LEFT FORK SANDY CREEK WATERSHED INVESTIGATION

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Submitted to:

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ABBREVIATIONS

AMD	acid mine drainage
cfu	colony-forming unit
CR	county road
CSR	Code of State Rules
DS	Downstream Strategies
HPC	heterotrophic plate count
LFSC	Left Fork Sandy Creek
LMFACWA	Laurel Mountain/Fellowsville Area Clean Watershed Association
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDL	method detection level
mg/L	milligram per liter
mL	milliliter
MTBE	methyl tertiary butyl ether
N	nitrogen
N/A	not applicable
NM	not measured
pCi/L	picocurie per liter
PQL	practical quantifiable limit
SPLP	synthetic precipitation leaching procedure
SU	standard unit
TPH-GRO	total petroleum hydrocarbons–gasoline-range organics
TPH-DRO	total petroleum hydrocarbons–diesel-range organics
µS/cm	microsiemen per centimeter
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection

1. INTRODUCTION

Starting in April 2007, almost 1,000 tanker trucks transferred about 3.3 million gallons of acid mine drainage (AMD) treatment sludge from the Omega mine in Monongalia County to drying pits at the F&M mine in Preston County, West Virginia (See Figure 1 and Map 1).[1] Based on the topography of the area and the dip of the local bedrock, the Left Fork Sandy Creek (LFSC) watershed is potentially influence by water moving from the F&M site. The Laurel Mountain/Fellowsville Area Clean Watershed Association (LMFACWA) requested that Downstream Strategies (DS) investigate whether the sludge additions were threatening the drinking water wells of downstream residents.

Figure 1: Tanker trucks unloading Omega mine sludge into F&M pits

Note: Two trucks unloading Omega mine sludge at F&M directly into the top-most of three connected pits on May 9, 2007.

Following an initial analysis completed in July 2007 (Hansen et al., 2007), DS conducted follow-up monitoring of Omega sludge on trucks, water leaving the F&M site, and wells and surface water in the watershed. Results from this follow-up monitoring effort are presented in this report.

[1] This figure is based on the reported 948 truckloads of sludge sent from Omega to F&M between April 2007 and July 13, 2007, each of which contained 3,500 gallons of sludge. The 948 truckloads include 294 in April, 321 in May, 276 in June, and 57 from July 1 through 13 (Reese, 2007a).

The F&M site is one of many bond forfeiture sites in north-central West Virginia where the West Virginia Department of Environmental Protection (WVDEP) actively treats AMD.[2] Three that are discussed in this report are shown in Map 1: the Omega mine in Monongalia County and the F&M and T&T mines in Preston County. Active treatment of AMD generates an iron-rich, alkaline sludge that is typically settled out in ponds. This sludge must be periodically removed so that the ponds continue to have sufficient volume for future settling.

1.1 The F&M site

The F&M mine was comprised of three sites with separate mining permits: S-57-84, S-1073-86, and S-1044-87. F&M surface mined the Lower Kittanning coal seam from 1984 through 1990. In the mid-to-late 1980s, residents of the LFSC watershed noticed that water quality downstream had declined. Government investigations confirmed these reports (See, for example, West Virginia Department of Energy, 1989).

Concerned citizens organized and took legal action. In 1993, as a result of this action, LMFACWA generated a trust fund to pay for active AMD treatment at F&M. WVDEP operates and maintains the treatment systems, and the agency owns part of the land. LMFACWA still maintains a strong interest in the treatment system, and any possible impacts downstream to surface water or drinking water wells.

Active treatment at F&M produces AMD sludge, which is ultimately sent to onsite sludge pits. The estimated total sludge production at F&M is 3,731 cubic yards per year, at 3% solids (Reese, 2007b).

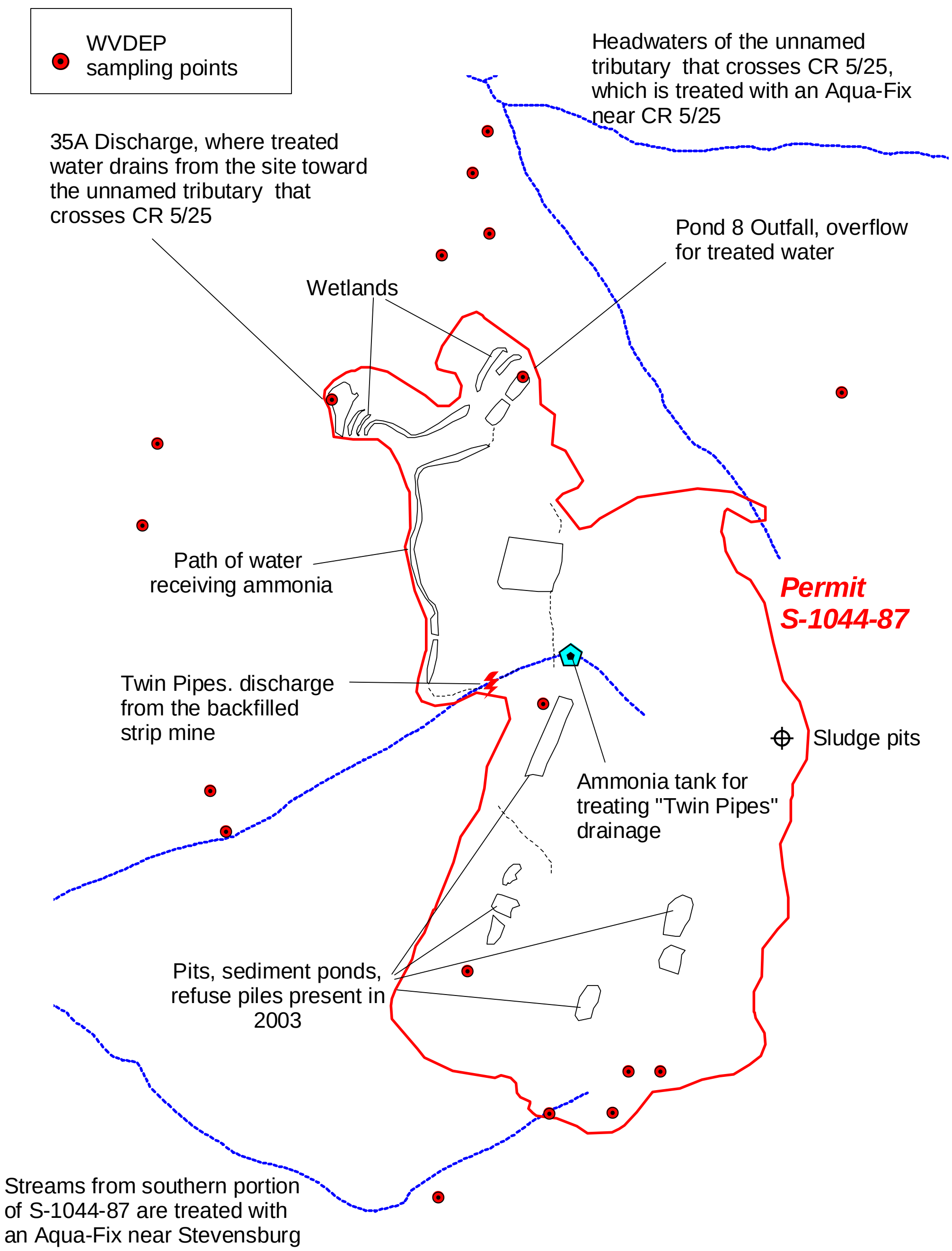
WVDEP's treatment system at F&M, key parts of which are shown in Figure 2, includes two anhydrous ammonia tanks, each of which discharges ammonia to mine drainage in multiple locations. One of these tanks is within the permitted area shown in Figure 2.

In addition to the discharges within the permit boundaries, monitoring by WVDEP documents other sources of AMD on adjacent properties. WVDEP uses three Aqua-Fix lime-dispensing units to treat the streams that carry the runoff from the permitted area. The Aqua-Fix units help neutralize AMD from the off-site sources as well.

While WVDEP conducts a considerable amount of monitoring of the outlets and receiving streams at F&M, it does not routinely measure trace metals. Trace metals are constituents of coal, and are concentrated in coal combustion waste. Coal combustion waste has been added to the Omega mine.

[2] At these sites, mining companies have forfeited their bonds and the responsibility for perpetual AMD treatment is transferred to WVDEP.

Figure 2: Features at the F&M mine site S-1044-87



Sludge drying pits, installed within the backfill of the former strip mine within the S-1044-87 permit boundary, are used for sludge generated at the F&M site. These pits were also used for the sludge trucked in from Omega in 2007. Two authors of this report visited the site on May 9, 2007.

During this site visit, Omega sludge was released into the top-most of the three pits (Figure 1). This top-most pit was already full of drying Omega sludge, and had virtually no capacity left in which the new liquid sludge could be dewatered. The liquid sludge flowed directly down a ditch to the second pit, and from there to a third pit. The three pits are shown with a single symbol in Figure 2.

1.2 The adjacent Bolyard and Howdershelt mines and Ridenour portals

The F&M mine is not the first mining operation in the immediate area. According to an investigation by the West Virginia Department of Energy (1989), the abandoned Bolyard and Howdershelt mines are adjacent to the F&M mine and are in the same coal seam. This report states:

> "Oxidation of pyritic materials as a result of F. & M. Coal's S-1073086 surface mine has caused the increased acidity and total iron concentrations at the Bolyard and Howdershelt Mines. Increased discharge volumes at the Bolyard Mine are the result of increased recharge area being diverted to the mine as a result of F. & M. Coal's S-1073-86 surface mine." (West Virginia Department of Energy, 1989)

The WVDEP Office of Abandoned Mine Lands and Reclamation has identified discharges from the Bolyard and Howdershelt mines as the Ridenour portals, described in Problem Area Description 4396. Portal locations from this description are shown in Map 2. The Office of Surface Mining, referencing the 1989 Department of Energy investigation, determined that the drainage from the Ridenour portals is ineligible for Abandoned Mine Land Trust Fund funding because this drainage was affected by mining at F&M (Office of Surface Mining, 1993).

1.3 The active Whitetail mine

The active underground Whitetail mine in Preston County is mining the Lower Kittanning coal seam, the same seam that was mined at F&M. Since mining permit U-1007-98 was issued to Kingwood Mining Company in 1999 for the Whitetail Complex K-Mine, seven revisions have been approved by WVDEP. These revisions have resulted in an increased mining area, and according to the permit documents, these new mining areas have the potential to impact additional drinking water wells. The most recent revision, approved August 1, 2007, added an additional 85 acres of underground mining area. With this revision, the Whitetail mine is moving directly under the LFSC watershed (See Map 1).

Some groundwater monitoring has been conducted by Kingwood Mining Company. According to monitoring results included in the company's groundwater inventory, the company monitored two drinking water wells that are also included in the current study. These wells are identified in this report as GW05 and GW06.

Table 1 compares the results from Kingwood Mining Company with the current report for Well GW05. Measurements from Well GW05 match relatively well.

Table 1: Well GW05 results from Kingwood Mining Company and Downstream Strategies

Parameter	From Kingwood Mining Company	From Downstream Strategies
Date	7/18/2007	3/5/2008
pH (SU)	7.13	7.52
Sulfate (mg/L)	6.3	15.3
Total dissolved solids (mg/L)	156	NM
Total suspended solids (mg/L)	<MDL	NM
Alkalinity (mg/L)	140	136
Aluminum (mg/L)	0.06	<MDL (<0.009)
Iron (mg/L)	<MDL	0.44
Manganese (mg/L)	0.04	0.05
Specific conductivity (umhos)	354	307
Acidity (mg/L)	<MDL	<MDL (<4.58)
E. coli	Absent	NM
Total coliforms	Absent	<MDL (<1.1 cfu/100 mL)

Source: Kingwood Mining Company results from Kingwood Mining Company (2007). MDLs were not provided for Kingwood Mining Company results.

For Well GW06, Kingwood Mining Company states “No bypass sample possible,” which presumably means that the sample was taken after the treatment system. Based on personal observation, however, it is indeed possible to take a sample from a spigot prior to treatment.

The sample collected by DS during the March 5, 2008 sweep was taken from this spigot, and therefore more accurately reflects the quality of the well water in the ground. Because of the poor water quality found during this initial visit, DS returned on May 16, 2008 to re-sample the water both before and after treatment. Results from both DS visits as well as results from Kingwood Mining Company, are shown in Table 2. Well GW06 is discussed in more detail in Section 4.2.4, because the well water is consistent with AMD.

Table 2: Well GW06 results from Kingwood Mining Company and Downstream Strategies

	Before treatment		After treatment	
Parameter	From Downstream Strategies	From Downstream Strategies	From Kingwood Mining Company	From Downstream Strategies
Date	3/5/2008	5/16/2008	6/8/2007	5/16/2008
pH (SU)	3.07	3.06	5.98	5.20
Sulfate (mg/L)	592	483	100	528
Total dissolved solids (mg/L)	NM	NM	520	NM
Total suspended solids (mg/L)	NM	NM	<MDL	NM
Alkalinity (mg/L)	<MDL (<2.81)	<MDL (<2.81)	54.5	4.70
Aluminum (mg/L)	1.48	9.45	0.24	0.03
Iron (mg/L)	34.8	76.7	1.99	0.34
Manganese (mg/L)	0.13	0.63	<MDL	<PQL (<0.01)
Specific conductivity (umhos)	1,534	1,027	974	1,064
Acidity (mg/L)	528	274	<MDL	8.80
E. coli	NM	<2 cfu/100 mL	Absent	<2 cfu/100 mL
Total coliforms	11 cfu/100 mL	<2 cfu/100 mL	Absent	<2 cfu/100 mL

Source: Kingwood Mining Company results from Kingwood Mining Company (2007). MDLs were not provided for Kingwood Mining Company results. For 5/16/2008 DS results, PQLs instead of MDLs were provided by the laboratory. For 5/16/2008, the chain of custody record and laboratory results label the samples as GW03 and GW03-T; however, these samples were the only ones taken on that date and were taken at GW06.

1.4 The junkyard

A junkyard located along LFSC is a potential source of gasoline, diesel fuel, antifreeze (ethylene glycol), and lead and sulfuric acid from batteries. The approximate boundary for this junkyard is shown in Map 2. Based on site observations from the road, the site holds junk cars, equipment, and engines throughout the valley and hillside, without apparent measures that would prevent contamination to surface and or groundwater.

1.5 Recent monitoring

On May 9, 2007, DS sampled sludge directly from a truck delivering sludge from Omega to F&M, as well as dried sludge from previous deliveries that was left in the second of three connected drying pits. Using measurements of total metal content in the sludge and water content of the sludge from the truck and in the pit, DS calculated metal concentrations in the water that likely drained from the sludge. According to these calculations, which are summarized in a previous report (Hansen et al., 2007), concentrations of antimony, arsenic, mercury, and thallium exceed the most stringent of the respective groundwater or surface water standards.

Meanwhile, WVDEP conducted its own analyses of Omega sludge. WVDEP also analyzed sludge generated at the F&M treatment systems. At a later meeting, WVDEP and DS compared their results. WVDEP critiqued DS's results because they were based on single samples of the wet and dried sludge. They also stated that graphite furnace measurements of trace metals in digests could be unreliable at such low concentrations.

WVDEP presented an alternative method of analysis: sludge was extracted using the synthetic precipitation leaching procedure (SPLP), and those extracts were analyzed for a number of trace elements. Their analyses showed that one of the five Omega sludge samples would qualify as toxic waste if the toxic characteristic leaching procedure were used, rather than SPLP, because of silver concentrations.

DS pointed out that WVDEP did not compare the results against the appropriate thresholds. WVDEP compared their results to a threshold that would determine whether the material could be placed in a landfill or whether it would have to be treated as toxic waste. DS believed the appropriate thresholds are state groundwater standards and federal drinking water standards and health advisory levels because people are using the groundwater for drinking water. These standards are shown in Table 7 in Appendix A.

As shown in Table 3, the method detection levels (MDLs) used by WVDEP were too high to compare against the most stringent thresholds for six parameters. For these parameters, it is not known whether measured values are safe.

For the other 12 parameters, the MDLs used by WVDEP were sufficiently low to make these comparisons. Aluminum, boron, manganese, and silver measurements exceeded the most stringent thresholds for the F&M sludge samples. For the Omega samples, aluminum, iron, manganese, selenium, and silver exceeded the most stringent thresholds.

Table 3: WVDEP results compared with appropriate thresholds

Element	MDL (mg/L)	Threshold (mg/L)	Type of threshold(s)	F&M samples exceeding threshold	Omega samples exceeding threshold
MDL too high to compare with most stringent threshold					
Antimony	0.035	0.006	Groundwater standard, MCL	N/A	N/A
Arsenic	0.047	0.01	Groundwater standard, MCL	N/A	N/A
Cadmium	0.014	0.005	Groundwater standard, MCL	N/A	N/A
Lead	0.032	0.015	Groundwater standard, MCL	N/A	N/A
Molybdenum	0.05	0.04	Life-time health advisory	N/A	N/A
Thallium	0.04	0.002	Groundwater standard, MCL	N/A	N/A
MDL low enough to compare with most stringent threshold					
Aluminum	0.021	0.05	Secondary standard	100%	100%
Barium	0.012	2	MCL	0%	0%
Boron	0.014	0.9	Ten-day health advisory for 10-kg child	20%	0%
Chromium	0.012	0.1	MCL	0%	0%
Copper	0.015	1.0	Secondary standard	0%	0%
Iron	0.013	0.3	Secondary standard	0%	50%
Manganese	0.017	0.05	Secondary standard	100%	100%
Mercury	0.0001	0.002	MCL	0%	0%
Nickel	0.019	0.1	Life-time health advisory	0%	0%
Selenium	0.045	0.05	MCL	0%	33%
Silver	0.045	0.1	Secondary standard	100%	17%
Zinc	0.016	2	Life-time health advisory	0%	0%

Note: WVDEP did not measure beryllium or strontium. WVDEP measured vanadium, but no standards were found for that metal.

The United States Environmental Protection Agency (USEPA) sets primary drinking water standards, which include maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs). An MCL is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards. An MCLG is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.

Secondary drinking water standards are non-enforceable guidelines for contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

1.6 Summary of monitoring conducted for this report

The monitoring conducted for this report is intended to shed additional light on whether contaminants are draining from the sludge pits off the F&M site. It also aims to determine whether drinking water wells below the F&M site are contaminated. Monitoring was conducted in phases.

In the first phase in late 2007, DS collected samples of Omega sludge directly from tanker trucks. By late 2007, deliveries to F&M had ceased, and the trucks were delivering the Omega sludge to the T&T mines (See Map 1). Results from this phase are described in Section 2.

Also in late 2007, DS monitored discharges from the F&M site, at the three locations shown in Map 3. These discharges included untreated water from the backfill at F&M, plus discharges from two outlets after the AMD is treated. Results from this monitoring are discussed in Section 3.

On March 5, 2008, DS conducted a one-day sweep of drinking water wells, surface water sites, and F&M discharge locations to get a snapshot of several parameters that might indicate drinking water contamination from F&M, other nearby mines, and the junkyard. Results from drinking water wells are discussed in Section 4, and results from F&M and downstream surface water are discussed in Section 5. Maps 4 through 11 help explain these results for key parameters.

2. SLUDGE TRUCKS IN LATE 2007

2.1 Methods

To determine levels of trace metals that would likely drain from the sludge pits at F&M into shallow groundwater, samples were taken directly from sludge trucks that were delivering Omega sludge to T&T. Omega sludge deliveries to F&M had ceased by the time that this follow-up monitoring was conducted.

A procedure similar to the SPLP was used. The SPLP calls for an initial separation of the material into a liquid and solid phase by filtration, extraction of the solid material with a dilute acid, and then mixing of this extract with the original liquid phase. Because the sludge has such a high water content, the majority of the liquid to be analyzed comes from filtration, rather than from the extraction. Furthermore, the water that will pass through the sludge may or may not resemble the dilute acids used in the SPLP procedure. Therefore, DS decided to analyze the filtered, liquid phase of the sludge, rather than an SPLP combined “extract.”

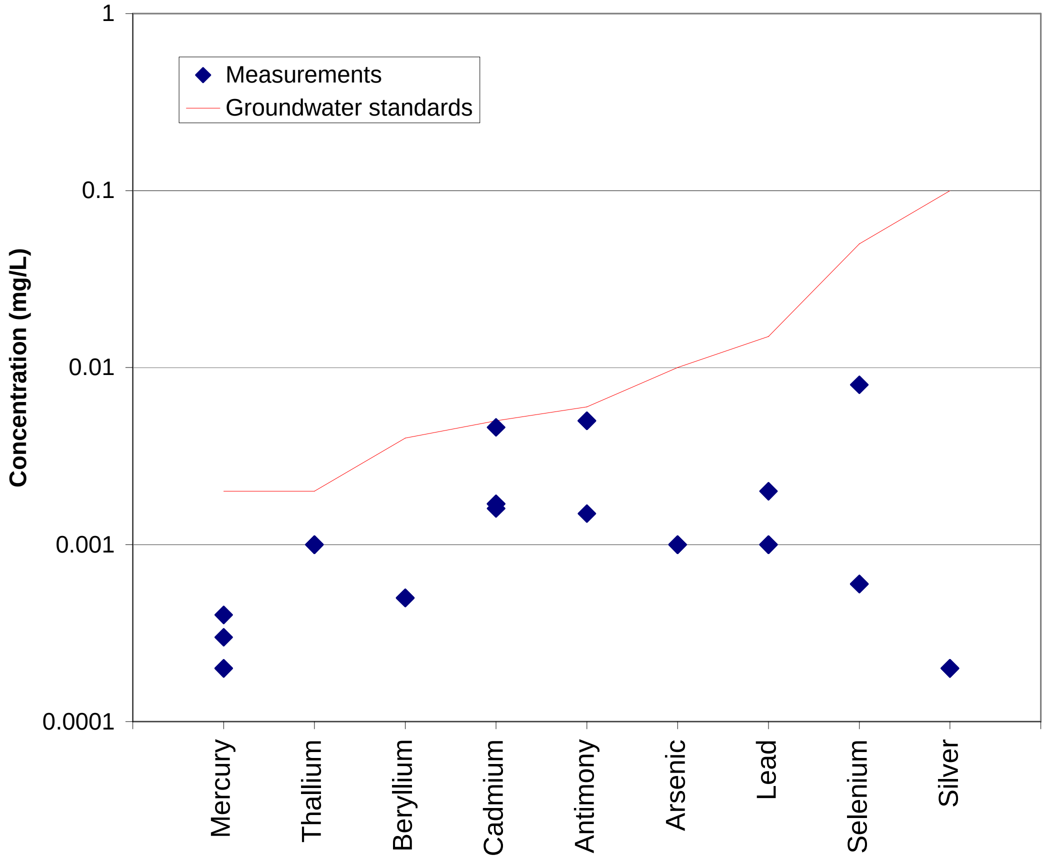
DS sampled sludge on four occasions. The sludge was collected as it was being discharged from trucks into a settling pond at the T&T mine. A composite sample of the sludge was taken at three intervals: full-tank, mid-tank, and bottom-tank.

These samples were collected in clean containers and delivered to a certified laboratory with chain of custody records. DS requested that the laboratory pressure filter the sludge through glass-fiber filters, as specified by the SPLP procedure, and then analyze the filtrate using a sensitive graphite furnace method. This method is required so that results could be compared against drinking water and groundwater standards. Analyses were not conducted on digests, so this method is not subject to WVDEP’s criticism of DS’s earlier analyses of Omega sludge on May 9, 2007.

2.2 Results

Full results are included in Appendix A. As shown in Figure 3, Omega sludge filtrates did not violate groundwater standards for any of the elements tested. While the procedure used here does not simulate the exact field conditions at the sludge pits at F&M, it does give some indication of the order of magnitude of pollutant concentrations that would drain from the pits if the sludge pits acted as a filter and only dissolved pollutants were released into groundwater.

Figure 3: Trace element concentrations in extracts from Omega Mine AMD treatment sludge



Note: State groundwater standards from 46 CSR 12. Measurements below MDL are shown at MDL in this figure.

3. F&M SURFACE WATER IN LATE 2007

3.1 Methods

On five occasions in late 2007, DS also sampled water draining out the F&M backfill both before and after that water was neutralized with ammonia by WVDEP. Water draining from the backfill was sampled at the "Twin Pipes." The two discharge points are labeled "Pond 8 Outfall" and "35A Discharge." These three locations are shown in Map 3.

On all trips, DS personnel were accompanied by WVDEP staff. Field measurements were collected using a pH meter, conductivity meter, and dissolved oxygen meter. Before each round of sampling, these instruments were calibrated. All field measurements were recorded on sampling forms and entered into a database.

Grab samples were collected in clean containers, preserved with nitric acid, and delivered to a certified laboratory within proper holding times and with chain of custody records. As with the sludge filtrates, a sensitive graphite furnace method was used so that results could be compared against drinking water and groundwater standards.

3.2 Results

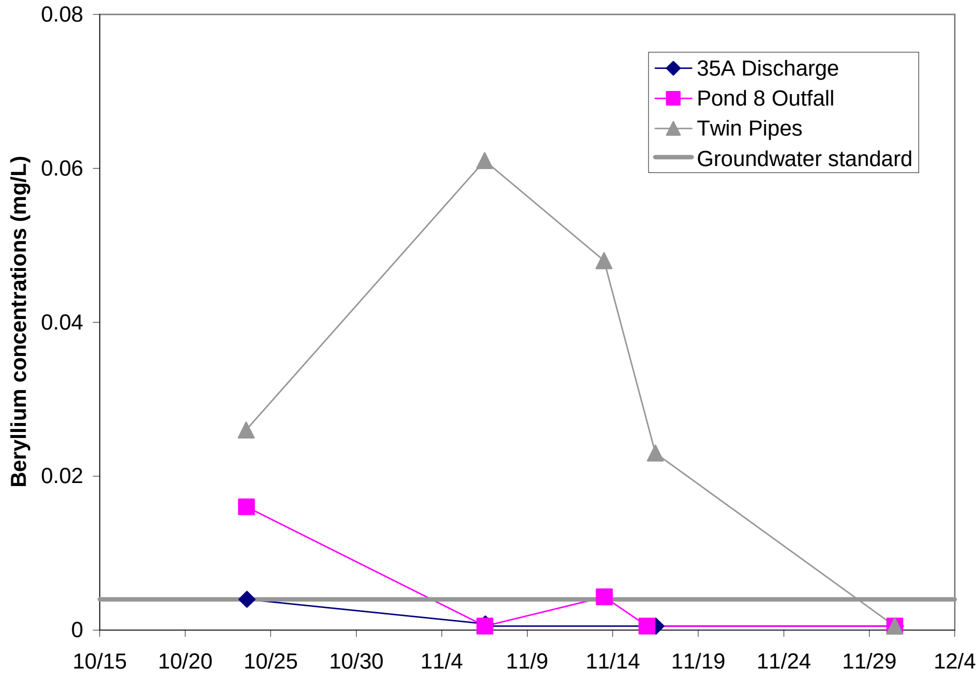
Concentrations of four metals exceeded groundwater standards: beryllium, arsenic, cadmium, and thallium.

Beryllium concentrations at Twin Pipes exceeded the groundwater standard on all but one date (Figure 4). Beryllium violated the groundwater standard at the Pond 8 Discharge on one occasion.

Water from the Twin Pipes also exceeded groundwater standards for arsenic, cadmium, and thallium (Figure 5). On November 16, the arsenic concentration of 0.423 mg/L exceeded the groundwater standard by a factor of 42. Cadmium and thallium exceeded standards by as much as 92% and 100%. No other metals violated groundwater standards at the Pond 8 Discharge or the 35A Outfall on any day.

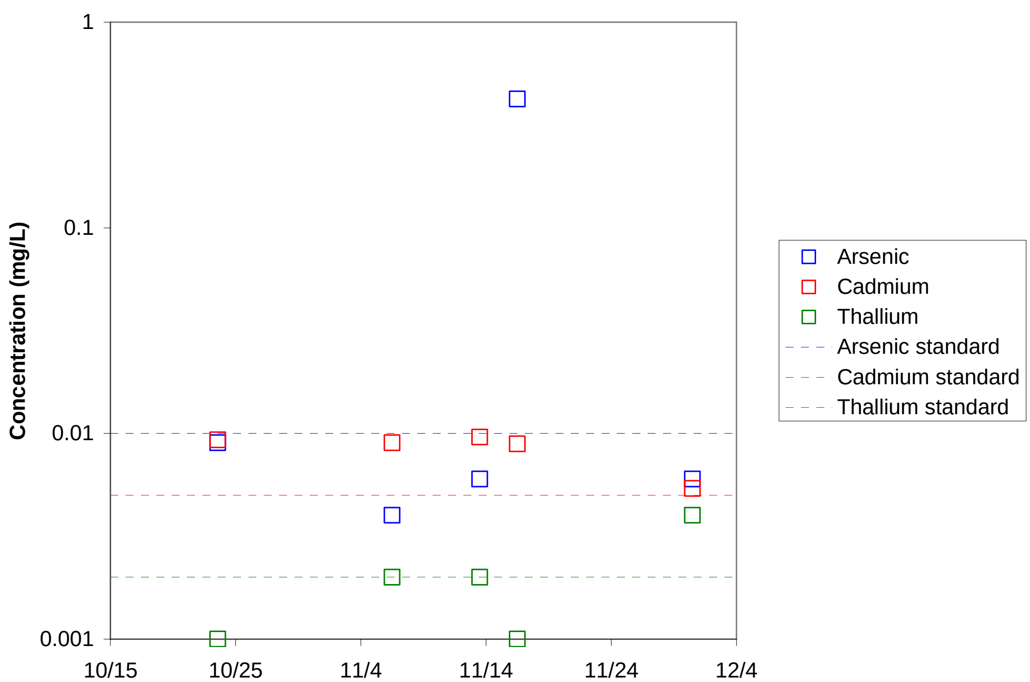
It should be noted that groundwater standards do not apply to surface water discharges; however, these thresholds are used as screening tools to judge whether or not levels are high enough to justify additional monitoring of wells and surface waters that are potentially downstream and downgradient from F&M.

Figure 4: Beryllium concentrations in untreated and treated water on the F&M site



Note: Sampling dates are in 2007. Groundwater standard from 46 CSR 12.

Figure 5: Concentrations of trace elements that violated groundwater standards at Twin Pipes



Note: Sampling dates are in 2007. Groundwater standards from 46 CSR 12.

4. DRINKING WATER WELLS IN MARCH 2008

In the next phase of follow-up monitoring, DS undertook a one-day sweep of wells, surface water, and the same three discharges from the F&M site on March 5, 2008. The goal was to determine whether wells contain water safe to drink, and if contamination was found, to determine likely contamination pathways. This section describes the results for the wells, and Section 5 discusses the results for surface water and F&M discharges.

The backfill at the F&M site contains a reservoir of toxic water at high elevation above and up-dip from the settled LFSC valley. Based on the topography of the area and the dip of the local bedrock, the LFSC watershed is potentially influence by water moving from the F&M site. Residents of the valley have complained of changes in the quality of their well water, used by many residents for drinking water.

DS sampled water from wells of several residents to determine whether their well water carried the toxic constituents that had been found in the previous Twin Pipes monitoring visits.

DS also responded to landowner concerns about whether their well water was safe to drink. The sampling regime tested whether the wells were connected to surface water by measuring bacteria levels in the wells and in streams. DS also requested analyses of organic chemicals to determine whether the groundwater contained contaminants that might come from a local junkyard.

4.1 Methods

Of the 14 drinking water wells monitored, 11 lay near LFSC, possibly within the zone of influence of F&M. These wells are labeled GW01 through GW11. Three additional wells—GW12 through GW14—were sampled as controls that were likely outside of that zone of influence. Well locations are shown in Map 2; homeowner names are not used in this report to preserve confidentiality.

On December 10, 2007, DS conducted face-to-face surveys with well owners to understand self-reported issues with the 11 wells near LFSC.

This sampling trip on March 5, 2008 occurred following a sizeable rain event. According to a rain gauge at the F&M site, 1.07 inches of rain fell in the previous 24-hour period. March 4 rainfall amounted to 1.24 inches in Morgantown, located 24 miles from the F&M site. The results presented here may not reflect conditions under different hydrologic conditions.

Protocols followed in this study were based upon WVDEP standard operating procedures (WVDEP, 2002).

4.2 <u>Results</u>

4.2.1 Well surveys

Detailed results from the December well surveys are included as Appendix B. These interviews consisted of a series of questions and observations outlined in the proposed scope of work. The survey results demonstrate commonalities among resident responses, in particular well depth, a timeline of events, and overall degradation of groundwater quality.

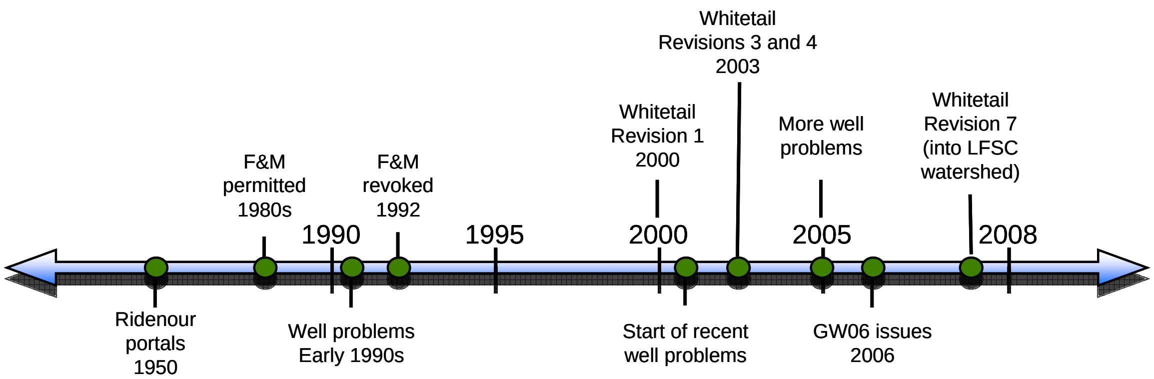
Well depths are shallower than dictated by typical drinking water well construction practices. Self-reported well depths range from 20 to 180 feet below ground surface, with an average of 91 feet below ground surface. In most cases, well drillers stated that water was reached at a shallow depth and that there was no need to drill farther; however, most residents were given the option at an increased price. In general, the residents chose not to drill deeper to avoid the additional expense.

Based on the interviews, some of the serious well issues began around the early 1990s. For reference, production at F&M stopped in 1990 (F&M Coal Company, Undated). Some residents recalled significant blasting that coincided with degraded groundwater quality. Since these initial issues that residents associate with the F&M mine while it was still active or recently forfeited, two additional issues have arisen. These additional issues coincide with some of the Whitetail mine activity to the north. Most respondents claim that within the past two years, water quality has deteriorated. During this timeframe, based on a permit review, the Whitetail mine has been expanding into the LFSC watershed (See the extent of mining in Map 1, as of 2007).

Well GW06 provides the most dramatic example of these recent changes. Owners of Well GW06 recall a severe change is static water level in summer 2006. The water level dropped from 8 feet to 20 feet below ground surface in a very short span of time. During the same time frame a neighbor’s pond dried up and a typical wet boggy field turned dry. A WVDEP complaint was filed and an investigation was conducted. WVDEP determined that the Whitetail mine could not have caused the issue with GW06 due to the distance to the mine and the geology, and the case was closed (WVDEP, 2006).

Most residents report similar issues with regards to the groundwater quality. Overall, a rotten/iron taste and smell was noted throughout the survey. Approximately half of the respondents report that most issues arise during drier periods, usually the summer months. In addition to well water, some residents stated they noticed changes in certain streams during high flow or dry conditions: some streams turning black or disappearing during low rainfall periods and some streams having a red tint or sludge-like appearance during high rain events. Based on these interviews and other information collected for this report, a timeline of well issues and mining activity in the vicinity is shown in Figure 6.

Figure 6: Timeline of drinking water issues and nearby mining activity



4.2.2 Trace metals

None of the trace metals that exceeded groundwater standards at the Twin Pipes sampling point were detected in wells. Detailed trace metal results are included in Appendix A.

4.2.3 Other results

Results for other parameters—including aluminum, iron, manganese, pH, total coliforms, total petroleum hydrocarbons–diesel-range organics (TPH-DRO), ethylene glycol, and alpha radiation—are shown in Maps 4 through 11.

As shown in Figure 7, one well, GW06, had pH, iron, and sulfate values that were consistent with AMD.[3] The aluminum concentration in this well, 1.48 mg/L, was also consistent with AMD. Well GW06 is discussed in more detail in Section 4.2.4.

Other wells had concentrations of iron that violated secondary drinking water standards. While GW04 had the second-highest iron levels of the wells, this high iron measurement was not associated with a high sulfate concentration or a low pH value.

Three household wells were tested for gross alpha and gross beta radiation because elevated radiation is an indicator of fly ash. Radiation was found, but not at high enough levels to reach drinking water standards.

Six of the wells were tested for organic chemicals. TPH-DRO was found in all six wells and were as high as 1.56 mg/L in one well, but these results showed no obvious spatial relationships. Benzene, ethylbenzene, toluene, xylene, methyl tertiary butyl ether (MTBE), and total petroleum hydrocarbons–gasoline-range organics (TPH-GRO) were not detected in any of the six drinking water well samples.

Ethylene glycol—antifreeze—was also measured in these six wells and was detected in three samples. Like with TPH-DRO, no obvious spatial relationship was apparent.

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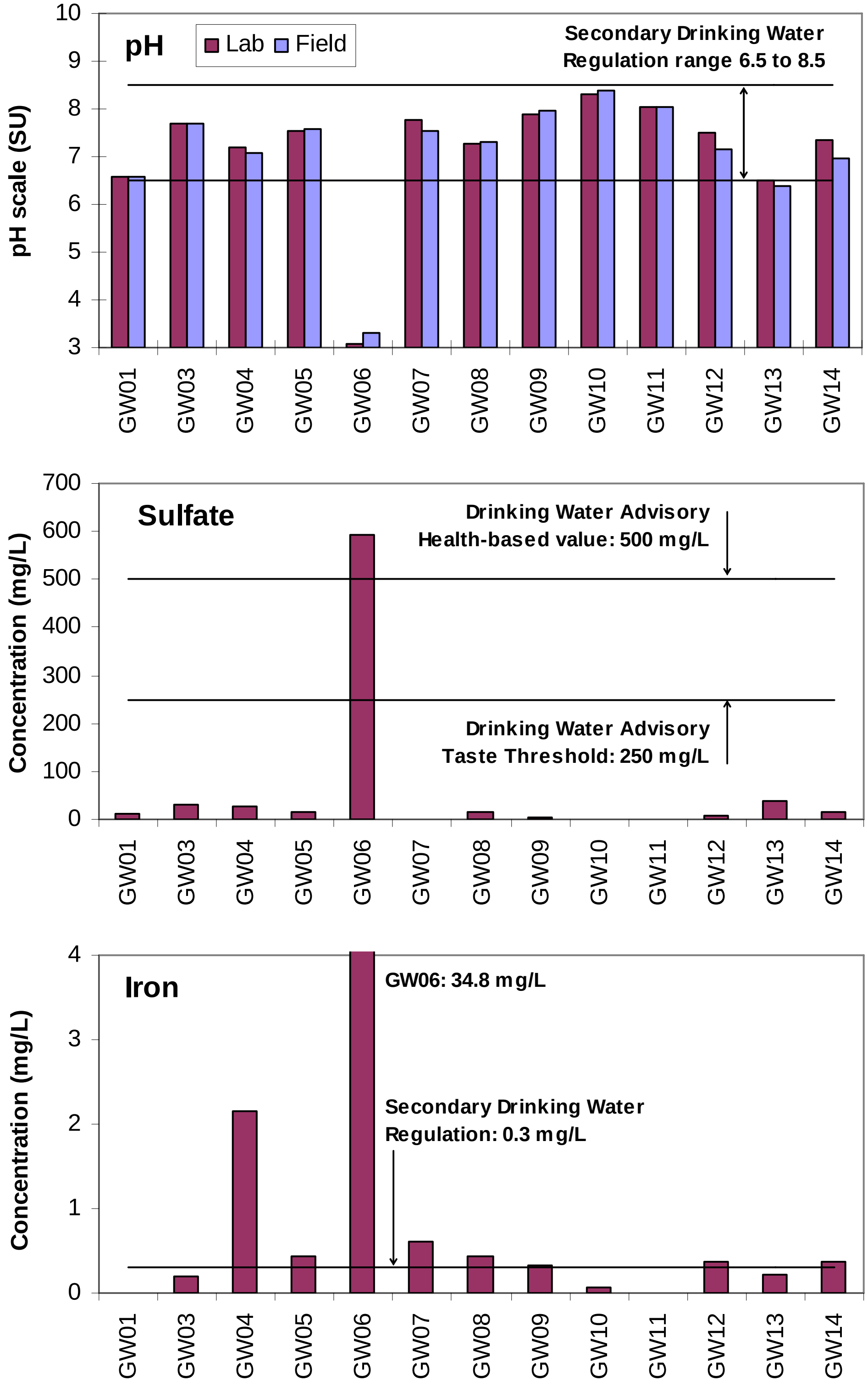
[3] AMD typically has low pH and high concentrations of sulfate as well as iron, aluminum, and/or manganese.

Figure 7: pH, sulfate, and iron in wells



While TPH-DRO and ethylene glycol were found in wells, there are no drinking water standards for these parameters. Additional testing of specific diesel-range organics would yield additional information about the particular contaminants in the wells, which could then be compared against standards. Additional ethylene glycol monitoring may also be warranted.

4.2.4 Well GW06

As mentioned above, Well GW06 has water consistent with AMD. Because of the poor water quality found on March 5, 2008, DS returned on May 16, 2008 to confirm and expand upon the well survey results, and to re-sample the water both before and after treatment. Results from both DS visits as well as results from Kingwood Mining Company, which has also monitored this well, are shown above in Table 2.

According to the well survey, the current residents have lived there for over 40 years; however, they switched from spring water to a well in 1988. When that well was drilled, several attempts were made on the property with no success. The abandoned holes were covered with rocks and soil. Results from a WVDEP well completion report are shown in Table 4.

Table 4: Well completion report information for Well GW06

Depth (ft)	Material
0-2	Topsoil
2-29	Hard shale stone
29-35	Brown shale
35-50	Dark brown shale
Yield (gallons per minute)	8
Static well level (feet)	23
Well depth (feet)	50

Source: Bethlehem Drilling (1988).

The residents have been treating their water since 1988. Because of the reported chronic staining and taste of the well water, it is presumed that treatment was instituted due to high levels of iron. The residents are now on their second water treatment system.

According the residents, the static well level was eight feet for years.[4] Then, in June 2006, the well water level dropped to 20 feet in one event. This change coincided with a pond drying and a normally swampy field becoming dry, all within an estimated 500-foot distance. In addition to the water drop, the residents noticed an increase in corrosion of their faucets, and dentures worn by a resident began to rapidly deteriorate. On June 26, 2006, the residents removed the existing well pipe and replaced it with a longer, 40-foot pipe, in order to reach the new static water level.

The residents filed a complaint with WVDEP. The agency responded by asserting that mining activity did not affect this well due to the distance to the mine and the geology (WVDEP, 2006).

According to the residents, Whitetail representatives have sampled and measured their well depth four times in the last two years. During these visits, the technician would remove the well cap and measure depth to groundwater by dropping a measuring tape fixed with a sensor. Depths measured

[4] This self-reported static well level is different from the level in the 1988 well completion report.

between June 8, 2007 and September 13, 2008 varied between 20.12 and 22.21 feet below ground surface. The technician stated the results would be shared within a matter of weeks; however, no results have ever been provided to the residents.

The residents were not notified, as WVDEP protocols dictate, about whether or not the equipment used by the Whitetail technicians was disinfected. In addition, the residents report that no disinfectant was applied after the measurement, which is also a standard WVDEP protocol (WVDEP, 2002).

The residents have been treating the well as instructed by the water treatment contractor. According to the residents, the treatment involves applying five pints of Clorox and five pints of caustic directly to the well. Further investigations should confirm exactly what is meant by "caustic," and whether this caustic is truly applied into the well or to the water treatment system.

According to the residents, the last application of both Clorox and caustic was February 7, 2008. It should be noted that this application was about one month before the March 5, 2008 sampling date. The residents report applying an additional five pints of Clorox on April 28, 2008, less than one month before the well was re-sampled on May 16, 2008.

GW06 residents, as well as LMFACWA members, report that an artesian well drains to a nearby stream. On the May 16 visit, this was investigated in order to collect additional data that might help explain water quality in Well GW06. During this visit, the DS technician was shown a structure that, according to the resident, was built by a mining company and covered a well. The resident stated that a metal pipe drained this well into the nearby stream. A metal pipe approximately 2 inches in diameter was observed discharging into the stream; however, this discharge point was underwater so no sample taken. At this time it is not known who drilled this well, when it was drilled, or for what purpose. Additional investigation of this discharge might help draw conclusions about water quality in drinking water well GW06.

5. F&M AND DOWNSTREAM SURFACE WATER IN MARCH 2008

During the same March 5, 2008 sweep during which well water samples were taken, six surface water samples and three samples on the F&M site were also collected. The samples on the F&M site—Twin Pipes, Pond 8, and 35A Discharge—correspond to the locations sampled in the previous phase.

The purpose of this surface water monitoring was to help draw possible connections between wells and surface water quality, and to make general observations of surface water quality.

5.1 Connections between well water and surface water

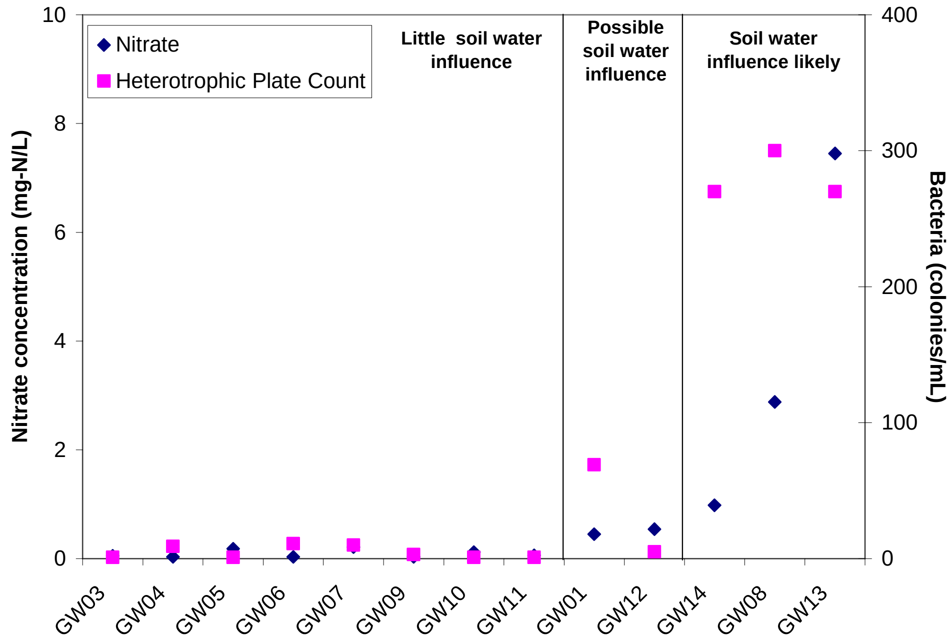
Bacteria counts served to identify possible connections between wells and groundwater and also provided some information about whether well water was contaminated by disease-causing microorganisms. One household well, GW06, contained coliform bacteria, indicating that this well may be unsafe to drink (See Table 14 in Appendix A).

As shown in Figure 8, groundwater samples from wells differed widely in nitrate concentrations and in heterotrophic plate counts (HPCs). High HPC values may indicate exposure of a water system to the environment, and may interfere with accurate coliform counts. None of the wells had HPC values that would interfere with total coliform determinations, nor levels that would require action at a water supply facility. Nor did any well have nitrate concentrations that exceeded drinking water standards. However, high values for HPC generally occurred in the same wells with high values for nitrate.[5]

The wells with high values appear to be safe, but influenced by soil processes. These wells likely draw water from shallower levels, are not constructed correctly, or both.

[5] Log-transformed values had a statistically significant correlation coefficient of 0.7.

Figure 8: Measurements indicating connections to soil or surface water



5.2 Other surface water results

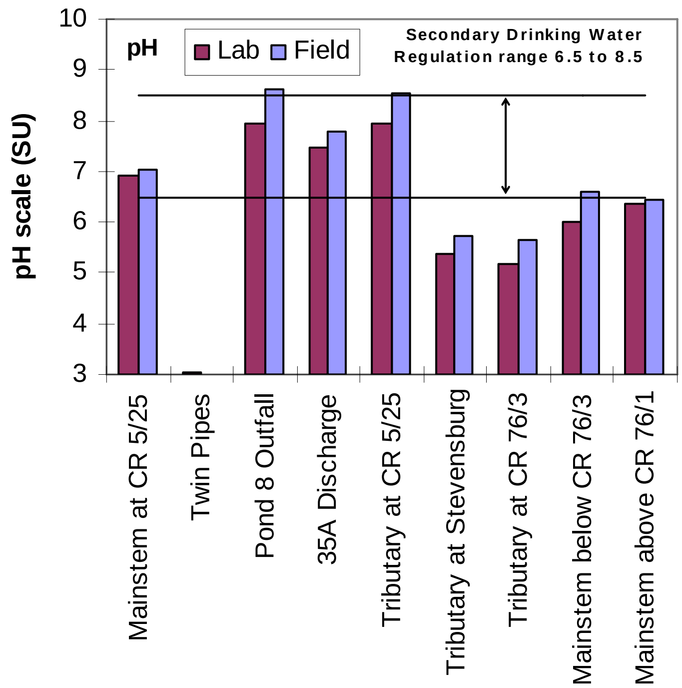
Complete surface monitoring results are shown in Appendix A, and selected parameters are included in Maps 4 through 11. Site abbreviations for surface monitoring locations are shown in Table 5.

Table 5: Surface monitoring site abbreviations

Surface water site	Abbreviation
Mainstem at County Road 5/25	LFSC5025
Twin Pipes	TWNPIPES
Pond 8 Outfall	POND8OUT
35A Discharge	35ADISCH
Tributary at County Road 5/25	UTCR5025
Tributary at Stevensburg	UTSTVBRG
Tributary at County Road 76/3	UTCR7603
Mainstem below County Road 76/3	LFSCB763
Mainstem above County Road 76/1	LFSCA761

Surface water pH results, shown in Figure 9, confirm that acidic water discharges from the Twin Pipes and is treated to neutrality before discharging via Pond 8 Outfall and 35A Discharge. Water is then discharged to the tributary of LFSC that crosses County Road 5/25, which is above pH 7.

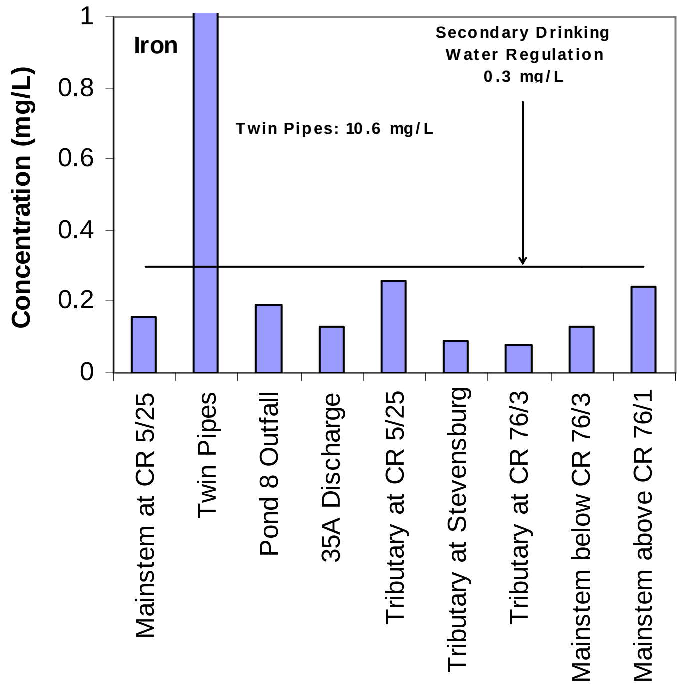
Figure 9: pH values in surface water draining to LFSC

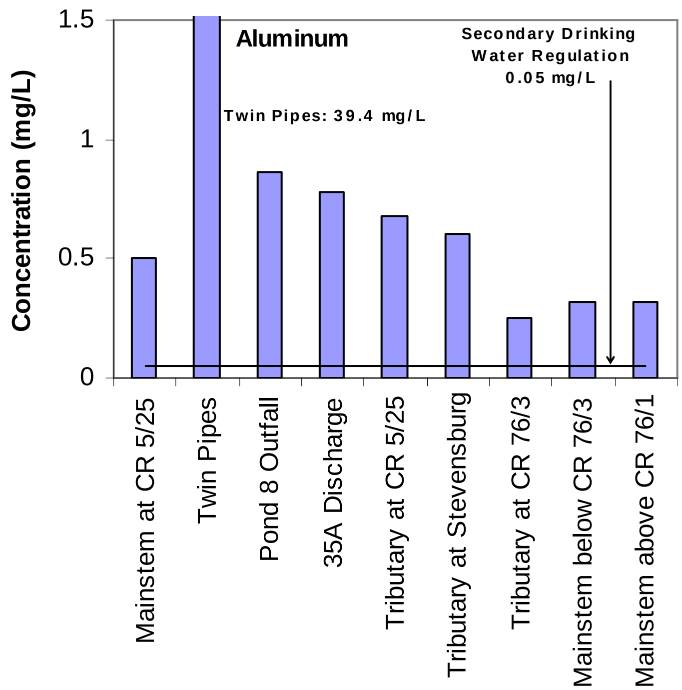


Iron was also high in the water from the Twin Pipes, but was decreased substantially by the neutralization and settling process (Figure 10). Iron increased between the discharge from the F&M site and the sampling point on the unnamed tributary at County Road 5/25. The source of the additional iron may be Ridenour portals associated with the Bolyard and Howdershelt mines (See Section 1.2 above and Map 2).

Iron also increases somewhat between two surface monitoring sites on the mainstem: below County Road 76/3 and above County Road 76/1. This increase occurs as the stream passes the junkyard and may be due to an iron source or to iron-containing sediment collected during high flow.

Figure 10: Iron and aluminum concentrations in surface water draining to LFSC





6. CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the data collected from Omega sludge trucks, untreated water draining the backfill at F&M, treated water draining from F&M to surface water, surface water downstream from F&M, and drinking water wells along LFSC. In addition, interviews with well owners, information from Whitetail's permit file, and a review of basic, publicly accessible geological information was considered. This report, therefore, uses monitoring data and other easily-accessible information to identify broad issues, and does not conclusively target the *cause* of specific issues.

1. **In general, the hydrogeology of this area should be better understood.** Important questions include the extent of rock fracturing near and underneath the F&M mine, the extent of interactions between F&M and the Ridenour portals, and possible interactions between the F&M mine and the active Whitetail mine. In particular, the water in Well GW06 (discussed below), which recently became degraded and is consistent with AMD, indicates that it may be impacted by both.
    - *Recommendation: Serious consideration should be given to conducting an independent hydrogeological study of the area. Such an investigation should also be a required part of any further Whitetail expansions into the watershed.*

2. **Trace metals were transported to F&M in the Omega sludge.** Based on measurements of Omega sludge on tanker trucks, trace metals were indeed transported to F&M. However, low concentrations of these metals—below groundwater standards—were likely released to groundwater.
    - *Recommendation: If additional shipments of Omega sludge are planned for F&M, direct monitoring of these sludge shipments would be warranted.*

3. **Rock near the F&M site was fractured, and F&M water may be discharging via the nearby abandoned Ridenour portals.** The Office of Surface Mining made such a determination in 1993. Due to the high elevation of the pool and the fractured bedrock, water from the pool may be infiltrating into groundwater.
    - *Recommendation: Further investigation into the fracturing of bedrock below the F&M site is warranted. This investigation can help clarify connections between F&M and the Ridenour portals, and between F&M and downgradient wells.*

4. **The F&M mine generates pollution, but onsite treatment is generally sufficient to prevent direct surface water discharges.** Discharges from Twin Pipes—which indicates contamination levels from the backfill under the sludge pits—sometimes contain concentrations of metals that violate groundwater standards. Treated water that discharges from F&M via Pond 8 and 35A Discharge, however, does not usually violate groundwater standards. Based on a visual observation, not all water draining from the site is directed through the treatment system. Also, the toxic water in the backfill has the potential to infiltrate into groundwater through the rock strata that were disturbed during the F&M strip-mining operation, or by seeping out of surface water and into the bedrock layers.
    - *Recommendation: Periodic monitoring is warranted for discharges from Twin Pipes, Pond 8, 35A Discharge, and for water that is not directed through the*

treatment system. Monitoring should include unfiltered water samples because people may drink unfiltered water from their wells.

5. **WVDEP monitoring of the outlets and receiving streams at F&M has been insufficient to determine whether trace metals are being appropriately treated.** Monitoring is also insufficient to determine whether trace metals are being discharged at the Omega site. Monitoring trace metals is particularly important there, and at locations where Omega sludge is deposited, because coal combustion waste has been placed in the Omega mine.
   - *Recommendation: Monitoring should include not just general chemistry and AMD parameters, but also trace metals. Unfiltered samples should be included. In addition, household wells should be monitored periodically in case toxic chemicals are gradually seeping from the high elevation pool towards the wells.*

6. **Some wells are likely connected to surface water.** Based on bacteria and nitrate measurements, between three and five of the 14 wells are likely connected to surface water. This can occur if wells are too shallow or improperly constructed.
   - *Recommendation: For wells with likely surface connections, owners should consider their options, including finding and fixing any problems with the existing well; drilling new, deeper wells; or connecting to public water should it become available. Before choosing the most appropriate option, careful consideration should be given to the current and planned expansion of the Whitetail mine.*

7. **Well GW06 contains water consistent with AMD.** The high iron, aluminum, and manganese, and low pH suggest that water in Well GW06 may be AMD.
   - *Recommendation: Further monitoring is recommended to confirm pollution levels in Well GW06, both before and after treatment inside of the home. Further investigation is also recommended to understand and correct the source of this contamination. Additions of Clorox and caustic by the well owners must be part of this research. Research and monitoring of the artesian well that reportedly drains to a stream close to GW06 should be part of this investigation, as should possible influences of the F&M and Whitetail mines.*

8. **Well GW06 is the only well that detected coliform bacteria.** At all other wells, total coliforms were not detected.
   - *Recommendation: Further investigation is recommended to confirm, understand, and correct the source of this bacteria. Additions of Clorox and caustic by the well owners must be part of this research. The disinfection practices used by Whitetail technicians—who periodically drop instruments into this well to measure static water levels—should be researched.*

9. **Well GW04 contains high iron and manganese.** While well GW04 contains the second-highest levels of iron and manganese, aluminum and sulfate concentrations are low and pH is neutral.

- *Recommendation: Further monitoring is advised to confirm the iron and manganese levels at Well GW04, and to consider options for correcting these problems. Unfiltered samples should be included in the analysis.*

10. **TPH-DRO and ethylene glycol are found, but without a discernable pattern.** TPH-DRO and ethylene glycol are consistent with contaminants that might be introduced from a junkyard.
    - *Recommendation: Where TPH-DRO was found, additional monitoring of specific diesel constituents including MTBE should be considered, and monitoring results should be compared against drinking water standards for these parameters. Follow-up monitoring of ethylene glycol may also be warranted. Monitoring sites should be chosen to help understand the potential for contamination from the junkyard. Remediation may be warranted.*

11. **Iron concentrations increase between the F&M discharges (Pond 8 and 35A) and the surface monitoring site 5025, indicating a possible iron source.** This increase in iron concentrations occurs as the stream passes the abandoned Ridenour portals.
    - *Recommendation: Monitoring of the Ridenour portals, as well as upstream and downstream of the portals, would be important to determine whether it is a significant source of contamination.*

12. **Iron also increases between surface monitoring sites 76/3 and 76/1, as the stream passes the junkyard.** This may be due to an iron source or to iron-containing sediment collected during high flow.
    - *Recommendation: Repeating these surface monitoring measurements would confirm whether or not a true iron source were located between these sampling points*

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APPENDIX A: FULL MONITORING RESULTS

This appendix presents all monitoring, together with MDLs for each parameter. In addition, results are compared with a number of thresholds to determine whether the measured levels are harmful. These thresholds are taken from USEPA (2006).

Table 6: Thresholds for comparison with monitored concentrations

Footnote in the following tables	Threshold
a	Above Secondary Drinking Water Regulation
b	Above MCLG
c	Above MCL
d	Above One-day Health Advisory for a 10-kg Child
e	Above Ten-day Health Advisory for a 10-kg Child
f	Above Drinking Water Equivalent Level Health Advisory
g	Above Life-Time Health Advisory
h	Above Concentration for 10^{-4} Cancer Risk
i	Above Health-based Drinking Water Advisory
j	Above Taste Threshold Drinking Water Advisory

Note: Thresholds are from USEPA (2006).

Table 7: Drinking water and groundwater standards for measured parameters

Parameter	Unit	Groundwater standard	MCLG	MCL	Secondary standard
Aluminum	mg/L	None	None	None	0.05
Antimony	mg/L	0.006	0.006	0.006	None
Arsenic	mg/L	0.01	0	0.01	None
Benzene	mg/L	0.005	0	0.005	None
Beryllium	mg/L	0.004	0.004	0.004	None
Cadmium	mg/L	0.005	0.005	0.005	None
Ethylbenzene	mg/L	0.7	0.7	0.7	None
Ethylene glycol	N/A	None	None	None	None
Alpha particles	pCi/L	15	0	15	None
Beta particles	mpy	4	0	4	None
HPC	cfu/mL	None	None	See note	None
Iron	mg/L	None	None	None	0.3
Lead	mg/L	0.015	0	0.015	None
Manganese	mg/L	None	None	None	0.05
Mercury (inorganic)	mg/L	0.002	0.002	0.002	None
MTBE	N/A	None	None	None	None
Nitrate (measured as N)	mg/L	10	10	10	None
pH (lower limit)	SU	None	None	None	6.5
pH (upper limit)	SU	None	None	None	8.5
Selenium	mg/L	0.05	0.05	0.05	None
Silver	mg/L	None	None	None	0.1
Strontium	N/A	None	None	None	None
Sulfate	mg/L	None	None	None	250
Thallium	mg/L	0.002	0.0005	0.002	None
Toluene	mg/L	1	1	1	None
Total coliforms	cfu/100 mL	None	0	See note	None
TPH-DRO	N/A	None	None	None	None
TPH-GRO	N/A	None	None	None	None
Xylenes (total)	mg/L	10	10	10	None

Note: MCLGs, MCLs, and secondary standards are from USEPA (2006). Groundwater standards are from 46 CSR 12. For HPC, USEPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to have no more than 500 cfu/mL. For total coliform, USEPA requires that no more than 5% of samples be total coliform-positive in a month.

Sludge trucks in late 2007

Table 8: Concentrations (mg/L) of trace elements in pressure filtrates of Omega sludge

Element	MDL	11/6/2007	11/13/2007	11/16/2007	11/30/2007
Antimony	0.005	<MDL	0.005	<MDL	0.0015
Arsenic	0.001	<MDL	<MDL	<MDL	<MDL
Beryllium	0.0005	<MDL	<MDL	<MDL	<MDL
Cadmium	0.0005	0.0046	0.0017	0.0016	0.0017
Lead	0.001	<MDL	<MDL	0.002[b]	0.001[b]
Mercury	0.0002	0.0003	0.0004	<MDL	<MDL
Selenium	0.0006	0.008	<MDL	<MDL	<MDL
Silver	0.0002	<MDL	<MDL	<MDL	<MDL
Thallium	0.001	<MDL	<MDL	<MDL	<MDL

Note: Pressure filtrates of Omega sludge were not analyzed on 10/23/07.

Table 9: Inorganic constituents and other characteristics of Omega sludge and pressure filtrates

Measurement	11/6/2007	11/13/2007	11/16/2007	11/30/2007
pH of sludge, in field (SU)	5.96[a]	8.01	7.95	8.05
pH of filtrate, in lab (SU)	8.07	7.94	7.95	8.02
Percent solids, by filtration	10.0	26.2	24.9	25.2
Percent solids, by drying	1.3	3.6	4.0	4.6
Specific conductance (µS/cm)	4,330	1,000	NM	425

Note: Pressure filtrates of Omega sludge were not analyzed on 10/23/07.

F&M surface water in late 2007

Table 10: Concentrations (mg/L) of trace elements in surface water sampled on the F&M site

Element	Location	10/23/2007	11/6/2007	11/13/2007	11/16/2007	11/30/2007
Antimony	Twin Pipes	<MDL	<MDL	<MDL	<MDL	<MDL
	Pond 8 Outfall	<MDL	<MDL	<MDL	<MDL	<MDL
	35 A Discharge	<MDL	<MDL	<MDL	<MDL	<MDL
Arsenic	Twin Pipes	0.009[bh]	0.004[bh]	0.006[bh]	0.423[bcfh]	0.006[bh]
	Pond 8 Outfall	<MDL	<MDL	<MDL	<MDL	<MDL
	35 A Discharge	<MDL	<MDL	<MDL	<MDL	<MDL
Beryllium	Twin Pipes	0.026[bc]	0.061[bc]	0.048[bc]	0.023[bc]	<MDL
	Pond 8 Outfall	0.016[bc]	<MDL	0.0043[bc]	<MDL	<MDL
	35 A Discharge	0.004	0.0008	0.0006	<MDL	<MDL
Cadmium	Twin Pipes	0.0093[bcg]	0.009[bcg]	0.0096[bcg]	0.0089[bcg]	0.0054[bcg]
	Pond 8 Outfall	0.0007	<MDL	<MDL	<MDL	<MDL
	35 A Discharge	0.0005	0.0005	<MDL	<MDL	<MDL
Lead	Twin Pipes	<MDL	<MDL	0.002[b]	<MDL	0.003[b]
	Pond 8 Outfall	<MDL	<MDL	0.001[b]	<MDL	<MDL
	35 A Discharge	<MDL	<MDL	<MDL	<MDL	<MDL
Mercury	Twin Pipes	<MDL	0.0005	<MDL	<MDL	<MDL
	Pond 8 Outfall	<MDL	0.0005	<MDL	<MDL	<MDL
	35 A Discharge	<MDL	0.0005	<MDL	<MDL	<MDL
Selenium	Twin Pipes	0.0093	0.0089	0.0063	0.0059	<MDL
	Pond 8 Outfall	0.0011	0.0007	0.006	<MDL	<MDL
	35 A Discharge	0.0014	<MDL	<MDL	<MDL	<MDL
Silver	Twin Pipes	<MDL	<MDL	<MDL	<MDL	<MDL
	Pond 8 Outfall	<MDL	<MDL	<MDL	<MDL	<MDL
	35 A Discharge	<MDL	<MDL	<MDL	<MDL	<MDL
Thallium	Twin Pipes	0.001[b]	0.002[b]	0.002[b]	0.001[b]	0.004[bcf]
	Pond 8 Outfall	0.001[b]	<MDL	<MDL	<MDL	0.001[b]
	35 A Discharge	0.002[b]	<MDL	<MDL	<MDL	0.001[b]

Note: MDLs are noted in Table 8.

Table 11: Inorganic constituents and other characteristics in surface water sampled on the F&M site

Measurement	Location	10/23/2007	11/6/2007	11/13/2007	11/16/2007	11/30/2007
Flow (gallons per minute)	Twin Pipes	21.4	24.5	23.9	137.3	76.2
	Pond 8 Outfall	0.7	3.2	4.9	167.1	37.4
	35A Discharge	0.1	9.1	57.1	138.1	78.3
Temperature (°C)	Twin Pipes	11.2	11.3	11.9	NM	10.9
	Pond 8 Outfall	17.4	6.6	11.3	5.9	5
	35A Discharge	18.7	7	13.6	4.5	5.6
pH, in field (SU)	Twin Pipes	3.15[a]	4.91[a]	3.38[a]	2.95[a]	3.22[a]
	Pond 8 Outfall	NM	NM	8.16	8.46	8.83[a]
	35A Discharge	NM	NM	7.15	6.06	8.03
Specific conductance, in field (µS/cm)	Twin Pipes	2,800	2,720	1,366	2,520	2,390
	Pond 8 Outfall	2,900	2,400	NM	967	1,472
	35A Discharge	2,160	1,822	NM	1,246	1,417

Drinking water wells in March 2008

Table 12: Concentrations (mg/L) of acid mine drainage metals measured in drinking water wells during March 5, 2008 sampling

Well	Aluminum	Iron	Manganese
MDL	0.009	0.005	0.007
GW01	<MDL	<MDL	<MDL
GW03	<MDL	0.2	0.07[a]
GW04	<MDL	2.15[a]	0.11[a]
GW05	<MDL	0.44[a]	0.05
GW06	1.48[a]	34.8[a]	0.13[a]
GW07	<MDL	0.61[a]	<MDL
GW08	0.18[a]	0.43[a]	<MDL
GW09	<MDL	0.32[a]	<MDL
GW10	<MDL	0.06	0.09[a]
GW11	<MDL	<MDL	<MDL
GW12	<MDL	0.37[a]	<MDL
GW13	0.23[a]	0.21	0.09[a]
GW14	0.14[a]	0.38[a]	<MDL

Table 13: Concentrations (mg/L) of trace elements in drinking water wells during March 5, 2008 sampling

Well	Arsenic	Beryllium	Cadmium	Lead	Thallium	Strontium
MDL	0.001	0.001	0.0002	0.001	0.0005	0.01
GW01	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
GW03	<MDL	<MDL	<MDL	<MDL	<MDL	0.21
GW04	<MDL	<MDL	<MDL	<MDL	<MDL	0.15
GW05	<MDL	<MDL	<MDL	<MDL	<MDL	0.25
GW06	<MDL	<MDL	<MDL	<MDL	<MDL	0.19
GW07	<MDL	<MDL	<MDL	<MDL	<MDL	0.23
GW08	<MDL	<MDL	<MDL	<MDL	<MDL	0.06
GW09	<MDL	<MDL	<MDL	<MDL	<MDL	0.13
GW10	<MDL	<MDL	<MDL	<MDL	<MDL	0.18
GW11	<MDL	<MDL	<MDL	<MDL	<MDL	0.17
GW12	<MDL	<MDL	<MDL	<MDL	<MDL	0.23
GW13	<MDL	<MDL	<MDL	<MDL	<MDL	0.08
GW14	<MDL	<MDL	<MDL	<MDL	<MDL	0.13

Table 14: Microorganism counts in drinking water wells during March 5, 2008 sampling

Well	Total coliforms (cfu/100 mL)	HPC (cfu/mL)
MDL	See note	See note
GW01	<MDL	69
GW03	<MDL	<MDL
GW04	<MDL	9
GW05	<MDL	<MDL
GW06	11[b]	11
GW07	<MDL	10
GW08	<MDL	300
GW09	<MDL	3
GW10	<MDL	<MDL
GW11	<MDL	<MDL
GW12	<MDL	5
GW13	<MDL	270
GW14	<MDL	270

Note: MDLs are not listed in the MDL column of the data sheets, but values are reported as “<1.1” for total coliforms and “<1 est” for HPC.

Table 15: Concentrations (mg/L) of organic chemicals detected in drinking water wells during March 5, 2008 sampling

Well	TPH-GRO	Benzene	Toluene	Ethylbenzene	Xylene	MTBE	TPH-DRO	Ethylene glycol
MDL	0.12	0.0007	0.002	0.0014	0.003	0.003	0.2	1
GW01	NM	NM	NM	NM	NM	NM	NM	NM
GW03	NM	NM	NM	NM	NM	NM	NM	NM
GW04	NM	NM	NM	NM	NM	NM	NM	NM
GW05	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	1.02	2
GW06	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	1.19	<MDL
GW07	NM	NM	NM	NM	NM	NM	NM	NM
GW08	NM	NM	NM	NM	NM	NM	NM	NM
GW09	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.55	<MDL
GW10	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	0.78	4
GW11	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	1.56	<MDL
GW12	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	1.27	1
GW13	NM	NM	NM	NM	NM	NM	NM	NM
GW14	NM	NM	NM	NM	NM	NM	NM	NM

Table 16: Radioactivity measurements (pCi/L) in drinking water wells during March 5, 2008 sampling

Well	Gross alpha radiation	Gross beta radiation
MDL	0.6	0.6-1.4
GW01	0.6[b]	10.2[b]
GW03	<MDL	2.5[b]
GW04	1.2[b]	2.4[b]
GW05	NM	NM
GW06	NM	NM
GW07	NM	NM
GW08	NM	NM
GW09	NM	NM
GW10	NM	NM
GW11	NM	NM
GW12	NM	NM
GW13	NM	NM
GW14	NM	NM

Note: Radiation MDLs are different for different wells.

Table 17: Inorganic constituents and other characteristics of drinking water wells during March 5, 2008 sampling

		pH		Specific conductance							
Well	Temp. (°C)	Field (SU)	Lab (SU)	Field (μS/cm)	Lab (μS/cm)	Alkalinity (mg-CaCO$_3$/L)	Acidity (mg-CaCO$_3$/L)	Hard-ness (mg/L)	Nitrate (mg-N/L)	Sulfate (mg/L)	DO (mg/L)
MDL					0.14	2.81	4.58	0.31	0.028	0.05	
GW01	13.7	6.56	6.59	73	58	19	<MDL	30	0.5	9.6	11.1
GW03	12.22	7.68	7.68	270	258	100	<MDL	172	0.1	28.7	12.3
GW04	12.7	7.09	7.19	228	214	67	<MDL	140	<MDL	26.2	11.7
GW05	13.2	7.57	7.52	319	307	136	<MDL	172	0.2	15.3	11.1
GW06	12.2	3.29[a]	3.07[a]	1574	1534	<MDL	528	840	<MDL	592.0[aij]	0.2
GW07	11.1	7.55	7.76	228	252	119	<MDL	112	0.2	1.2	6.5
GW08	12.2	7.32	7.27	193	182	53	<MDL	92	2.9	17.0	12.1
GW09	13.2	7.97	7.9	243	239	115	<MDL	100	<MDL	2.3	11.7
GW10	13.4	8.37	8.29	324	310	155	<MDL	96	0.1	0.4	5.2
GW11	13.2	8.03	8.04	279	273	132	<MDL	56	0.1	0.7	12.4
GW12	13	7.17	7.5	263	258	115	<MDL	150	0.5	5.9	6.5
GW13	12.9	6.4[a]	6.51	229	214	58	<MDL	108	7.5	39.3	7.7
GW14	13.1	6.95	7.35	295	278	103	<MDL	172	1.0	13.4	10.3

F&M and downstream surface water in March 2008

Table 18: Concentrations (mg/L) of acid mine drainage metals in surface water during March 5, 2008 sampling

Surface water site	Aluminum	Iron	Manganese
MDL	0.009	0.005	0.007
LFSC5025	0.50[a]	0.16	1.2[a]
TWNPIPES	39.4[a]	10.6[a]	31.1[a]
POND8OUT	0.86[a]	0.19	5.4[a]
35ADISCH	0.78[a]	0.13	4.6[a]
UTCR5025	0.68[a]	0.26	1.1[a]
UTSTVBRG	0.60[a]	0.09	0.5[a]
UTCR7603	0.25[a]	0.08	0.1[a]
LFSCB763	0.32[a]	0.13	0.3[a]
LFSCA761	0.32[a]	0.24	0.3[a]

Note: While these measurements are compared with the thresholds in Table 7, this is not meant to imply that these thresholds apply to surface waters.

Table 19: Concentrations (mg/L) of trace elements in surface water during March 5, 2008 sampling

Surface water site	Arsenic	Beryllium	Cadmium	Lead	Thallium	Strontium
MDL	0.001	0.001	0.0002	0.001	0.0005	0.01
LFSC5025	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
TWNPIPES	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
POND8OUT	<MDL	<MDL	<MDL	<MDL	<MDL	0.05
35ADISCH	<MDL	<MDL	<MDL	<MDL	<MDL	0.05
UTCR5025	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
UTSTVBRG	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
UTCR7603	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
LFSCB763	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL
LFSCA761	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL

Note: While these measurements are compared with the thresholds in Table 7, this is not meant to imply that these thresholds apply to surface waters.

Table 20: Microorganism counts in surface water during March 5, 2008 sampling

Surface water site	Total coliforms (cfu/100 mL)	HPC (cfu/mL)
MDL	See note	See note
LFSC5025	<MDL	180
TWNPIPES	NM	NM
POND8OUT	NM	NM
35ADISCH	NM	NM
UTCR5025	<MDL	260
UTSTVBRG	23[b]	140
UTCR7603	4[b]	220
LFSCB763	<MDL	210
LFSCA761	80[b]	290

Note: While these measurements are compared with the thresholds in Table 7, this is not meant to imply that these thresholds apply to surface waters. MDLs are not listed in the MDL column of the data sheets, but values are reported as “<2” for total coliforms.

Table 21: Concentrations (mg/L) of organic chemicals measured in surface water during March 5, 2008 sampling

Surface water site	TPH-GRO	Benzene	Toluene	Ethyl-benzene	Xylene	MTBE	TPH-DRO	Ethylene glycol
MDL	0.12	0.0007	0.002	0.0014	0.003	0.003	0.2	1
LFSC5025	NM	NM	NM	NM	NM	NM	NM	NM
TWNPIPES	NM	NM	NM	NM	NM	NM	NM	NM
POND8OUT	NM	NM	NM	NM	NM	NM	NM	NM
35ADISCH	NM	NM	NM	NM	NM	NM	NM	NM
UTCR5025	NM	NM	NM	NM	NM	NM	NM	NM
UTSTVBRG	NM	NM	NM	NM	NM	NM	NM	NM
UTCR7603	NM	NM	NM	NM	NM	NM	NM	NM
LFSCB763	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	1.48	<MDL
LFSCA761	<MDL	<MDL	<MDL	<MDL	<MDL	<MDL	2.28	<MDL

Note: While these measurements are compared with the thresholds in Table 7, this is not meant to imply that these thresholds apply to surface waters.

Table 22: Radioactivity measurements (pCi/L) in surface water during March 5, 2008 sampling

Surface water site	Gross alpha radiation	Gross beta radiation
MDL	0.5-2.1	1.4-1.5
LFSC5025	NM	NM
TWNPIPES	15.1[bc]	8.0[b]
POND8OUT	NM	NM
35ADISCH	NM	NM
UTCR5025	NM	NM
UTSTVBRG	NM	NM
UTCR7603	NM	NM
LFSCB763	0.6[b]	<MDL
LFSCA761	NM	NM

Note: While these measurements are compared with the thresholds in Table 7, this is not meant to imply that these thresholds apply to surface waters.

Table 23: Field and general chemical measurements in surface water during March 5, 2008 sampling

Surface water site	Temp. (°C)	pH		Specific conductance		Alkalinity (mg-$CaCO_3$/L)	Acidity (mg-$CaCO_3$/L)	Hard-ness (mg/L)	Nitrate (mg-N/L)	Sulfate (mg/L)
		Field (SU)	Lab (SU)	Field (µS/cm)	Lab (µS/cm)					
MDL					0.14	2.81	4.58	0.31	0.028	0.05
LFSC5025	6.1	7.02	6.92	231	213	12	6	80	1.0	73.7
TWNPIPES	10.8	3.00[a]	3.02[a]	1,624	1,568	<MDL	359	800	1.6	833[aij]
POND8OUT	7.3	8.62[a]	7.96	801	748	24	15	430	2.6	327[aj]
35ADISCH	5.6	7.80	7.48	781	735	19	7	176	0.4	327[aj]
UTCR5025	5.7	8.54[a]	7.93	220	203	14	11	60	1.3	74.2
UTSTVBRG	5.5	5.71[a]	5.39[a]	80	72	4	12	40	0.6	18.3
UTCR7603	6.1	5.63[a]	5.19[a]	24	27	4	10	26	0.4	7.2
LFSCB763	5.9	6.58	5.99[a]	91	75	6	12	36	0.5	21.9
LFSCA761	5.9	6.46[a]	6.35[a]	84	81	7	11	56	0.7	31.4

Note: While these measurements are compared with the thresholds in Table 7, this is not meant to imply that these thresholds apply to surface waters.

APPENDIX B: FULL WELL SURVEY RESULTS

Interviews with well owners in the LFSC watershed were conducted on December 10, 2007, prior to collecting well data in March 2008. Owners of Well GW06 were interviewed again on May 16, 2008, on the same day that additional water samples were collected.

Table 24: Resident information

Well	No. in household	Years in residence
GW01	2	59
GW02	2	22
GW03	3	30
GW04	1	30
GW05	2	32
GW06	2	43
GW07	2	30
GW08	2	67
GW09	1	56
GW10	3	26
GW11	2	37

Note: Information is reported by well owners.

Table 25: Well data

Well	Well elevation (ft)	Well depth (feet below ground surface)	Static well level (feet below ground surface)	Cement or grout	Casing depth (feet)	Drill date	Diameter (Inches)	Casing type
GW01	1798	105	Unknown	Cemented	Unknown	1998	Unknown	Unknown
GW02	1641	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
GW03	1584	100	Unknown	Cemented	Unknown	1975	6	PVC
GW04	1452	20	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
GW05	1453	120	20	Cemented	40	Unknown	6	Steel
GW06	1409	50	23	Cemented	19	Unknown	6	Plastic
GW07	1371	32	4	Unknown	20	Unknown	8	Metal
GW08	1416	180	58	Grouted	Unknown	Unknown	6	PVC
GW09	1356	160	6	Cemented	Unknown	Unknown	6	PVC
GW10	1348	100	10	Cemented	40	Unknown	6	Unknown
GW11	1336	46	2	Cemented	20	1990	6	Steel

Note: Information is reported by well owners, except well elevations, which are from topopgraphical maps.

Table 26: Water information

Well	Water appearance	Water taste	Water smell
GW01	Clean	Normal	Neutral
GW02	Clear, no issues	Iron	Neutral
GW03	Particles all the time, leaves iron discoloration on sink and toilet.	Tastes fair	No odor
GW04	Faint yellow	Iron/acidic	Rotten eggs
GW05	Clear	Good	Normal
GW06	With treatment the water is fine. Before treatment, water has iron/AMD appearance.	Fair	
GW07	Slight yellow color	Iron	Iron
GW08	Has been turning black lately	Rotten taste	Rotten eggs
GW09	Unknown	Sulfur/rotten	Sulfur/rotten
GW10	Normal	Not a bad taste, stains tub	Sometimes has rotten smell
GW11	Yellowish	Iron	Sulfur/rotten eggs

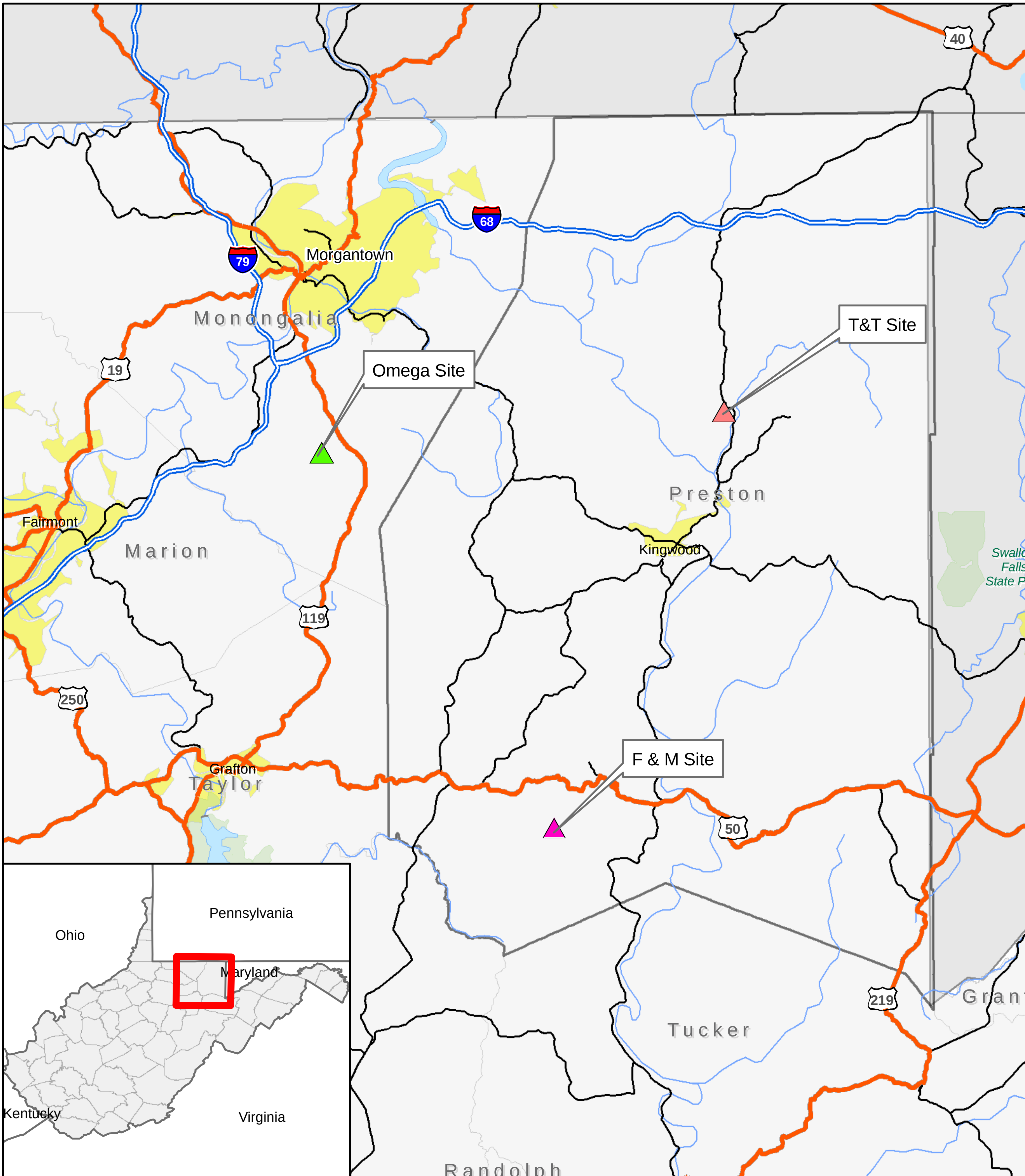
Note: Information is reported by well owners.

Table 27: Well and land use changes

Well	Well changes?	When did changes occur?	What are the changes?	When do changes occur?	Land use changes?	What are the changes?
GW01	TRUE	Every summer	Low flow and bad smell	Unknown	FALSE	
GW02	TRUE	Summer 2007	Bad smell, hard to bathe, turns toilet red, stains clothes	Summer. Stained clothes for years, though	TRUE	
GW03	FALSE	Unknown	Unknown	Unknown	TRUE	Logging past church, up west end of hollow
GW04	TRUE	Early 1990s	Color, taste, and smell	All the time	FALSE	
GW05	TRUE	3 years ago	Rotten smell	Summer time, when water is low	FALSE	
GW06	TRUE	Summer 2006	Smell, taste, and flow. Smell and taste went to iron/AMD, flow decreased substantially (water level dropped from 8 to 20 feet below ground surface)	All conditions	TRUE	Well dried up about a year ago. Son’s pond, located adjacent to this property, disappeared.
GW07	FALSE	Unknown	Unknown	Unknown	FALSE	
GW08	TRUE	1.5-2 years ago	Everything, was always really good, smell, color, taste	Mostly during summer months, not as bad during the winter or spring	FALSE	
GW09	TRUE	2 years ago	Color, smell, taste, all the above	Unknown	FALSE	
GW10	TRUE	Early 1990s	Smells and stains	If you don’t use it a lot or low flow, water quality decreases. With more rain, water quality improves.	TRUE	Timbering, going on for about 10 years.
GW11	TRUE	3-4 years ago	Yellowish color, sulfur smell	All the time	FALSE	

Note: Information is reported by well owners.

APPENDIX C: MAPS



Map 1 - Site Location Map
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

Downstream Strategies

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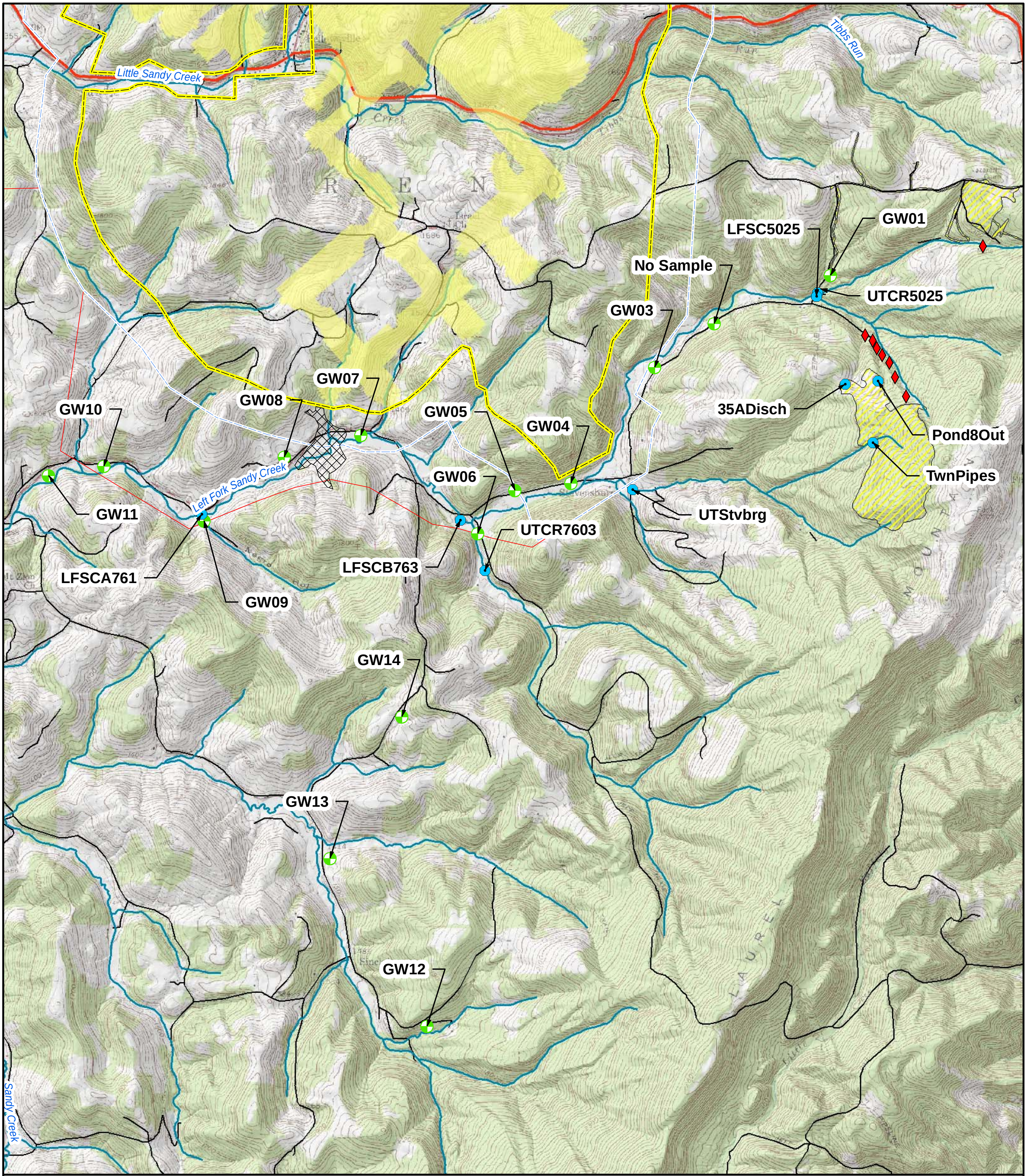


Legend

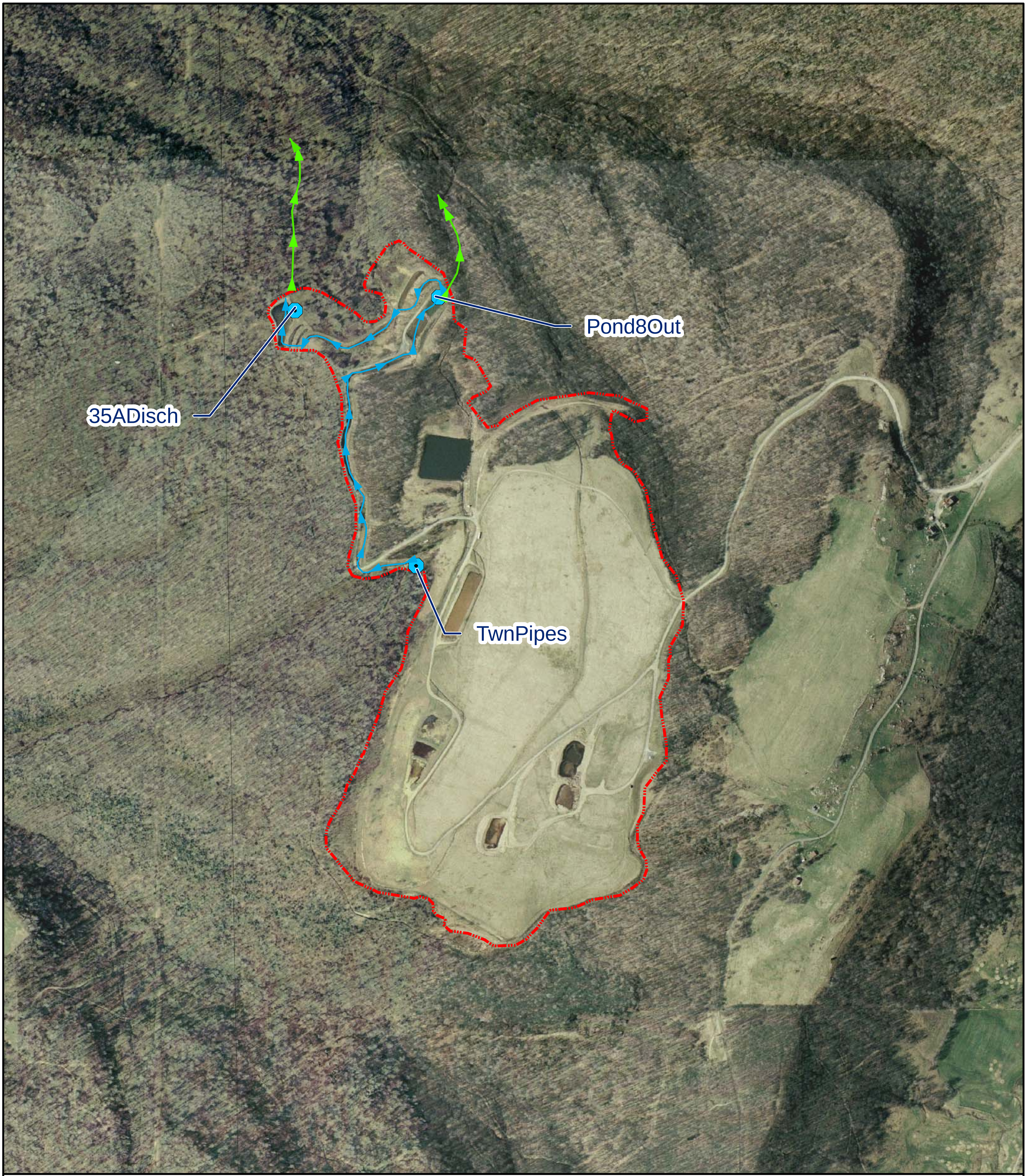
Surface Water Sample Location
Groundwater Sample Location
Ridenour Portal Locations
Streams
US 50
Local Roads
Approximate Junkyard Boundary
F&M Permit Boundary
Whitetail Mine 1000' Limits
Whitetail Deep Mine Boundary
Whitetail GW Inventory Limits
Whitetail Underground Mining

Map 2 - Sample Location Map
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

0 1,000 2,000 4,000 Feet

Downstream Strategies

\\CHEAT\DOWNSTREAM\PROJECTS\F_M_SITE\GIS\MAPFILES\REPORT_MAPS\FIGURE_2_SAMPLE_LOCATIONS.MXD FIGURE_2_SAMPLE_LOCATIONS.MXD 5/13/2008 16:17:22



Legend

Surface Water Sample Location

F&M Permit Boundary

Treatment Flow Path

Flow Path Off-site

Map 3 - F & M Sampling Locations
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

Downstream Strategies

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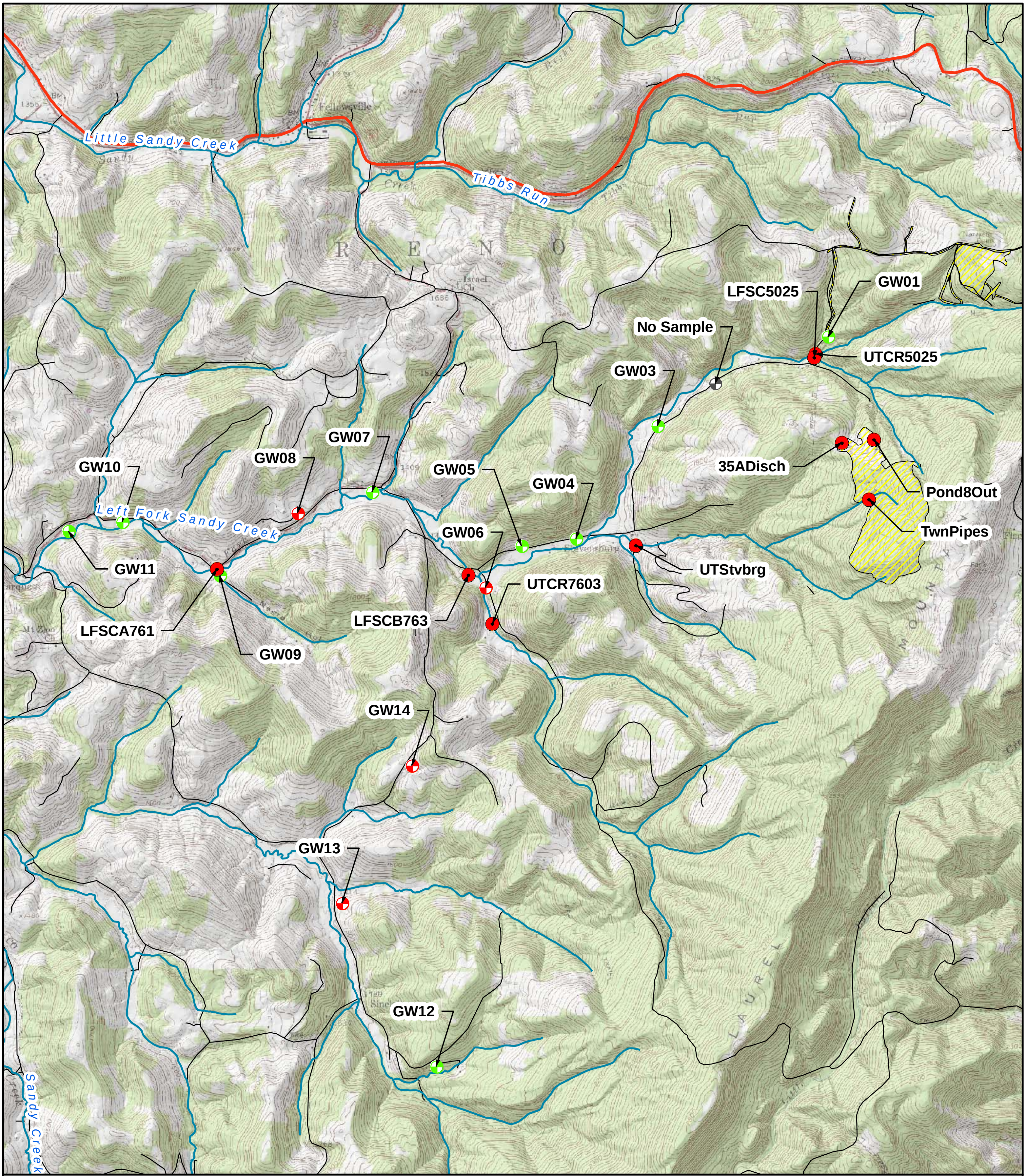


Legend

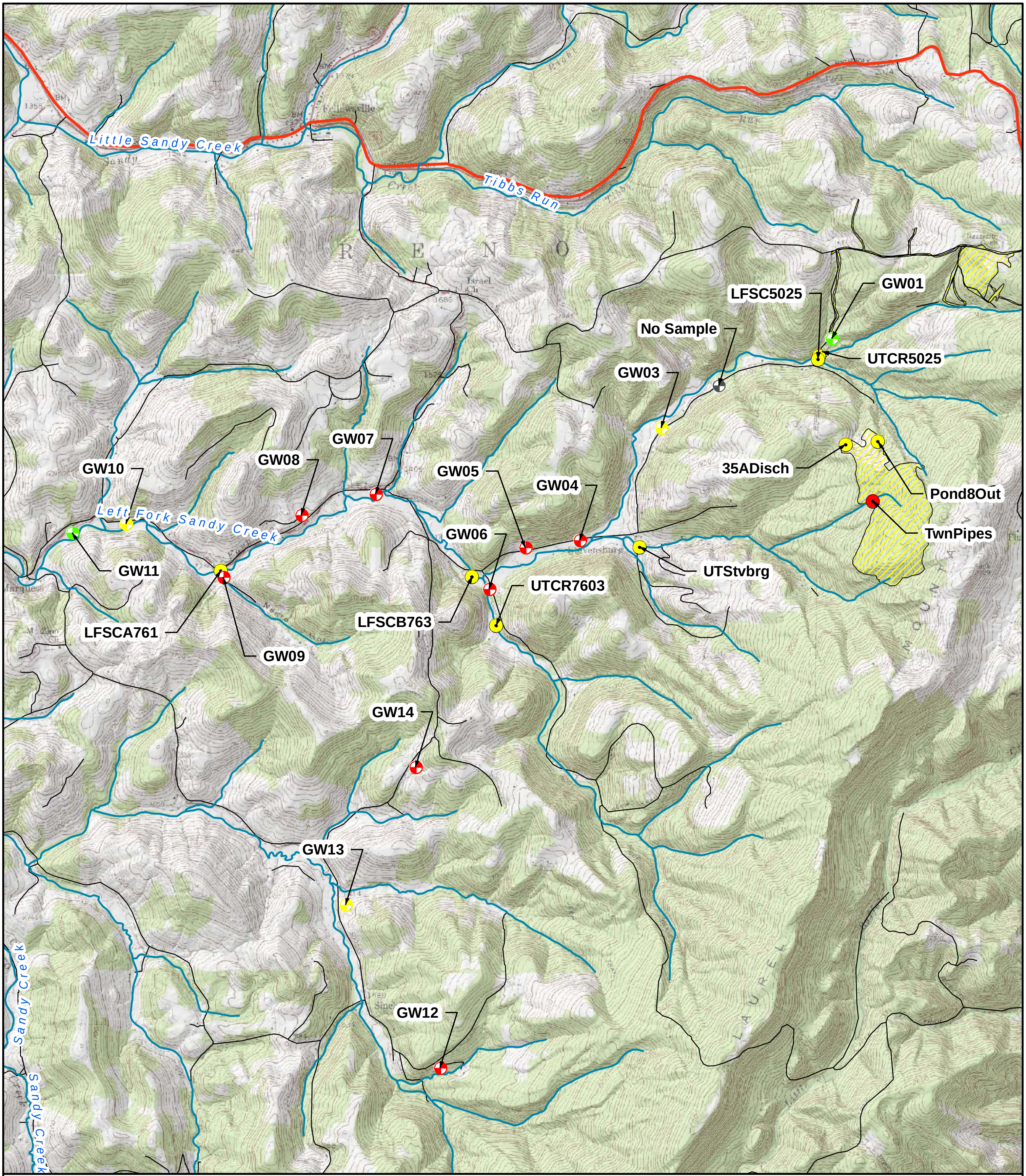
- Surface Water Above MDL* & Drinking Water Standard**
- Groundwater Above MDL* & Drinking Water Standard**
- Surface Water Above MDL*
- Groundwater Above MDL*
- Surface Water Below MDL*
- Groundwater Below MDL*
- Surface Water not Sampled
- Groundwater not Sampled
- F&M Permit Boundary

Map 4 - Aluminum Results
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

0 1,000 2,000 4,000 Feet

Downstream Strategies

*Lab Method Detection Level --- ** Refer to Appendix A for Drinking Water Standards



Legend

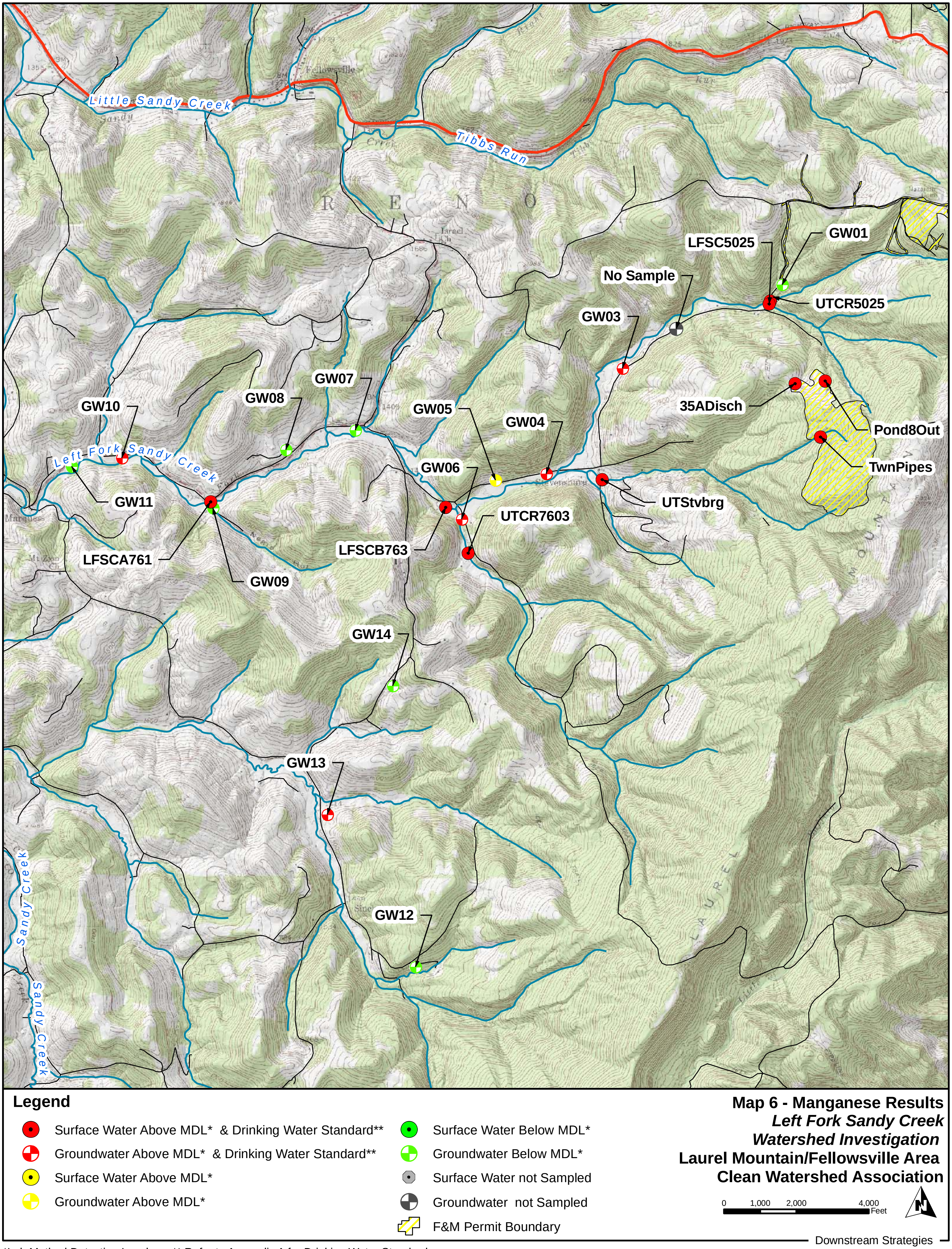
- Surface Water Above MDL* & Drinking Water Standard**
- Groundwater Above MDL* & Drinking Water Standard**
- Surface Water Above MDL*
- Groundwater Above MDL*
- Surface Water Below MDL*
- Groundwater Below MDL*
- Surface Water not Sampled
- Groundwater not Sampled
- F&M Permit Boundary

Map 5 - Iron Results
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

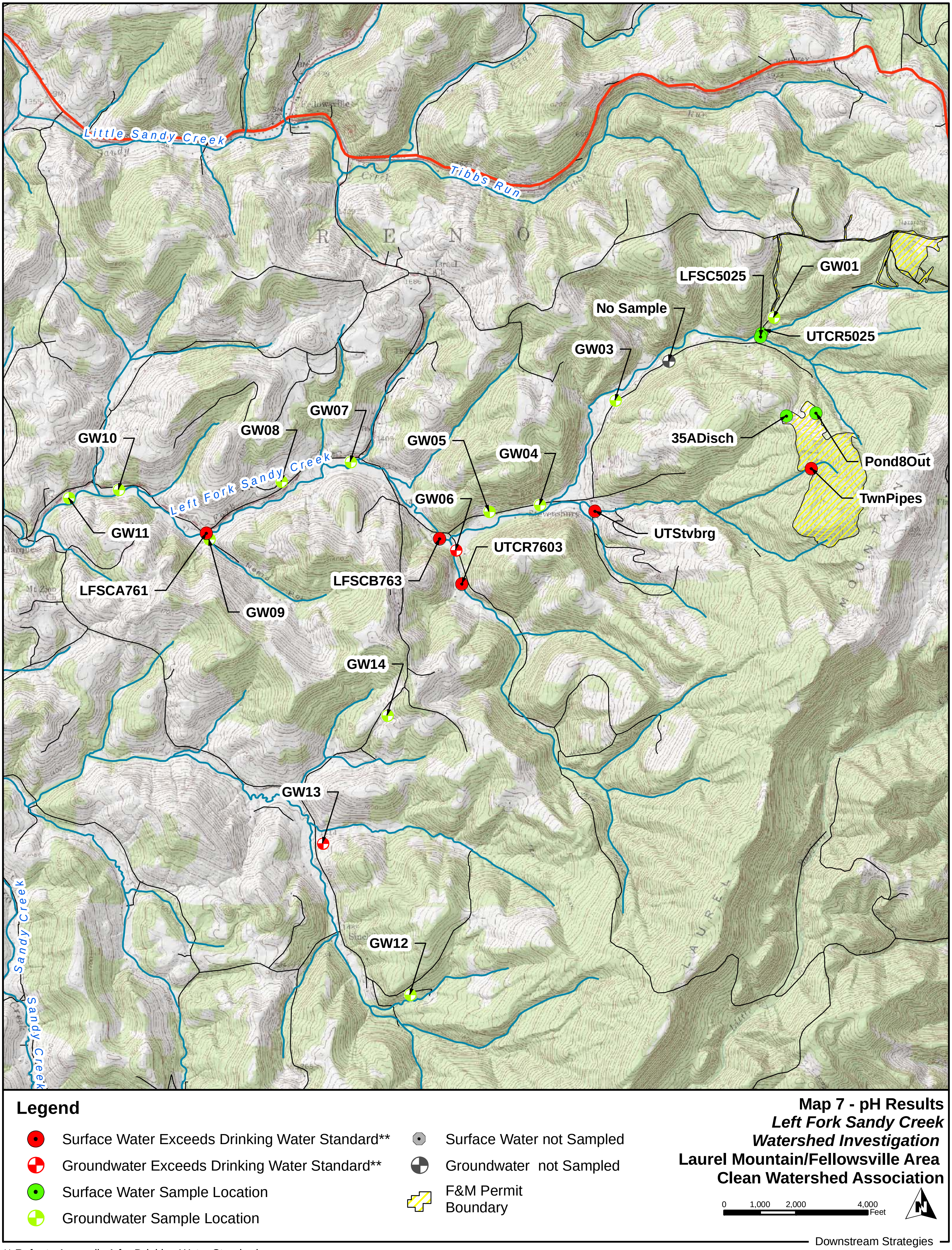
0 1,000 2,000 4,000 Feet

Downstream Strategies

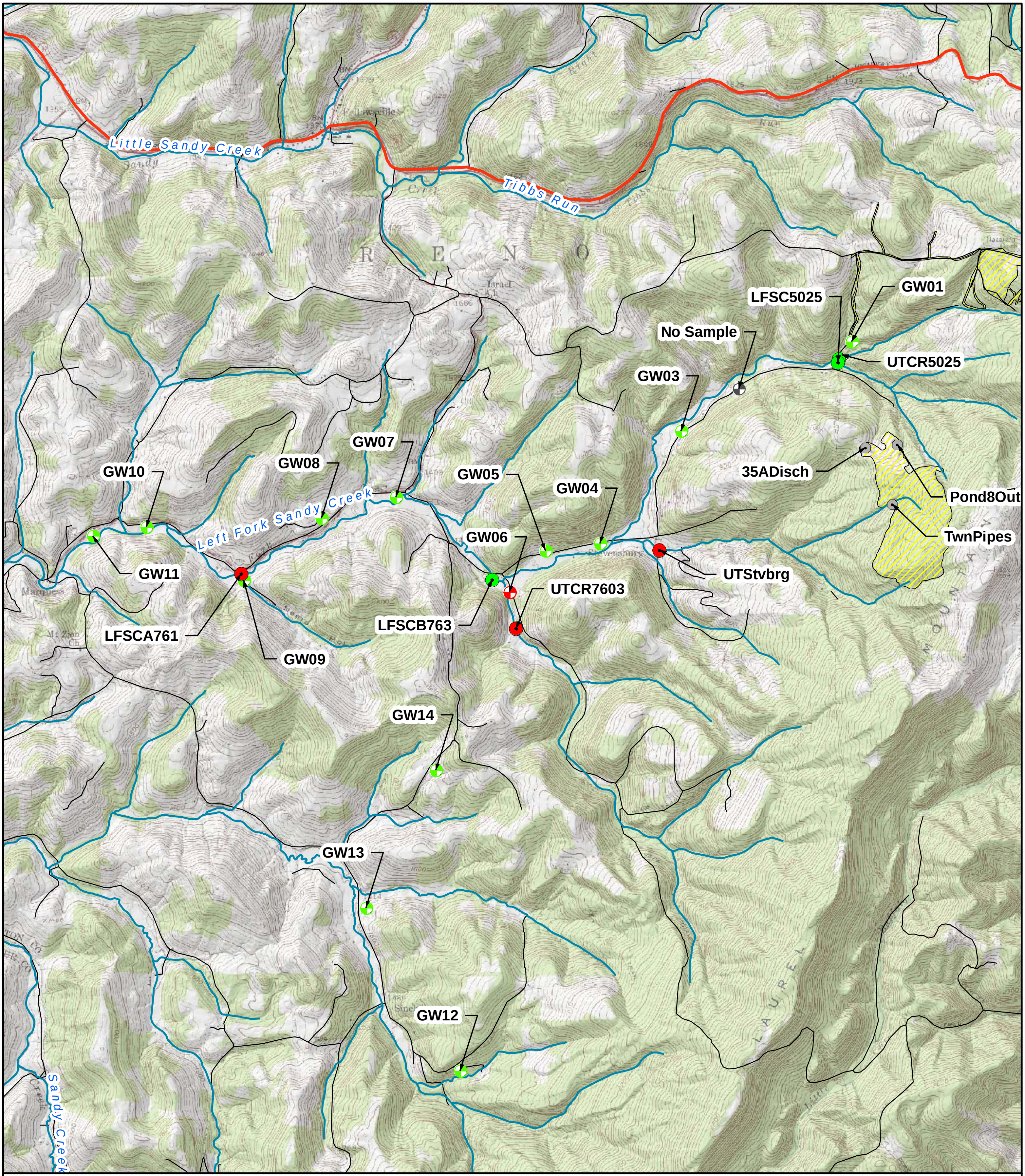
*Lab Method Detection Level --- ** Refer to Appendix A for Drinking Water Standards



*Lab Method Detection Level --- ** Refer to Appendix A for Drinking Water Standards



** Refer to Appendix A for Drinking Water Standards



Legend

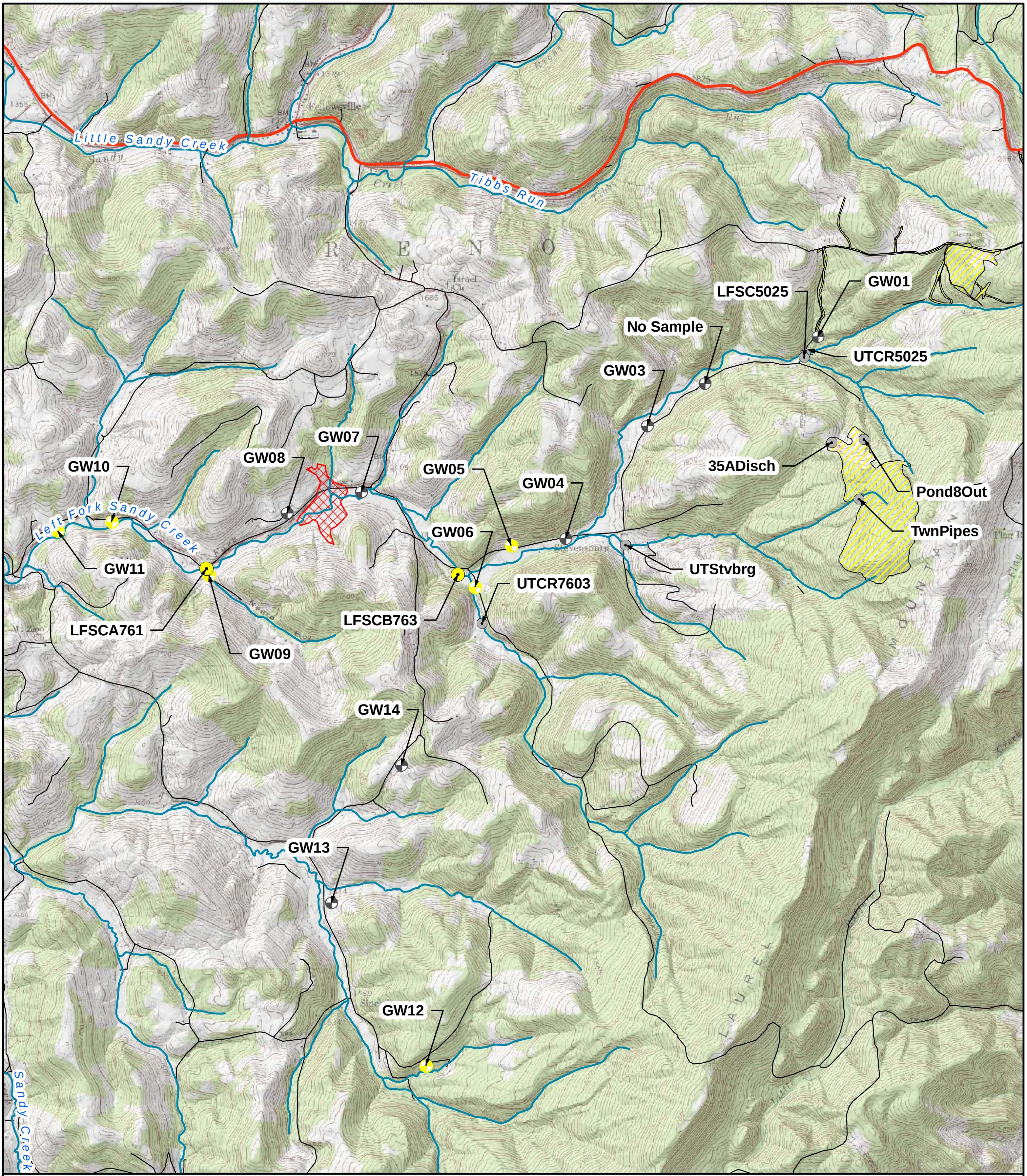
- Surface Water Above MDL* & Drinking Water Standard**
- Groundwater Above MDL* & Drinking Water Standard**
- Surface Water Above MDL*
- Groundwater Above MDL*
- Surface Water Below MDL*
- Groundwater Below MDL*
- Surface Water Not Sampled
- Groundwater Not Sampled
- F&M Permit Boundary

Map 8 - Total Coliforms Results
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

0 1,000 2,000 4,000 Feet

Downstream Strategies

*Lab Method Detection Level --- ** Refer to Appendix A for Drinking Water Standards



Legend

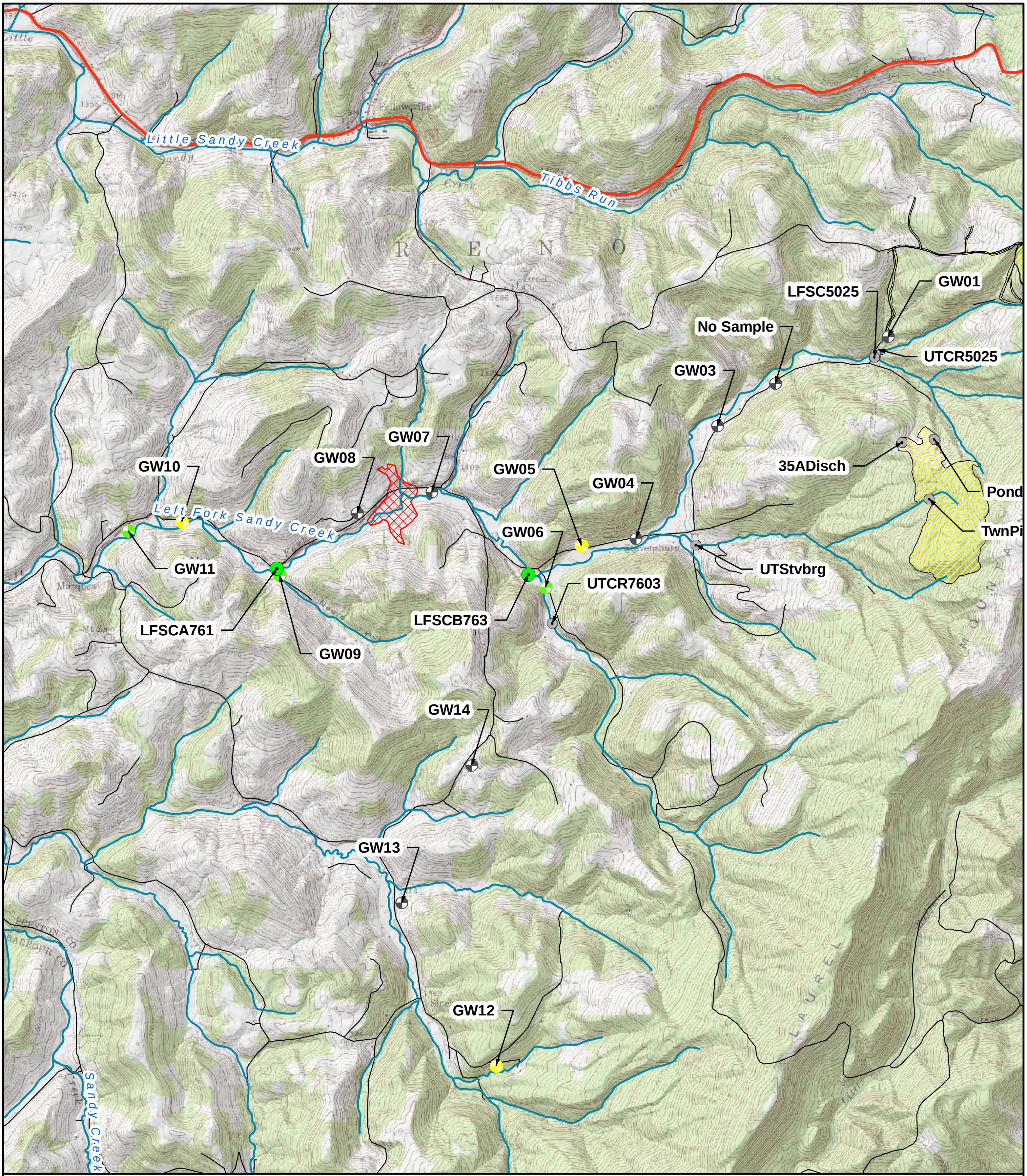
- Surface Water Above MDL*
- Groundwater Above MDL*
- Surface Water Below MDL*
- Groundwater Below MDL*
- Surface Water Not Sampled
- Groundwater Not Sampled
- Approximate Junkyard Extent
- F&M Permit Boundary

Map 9 - TPH- Diesel Range Organics Results
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

0 1,000 2,000 4,000 Feet

Downstream Strategies

*Lab Method Detection Level



Legend

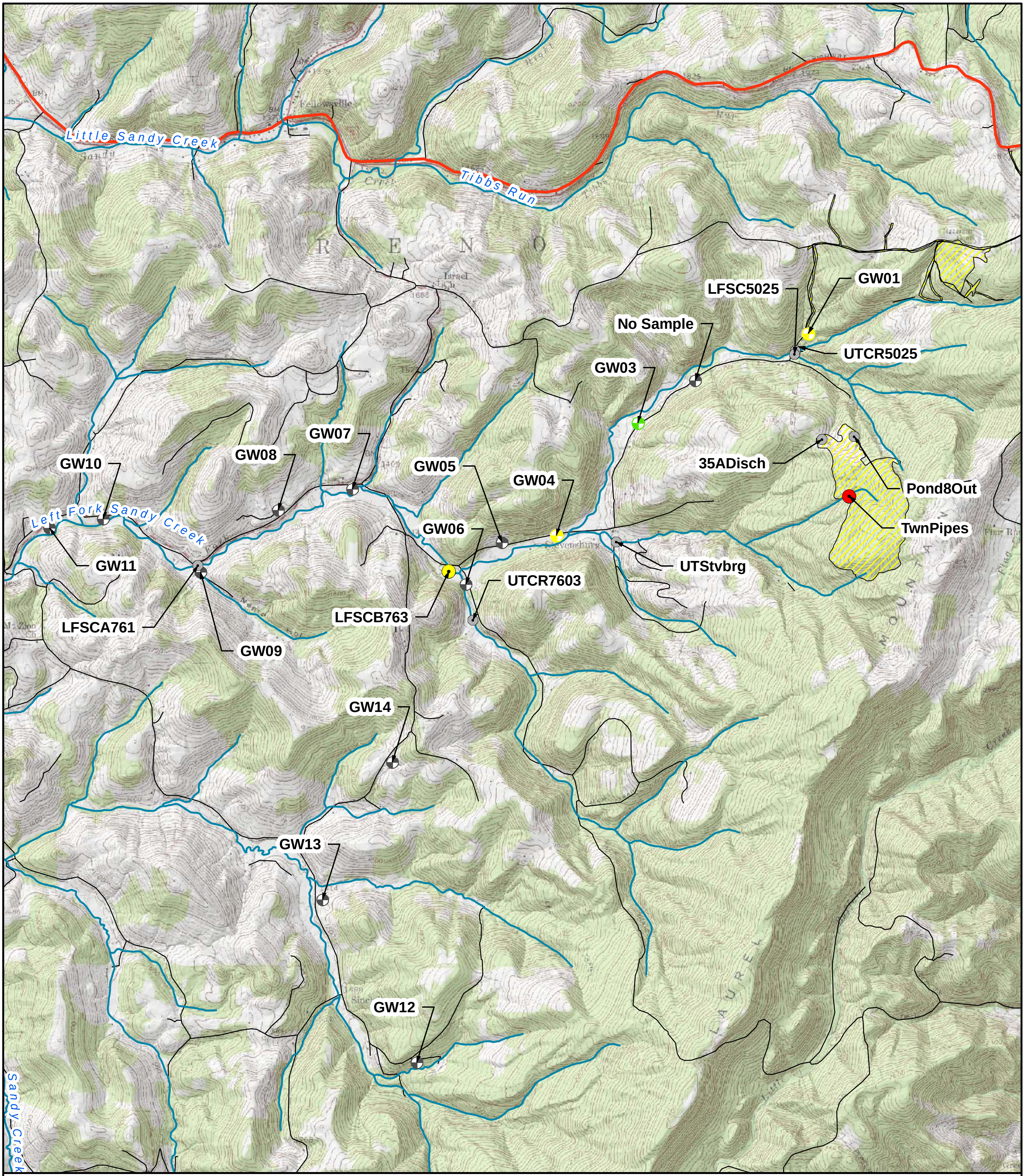
- Surface Water Above MDL*
- Groundwater Above MDL*
- Surface Water Below MDL*
- Groundwater Below MDL*
- Surface Water Not Sampled
- Groundwater Not Sampled
- Approximate Junkyard Extent
- F&M Permit Boundary

Map 10 - Ethylene Glycol Results
Left Fork Sandy Creek
Watershed Investigation
Laurel Mountain/Fellowsville Area
Clean Watershed Association

0 1,000 2,000 4,000 Feet

Downstream Strategies

*Lab Method Detection Level



Legend

- Surface Water Above MDL* & Drinking Water Standard**
- Groundwater Above MDL* & Drinking Water Standard**
- Surface Water Above MDL*
- Groundwater Above MDL*
- Surface Water Below MDL*
- Groundwater Below MDL*
- Surface Water Not Sampled
- Groundwater Not Sampled
- F&M Permit Boundary

Map 11 - Radiation (Alpha) Results

Left Fork Sandy Creek Watershed Investigation

Laurel Mountain/Fellowsville Area Clean Watershed Association

0 1,000 2,000 4,000 Feet

Downstream Strategies

*Lab Method Detection Level --- ** Refer to Appendix A for Drinking Water Standards