

PEACH CREEK – A NATURALLY ACIDIC DRAINAGE NEAR GIBBONS CREEK LIGNITE MINE, TEXAS¹

by

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Abstract

Peach Creek near Gibbons Creek lignite mine in east-central Texas offers an example of a drainage that is naturally acidic as opposed to drainages that may be acidic due to mining activities. The acidity in Peach Creek is caused by the oxidation of iron disulfide (pyrite) that is present in the undisturbed geological formations. The pyrite appears to be exposed to oxidizing conditions where groundwater flow intersects surface topography. This is usually along tributaries of Peach Creek which are more incised rather than in the main channel of Peach Creek which is less incised. The oxidation of the pyrite results in low pH values and relatively high salinity with elevated sulfate concentrations. In some tributaries the pH is low enough to maintain ferric iron in solution. But the pH is increased when these waters mix with the less acid water in the main channel. Where the pH change is large enough, a characteristic reddish-brown precipitate of iron oxyhydroxides appears in the stream-bed below the confluence. Although aluminum was not analyzed for, there are indications that aluminum oxyhydroxides are also precipitated due to pH changes. The acidity is most evident at times of low flow when it is not diluted by rainfall runoff.

Introduction

The purpose of this paper is to review the naturally occurring acidity of Peach Creek, an undisturbed drainage in the vicinity of Texas Municipal Power Agency's (TMPA) Gibbons Creek lignite mine in east-central Texas. In particular, this paper examines how the acidity varies with time and with location in the Peach Creek drainage system and why these effects may not be evident in the course of routine baseline monitoring.

As had been previously discussed (Horbaczewski, 2007), acid seeps and acid drainages occur naturally in the pre-mining condition in Texas lignite areas. These features were recognized by early settlers and have given rise to the numerous "Sulphur Creeks" and "Sulphur Springs" to be found on maps of these areas. The "sulphur" terminology probably arose from the hydrogen sulfide (H₂S) smell of "rotten eggs" associated with these formations. But the other related sulfide in the lignite-bearing strata is iron disulfide or pyrite (FeS₂), also known as "fools' gold". The significance of the iron disulfide is that it is decomposed by atmospheric oxygen to form sulfuric acid that when concentrated may adversely impact plant and animal life.

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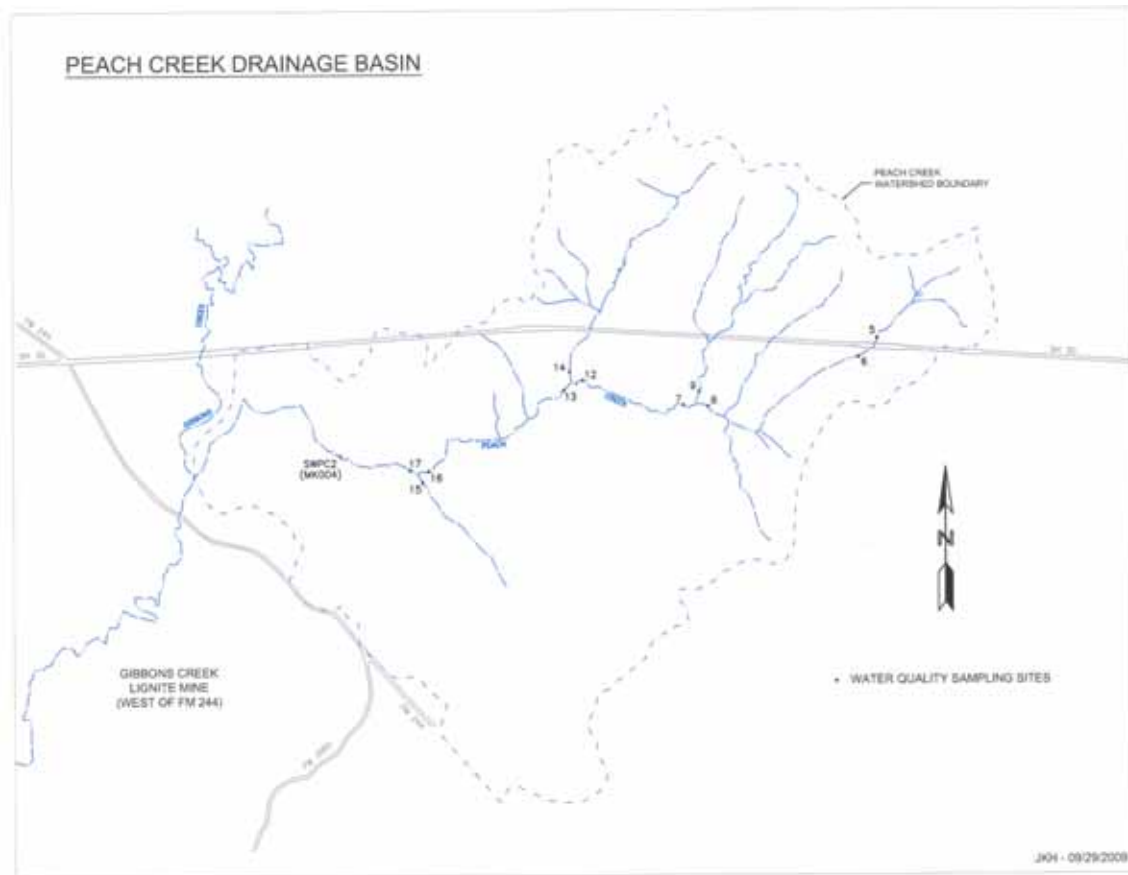
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It should be noted that both the hydrogen sulfide and the iron disulfide are natural constituents of the local lignite-bearing geological formations. They are products of the same highly anaerobic reducing conditions in which vegetation was prevented from decaying and gradually became converted to lignite approximately 35 million years ago in the late Eocene of the Tertiary period.

The Peach Creek Drainage Basin

Peach Creek is located in Grimes County, Texas, east of the reclaimed Gibbons Creek mine and flows into Gibbons Creek just east of Farm-to-Market Road (FM) 244 and south of State Highway (SH) 30 (Figure 1). The entire Peach Creek watershed is approximately 6.4 miles long and covers an area of 5,397 acres (just over 8 square miles). The streambed falls 201 feet from elevation 413 feet above mean sea level (msl) to 212 feet above msl – on average 32 feet per mile (Texas Municipal Power Agency, 1993a, Section .129 – Surface Water Information).

Figure 1 – Map of Peach Creek drainage basin



Peach Creek was studied intensively because mining activities were to move east across FM 244 into the Peach Creek drainage basin. But in 1996 TMPA switched from the relatively high-sulfur lignite of the Gibbons Creek mine to low-sulfur “compliance” coal from the Powder River Basin in Wyoming. The Gibbons Creek lignite mine was closed in February 1996 and the Peach Creek drainage was never disturbed by mining. Data from the baseline studies, however, remain and form the basis of this paper.

The surface water baseline studies were of two types:

- Surface water monitoring at downstream site SWPC2
- Special-purpose survey along the main channel and tributaries of Peach Creek.

Surface water monitoring at downstream site SWPC2 (MK004)

Surface water monitoring station SWPC2 (Figure 2), also known as MK004, is located on the downstream end of Peach Creek, approximately 1,200 yards from its discharge into Gibbons Creek. Approximately 2,954 acres (4.6 square miles) of the Peach Creek watershed are upstream of monitoring station SWPC2 (MK004).

Figure 2 – Surface water monitoring station SWPC2 on Peach Creek



Studies completed on the basis of data collected at this site include the following:

- Baseline characterization based on data collected between February 1989 and January 1990
- Statistical analysis of data collected between March 1985 and November 1992
- Time sequence of data collected between January 1990 and April 1994
- Baseline water data collected between July 1991 and September 1992

Baseline characterization based on data collected between February 1989 and January 1990

A baseline characterization based on monthly monitoring at site SWPC2 over the period February 20, 1989 to January 20, 1990 was prepared for TMPA by Blackwell & Woods, Consulting Engineers (Texas Municipal Power Agency, 1991). The report found pH readings in the range pH 4.7 – pH 6.2, Total Dissolved Solids (TDS) in the range 451 mgL^{-1} – $1,021 \text{ mgL}^{-1}$. Analyses of major cations and anions were

not included. The monitoring period was recorded as one of severe drought and therefore no flow data were collected even though the monitoring station was inspected on a weekly basis.

Statistical analysis of data collected between March 1985 and November 1992

A statistical analysis that included the chemistry of Peach Creek, based on sampling data from site SWPC2 over the period March 1985 to November 1992, was compiled by TMPA Staff in a report entitled “*Surface Water Quality Atlas for the Gibbons Creek/Navasota River Drainage Area*” (Texas Municipal Power Agency, 1993b). This analysis of variance covered 15 surface water monitoring stations in the area of the Gibbons Creek lignite mine and the Gibbons Creek Steam Electric Station. The database included the following parameters: Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Silver (Ag), Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), Manganese (Mn), Nickel (Ni), Lead (Pb), Selenium (Se), Zinc (Zn), and Fluoride (F).

In comparison to the mean values of the data from all 15 stations, Peach Creek exhibited:

- Significantly higher TDS content, with average concentrations in excess of 500 mgL⁻¹.
- Significantly higher Cr, Mn, Ni, and Zn contents.
- Significantly lower TSS and As contents.

Time sequence of data collected between January 1990 and April 1994

A time sequence of pH data is available for the same surface water monitoring station SWPC2. These data cover the period January 1990 - April 1994. The results are presented in Table 1 in relation to rainfall over the preceding week (as a surrogate for flow in the creek).

Table 1 – pH of water at monitoring station SWPC2 in relation to rainfall

Date	pH (s.u.)	Rainfall* (in)
02/14/90	5.4	0.2
05/10/90	5.6	1.6
08/9/90	4.5	0.2
11/14/90	4.5	2.3
03/5/91	7.0	0.5
05/10/91	6.3	1.6
07/31/91	4.4	1.1
11/13/91	4.9	0.1
03/9/92	5.4	2.2
05/28/92	4.6	0.5
09/1/92	4.0	0.0
12/8/92	4.5	0.2
03/4/93	5.0	0.5
04/12/93	5.2	1.2
07/8/93	5.0	0.0
11/4/93	4.7	0.8
02/15/94	5.0	0.3
04/6/94	4.5	0.2

* Total rainfall over preceding week

Baseline water data collected between July 1991 and September 1992

The fourth study performed with data collected at monitoring station SWPC2 (MK004) included water chemistry and flow data that were submitted to the Railroad Commission of Texas in a permit application (Texas Municipal Power Agency, 1993a, Section .129 – Surface Water Information). These data were

collected by Morrison Knudsen Corporation on a monthly basis over the period July 1991 – September 1992. On a few occasions, the sampling was performed during storm events to test the variability of the chemistry with flow.

The report made the following findings:

Unlike the other drainages with intermittent flow, Peach Creek was determined to have continual flow at site MK004 (SWPC2). This was attributed to sources other than direct overland runoff from storm events, such as seeps or springs. The report concluded that they were fed by shallow groundwater due to rainfall infiltration.

This conclusion is supported by the relationships between stream flow (in cubic feet per second – cfs) and the chemistry of Peach Creek water. Although not perfect, the relationships show that as stream flow increases, the pH generally increases (Figure 3) and total dissolved salts (TDS) and sulfate concentrations generally decrease (Figure 4). This supports the theory that at times of low stream flow, saline (mostly sulfate) groundwater is the main component of the water, whereas at times of high flow, the main component is near-neutral, non-saline rainfall runoff. The study concluded that the elevated sulfate concentrations and the lower pH were probably due to oxidation of naturally occurring pyrite in the geologic strata within the Peach Creek drainage basin.

Figure 3 – Relationship between stream flow and pH at SWPC2

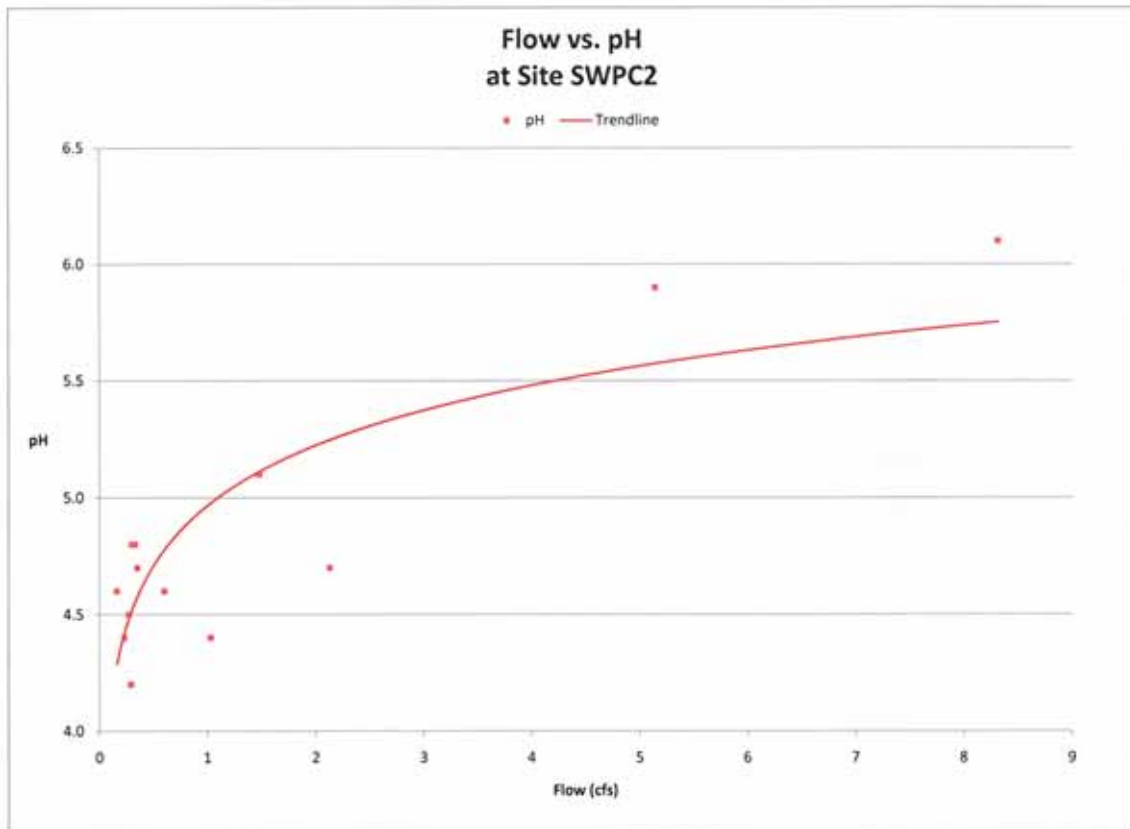
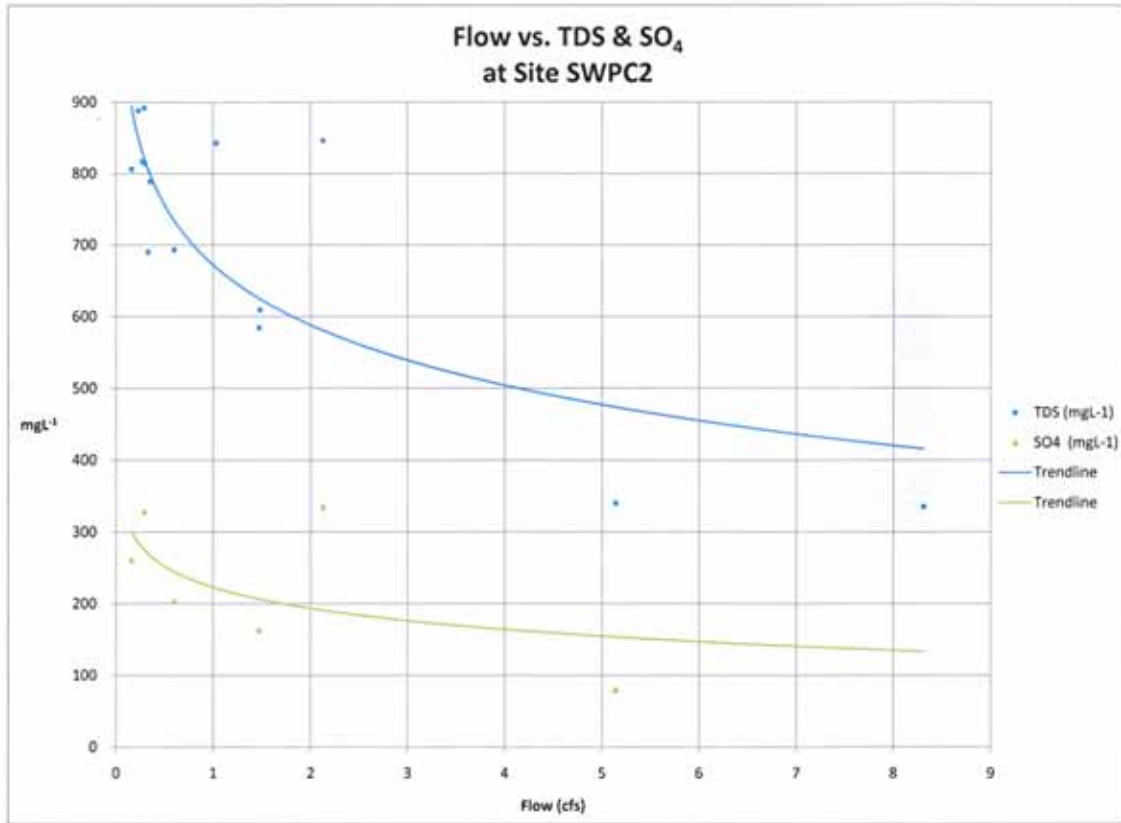


Figure 4 – Relationships between stream flow and TDS and sulfate concentrations at SWPC2



Special-purpose survey along the main channel and tributaries of Peach Creek

In order to better understand the baseline surface water chemistry observed at monitoring station SWPC2, it was decided in 1994 to perform a survey of the variability of pH and salinity along the main channel and tributaries of Peach Creek (Figure 1). This more detailed survey was performed by staff from TMPA, Morrison Knudsen Corporation and Navasota Mining Company on June 10, 1994. Analyses of pH and electrical conductivity (E.C.) were performed in the field and samples were delivered for more detailed analysis to Inter-Mountain Laboratories, Inc. (IML) of College Station, Texas. Partial surveys for verification purposes were performed on July 7, 1994 and July 29, 1994.

Water Chemistry Changes at Three Confluences along Peach Creek

In particular, samples of surface water were collected at three confluences of tributaries within the main Peach Creek channel (Figure 5). In this paper, they are described as the Upper Peach Creek Confluence (sampling Sites 8, 9, and 7), the Middle Peach Creek Confluence (Sites 12, 14, and 13), and the Lower Peach Creek Confluence (Sites 16, 15, and 17). The results of the analyses of samples collected on June 10, 1994 are summarized in Table 2.

Figure 5 – Location of the three Peach Creek confluences sampled on June 10, 1994

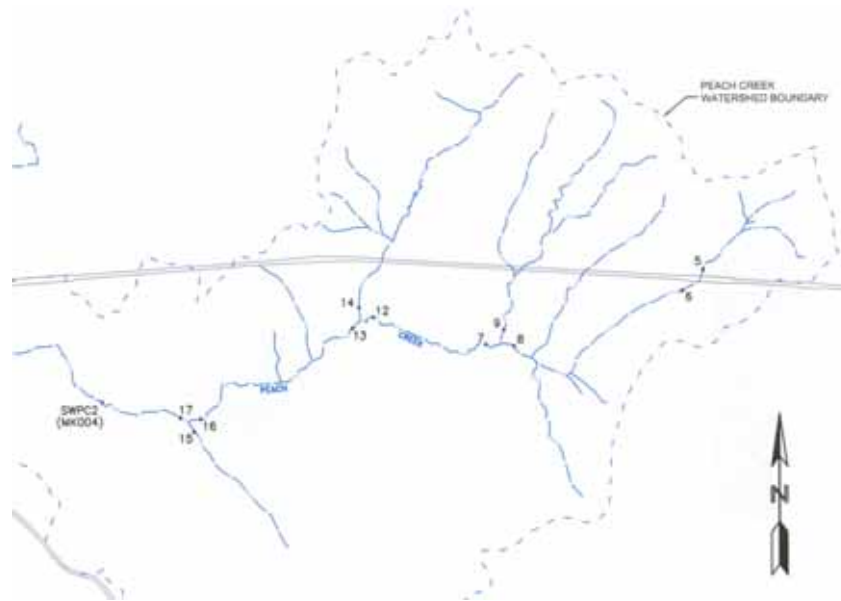


Table 2 – Chemistry of water at the three Peach Creek confluences on June 10, 1994

	pH (field)	TDS (mgL ⁻¹)	Ca	Mg	K	Na	SO ₄	Cl	SO ₄ / Cl	Ca/ Mg	Na/ Cl	Ca/ SO ₄
	(s.u.)	(mgL ⁻¹)	(meqL ⁻¹)						ratio			
Upper Peach Creek Confluence												
Site 8 (upstream)	4.1	2,160	8.1	3.8	0.3	10.5	15.8	8.6	1.8	2.1	1.2	0.5
Site 9 (tributary)	3.5	3,872	13.3	7.5	0.4	15.9	32.3	8.7	3.7	1.8	1.8	0.4
Site 7 (downstream)	3.9	2,430	9.1	4.5	0.3	11.4	18.5	8.6	2.2	2.0	1.3	0.5
Calculated contribution from tributary	-	16%	19%	19%	0%	17%	16%	0%	-	-	-	-
Middle Peach Creek Confluence												
Site 12 (upstream)	4.0	1,664	7.7	0.5	0.3	9.6	14.4	9.5	1.5	1.9	1.0	0.5
Site 14 (tributary)	6.7	308	1.0	0.6	0.1	1.7	1.3	1.6	0.8	1.7	1.1	0.8
Site 13 (downstream)	6.4	456	1.8	1.0	0.2	2.6	2.8	2.5	1.1	1.8	1.0	0.6
Calculated contribution from tributary	-	89%	88%	?	50%	89%	89%	89%	-	-	-	-
Lower Peach Creek Confluence												
Site 16 (upstream)	5.9	594	2.3	1.2	0.2	3.2	3.8	3.2	1.2	1.9	1.0	0.6
Site 15 (tributary)	3.8	1,096	5.0	2.5	0.4	5.5	9.4	6.0	1.6	2.0	0.9	0.5
Site 17 (downstream)	5.1	654	2.6	1.3	0.2	3.4	4.2	3.5	1.2	2.0	1.0	0.6
Calculated contribution from tributary	-	12%	11%	8%	0%	9%	7%	11%	-	-	-	-

The Upper Peach Creek Confluence is marked by the mixing of strongly acidic water (pH 3.5) from the tributary to the north (Site 9) with only slightly less acidic water (pH 4.1) in the main Peach Creek channel (Site 8) to give water of an intermediate acidity (pH 3.9) at Site 7 downstream of the confluence. This confluence is also characterized by the mixing of highly saline water from the tributary (TDS of 3,872 mgL⁻¹ at Site 9) with moderately saline water in the main Peach Creek channel (TDS of 2,160 mgL⁻¹ at Site 8). Based on the dilution of the TDS and of the major cations and anions, it is estimated that the proportion of flow contributed by the tributary was about 16% - 19% at the time of sampling.

Almost half of the salinity of the water in the tributary is due to the sulfate ion alone. The sulfate to chloride ratio (at 3.7) is much higher than the general background level (around 1.5 or less), which suggests that the chemistry of the water in the tributary is strongly influenced by the products of oxidation of metal sulfides such as pyrite. The water is acidic because there is a deficit of calcium and other bases (cations) to balance the sulfate anion (the calcium to sulfate ratio is 0.5 or less). In contrast, the sodium to chloride ratio is close to 1.0 at most sites suggesting simple solution of pre-existing sodium chloride salt from the geological formation.

Although analyses for iron were not run, it is evident that there must have been a considerable amount of iron in solution coming from the tributary. Mixing of the tributary water with the less acidic water from the Peach Creek channel upstream of the confluence (Figure 6) evidently caused precipitation of the iron resulting in the characteristic reddish-brown staining downstream of the confluence (Figure 7).

Figure 6 – Peach Creek sampling site 8 (upstream of confluence)



Figure 7 – Peach Creek sampling site 7 (downstream of confluence)



In contrast, the Middle Peach Creek Confluence is marked by the mixing of almost neutral water (pH 6.7) from the tributary to the north (Site 14) with strongly acidic water (pH 4.0) in the main Peach Creek channel (Site 12) to give water of an intermediate acidity (pH 6.4) downstream of the confluence (Site 13). Based on the dilution of other constituents in the water, the proportion of flow contributed by the tributary was about 89% at the time of sampling.

From all the chemical indicators, the effect of the tributary is to dilute and neutralize the acidity of the water in the main Peach Creek channel. The milky appearance of the water at Site 13 downstream of the mixing zone (Figure 8) may indicate the precipitation of aluminum hydroxide which, at the nearby Gibbons Creek mine, has been observed to occur in the range of pH 4.6 to pH 4.9 (Horbaczewski, 2001; Horbaczewski, 2006).

Figure 8 – Middle Peach Creek confluence (photograph taken from Site 13; Site 14 on tributary to the left; Site 12 in main channel to the right)



The Lower Peach Creek Confluence marks another pH reversal. Strongly acidic water (pH 3.8) from the tributary to the south (Site 15) mixes with very slightly acidic water (pH 5.9) in the main Peach Creek channel (Site 16) to give water of an intermediate acidity (pH 5.1) downstream of the confluence at Site 17 (Figure 9). Based on the dilution of other constituents in the water, the proportion of flow contributed by the tributary is estimated at 7% - 12% at the time of sampling. Just as at the Middle Peach Creek Confluence, the milky appearance of the water at Site 17 may be due to the precipitation of aluminum hydroxide.

In summary, the water in the main channel of Peach Creek at the time of sampling displayed major changes in chemistry as it flowed past each of the three tributaries described. There may have been more such changes that were missed in the survey. For example, the upper reaches of the main channel showed near-neutral pH values (pH 6.2 at Site 5 and pH 5.9 a few hundred yards farther downstream at Site 6). However, by the time the water flow reached Site 8 just above the Upper Peach Creek Confluence it was already down to pH 4.1. Similar pH changes may also occur along the tributaries themselves.

Figure 9 – Lower Peach Creek confluence (photograph taken from Site 17; Site 16 on main channel to the left; Site 15 on tributary to the right)



Variations in pH and E.C. with time

The initial sampling was performed on June 10, 1994, and was partially repeated a few weeks later on July 7 and July 29, 1994. The changes in pH and E.C. over that period are summarized in Table 3.

Table 3 – pH and E.C. data from Peach Creek surveys

Sampling site	pH (standard units)			Electrical Conductivity (mmho/cm)		
	06/10/94	07/7/94	07/29/94	06/10/94	07/7/94	07/29/94
1	4.6 (f) ---	4.7 (f) 4.4 (l)	4.6 (f) 4.4 (l)	0.8	1.0	1.1
7	3.9 (f) ---	3.0 (f) 3.7 (l)	4.2 (f) 4.0 (l)	2.8	2.7	2.9
8	4.1 (f) ---	4.0 (f) 4.0 (l)	4.0 (f) 3.7 (l)	2.5	2.7	3.1
9	3.5 (f) ---	3.4 (f) 3.4 (l)	3.5 (f) 3.3 (l)	3.9	3.8	5.5
12	4.0 (f) 4.0 (l)	---	---	2.3	---	---
13	6.0 (f) 6.4 (l)	---	---	0.6	---	---
14	6.4 (f) 6.7 (l)	---	---	0.4	---	---
15	2.1 (f) 3.8 (l)	3.4 (f) 3.6 (l)	2.9 (f) 3.5 (l)	1.5	1.6	1.7
16	4.1 (f) 5.9 (l)	6.1 (f) 6.1 (l)	4.8 (f) 6.4 (l)	0.8	0.5	0.5
17	3.7 (f) 5.1 (l)	4.9 (f) 4.4 (l)	4.4 (f) 4.5 (l)	0.8	1.0	1.1

Notes: (f) – field determination of pH.

(l) – laboratory determination of pH (performed by IML on the same day as sampled).

In general, the data are consistent with some slight decreases in pH accompanied by slight increases in E.C., suggesting less dilution by rainfall runoff as the summer progressed.

Interpretation

The following discussion is an interpretation of the data presented earlier.

Source of stream flow

Stream flow may be composed of two major sources – surface water runoff from rainfall and base flow from groundwater discharges.

At the time of the survey on June 10, 1994, there had not been any significant rain for almost a month (Table 4) and flow rates were low, as evident at Site 8 (Figure 10). The flow at SWPC2 is estimated to have been less than 0.5 cfs on that day (approximately 225 gallons per minute – gpm), compared to a flow of 8.31 cfs (3,750 gpm) measured during a storm event on February 27, 1992 (Texas Municipal Power Agency, 1993a, Section .129 – Surface Water Information).

Table 4 – Rainfall distribution for January-June 1994

Date	Rainfall (inches)
01/11/94	0.14
01/13/94	0.03
01/17/94	0.10
01/24/94	0.20
01/27/94	0.31
01/28/94	0.85
01/30/94	0.06
02/10/94	0.35
02/11/94	0.45
02/21/94	1.59
02/23/94	1.26
03/2/94	0.69
03/7/94	0.06
03/9/94	1.25
03/16/94	0.64
03/28/94	0.09
04/6/94	0.23
04/12/94	0.36
04/16/94	0.33
04/20/94	1.92
04/25/94	0.35
05/3/94	1.17
05/11/94	0.06
05/14/94	2.44
05/16/94	0.46
05/29/94	0.18
05/30/94	0.61
06/3/94	0.41
06/13/94	1.16
06/15/94	0.20
06/20/94	0.96
06/21/94	0.06
06/23/94	0.41
Total January-June 1994	19.38

Note: Rainfall events greater than 1 inch shown in bolded type.

Figure 10 – Evidence of low flow over rock ledge at Site 8 on June 10, 1994



As already discussed, the combination of low pH and relatively high sulfate concentrations suggests a groundwater origin for some of the stream flow. A groundwater baseline investigation performed by Morrison Knudsen Corporation over the period August 1991 to June 1992 suggested three potential sources of groundwater in the Peach Creek area – the 4525 aquifer (Yuma sand), the 5525 sand and the 5527 sand (Texas Municipal Power Agency, 1993a, Section .146 – Probable Hydrologic Consequences). The 4525 sand was considered to be the most probable source because it is sufficiently well developed for the mapping of a potentiometric surface and the derivation of a groundwater flow direction; the 5525 and 5527 sands were discontinuous and did not constitute mappable aquifer units.

Studies of the 4525 aquifer showed that the groundwater flow was generally to the east. However, this eastward flow was strongly controlled by significant structural faults. For example, the strike-oriented fault running along the down-dip edge of the P5 Mine Block has a vertical displacement of 150 feet (with a downthrow to the north-west). The channeling of the groundwater flow results in an elevated potentiometric surface, which the study found to intersect, and to discharge into, a surface water drainage east of the mine block. The geography of the area suggests that this is probably the same acidic tributary, sampled at Site 9, that drains to the Upper Peach Creek Confluence.

Generation of acidity

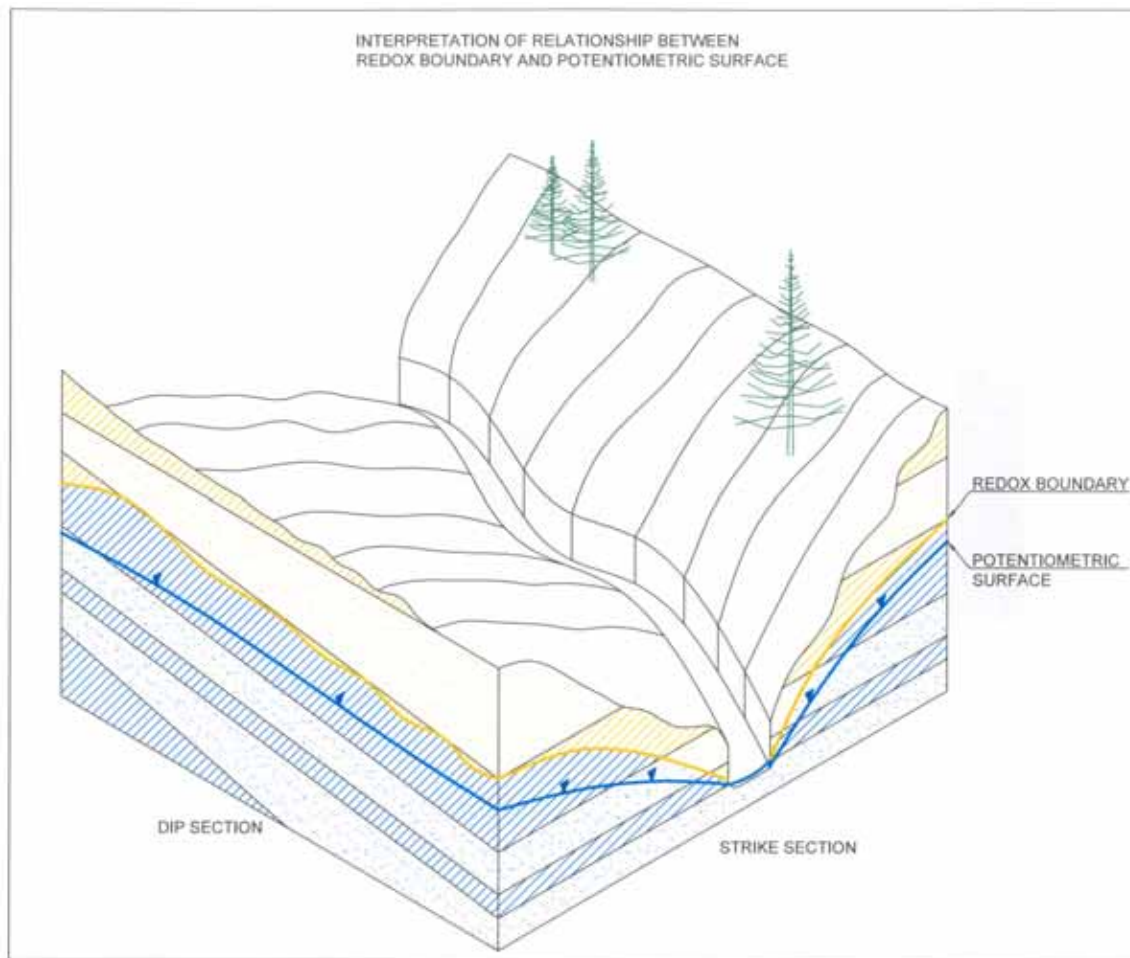
Thus, the generation of acidity in the Peach Creek system is probably different to that previously described (Horbaczewski, 2007):

Normally, the natural oxidation of pyrite in geological formations occurs from the surface downwards. Its progress is determined by the rate at which atmospheric oxygen and rain water can advance through the resisting geological formations. A fractionation of sorts develops resulting in a geochemical profile, one of

the most striking features of which is an oxidation-reduction (“redox”) boundary at a depth of about 27 feet. Geological materials above the redox boundary have a characteristic tan, brown, or red coloration indicative of oxidized (ferric) iron (Fe^{3+}) oxy-hydroxides and decomposed organic matter. Geological materials below the redox boundary have dark greenish-gray colors due to the presence of reduced (ferrous) iron (Fe^{2+}) and undecomposed organic matter, including lignite seams.

But in the Peach Creek situation, there is an additional complication in which percolating rainwater mixes with discharging groundwater in the vicinity of the redox boundary. The generation of acidity suggests that there is fresh pyritic material available for oxidation and this must mean that the reactions are occurring above a redox boundary. On the other hand, oxidation cannot occur if conditions are reducing as in anaerobic conditions where there is saturation with water. This suggests that a relationship as shown in Figure 11 may be present – with a water table or potentiometric surface underlying a redox boundary. However, this is no more than an interpretation and has not been tested in the field.

Figure 11 – Interpretation of relationship between water table/potentiometric surface and redox boundary



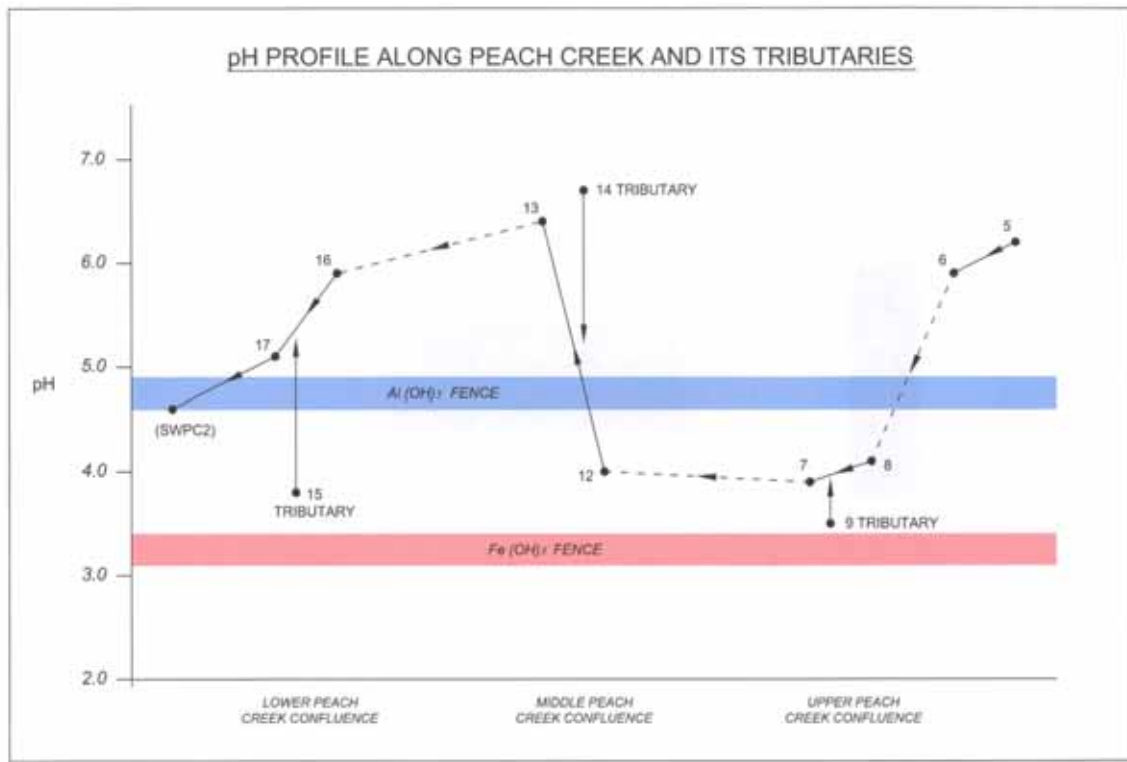
Neutralization of acidity

The acidity generated at various sites in the Peach Creek system was also neutralized or partly neutralized as it flowed past various confluences where it mixed with water of different pH. In some cases, the pH changes crossed the critical pH ranges or “fences” for the precipitation of iron hydroxides and aluminum hydroxides. These ranges (Figure 12) were derived earlier from observations of the precipitation of these minerals at the nearby Gibbons Creek lignite mine (Horbaczewski, 2001).

Interpretation of this graph suggests the following:

At the Upper Peach Creek Confluence very acidic water (pH 3.5) from the tributary (Site 9) mixed with less acidic water (pH 4.1) from the main channel (Site 8). Downstream of this confluence (Site 7 with pH 3.9), there is visible evidence of precipitation of iron oxyhydroxides from the reddish-brown staining of the stream-bed. The pH fence for iron hydroxide precipitation is in the general range of pH 3.1 - pH 3.4. This suggests that, at times, the pH of the water from the tributary had a pH lower than this range, which is consistent with the laboratory testing of a sample collected on July 29, 1994 that showed pH 3.3 (Table 3). The water downstream of the Upper Peach Creek Confluence was still sufficiently acidic to stay below the aluminum hydroxide fence so aluminum was able to stay in solution.

Figure 12 – pH profile of Peach Creek vs. precipitation ranges of iron and aluminum oxyhydroxides



Note: The pH ranges of the Al(OH)₃ and Fe(OH)₃ “fences” are based on Horbaczewski (2001)

However, at the Middle Peach Creek Confluence, the injection of nearly neutral (pH 6.7) water from a tributary (Site 14) raises the downstream acidity to pH 6.4 (Site 13), crossing the aluminum hydroxide fence and apparently precipitating aluminum hydroxide from solution as evidenced in the milky appearance of the water (Figure 8).

At the Lower Peach Creek Confluence, there is another addition of very acidic (pH 3.8) water from a tributary (Site 15). This lowers the pH of Peach Creek from pH 5.9 (Site 16) to pH 5.1 (Site 17). The water from the tributary crosses the aluminum hydroxide fence and that may account for the somewhat milky appearance of the water at Site 17 (Figure 9). It is possible that water in the tributary had even lower pH values to start with but had become partly neutralized even before reaching the confluence.

Finally, the water in Peach Creek appears to have received some more acidic drainage because by the time it reaches monitoring station SWPC2 it is at pH 4.6. At this pH aluminum becomes soluble again. Thus, in just the three confluences observed, the water chemistry crossed the iron hydroxide fence at least once and possibly twice, and the aluminum hydroxide fence at least three times and possibly four times. There may have been additional crossings of this nature within other segments of the Peach Creek drainage. The chemistry of the water at monitoring station SWPC2 is therefore a composite of many reactions, which have been masked by numerous neutralizations and dilutions.

Conclusions

The following conclusions may be drawn from this investigation:

- Peach Creek is fed by groundwater as well as rainfall runoff.
- The groundwater contribution from some of the tributaries is very acidic (less than pH 3.5).
- Water was acidic enough to hold iron and aluminum in solution.
- Mixing with water of higher pHs at various confluences caused the precipitation of visible iron hydroxides and presumed aluminum hydroxides.
- The water that finally reached the monitoring station SWPC2 was a composite of at least several reactions resulting from partial neutralizations and dilutions.
- The data from station SWPC2 were therefore difficult to interpret.
- The acidity is due to natural oxidation of pyrite in the geological formations.
- Oxidation of pyrite is known to generate water of even greater acidity than that observed in this study.
- It is possible that more detailed investigations would identify the sources of the acid drainage and their original pH values.

Acknowledgments

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Figures 1, 3, 4, 10, and 11 were drafted at TMPA by Rachel Brandt, with assistance from Joe Garcia (Figure 10) and Morriss Barney (Figures 3 and 4). The photographs were taken by the author.

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