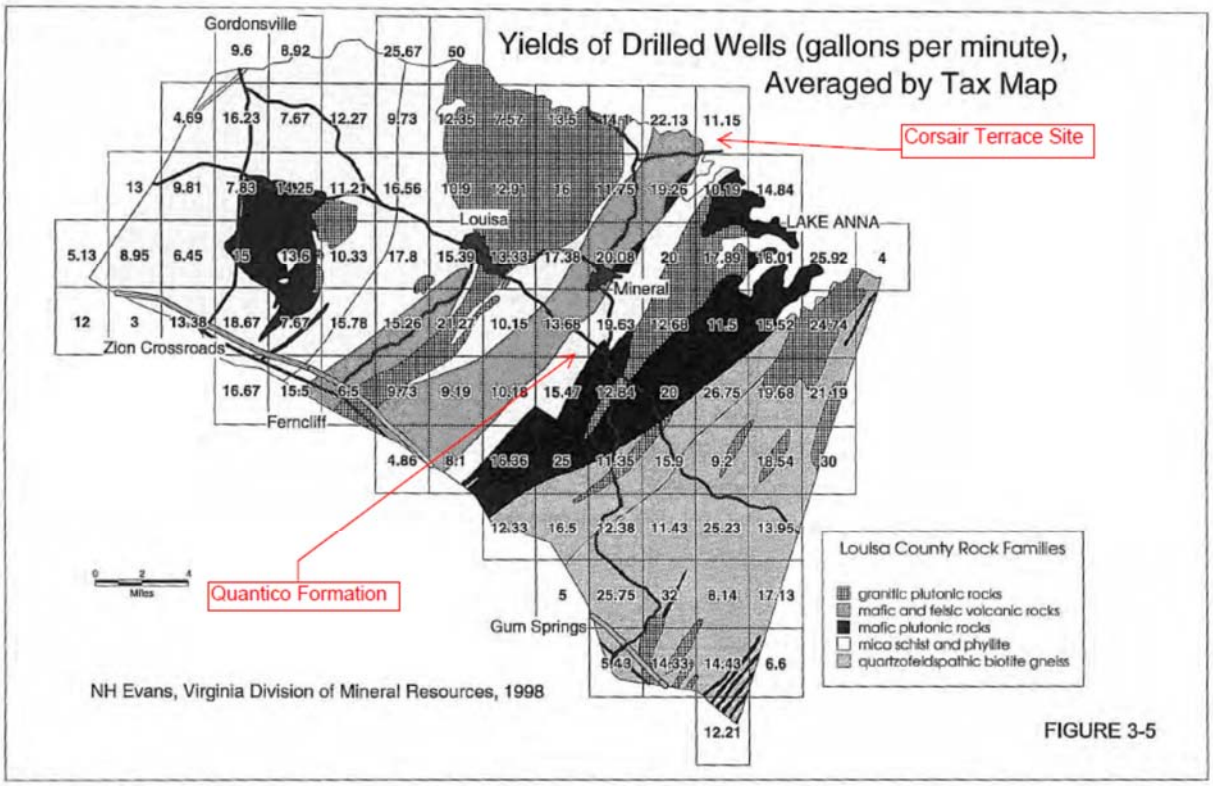
In addition, note in Figure 6 below that a large majority of these high yielding wells seem to cluster in the vicinity of the site, where the Quantico Formation intersects the Lake Anna Lineament.

Fig 6 High Yield Well Pattern



Finally, this 1998 study also shows that wells drilled into the Quantico Formation tend to have high yields, with average yields ranging from around 11gpm to as high as 20 gpm for the quadrangles that show some of this formation. Keep in mind these are randomly drilled wells, nearly all drilled until sufficient yield for a residential supply is found. Scientifically sited wells seeking higher yields, would tend to average higher.

Fig 7 High Average Yields for Quantico Formation



5. Nearby Well Analysis- Federal Databases

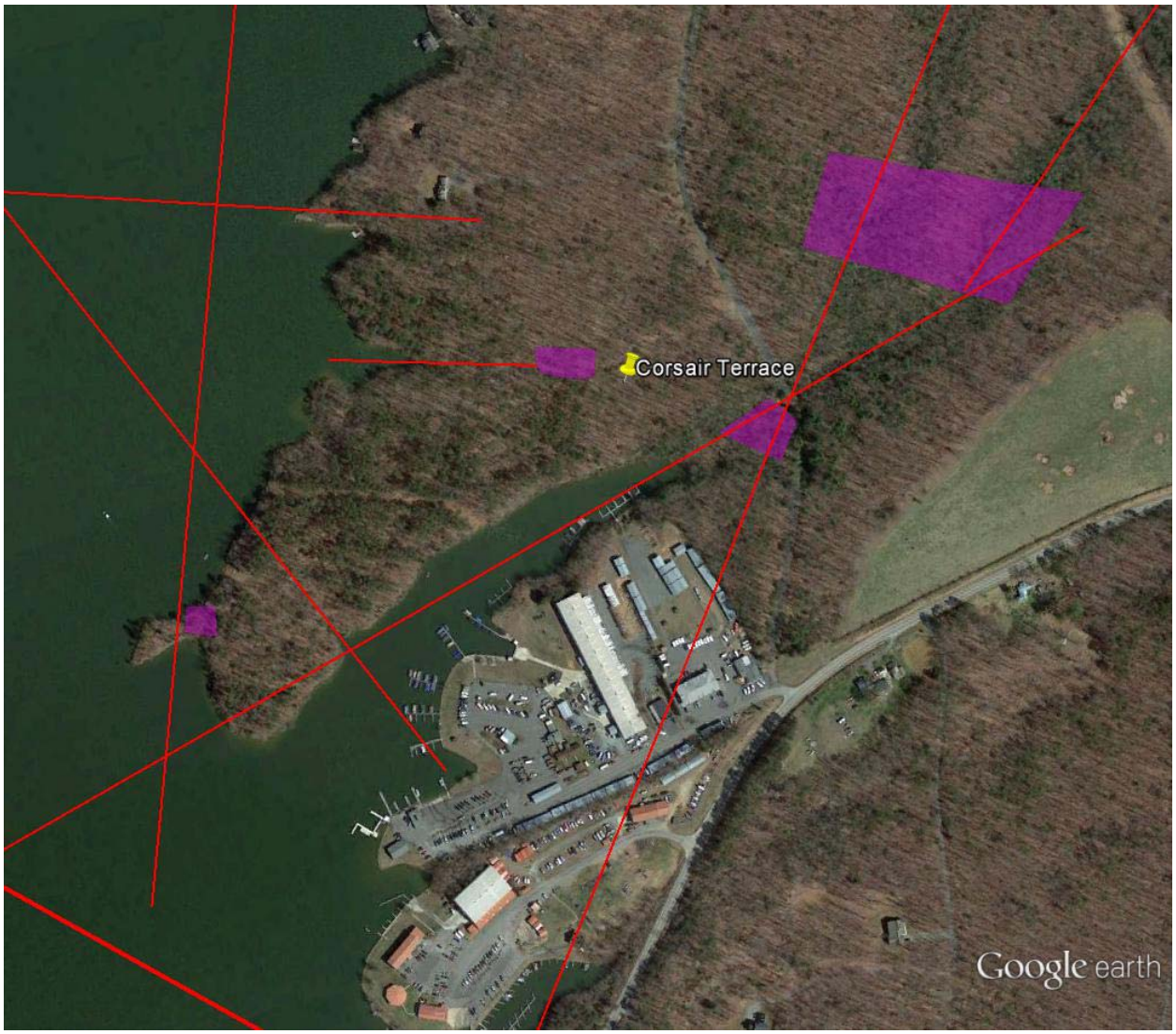
To supplement the previous well studies in the area, well locations from federal databases such as Storet were plotted and analyzed. That analysis supported previous findings of higher yields near Lake Anna. In addition to the previously identified high yielding public wells at the nearby marinas and Lake Anna State Park, this analysis includes details on high yielding wells at the North Anna Nuclear Plant, and the Village of Mineral. The distribution patterns of high yielding wells in conjunction with observed fracture traces and published geological mapping suggest the site has excellent potential for developing high yielding wells.

6. Site Visit- Target Areas

The site was walked on December 3, 2014 to observe site conditions and identify areas with the highest potential for geophysical studies to select sites. As a result of this, four areas have been identified as shown below. These are not precise areas,

but general locations identified for further study. I have marked up one of the site plans and attached it to this document, showing these areas. The prime site would be the one farthest west near the shore of Lake Anna, provided a site can be found in this area that shows a good geophysical signature and is not within the restricted riparian zone. The small site adjacent Corsair Terrace Road may be difficult to access. Geophysical surveying would be relatively easy, especially given the long road access across the site to the westernmost target area. The wooded areas are relatively open and geophysical surveying would be feasible and efficient.

Fig 8 Drilling Target Areas

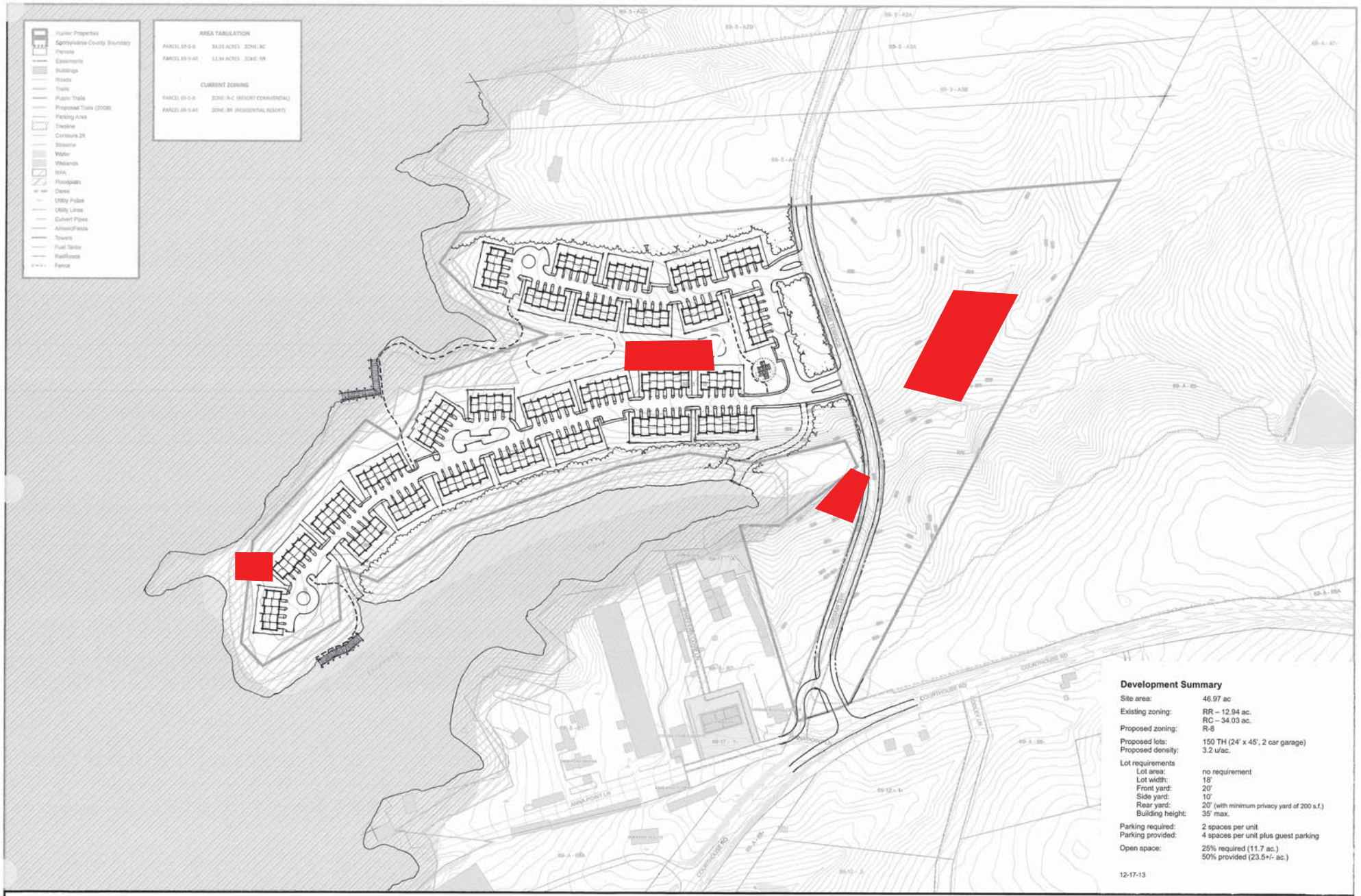


Please let me know if you have any questions.

Sincerely,

MAEVELLE ENERGY, LLC

Kenneth E. Bannister, CPG


Development Summary
Site area: 46.97 ac
Existing zoning: RR – 12.94 ac.
RC – 34.03 ac.
Proposed zoning: R-8
Proposed lots: 150 TH (24' x 45', 2 car garage)
Proposed density: 3.2 u/ac.
Lot requirements
Lot area: no requirement
Lot width: 18'
Front yard: 20'
Side yard: 10'
Rear yard: 20' (with minimum privacy yard of 200 s.f.)
Building height: 35' max.
Parking required: 2 spaces per unit
Parking provided: 4 spaces per unit plus guest parking
Open space: 25% required (11.7 ac.)
50% provided (23.5+/- ac.)
12-17-13
urban
CORSAIR TERRACE PROPERTIES
SPOTSYLVANIA COUNTY, VIRGINIA
100 50 0 100 200 300
1 inch = 100 feet February 24, 2012
N
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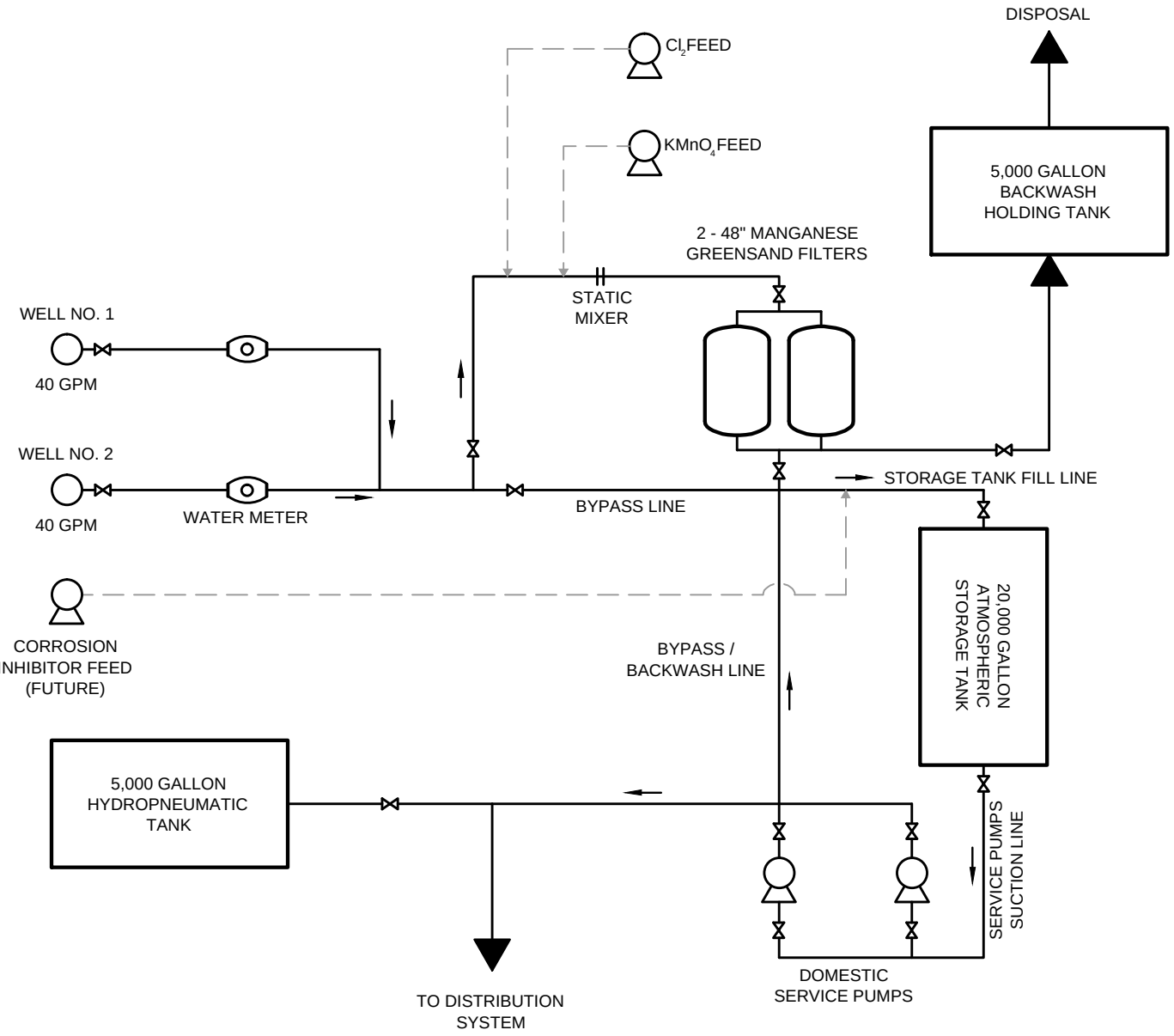
APPENDIX B – HYDRAULIC PROCESS SCHEMATIC



DWG: 6996–WPER–FIGS SCALE: N.T.S. JAN. 16, 2015

TOWNS AT POINT SEANNA

WATER SYSTEM

HYDRAULIC PROCESS SCHEMATIC

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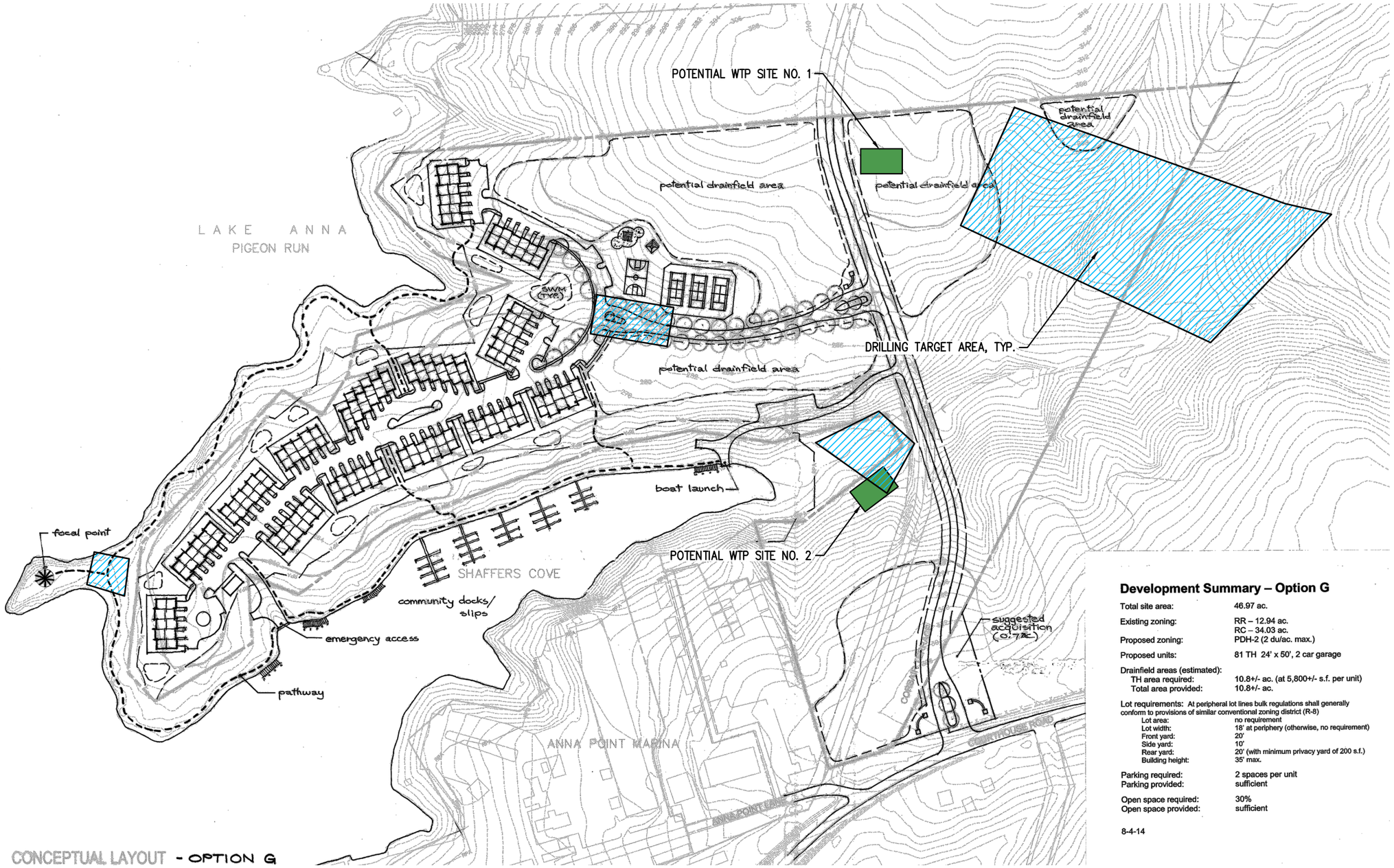
APPENDIX C – PRELIMINARY LAYOUTS

Sheet 1: Potential Well and Water Treatment Plant Locations

Sheet 2: Preliminary Mechanical Layout

Sheet 3: Preliminary Site Layout



CONCEPTUAL LAYOUT - OPTION G

Development Summary – Option G

Total site area:	46.97 ac.
Existing zoning:	RR – 12.94 ac. RC – 34.03 ac.
Proposed zoning:	PDH-2 (2 du/ac. max.)
Proposed units:	81 TH 24' x 50', 2 car garage
Drainfield areas (estimated):	
TH area required:	10.8+/- ac. (at 5,800+/- s.f. per unit)
Total area provided:	10.8+/- ac.

Lot requirements: At peripheral lot lines bulk regulations shall generally conform to provisions of similar conventional zoning district (R-8)

Lot area:	no requirement
Lot width:	18' at periphery (otherwise, no requirement)
Front yard:	20'
Side yard:	10'
Rear yard:	20' (with minimum privacy yard of 200 s.f.)
Building height:	35' max.
Parking required:	2 spaces per unit
Parking provided:	sufficient
Open space required:	30%
Open space provided:	sufficient

8-4-14

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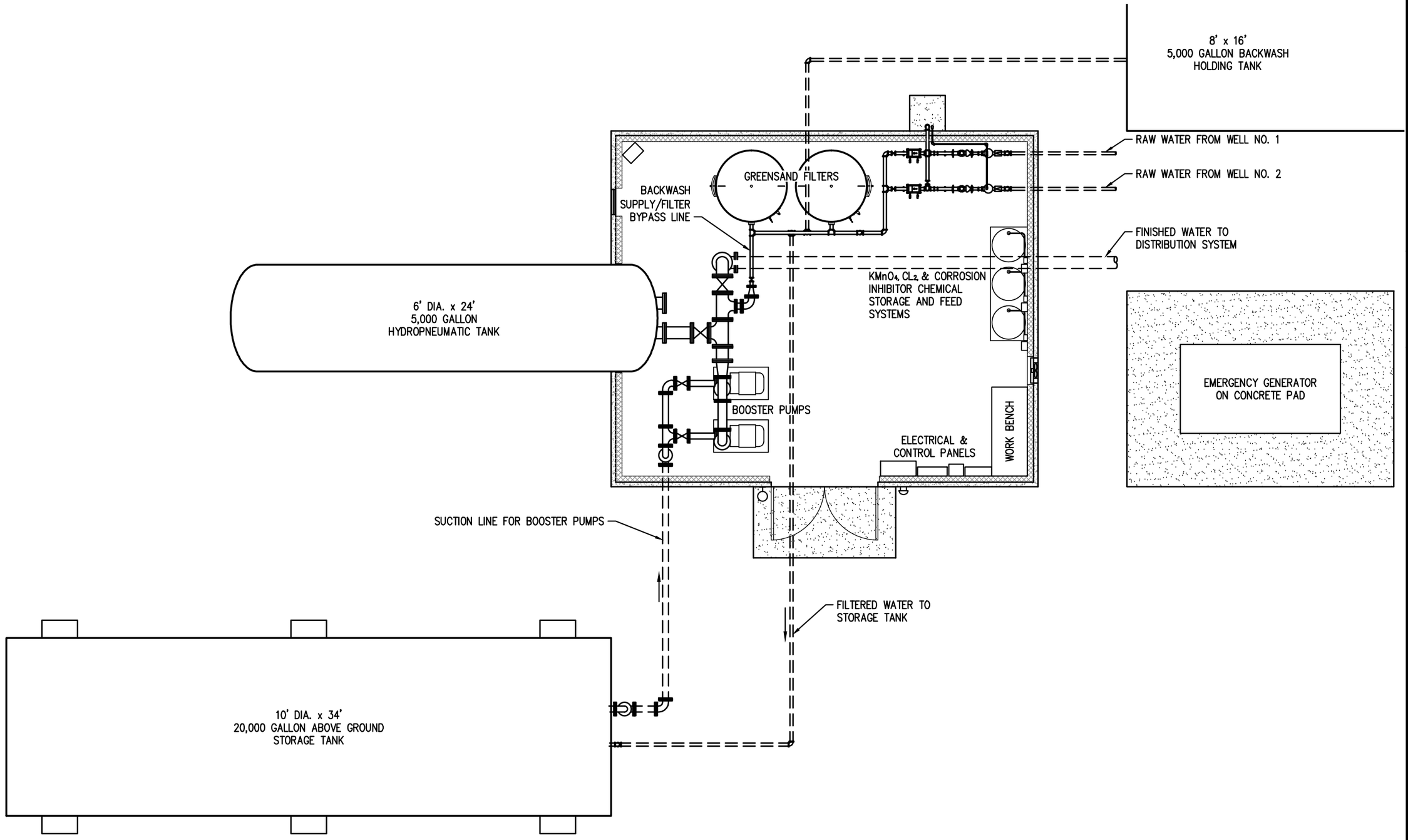
POTENTIAL WELL AND WTP SITES TOWNS AT POINT SEANNA WATER SYSTEM

KDO DESIGN	DWD DRAWN	KMB CHKD
SCALE	H: 1"=250' V: N/A	
JOB No.	6996-01-001	
DATE :	JAN. 16, 2015	
FILE No.	6996-WPER	
SHEET	1 OF 3	



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PRELIMINARY MECHANICAL LAYOUT
TOWNS AT POINT SEANNA
WATER SYSTEM

KDO	DWD	KMB
DESIGN	DRAWN	CHKD

SCALE	H: 3/16"=1' V: N/A
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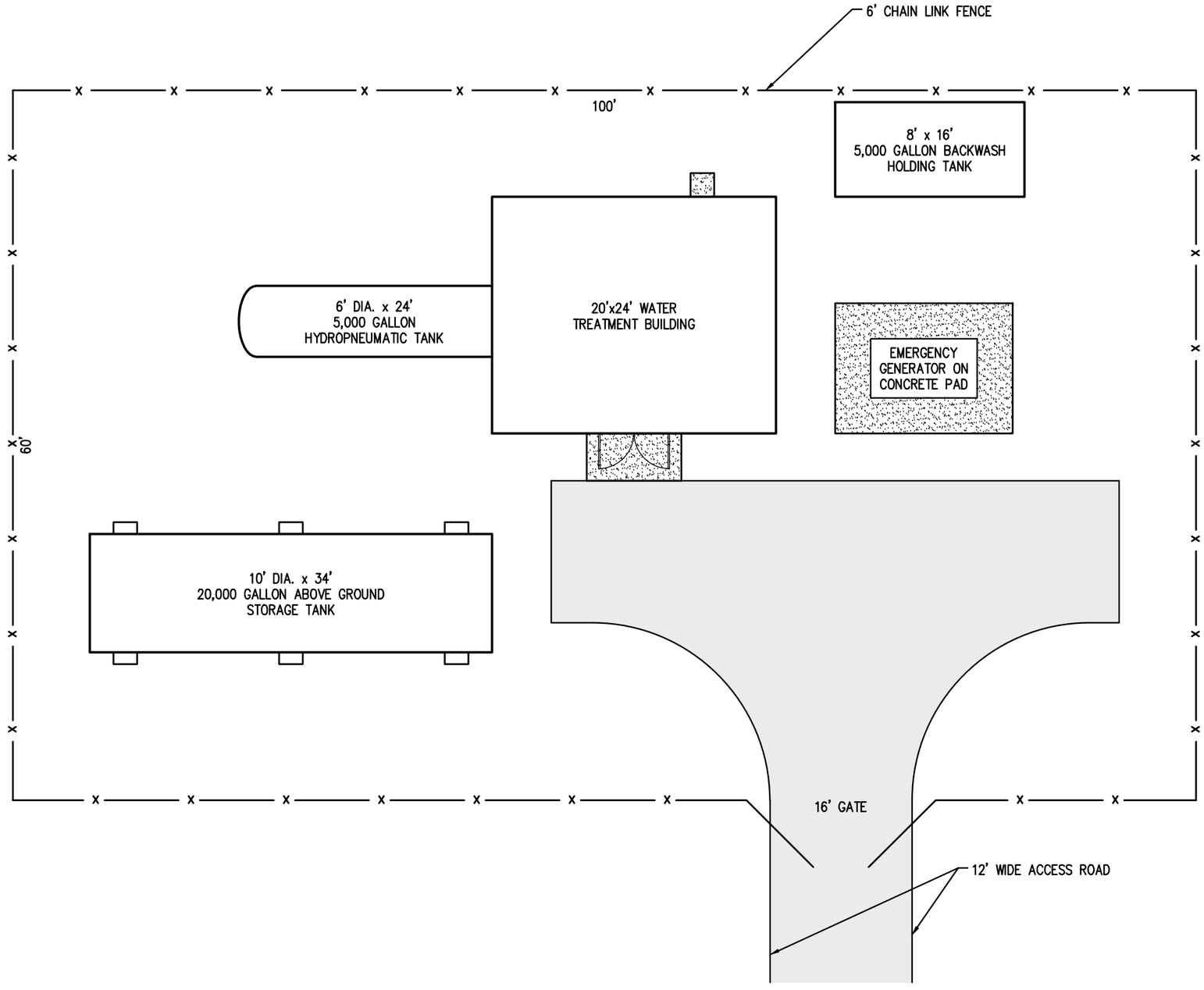
DATE :	JAN. 16, 2015
FILE No.	6996-WPER

SHEET 2 OF 3



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PRELIMINARY SITE LAYOUT
TOWNS AT POINT SEANNA
WATER SYSTEM

KDO	DWD	KMB
DESIGN	DRAWN	CHKD

SCALE H: 1"=10'
V: N/A

JOB No. 6996-01-001

DATE : JAN. 16, 2015

FILE No. 6996-WPER

SHEET 3 OF 3

APPENDIX D – PRELIMINARY COST ESTIMATE

460 McLaws Circle, Suite 120
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TOWNS AT POINT SEANNA WATER SYSTEM

PRELIMINARY CONSTRUCTION COST ESTIMATE

Item	Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization/Demobilization/Bonds/Permits	1	LS	$ 15,000	$ 15,000
2	Site Work	1	LS	$ 20,000	$ 20,000
3	Well Pump with Pitless Unit	2	EA	$ 15,000	$ 30,000
4	Pump Control Panel	2	EA	$ 15,000	$ 30,000
5	Site Piping at Water Treatment Building	1	LS	$ 10,000	$ 10,000
6	Raw Well Water Transmission Piping	1000	LF	$ 20	$ 20,000
7	Booster Pumps	2	EA	$ 10,000	$ 20,000
8	Atmospheric Storage Tank	20,000	GAL	$ 2	$ 40,000
9	5,000 Gal Hydropneumatic Tank	1	LS	$ 35,000	$ 35,000
10	Greensand Filtration System Incl Controls	1	LS	$ 100,000	$ 100,000
11	Backwash Holding Tank and Pumps	1	LS	$ 25,000	$ 25,000
12	Sodium Hypochlorite Feed System	1	LS	$ 7,500	$ 7,500
13	Potassium Permanganate Feed System	1	LS	$ 7,500	$ 7,500
14	Well Entry Piping Including Water Meter	1	LS	$ 7,500	$ 7,500
15	20' x 24' Precast Building	1	LS	$ 65,000	$ 65,000
16	Emergency Generator	1	LS	$ 65,000	$ 65,000
17	Extend Electrical Service to Site	1	LS	$ 40,000	$ 40,000
18	Misc Piping & Valves	1	LS	$ 10,000	$ 10,000
19	Misc Equipment	1	LS	$ 10,000	$ 10,000
20	Misc Electrical	1	LS	$ 30,000	$ 30,000
				Construction Subtotal:	$ 587,500
				Contingency (15% of Const.Subtotal):	$ 88,125
				Total Construction Cost:	$ 675,625

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