Source Water Protection Area Delineation Report
AWWB Well #3
Highway 29 South
Auburn, Lee County, Alabama

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Spectrum Project Number:
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Prepared For:
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Executive Summary

The Water Works Board of the City of Auburn has developed a new public-supply well (also known as "AWWB Well #3"), that derives ground water from a metamorphic rock aquifer in the Piedmont Province. The aquifer strikes northeast to southwest and dips predominantly to the southeast at moderate to high angles. This report is intended to provide the supporting documentation for the delineation of assessment areas for AWWB Well #3.

Source Water Protection Areas (SWPA) were delineated by conducting a multiphase hydrologic assessment of the area. For the first phase, aquifer characteristics were determined from the evaluation of data collected during continuous pumping tests conducted on the AWWB Well #3. The second phase involved the delineation of SWPA boundaries. The third phase involved conducting a water well survey to obtain static water-level measurements from identified wells to prepare a ground water elevation map illustrating the ground water flow system in the area. The final phase involved the identification of the potential contaminant sources within the SWPA boundaries.

Mapping of the groundwater elevation in the well head area indicates that ground-water flow generally is to the south mimicking topography. Ground-water gradients are greatest on hill slopes and lowest in valleys.

Aquifer characteristics were determined by conducting a step test and a constant pump test at and above the permit discharge rate of 1,200 gallons per minute. Results from the test indicate the AWWB Well #3 is capable of sustaining 1,200 gallons per minute discharge rate.

Results from hydrogeologic investigations in the wellhead area demonstrate that ground water is derived from a semi-confined, fractured, quartzite-dolomite aquifer. Alabama Department of Environmental Management (ADEM) regulations require the establishment of two SWPA boundaries for water supply sources in this type of aquifer. The SWPA 1 boundary is established at a 1,000-foot radius around the wellhead. Hydrogeologic mapping was used to establish the SWPA 2 boundary around the wellhead. Based on the configuration of these boundaries, 40 potential contaminant sources (PCS) were identified within the SWPA 1 and 2 boundaries established.

2.0 INTRODUCTION

2.1 Introduction to Source Water Protection

Nearly half of the population of Alabama is supplied by ground water provided by public water supply systems. While ground water sources and aquifers are regional in extent, protection of these sources can be accomplished on a local level. The ADEM administers a program that protects ground water sources from potential contamination. This program is known as the Source Water Assessment Delineation Program.

The 1986 amendment to the Safe Drinking Water Act requires public water supply systems to delineate certain capture zones around public water supply wells and to identify potential contaminant sources within the delineated areas. In response to the amendment, the ADEM adopted regulations that became effective January 2, 1996. These regulations are detailed in the ADEM Administrative Code Division 7 Water Supply Program. These regulations were last revised on January 18, 2011. Specific requirements for groundwater sources are located in chapter 335-7-15. The intent of the regulations is to protect public health by minimizing the introduction of contamination into the source water supply.

This report describes the geologic and hydrologic investigations conducted in the area that were used to delineate the SWPA boundaries and identifies PCS within the defined boundaries for AWWB Well #3.

2.2 Location

The AWWB Well #3 is located in Section 27 of Township 18 North, Range 25 East, as illustrated on the USGS 7.5 Minute Topographic Quadrangle, Loachapoka, Alabama dated 1971, revised 1983. More specifically, AWWB Well #3 is located Latitude 32° 31'13.0" Longitude 85° 31'55.9", and is approximately 432 feet above mean sea level (ft-msl). The AWWB Well #3 is depicted on Figure 1 (Attachment A).

2.3 System Service Area

The Water Works Board of the City of Auburn intends to supply approximately 18,255 customers with the AWWB Well #3.

2.4 Well Details

AWWB Well #3 is installed at total depth 230 feet below ground surface (ft-bgs). The static water level was recorded on May 16, 2009 at a depth of 53.4 ft-bgs. The well construction diagram for AWWB Well #3 is included as Attachment B and is as follows:

- 6" pilot borehole to 510 ft-bgs for lithologic description;
- 21.5" borehole from surface to 130 ft-bgs;
- 16-inch steel casing from surface to 130 ft-bgs;
- 14" borehole from 130 to 230 ft-bgs;
- 8-inch stainless steel screen from 121 to 222 ft-bgs;

3.0 REGIONAL CHARACTERISTICS

3.1 Geologic Setting

Auburn, Lee County, Alabama is located within two physiographic districts in Alabama. The physiographic districts include: the Southern Piedmont physiographic section of the Piedmont Upland District, and the Fall Line Hills district of the East Gulf Coastal Plain Physiographic Province. The Southern Piedmont covers a majority of the central and northern part of Lee County. The Fall Line Hills covers the southernmost parts of Lee County.

The Southern Piedmont District is an upland surface generally dissected by tributaries of the Chattahoochee and Tallapoosa Rivers. The Southern Piedmont is characterized by a rolling topography with no prominent topographic features indicative of a dissected peneplain of advanced erosional maturity. Elevations generally range from 500 ft-msl to 900 ft-msl with an average elevation throughout the district approximately 800 ft-msl.

The Fall Line Hills district is relatively flat to gently rolling uplands and broad, gently sloping valleys. The land surface ranges in altitude from about 350 to 650 ft-msl and local relief is usually less than 100 feet.

3.2 Hydrogeologic Setting

Precambrian to Late Paleozoic aged metamorphic and igneous rocks crop out in over 90 percent of Lee County. None of these rocks are considered a major aquifer because of low yields and hydraulic independence. Surface drainage divides these rocks and generally corresponds to the boundaries of aquifers that generally are not hydraulically interconnected. Recharge areas are coincident with outcrop areas of the aquifers (Kidd, 1989).

The movement of ground water in the aquifers is controlled by several factors: topography; the character and thickness of saprolite; and, the number, size and pattern of fractures in crystalline rock that underlie the saprolite. Ground water movement is influenced by topography whereby movement is from the hilltops and uplands to the streams and valleys.

Fractures in the bedrock of the aquifer may be joints, openings along planes of schistosity, or faults. Most of the fractures in the study area are vertical to steeply dipping and generally have definite alignments. The greatest amount of groundwater movement occurs mainly in the fractures of bedrock.

3.3 Climate

The climate in the area is subtropical and consists of hot summers and mild winters. The average daily temperature in the summertime is 81°F and approximately 51°F in the wintertime; the average annual temperature is approximately 64°F. Annual precipitation in Lee County averages about 52 inches. Remnants of hurricanes move through the area on occasion resulting in one to three days of extremely heavy rainfall (Kidd, 1989).

4.0 PHYSICAL SETTING

4.1 Geology

AWWB Well #3 is located in an area of extreme geologic contrasts. Coastal Plain sedimentary rocks consisting of varied amounts of sand, clay and gravel, unconformably overlying metamorphosed sedimentary and igneous rocks in the Southern Piedmont. Metamorphism and structural development of the Southern Piedmont in this area is interpreted to have occurred during the Alleghanian Orogeny (Raymond and others, 1988). In turn, all of the units are overlain by more recent Quaternary aged alluvial deposits as depicted in the geologic map on Figure 2 (Attachment A).

The oldest rocks are the Halawaka Schist of the Wacooche Complex. These rocks are overlain by the Hollis Quartzite and the Chewacla Marble of the Pine Mountain Group. Semi-consolidated sedimentary strata of the Cretaceous aged Tuscaloosa Group (undifferentiated) unconformably overlie these rocks in the area of the AWWB Well. Quaternary alluvial deposits occur within the flood plain in many of the larger streams in the area.

Test borings for AWWB Well #3 and two nearby wells were advanced in 2008 and 2009. The lithologies encountered were reported on the drillers logs (Attachment C) and a brief description of each rock unit and depth encountered in the borehole.

Wacooche Complex

Halawaka Schist - consists of medium gray quartz-diorite gneiss and feldspathic muscovite-biotite schist. This rock type was encountered at a depth of 330 to 510 ft-bgs in the bore hole.

Pine Mountain Group

Hollis Quartzite – consists of light- to medium-gray quartzite, containing minor quantities of mica and feldspar. Two distinctive types of Hollis are recognized. The first is light- to medium-gray medium- to coarse-grained sandstone. The second is light-gray mylonite with no discernable framework grains. This rock type was encountered at a depth of 181 to 330 ft-bgs in the bore hole.

Chewacla Marble – consists of medium- to light-gray, medium-bedded, coarse- to fine-grained dolomite marble. This rock type was encountered at a depth of 96 to 181 ft-bgs in the bore hole.

Cretaceous

Tuscaloosa Group undifferentiated – consists of light-gray to moderate-reddish-orange clayey, gravelly, fine to coarse-grained, massive mottled sandy clay and thin beds of indurated sandstone. Gravels consist of quartz and quartzite and range in size from very fine pebbles to large cobbles. This rock type was encountered at the surface to 96 ft-bgs in the bore hole.

Quaternary

Alluvial, coastal, and terrace deposits - Alluvial deposits in Lee and Macon Counties are Pleistocene to Holocene in age and occur along the larger streams and their larger tributaries. These deposits consist largely of light-gray to yellowish-orange, fine- to medium-grained, poorly sorted sand interbedded with silt and clay.

A Geologic Cross Section was prepared using drillers logs from AWWB Well #3 and two additional wells (Loachapoka Water Authority test well No. 2 and observation well) located to the east. These wells were also used to develop the ground water elevation map, which is further discussed in Section 5.4. The drillers logs for these wells are also included in Attachment C. A Geologic Cross Section was constructed using these drillers logs and is depicted on Figure 3 (Attachment A).

4.2 Hydrogeology

Three distinct aquifers supply groundwater to wells in the project area; the Tuscaloosa aquifer, the Hollis aquifer, and the Chewacla aquifer. The Tuscaloosa aquifer is a porous sandstone aquifer of variable thickness that is bounded by impermeable to semi-permeable silt and clay layers. The Hollis and Chewacla aquifers comprise metamorphic quartzite and dolomite marble, respectively. Matrix in these rocks has low permeability and transmissivity, and as a result, water is derived from fractures that cross cut both formations near the bottom of the casing and in the Hollis near the bottom of AWWB Well #3. No evidence for karst features, such as sink holes, solution valleys, caves, etc. were recognized in the area.

4.3 Surface Drainage

AWWB Well #3 is located approximately 500 feet northwest of an unnamed tributary. The unnamed tributary flows southeast towards Chewacla Creek. Chewacla Creek is a south-flowing creek located approximately 1.9 miles to the east. Choctafaula Creek, another major south-flowing drainage feature in the area is located approximately 1.3 miles to the west. Creeks in the Fall Line Hills District in Lee County display a dendritic drainage pattern indicating a lack of structural control (Kidd, 1989).

5.0 DELINEATION OF SWPA BOUNDARIES

5.1 Description of Methodology

A thorough understanding of an area's geology and ground-water hydrology is critical for defining SWPA boundaries. The geology and resulting aquifers within Alabama are highly variable. Table 1 is a list of the various types of flow in Alabama aquifers and indicates the physiographic regions where they occur.

Table 1 - Aquifer flow types and their occurrence by physiographic section in Alabama

Physiographic Region	Aquifer Flow Type		
	Porous Flow	Conduit Flow	Fracture Flow
Highland Rim	X	X	
Cumberland Plateau	X	X	X
Valley and Ridge	X	X	X
Piedmont Upland	X	X	X
East Gulf Coastal Plain	X	X	

SWPA boundary delineation in Alabama is based on the type of aquifer from which a particular well, well field, or spring produces ground water. Depending on the type of aquifer, either time-of-travel (TOT), analytical solution, and/or flow boundaries will be the primary criteria for delineation of a particular SWPA. Table 2 summarizes the protection area delineation criteria and thresholds by aquifer type.

Table 2 - Alabama Wellhead Protection Area criteria and thresholds

Protection Area	*Unconfined and semiconfined aquifers*				
	Porous	Karst		Fractured	
	Porous Flow	Porous Flow	Conduit Flow	Porous Flow	Conduit Flow
WHPA I	180-day TOT or 400-ft. radius	180-day TOT or 400-ft. radius	1,OOO-ft. radius	180-day TOT or 400-ft. radius	1,OOO-ft. radius
WHPA II	1O-yr TOT with Hydrogeologic flow boundaries	Hydrogeologic flow boundaries	Hydrogeologic flow boundaries	1O-yr TOT with Hydrogeologic flow boundaries	Hydrogeologic flow boundaries
WHPA III	Hydrogeologic flow boundaries	Not Required	Not Required	Hydrogeologic flow boundaries	Not Required

Table 2 (continued)- Alabama Wellhead Protection Area criteria and thresholds

Protection Area	*Confined aquifers*				
	Porous	Karst		Fractured	
	Porous Flow	Porous Flow	Conduit Flow	Porous Flow	Conduit Flow
WHPA I	180-day TOT or 400-ft. radius	180-day TOT or 400-ft. radius	1,OOO-ft. radius	180-day TOT or 400-ft. radius	1,OOO-ft. radius
WHPA II	1O-yr TOT with Hydrogeologic flow boundaries	Hydrogeologic flow boundaries	Hydrogeologic flow boundaries	1O-yr TOT with Hydrogeologic flow boundaries	Hydrogeologic flow boundaries
WHPA III	Not Required	Not Required	Not Required	Not Required	Not Required

Assessment of the project area was conducted in several phases.

- For the first phase, aquifer characteristics were determined from the evaluation of data collected during continuous pumping tests conducted on AWWB Well #3.
- The second phase involved the delineation of SWPA boundaries.
- The third phase involved conducting a water well survey to obtain static water-level measurements from identified wells to prepare a ground water elevation map illustrating the ground water flow system in the area.
- The final phase involved the identification of the PCSs within the SWPA boundaries.

5.2 Aquifer Characteristics

On May 15, 2009, CH2M Hill conducted a step-drawdown aquifer test on AWWB Well #3 (CH2M Hill memo, 2011). The static water level was measured to be 53.4 feet below top of the well casing. For the step-drawdown aquifer tests, the well was initially pumped at 1200 gallons per minute (GPM) for 8 hours with a drawdown of 9.4 feet, giving a specific capacity of 127.66 GPM/ft. The well was then pumped at 1700 GPM for 6 hours with a drawdown of 14.13 feet giving a specific capacity of 120.31 GPM/ft. The well was then pumped at 2500 GPM for 9 hours with a drawdown of 25.81 feet giving a specific capacity of 96.86 GPM/ft. On May 17, 2009 at 11:19 am, a 24-hour recovery test of the well was initiated. The step-drawdown data collected by CH2M Hill is included as Attachment D.

Following the step-drawdown aquifer test, A 1700 GPM constant-rate aquifer test began at 12:30 pm on May 18, 2009. After 44 hours the drawdown was recorded at 17.16 feet, giving a specific capacity of 99.07 GPM/ft. A 2500 GPM constant-rate aquifer test began at 9:00 am on May 20,

2009. After 20 hours the drawdown was recorded at 28.6 feet, giving a specific capacity of 87.41 GPM/ft. During constant-rate tests, data from the Reynolds Well (Loachapoka Water Authority Supply Well) was also recorded and used as part of the overall evaluation of aquifer characteristics. The constant-rate aquifer test data collected by CH2M Hill is included as Attachment E.

CH2M Hill analyzed the step-drawdown aquifer test data and the constant-rate aquifer test data using the program AQTESOLV for Windows. Three (3) solution methods were used to calculate aquifer characteristics in the AQTESOLV program. Below is a description of each solution method:

(Hantush-Jacob (1955) Solution Method for Leaky Confined Aquifers) A mathematical solution by Hantush and Jacob (1955) is useful for determining the hydraulic properties (transmissivity and storativity of aquifer; vertical hydraulic conductivity of aquitard) of leaky confined (semi-confined) aquifers. Analysis involves matching the Hantush-Jacob *w(u,r/B)* well function for leaky confined aquifers to drawdown data collected during a aquifer test. The solution assumes no storage in incompressible aquitard(s) and can account for partially penetrating wells (Hantush, 1961).

The following assumptions apply to the use of the Hantush-Jacob r/B solution:

- aquifer has infinite areal extent;
- aquifer is homogeneous, isotropic and of uniform thickness;
- control well is fully or partially penetrating;
- flow to control well is horizontal when control well is fully penetrating;
- aquifer is leaky confined;
- flow is unsteady;
- water is released instantaneously from storage with decline of hydraulic head;
- diameter of control well is very small so that storage in the well can be neglected;
- aquitards have infinite areal extent, uniform vertical hydraulic conductivity and uniform thickness;
- aquitards are overlain or underlain by an infinite constant-head plane source;
- aquitards are incompressible (no storage); and
- flow in the aquitards is vertical.

(Theis (1935)Soution Method for NonLeaky Confined Aquifers)A mathematical solution by Theis (1935) is useful for determining the hydraulic properties (transmissivity and storativity) of nonleaky confined aquifers. Analysis involves matching the Theis type curve for nonleaky confined aquifers to drawdown data collected during a aquifer test. Hantush (1961) extended the method for partially penetrating wells.

The following assumptions apply to the use of the Theis pumping test solution:

- aquifer has infinite areal extent;
- aquifer is homogeneous, isotropic and of uniform thickness;
- control well is fully or partially penetrating;
- flow to control well is horizontal when control well is fully penetrating;
- aquifer is nonleaky confined;
- flow is unsteady;
- water is released instantaneously from storage with decline of hydraulic head; and
- diameter of control well is very small so that storage in the well can be neglected.

(Gringarten and Witherspoon (1972) Solution Method for Fractured Aquifers with a Single Vertical Plane Fracture)A mathematical solution by Gringarten and Witherspoon (1972) is useful for determining the hydraulic properties (hydraulic conductivity, specific storage, hydraulic conductivity anisotropy and fracture length) of fractured aquifers with a single vertical plane fracture intersecting the pumped well. Analysis involves matching the solution to drawdown data collected during a pumping test. The solution estimates hydraulic conductivity anisotropy in a horizontal (x-y) plane.

The following assumptions apply to the use of the Gringarten and Witherspoon solution:

- aquifer has infinite areal extent;
- aquifer has uniform thickness;
- aquifer potentiometric surface is initially horizontal;
- fractured aquifer represented by anisotropic nonleaky confined system with a single plane vertical fracture that fully penetrates aquifer;
- flow is unsteady;
- water is released instantaneously from storage with decline of hydraulic head; and
- diameter of control well is very small so that storage in the well can be neglected.

Results of the data input in to the program are as follows:

Step-drawdown Calculations - This data collected was evaluated using the Theis (1935) step-drawdown test solution for a partially penetrating well in a confined aquifer. The calculation sheets output by Aqtesolv® are included in Attachment F.

The data collected from the pump test show that the water level in the well did not stabilize during the individual steps, as shown on the graph. Using the Theis model, a transmissivity (T) value for AWWB Well #3 of 16,130 square feet per day (ft2/day) was calculated. The calculated storativity (S) of 806.1 is greater than expected for a fractured aquifer.

As shown on the graph, the measured data (boxes) deviate from the predicted line curve. This is a function of the fracture flow conditions. Combined with the test data not reaching a point of equilibrium during each step the resulting aquifer parameter values are over estimated, therefore these derived values are not considered accurate. An alternative model, for step-drawdown test evaluations was applied to the data (Attachment F).

The Hantush-Jacob (1955) solution considers unsteady flow from a leaky confined aquifer and is likely more representative of the aquifer conditions in AWWB Well #3. Using this method, a T of 9685.4 ft2/day was calculated and is more consistent with the calculated values from the constant rate test (discussed below), however, the S values are still overestimated by comparison to predicted values. This is a result of not reaching steady-state conditions during the steps of the test.

Constant-Rate Calculations - The drawdown and recovery data collected from AWWB Well #3 and the observation wells were plotted on logarithmic and semi-logarithmic graphs versus time in order to derive the aquifer characteristics values. Transmissivity is defined as the capacity of the tested aquifer to transmit water and is equal to the hydraulic conductivity of the formation multiplied by the saturated thickness. Storativity, also referred to as the storage coefficient, is defined as the volume of water that an aquifer releases or adsorbs per unit of surface area and unit of change in head. The observation wells were evaluated for T and S using the Theis and Hantush solution for a partially penetrating well in a confined aquifer. The calculation sheets output by Aqtesolv® are presented in Attachment G.

The graph shows the actual measured drawdown data (shown as black boxes for each measurement) and the calculated, or predicted, drawdown data (blue line). By curve matching the modeled data to the actual data, the variables of T and S are derived. As shown, the early data from the test deviate from the predicted curve significantly. The measured data show rapid lowering of the water table surrounding the well in response to pumping, as the water immediately available in nearby fractures to the well was removed. With continued pumping and lowering of the water table, additional fracture flow was intersected and more water became available, resulting in a convergence of the predicted versus actual measured data (i.e. greater the 100 minutes into the test).

These findings are consistent with the expected results for a fractured rock aquifer. Hydraulic conductivity is not directly derived from the Theis and Hantush solution but can be calculated from T by the following equation.

$$K = T/b$$

Where:
K = hydraulic conductivity in ft/day
T = transmissivity in ft2/day
b = saturated thickness of the aquifer in ft

For this assessment, b was assumed to be 180 ft, which is equal to the length of the water column measured in the well. The resulting calculated K of 57.3 ft/day (0.02 cm/sec) is within the range of published values for fractured rock aquifers. The calculated S value of 3.8 X 10-4 falls between the expected ranges for confined and unconfined aquifers. This is reasonable, as the fractures tend to function in a manner consistent with semi-confining aquifer conditions.

For comparison, the data were evaluated using an additional model, which incorporates fracture flow and assumes that a vertical fracture intersects the well (Gringarten-Witherspoon, 1972). The results of this model are shown in Attachment H. The resulting calculated K of 60.03 ft/day is comparable to the results for the Theis and Hantush solution.

Based on the above evaluations of the step-test and constant-test data, the calculated aquifer parameters using the Theis and Hantush solution for the constant-test are considered to be the most accurate and are summarized as follows.

T = 1.031 ft2/day (110.9 cm2/sec)
K = 57.3 ft/day (2.0 X 10-2 cm/sec)
S = 3.8 X 10-4

These values are consistent with published and predicted values for a fractured rock aquifer. The specific capacity of the well was calculated using the following equation:

$$Sc = Q/d$$

Where:
Sc = specific capacity of the well in gpm/ft
Q = discharge rate in gpm
d = drawdown in ft

Ideally, the specific capacity should be calculated after a steady state drawdown is reached within the well under pumped conditions. During the first pumping interval of 1700 gpm on the constant-rate test, a steady state of drawdown was achieved and maintained during the latter portion of the pumping interval. Using the above equation, the Sc for AWWB Well #3 was calculated to be 100 gpm/ft.

AWWB Well #3 should provide a significant amount of potable groundwater. While the specific capacity of the well was calculated to be about 100 gallons per foot of drawdown, and the well is constructed such that at least 20 or more feet of drawdown should be available. Therefore the well should be capable of supplying the reported intended capacity of about 1200 gpm.

5.3 Hydrogeologic Mapping

A water well inventory was conducted in the area of AWWB Well #3. The inventory included both a study of published historical data from the U.S. and State Geological Surveys, and field work to update data or to add data points in areas where sparse data were available. AWWB Well #3 is identified as Map ID S-1. The Loachapoka Water Authority's test well and observation well is identified as Map ID S-4 and S-5. There were three (3) shallow wells located within the SWPA boundaries, which appear to be used for irrigation purposes. These wells are identified as Map ID S-18, S-20 and S-29.

Ground water levels from wells S-1 and S-4 were measured during the 2009 aquifer testing. A ground water level was measured in well S-18 on March 31, 2011. Wells S-4, S-20 and S-29 were not accessible during the March 31, 2011 field activities; therefore, no recent data could be collected. However, data for these three wells was recorded from previously published data (Guthrie & Associates, 2009). Wells located within the delineated area are noted as a potential contaminant sources and are discussed in the following section. Data collected in reference to the wells identified is summarized in Table 3.

Table 3 – Private Well Inventory Data

Map ID	Latitude	Longitude	Static Water Level (ft-bgs)	Date of Measurement	Water Level (ft-msl)	Elevation (ft-msl)
S-1	N32°31'13.0"	W85°31'55.9"	53.4	5/15/09	380.6	434
S-4	N32°31'12.0"	W85°31'45.8"	32.2	5/18/09	378.8	411
S-5	N32°31'10.9"	W85°31'45.1"	previously recorded		380	406
S-18	N32°31'31.7"	W85°31'47.7"	22.2	3/31/11	437.8	460
S-20	N32°31'27.3"	W85°31'36.1"	previously recorded		395	433
S-29	N32°31'22.3"	W85°31'10.5"	previously recorded		423	470

ft-bgs feet below ground surface
ft-msl feet above mean sea level

A ground water elevation map was generated by Spectrum using the data collected above. Although locally impacted by sparse data, the ground water elevation surface appears to trend generally to the south. The Ground Water Elevation Map is depicted on Figure 4 (Attachment A).

5.4 Delineation of SWPA Boundaries

Results from hydrogeologic investigations demonstrate that ground water is derived from a semi-confined fractured flow aquifer (Kidd, 1989). Therefore, the SWPA 1 boundary is established at a radius of 1,000 feet around the wellhead and the SWPA 2 boundary was established at hydrologic flow boundaries around the wellhead. SWPA 1 and SWPA 2 boundary lines are depicted on Figure 5 (Attachment A).

In order to establish SWPA 2 boundary, geologic and topographic maps were reviewed in an attempt to: infer the extent of aquifers; identify lithologic units that may act as flow boundaries or pathways; map joint patterns or karst features that may act as flow paths; identify faults that may act as flow barriers or flow paths; and, identify potential recharge areas.

Geologic mapping was conducted within close proximity of AWWB Well #3. No geologic contacts or faults were mapped in the immediate area. No karst features were observed during the geologic mapping. Based on these results, the SWPA 2 boundary was determined by following the topographic highs and surface water features in the vicinity of the wellhead.

5.5 Potential Contaminant Sources Inventory

To accomplish the objective of protecting ground-water resources, potential contaminant sources (PCS) must be identified, mapped, and managed in a manner that mitigates their possible adverse impacts on the resource. An inventory of PCS was accomplished via a windshield survey of SWPA 1 and SWPA 2 areas. Latitudes and longitudes for PCS were located with a handheld global positioning system (GPS) unit. Table 4 lists PCS codes designated by the ADEM.

Table 4
Potential Sources of Contamination and Source Codes

1	Gas stations/service stations	22	Meat packers/slaughter houses	43	Junk/salvage yards
2	Truck terminals	23	Concrete/asphaIUtar/coal companies	44	Subdivisions
3	Fuel oil distributors/storers	24	Treatment plant lagoons	45	Individual residences
4	Oil pipelines	25	On-site sewage	46	Heating oil storage (consumptive use) sites
5	Auto repair shops	26	Railroad yards	47	Golf courses/parks/nurseries
6	Body shops	27	Stormwater impoundment	48	Sand and gravel mining/other mining
7	Rust roofers	28	Cemeteries	49	Abandoned wells
8	Auto chemical suppliers wholesalers/retailers	29	Airport maintenance shops	50	Manure piles
9	Pesticide/herbicide/insecticide wholesalers/retailers	30	Airport fueling areas	51	Feed lots
10	Small engine repair shops	31	Airport fire fighter training areas	52	Agricultural chemical spreading/spraying
11	Dry cleaners	32	Industrial manufacturers	53	Agricultural chemical storage sites
12	Furniture strippers	33	Machine shops	54	Construction sites
13	Painters/finishers	34	Metal platers	55	Transportation corridors
14	Photographic processors	35	Heat treaters/smelters/descalers	56	Fertilized fields/agricultural areas
15	Printers	36	Wood preservers	57	Petroleum tank farms
16	Automobile washes	37	Chemical reclamation sites	58	Existing wells
17	Laundromats	38	Boat builder/refinishers	59	Nonagricultural applicator sites
18	Beauty salons	39	Industrial waste disposal sites	60	Sinkholes
19	Medical/dental/veterinarian offices	40	Wastewater impoundment areas	61	Injection wells
20	Research laboratories	41	Municipal wastewater treatment plants and land application areas	62	Drainage wells
21	Food processors	42	Landfills/dumps/transfer stations	63	Other

Spectrum personnel identified 40 PCSs (including the AWWB Well) located within SWPA 1 and SWPA 2 boundary. Two of the PCSs (identified by Map ID S-24 and S-40) are sand and gravel pits that do not appear to be in operation. The location of each PCS is depicted on Figure 6 (Attachment A).

Table 5
Identified Potential Contaminant Sources

Map ID	ADEM Code	Latitude	Longitude	Owner Information		
				Name	Address	Phone #
S-1	58	N32°31'13.0"	W85°31'55.9"	City of Auburn	1501 W Samford Ave. Auburn AL	334-826-1083
S-2	25	N32°31'15.2"	W85°31'55.0"	James E. Daniel	5534 Hwy 29 S. Auburn AL	334-502-6041
S-3	63	N32°31'6.6"	W85°31'51.2"	Auburn #2 Substation	Alagasco Birmingham AL	205-325-7410
S-4	58	N32°31'12.0"	W85°31'45.8"	Loachapoka Water Authority	4742 Lee Road 188 Auburn AL	334-887-3329
S-5	58	N32°31'10.9"	W85°31'45.1"	Loachapoka Water Authority	4742 Lee Road 188 Auburn AL	334-887-3329
S-6	45	N32°31'21.8"	W85°31'38.9"	Eddie L. Philpot	5393 Hwy 29 S. Auburn AL	334-826-1439
S-7	45	N32°31'24.3"	W85°31'37.8"	Eddie L. Philpot	5393 Hwy 29 S. Auburn AL	334-826-1439
S-8	45	N32°31'24.1"	W85°31'43.6"	Ernestine B. Evans	5426 Hwy 29 S. Auburn AL	334-821-5900
S-9	45	N32°31'27.8"	W85°31'39.2"	Willie F. Menifee	52 Lee Road 17 Auburn AL	334-826-5554
S-10	45	N32°31'28.9"	W85°31'39.9"	Scott C. Stanfield	66 Lee Road 17 Auburn AL	Not Available
S-11	45	N32°31'31.3"	W85°31'42.1"	Kenneth Ison	152 Lee Road 17 Auburn AL	334-887-1808
S-12	45	N32°31'32.3"	W85°31'43.0"	James T. Tyson, jr	162 Lee Road 17 Auburn AL	334-887-9810
S-13	45	N32°31'32.3"	W85°31'44.6"	Bobby Bradford	182 Lee Road 17 Auburn AL	Not Available
S-14	45	N32°31'32.3"	W85°31'46.7"	Brandon Bradford	230 Lee Road 17 Auburn AL	334-826-8417
S-15	45	N32°31'34.0"	W85°31'49.8"	Paul D. Bridge	258 Lee Road 17 Auburn AL	Not Available
S-16	45	N32°31'39.2"	W85°31'55.9"	Kellie W. Rodman	414 Lee Road 17 Auburn AL	Not Available
S-17	45	N32°31'34.5"	W85°31'50.2"	Billie R. Hunt	295 Lee Road 17 Auburn AL	334-887-9812
S-18	58	N32°31'31.7"	W85°31'47.7"	Robert L Wade	229 Lee Road 17 Auburn AL	334-887-8149
S-19	45	N32°31'23.4"	W85°31'39.9"	Not Available	Hwy 29&Lee Road 17 Auburn AL	Not Available
S-20	58	N32°31'27.3"	W85°31'36.1"	R & B Vickery	5299 Hwy 29 S. Auburn AL	334-887-3765

Table 5 continued
Identified Potential Contaminant Sources

Map ID	ADEM Code	Latitude	Longitude	Owner Information		
				Name	Address	Phone #
S-21	45	N32°31'28.1"	W85°31'35.3"	Jonathan G Savage	5281 Hwy 29 S. Auburn AL5245 Hwy 29 S. Auburn AL	334-826-3283
S-22	45	N32°31'28.9"	W85°31'34.8"	R & B Vickery	5201 Hwy 29 S. Auburn AL	334-887-3765
S-23	45	N32°31'30.1"	W85°31'33.9"	R & B Vickery	5245 Hwy 29 S. Auburn AL	334-887-3765
S-24	48	N32°31'35.6"	W85°31'33.9"	Abandoned pit		
S-25	45	N32°31'40.2"	W85°31'20.4"	Kevin Cobb	80 Lee Road 20 Auburn AL	334-826-1998
S-26	45	N32°31'37.5"	W85°31'19.2"	Dennis L. Franklin	118 Lee Road 20 Auburn AL	Not Available
S-27	45	N32°31'35.1"	W85°31'15.8"	Evelyn Franklin	200 Lee Road 20 Auburn AL	334-887-8464
S-28	45	N32°31'31.6"	W85°31'11.7"	John L. Johnson	288 Lee Road 20 Auburn AL	334-821-3780
S-29	58	N32°31'22.3"	W85°31'10.5"	James W Dowdell	500 Lee Road 20 Auburn AL	334-826-6891
S-30	45	N32°31'30.6"	W85°31'10.1"	Patrick L. Pugh	339 Lee Road 20 Auburn AL	Not Available
S-31	28	N32°31'44.2"	W85°31'20.9"	Mt Vernon Baptist	4881 S. College St. Auburn AL	334-826-0454
S-32	45	N32°31'44.7"	W85°31'25.9"	Willie J. Hill	64 Lee Road 18 Auburn AL	334-826-1663
S-33	45	N32°31'46.4"	W85°31'26.1"	Charles Mitchell	95 Lee Road 18 Auburn AL	Not Available
S-34	45	N32°31'44.6"	W85°31'26.0"	Herman Hill	73 Lee Road 18 Auburn AL	334-887-7895
S-35	45	N32°31'44.2"	W85°31'26.1"	Nadine C. Willis	53 Lee Road 18 Auburn AL	334-887-8668
S-36	45	N32°31'42.9"	W85°31'25.6"	Mckinley Floyd jr	33 Lee Road 18 Auburn AL	334-209-1113
S-37	45	N32°31'42.7"	W85°31'23.6"	John L. Dowdell	15 Lee Road 18 Auburn AL	334-826-0844
S-38	45	N32°31'39.6"	W85°31'26.3"	Thelma Echols	5000 Hwy 29 S. Auburn AL	334-887-3962
S-39	45	N32°31'39.3"	W85°31'27.1"	Bernice Hutchinson	5020 Hwy 29 S. Auburn AL	334-821-1025
S-40	48	N32°31'14.5"	W85°31'13.2"	Abandoned pit		

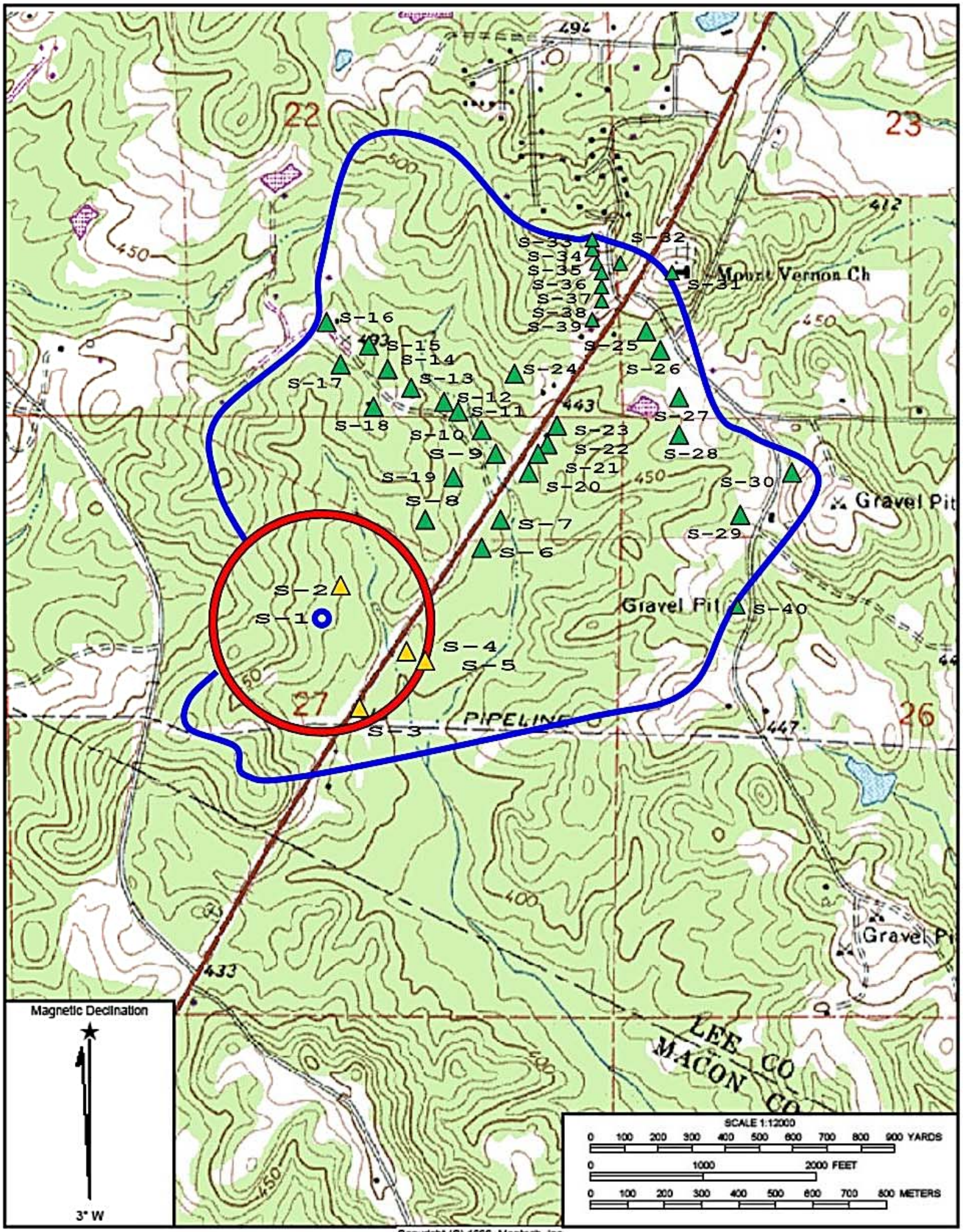
Table 5 - Revised per Susceptibility Analysis Results

Identified Potential Contaminant Sources

Map ID	ADEM Code	Latitude	Longitude	Owner Information: Name	Address	Phone#	Overall Susceptibility Ranking
S-1	58	N32°31'13.0"	W85°31'55.9"	City of Auburn	1501 W Samford Ave. Auburn AL	334-826-1083	Moderately-Susceptable
S-2	25	N32°31 '15.2"	W85°31'55.0"	James E. Daniel	5534 Hwy 29 S. AuburnAL	334-502-6041	Moderately-Susceptable
S-3	63	N32°31'6.6"	W85°31 '51.2"	Auburn#2 Substation	Alagasco Birmingham AL	205-325-7410	Moderately-Susceptable
S-4	58	N32°31' 12.0"	W85°31'45.8"	Loachapoka Water Authority	4742 Lee Road 188 AuburnAL	334-887-3329	Moderately-Susceptable
S-5	58	N32°31' 10.9"	W85°31'45.1"	Loachapoka Water Authority	4742 Lee Road 188 AuburnAL	334-887-3329	Moderately-Susceptable
S-6	45	N32°31 '21.8"	W85°31 '38.9"	Eddie L. Philpot	5393 Hwy 29 S. AubumAL	334-826-1439	Non-Susceptable
S-7	45	N32°31'24.3"	W85°31 '37.8"	Eddie L. Philpot	5393 Hwy 29 S. AubumAL	334-826-1439	Non-Susceptable
S-8	45	N32°31 '24.1"	W85°31'43.6"	Ernestine B. Evans	5426 Hwy 29 S. Auburn AL	334-821-5900	Non-Susceptable
S-9	45	N32°31 '27.8"	W85°31 '39.2"	Willie F. Menifee	52 Lee Road 17 AuburnAL	334-826-5554	Non-Susceptable
S-10	45	N32°31 '28.9"	W85°31 '39.9"	Scott C. Stanfield	66 Lee Road 17 AubumAL	Not Available	Non-Susceptable
S-11	45	N32°31 '31.3"	W85°31'42.1"	Kenneth Ison	152 Lee Road 17 AuburnAL	334-887-1808	Non-Susceptable
S-12	45	N32°31 '32.3"	W85°31 '43.0"	James T. Tyson,jr	162 Lee Road 17 AuburnAL	334-887-9810	Non-Susceptable
S-13	45	N32°31 '32.3"	W85°31 '44.6"	Bobby Bradford	182 Lee Road 17 AubumAL	Not Available	Non-Susceptable
S-14	45	N32°31 '32.3"	W85°31 '46.7"	Brandon Bradford	230 Lee Road 17 AubumAL	334-826-8417	Non-Susceptable
S-15	45	N32°31 '34.0"	W85°31'49.8"	Paul D. Bridge	258 Lee Road 17 AubumAL	Not Available	Non-Susceptable
S-16	45	N32°31 '39.2"	W85°31 '55.9"	Kellie W. Rodman	414 Lee Road 17 AuburnAL	Not Available	Non-Susceptable
S-17	45	N32°31 '34.5"	W85°31 '50.2"	Billie R. Hunt	295 Lee Road 17 Auburn AL	334-887-9812	Non-Susceptable
S-18	58	N32°31'31.7"	W85°31'47.7"	Robert L Wade	229 Lee Road 17 AubumAL	334-887-8149	Non-Susceptable
S-19	45	N32°31 '23.4"	W85°31'39.9"	Not Available	Hwy 29&Lee Road 17 AuburnAL	Not Available	Non-Susceptable
S-20	58	N32°31'27.3"	W85°31'36.1"	R& B Vickery	5299 Hwy 29 S. AubumAL	334-887-3765	Non-Susceptable

Table 5 cont - Revised per Susceptibility Analysis Results
Identified Potential Contaminant Sources

Map ID	ADEM Code	Latitude	Longitude	Owner Information			Overall Susceptibility Ranking
				Name	Address	Phone#	
S-21	45	N32°31'28.1"	W85°31'35.3"	Jonathan G Savage	5281 Hwy 29 S. Auburn AL5245 Hwy 29 S. Auburn AL	334-826-3283	Non-Susceptable
S-22	45	N32°31'28.9"	W85°31'34.8"	R&B Vickery	5201 Hwy 29 S. Auburn AL	334-887-3765	Non-Susceptable
S-23	45	N32°31'30.1"	W85°31'33.9"	R & B Vickery	5245 Hwy 29 S. Auburn AL	334-887-3765	Non-Susceptable
S-24	48	N32°31'35.6"	W85°31'33.9"	Abandoned pit			Non-Susceptable
S-25	45	N32°31'40.2"	W85°31'20.4"	Kevin Cobb	80 Lee Road 20 Auburn AL	334-826-1998	Non-Susceptable
S-26	45	N32°31'37.5"	W85°31'19.2"	Dennis L. Franklin	118 Lee Road 20 Auburn AL	Not Available	Non-Susceptable
S-27	45	N32°31'35.1"	W85°31'15.8"	Evelyn Franklin	200 Lee Road 20 Auburn AL	334-887-8464	Non-Susceptable
S-28	45	N32°31'31.6"	W85°31'11.7"	John L. Johnson	288 Lee Road 20 Auburn AL	334-821-3780	Non-Susceptable
S-29	58	N32°31'22.3"	W85°31'10.5"	James W Dowdell	500 Lee Road 20 Auburn AL	334-826-6891	Non-Susceptable
S-30	45	N32°31'30.6"	W85°31'10.1"	Patrick L. Pugh	339 Lee Road 20 Auburn AL	Not Available	Non-Susceptable
S-31	28	N32°31'44.2"	W85°31'20.9"	Mt Vernon Baptist	4881 S. College St. Auburn AL	334-826-0454	Non-Susceptable
S-32	45	N32°31'44.7"	W85°31'25.9"	Willie J. Hill	64 Lee Road 18 Auburn AL	334-826-1663	Non-Susceptable
S-33	45	N32°31'46.4"	W85°31'26.1"	Charles Mitchell	95 Lee Road 18 Auburn AL	Not Available	Non-Susceptable
S-34	45	N32°31'44.6"	W85°31'26.0"	Herman Hill	73 Lee Road 18 Auburn AL	334-887-7895	Non-Susceptable
S-35	45	N32°31'44.2"	W85°31'26.1"	Nadine C. Willis	53 Lee Road 18 Auburn AL	334-887-8668	Non-Susceptable
S-36	45	N32°31'42.9"	W85°31'25.6"	Mckinley Floydjr	33 Lee Road 18 AuburnAL	334-209-1113	Non-Susceptable
S-37	45	N32°31'42.7"	W85°31'23.6"	John L. Dowdell	15 Lee Road 18 Auburn AL	334-826-0844	Non-Susceptable
S-38	45	N32°31'39.6"	W85°31'26.3"	Thelma Echols	5000 Hwy 29 S. Auburn AL	334-887-3962	Non-Susceptable
S-39	45	N32°31'39.3"	W85°31'27.1"	Bernice Hutchinson	5020 Hwy 29 S. AuburnAL	334-821-1025	Non-Susceptable
S-40	48	N32°31'14.5"	W85°31'13.2"	Abandoned pit			Non-Susceptable



USGS Map Loachapoka, AL., 1971, Photo revised 1983.

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Drawn By:	Date:
KB	8/7/2012
Checked By:	Date:
TL	8/7/2012
Project Mgr.:	File Name:
TL	

▲ = Non-Susceptible

▲ = Moderately Susceptible

WATER WORKS BOARD AUBURN
1501 West Samford Ave.
Auburn, AL 36832
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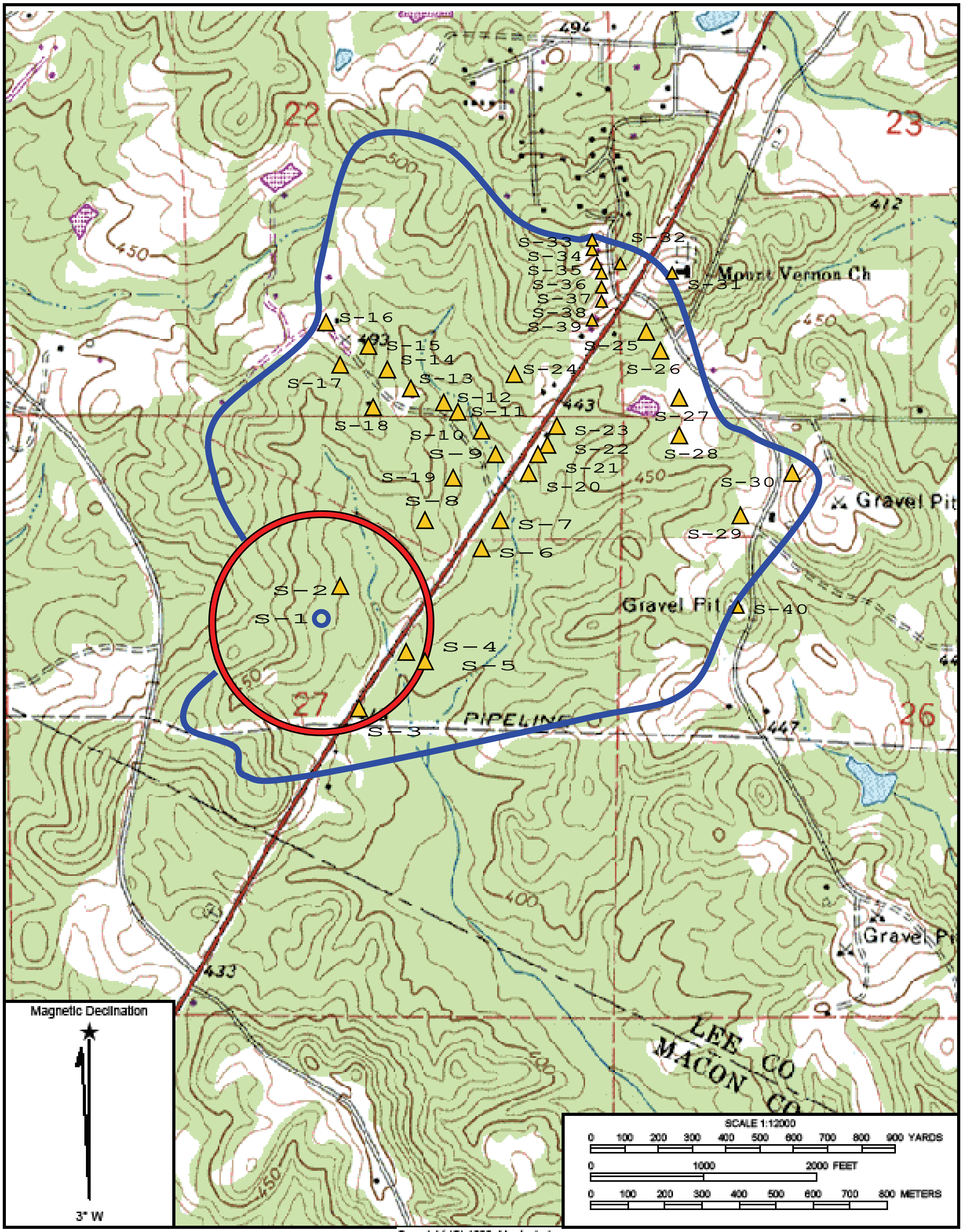
PHONE (334) 501-3060

TITLE

PCS Inventory Location Map
Susceptibility Rankings
AWWB Well
Highway 29 South
Auburn, Alabama



USGS Map Loachapoka, AL., 1971, Photo revised 1983.

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Drawn By: JF	Project #: 2476-001
Checked By: BW	Date: 4/4/11
Project Mgr.: JF	File Name:

SPECTRUM Environmental Inc.
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Alabaster, AL 35007
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TITLE

Figure 2476001-6
PCS Inventory Location Map
AWWB Well
Highway 29 South
Auburn, Alabama

6.0 SUMMARY

The AWWB Well is located near the transition between the Fall Line Hills district of the Coastal Plain Physiographic Province to the south from the Southern Piedmont Uplands district of the Piedmont Province to the north. The area is developed on un-deformed Cretaceous sedimentary rocks that unconformably overlie metamorphosed and deformed sedimentary and igneous rocks of the Southern Piedmont.

Three aquifers are found in the Lee County: the Tuscaloosa aquifer, consisting of clastic sedimentary rock, and the Chewacla and Hollis aquifers, both comprised of fractured metamorphic rock (Kidd, 1989).

The AWWB Well will produce from fracture zones in the Chewacla and Hollis aquifer. Clay layers in the overlying Tuscaloosa form confining layers to the underlying metamorphic rock aquifer.

Aquifer testing indicates that the well is capable of sustaining a discharge rate of 1,200 gallons per minute of high water quality.

Water level mapping of the ground water elevation surface within the SWPA boundaries indicates that groundwater flow generally is to the south.

To comply with ADEM regulations for semi-confined fractured aquifers, SWPA 1 boundary was established at a 1,000-foot radius around the well head and SWPA 2 boundary was defined by hydrogeologic mapping.

As a result of this mapping, 40 potential contaminant sources were identified within the SWPA 1 and 2 boundaries established.

7.0 CERTIFICATION

This Source Water Protection Area Delineation and Potential Contaminant Source Inventory has been conducted in accordance with standard geologic practices consistent with similarly situated environmental professionals in this area. All information collected was reviewed and the collecting of information was overseen by a geologist experienced in subsurface investigation. The information submitted herein, to the best of my knowledge and belief is, true, accurate, and complete.

Jeff Fincher, ALPG
Project Manager

5/18/11
Date

8.0 REFERENCES

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Kidd, R. E., 1989, Geohygrology and Susceptibility of Aquifers to Surface Contamination in Alabama; Area 5, Water-resource Investigation Report 88-4083

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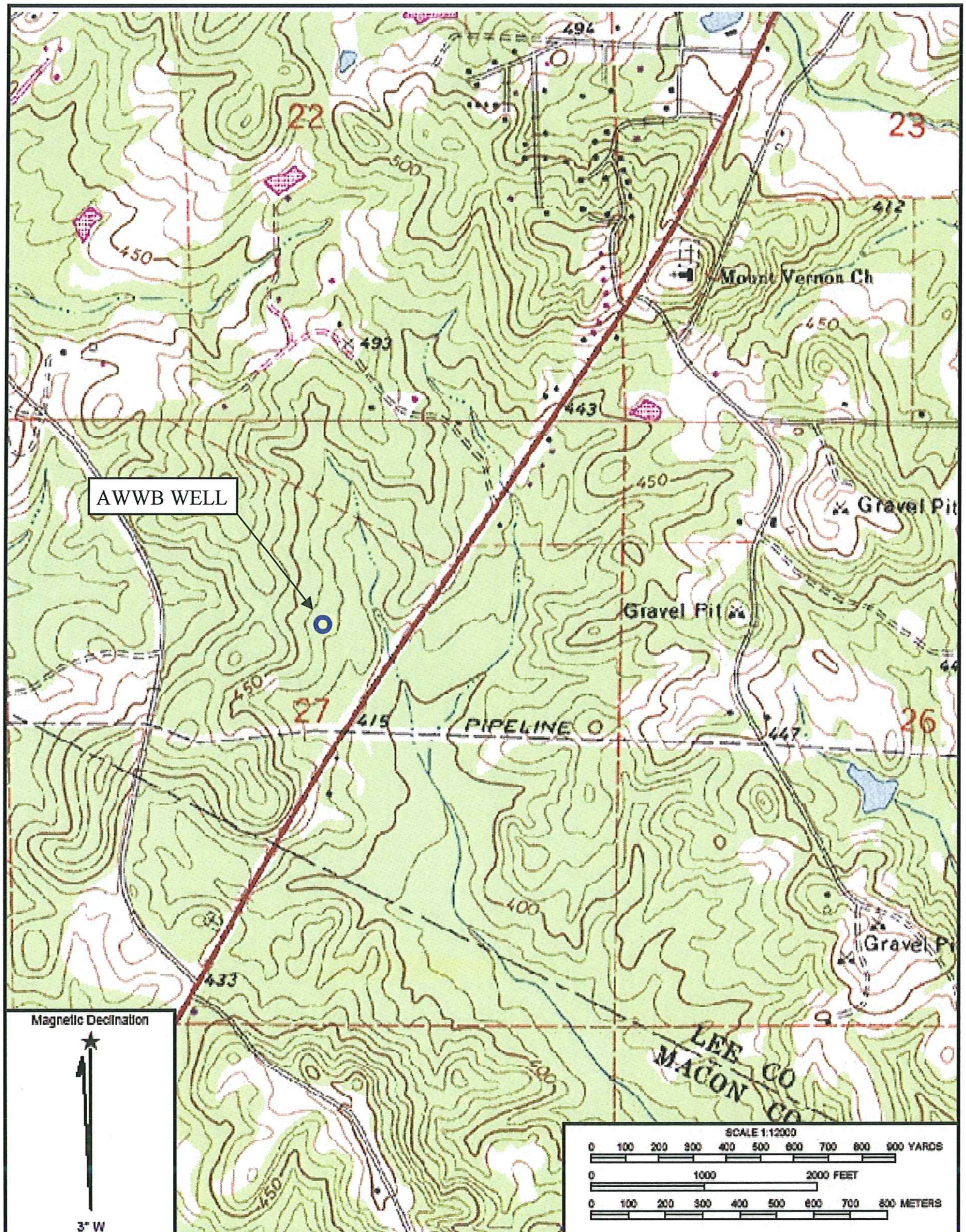
ATTACHMENT A

FIGURES



USGS Map Loachapoka, AL., 1971, Photo revised 1983.

NO.	DATE	REVISION NOTE	BY

Drawn By:	Project #:
JF	2476-001
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BW	4/4/11
Project Mgr.:	File Name:
JF	

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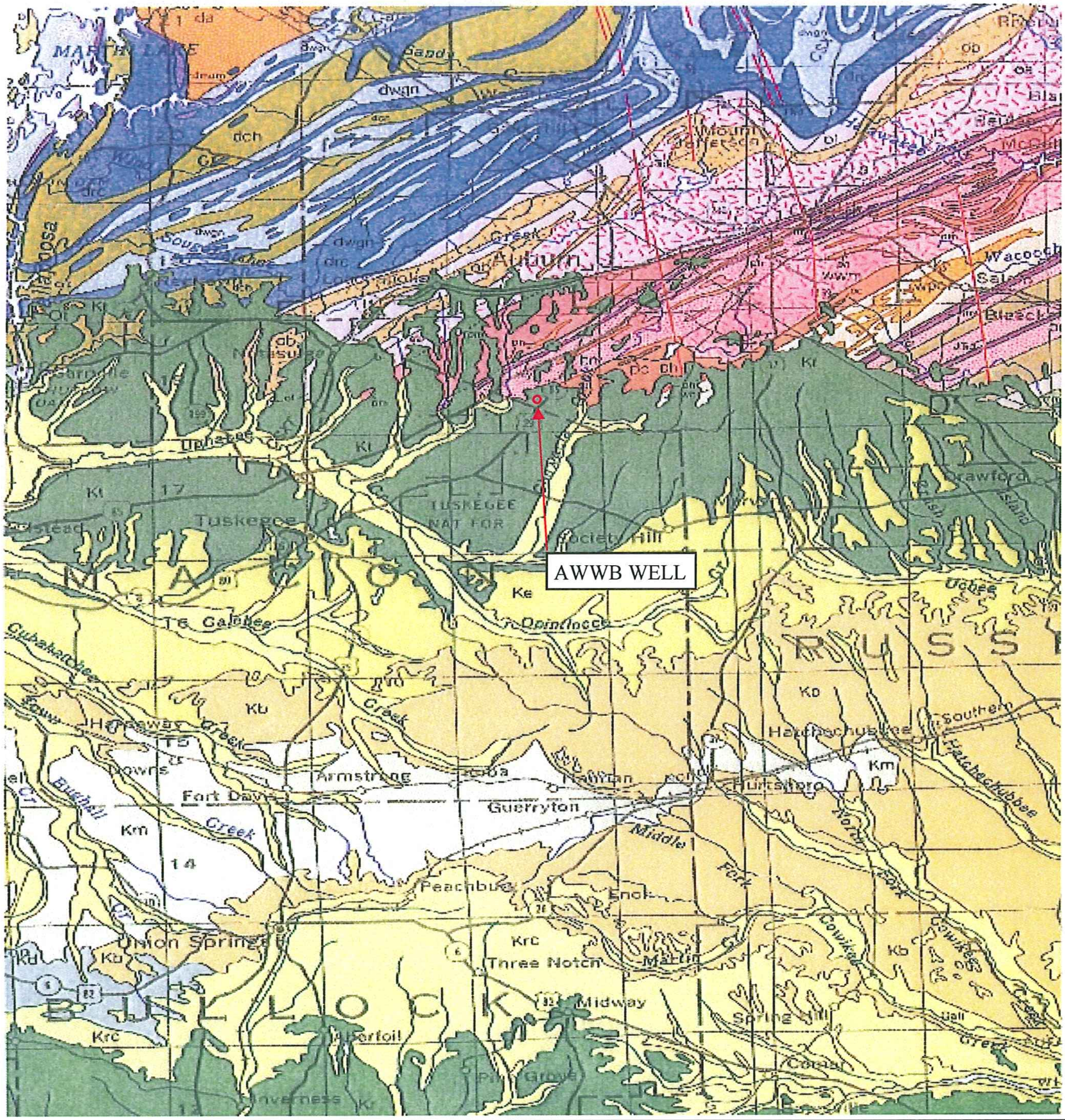
TITLE

Figure 2476001-1
Site Location Map
AWWB Well
Highway 29 South
Auburn, Alabama



GEOLOGIC MAP OF ALABAMA—1989

Qalt	Alluvial, coastal and low terrace deposits
Kt	Tuscaloosa Group undifferentiated
pc	Chewacla Marble
ph	Hollis Quartzite

NOT TO SCALE

Magnetic Declination

3° W

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SPECTRUM Environmental Inc.

85 Spectrum Cove
Alabaster, AL 35007
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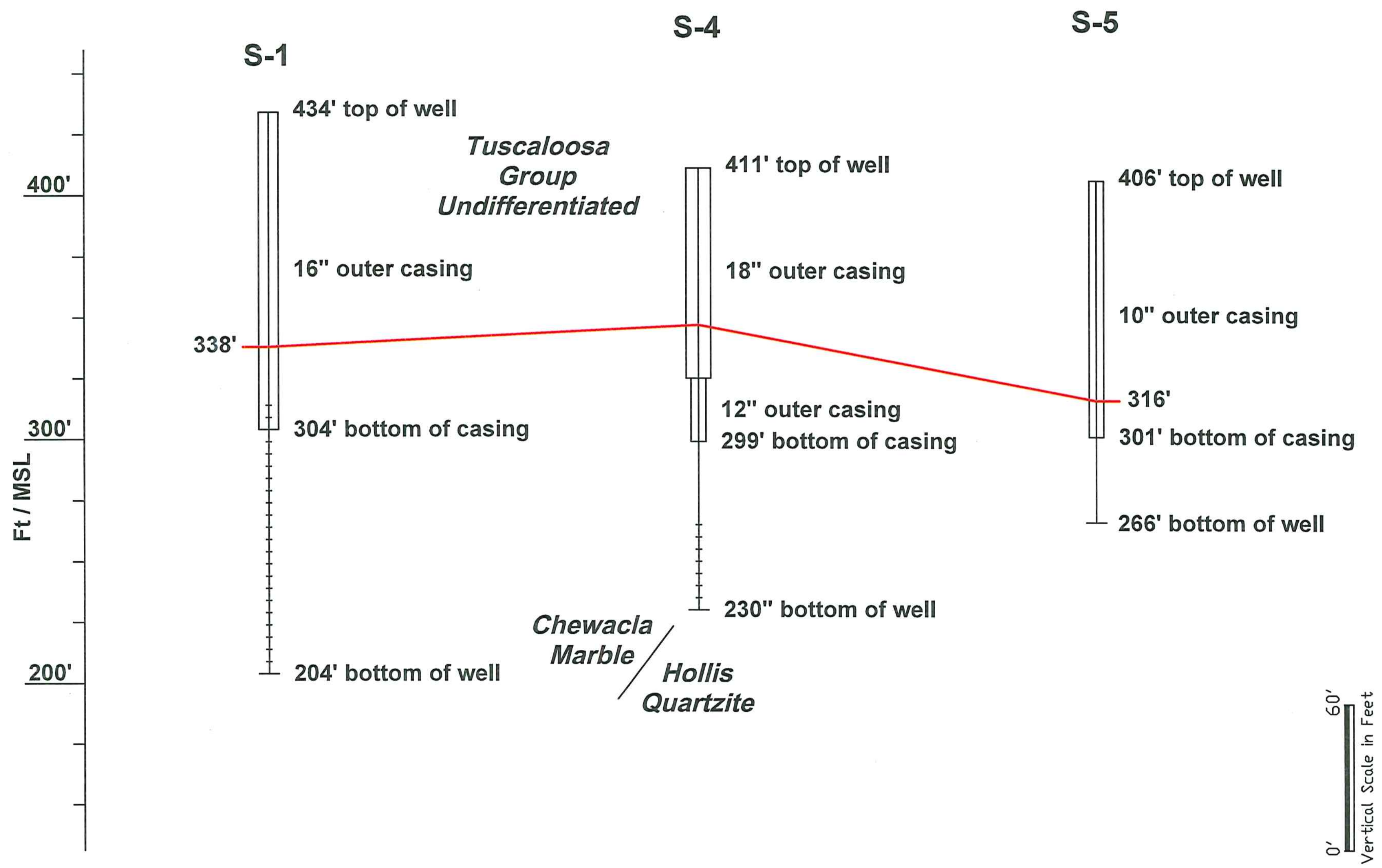
TITLE

Figure 2476001-2
Geologic Map
AWWB Well
Highway 29 South
Auburn, Alabama



NO.	DATE	REVISION NOTE	BY

Drawn By: JF	Project #: 2476-001
Checked By: BW	Date: 4/19/11
Project Manager: BW	File Name: 2476001-3

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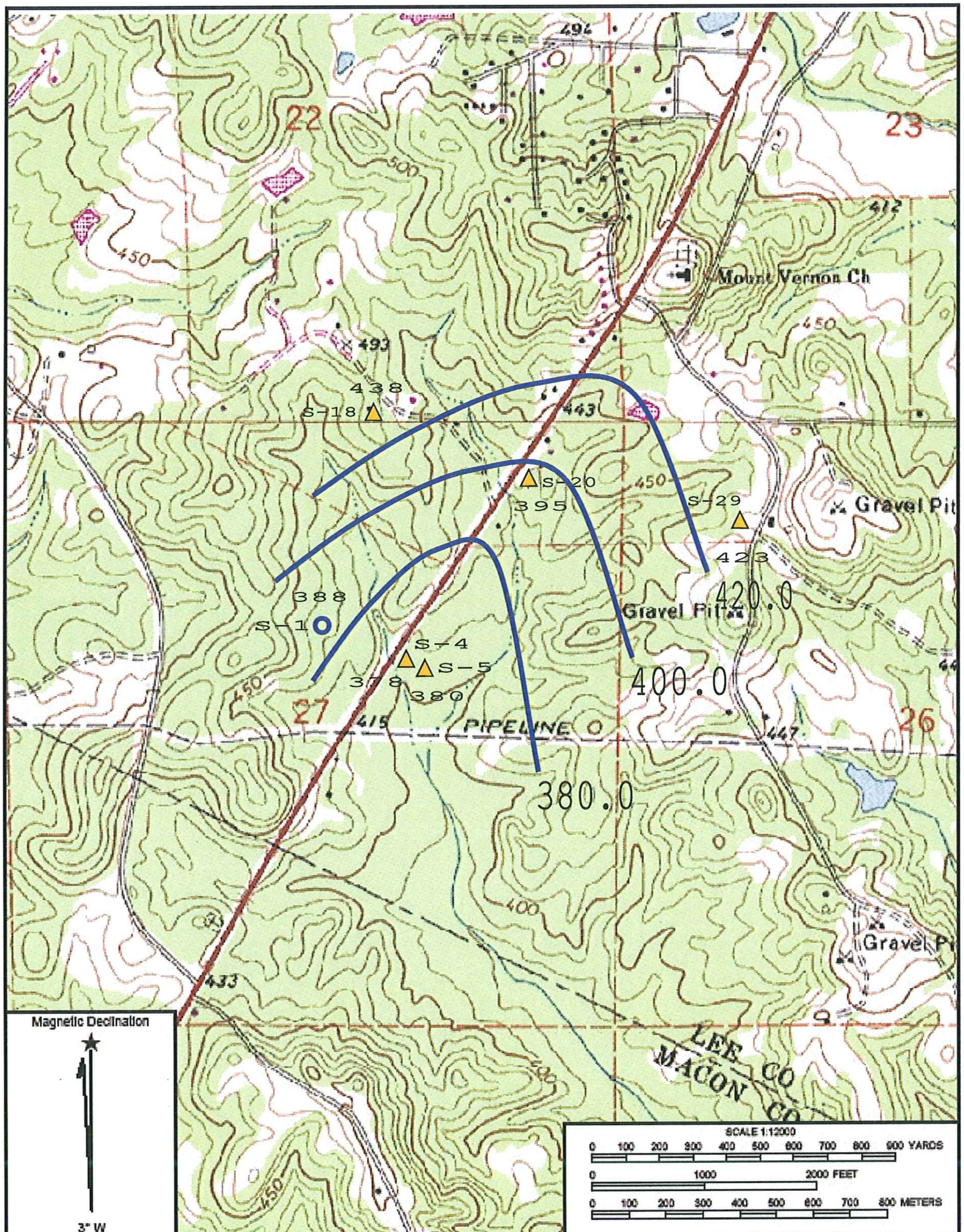
TITLE

Figure 2476001-3
Geological Cross Section
AWWB Well
Highway 29 S.
Auburn, Alabama



USGS Map Loachapoka, AL., 1971, Photo revised 1983.

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JF	2476-001
Checked By:	Date:
BW	4/4/11
Project Mgr.:	File Name:
JF	

SPECTRUM Environmental Inc.
85 Spectrum Cove
Alabaster, AL 35007
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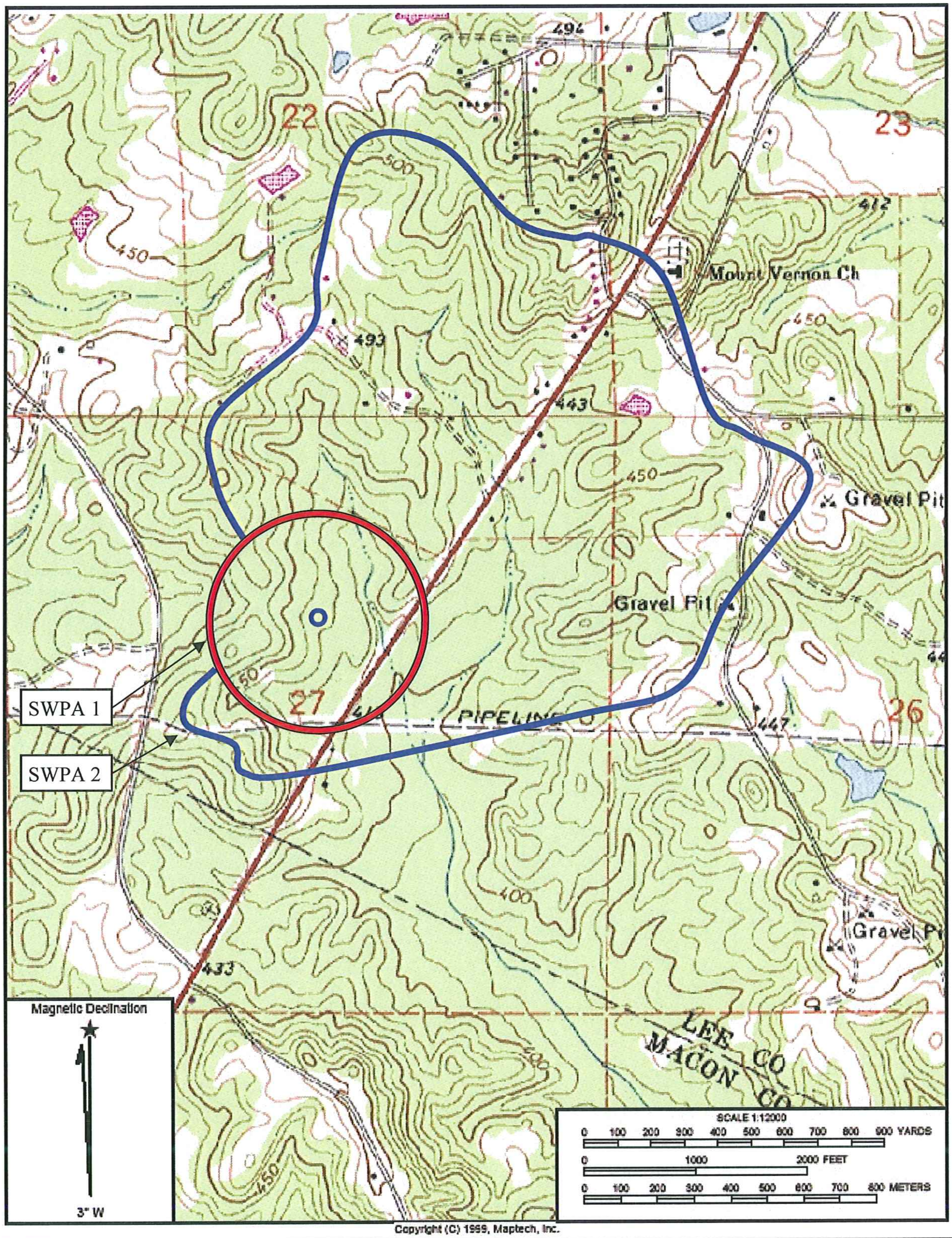
TITLE

Figure 2476001-4
Ground Water Elevation Map
AWWB Well
Highway 29 South
Auburn, Alabama



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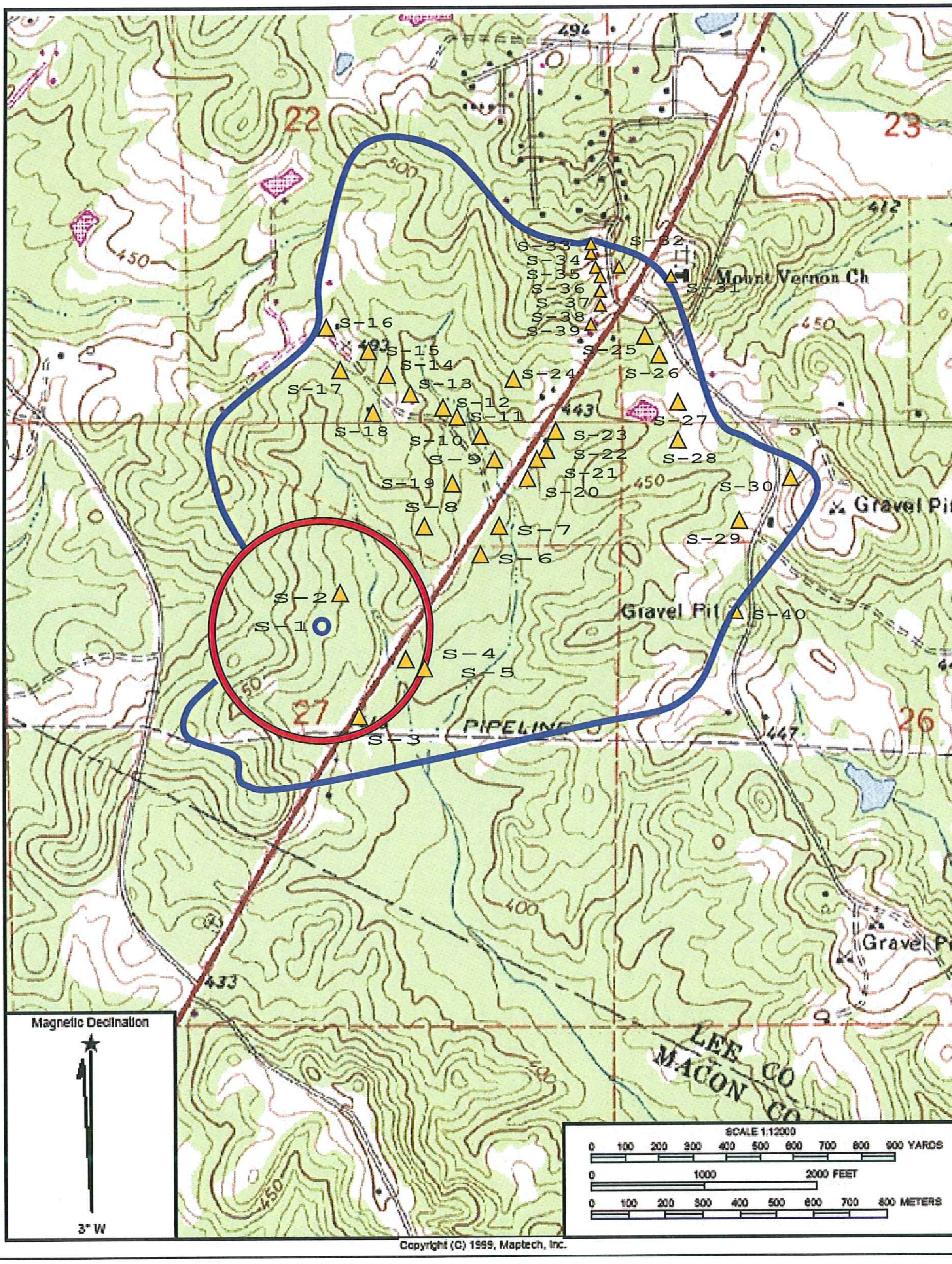
TITLE

Figure 2476001-5
SWPA 1 & 2 Boundaries Map
AWWB Well
Highway 29 South
Auburn, Alabama



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JF	

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TITLE

Figure 2476001-6
PCS Inventory Location Map
AWWB Well
Highway 29 South
Auburn, Alabama