

Chemical Contamination in the Green River

**final project for
Environmental Studies 102**

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A-

Good
job!

Introduction: The purpose of this paper is to analyze the chemical contamination of the Green River. Specifically, I have looked at the levels of nitrate and sulfate contamination at different points along the river. In order to isolate the different sources of the contamination level, I have researched natural and chemical sources of nitrate and sulfate contamination, obtained data about acid precipitation, and tested the river for bacterial levels and ion concentration. The water samples were collected from the part of the Green River where Route 43 and Route 7 meet. This data, obtained from seven different locations, helps isolate how different factors, including human waste, animal husbandry, storm run-off, precipitation, and automobile traffic, contribute to chemical contamination.

→ weathering of rocks
should be here too

Literature: In order to interpret my field and laboratory work in the larger context of the general body of research on sulfates and nitrates, I read a variety of ^{pertinent} ~~pertain~~ing literature. Environmental chemistry texts provided information on natural sources of the ions and sources of contamination. They provided statistics on industrial and agricultural sources of contamination and the impacts of such contamination. I relied on the following sources of

information:

1. Thomas G. Spiro and William M. Stigliani, Environmental Issues in Chemical Perspective. This provided a thorough discussion of acid rain, nitrogen in both the atmosphere and hydrosphere, and the serious impacts of agricultural sources of water contamination.

2. R.A. Bailey's Chemistry of the Environment covered water quality criteria and general information about the chemical reactions of sulfur and nitrogen.

3. Melvin D. Joesten et al, Chemistry - Impact on Society looked at the effects that nitrate and sulfate contamination have on human health and the ecosystem.

4. John D. Hem's Study and Interpretation of the Chemical Characteristics of Natural Waste Water provided the most in depth analysis of the natural sources of ions in fresh water.

Dates?
Publishers?
Give full
reference

Methodology: The laboratory part of my research consisted of field sampling

of the Green River and lab testing of the samples for ion concentration and

bacteria. I took seven samples at different points along the river. Sampling

took place on Tuesday, April 25 at approximately twelve o'clock. The weather

was sunny and clear and the river flow was relatively low for spring. I

collected about ⁵⁰⁰200 ml of water in sterilized bottles and was careful that

neither my hands nor shoes contaminated the river water upstream of the

sample location. I took careful notes on each site's variable characteristics.

Site 1 - Approximately fifty yards from the junction of Route 7 and Route 43.

This site was slightly downstream of a golf course, and two houses were situated in close proximity of the river banks. There was no farm land nearby.

Site 2 - The second sample was taken downstream of two storm drainage pipes which fed the river, approximately ten feet from an overhead bridge and 25 yards from the junction. There was much human use in the area and the rocks were slightly covered with brownish algae.

→ specifically?

Site 3 - The water was taken from a small side stream, separated from the main river by a gravel bar. The water velocity was significantly lower than the main river. Inflow from a small storm drainage pipe entered nearby.

Site 4 - This sample was taken ten feet past the area where brown sludgy, smelly, paint-like material entered the stream from the banks. The rocks were thickly covered with brown growth and a distinct odor was detectable.

Also a small store, gas station, and several houses were located nearby → of what?

Site 5 - Located directly below an area of heavy construction where The Store at Five Corner's is doing construction work. Although the store owners suspiciously refused to comment on the project, they probably are replacing a leaky gas tank and recently installed a septic tank. Several hay bales limit the erosion, but some run-off still eroded the banks and entered the river, depositing construction residue. This sample was also collected near the brown sludge.

Site 6 - Collected directly below an active dairy farm, approximately ten feet below a storm drainage pipe.

Site 7 - The final sample was collected one and a half miles downstream of the junction, at the Blair Road Bridge near Mount Hope Farm. No houses or active agriculture was noted.

The first laboratory procedure was the fecal and total coliform tests. I performed the tests on samples 1, 5, 6, and 7 the same afternoon as I gathered the samples so no storage was necessary. I tested samples 2, 3, and 4 twenty-four hours later. The samples were stored under refrigeration. I followed the procedures outlined in steps one through eight of Laboratory Exercise #2, with the exception of step three. Rather than using 10 ml of sample, diluting and rinsing, I used 50 ml, and rinsed with the 50 ml of sterile water which also completed the dilution. The second laboratory procedure involved testing for ions using the ion chromatograph. This test was performed twenty four hours after sampling, during which time the samples were under refrigeration. I used the autosampler in order to test my seven samples. I used the water filtered and diluted during the coliform tests and followed standard IC procedure as outlined in Laboratory Exercises #1 and #2.

Data: The coliform bacterial analysis and ion tests provided the following information on the contamination of the Green River:

. (please see Appendixes 1-3 for raw data)

Figure 1

Coliform Data for the Green River

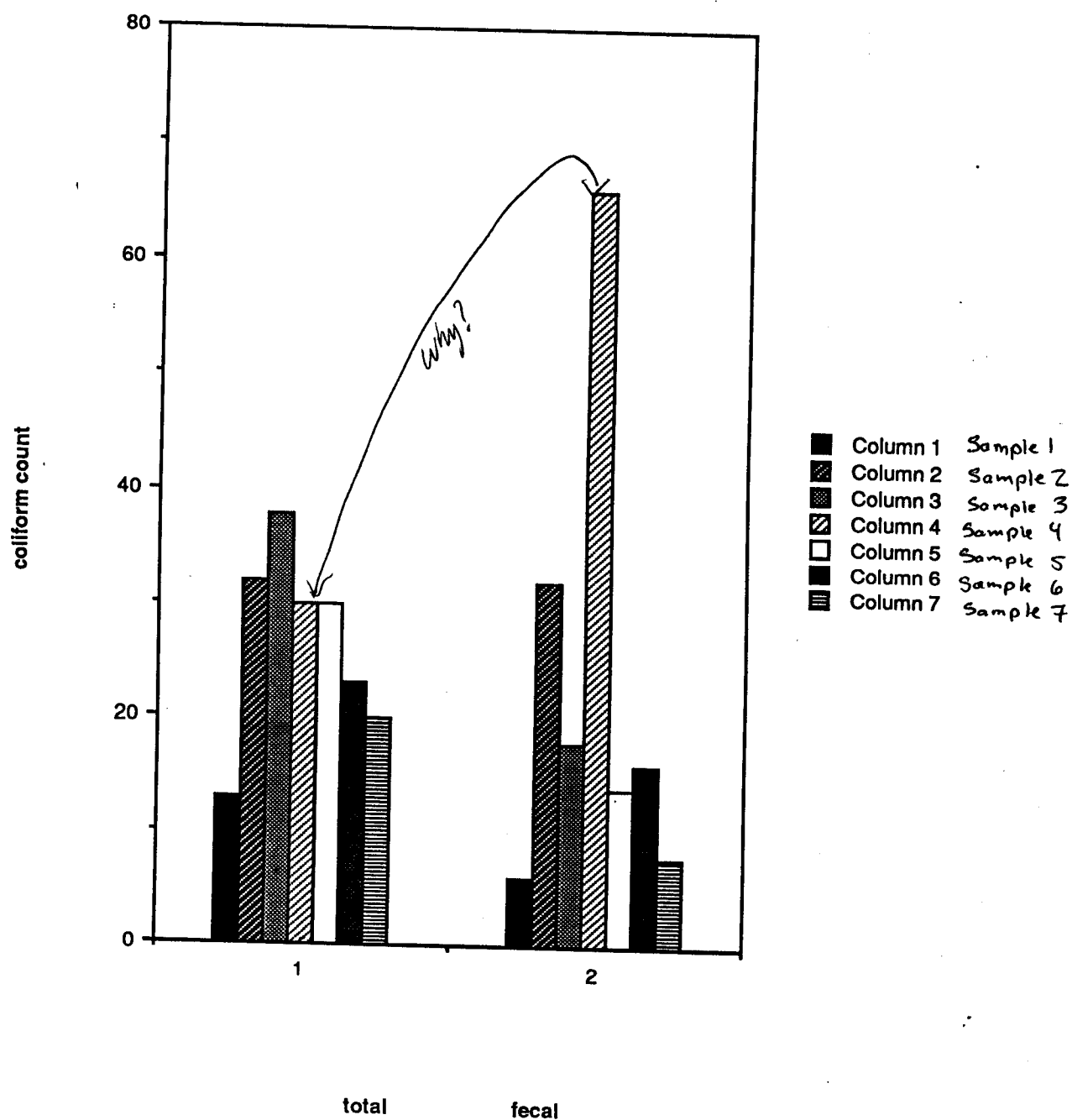


Figure 2

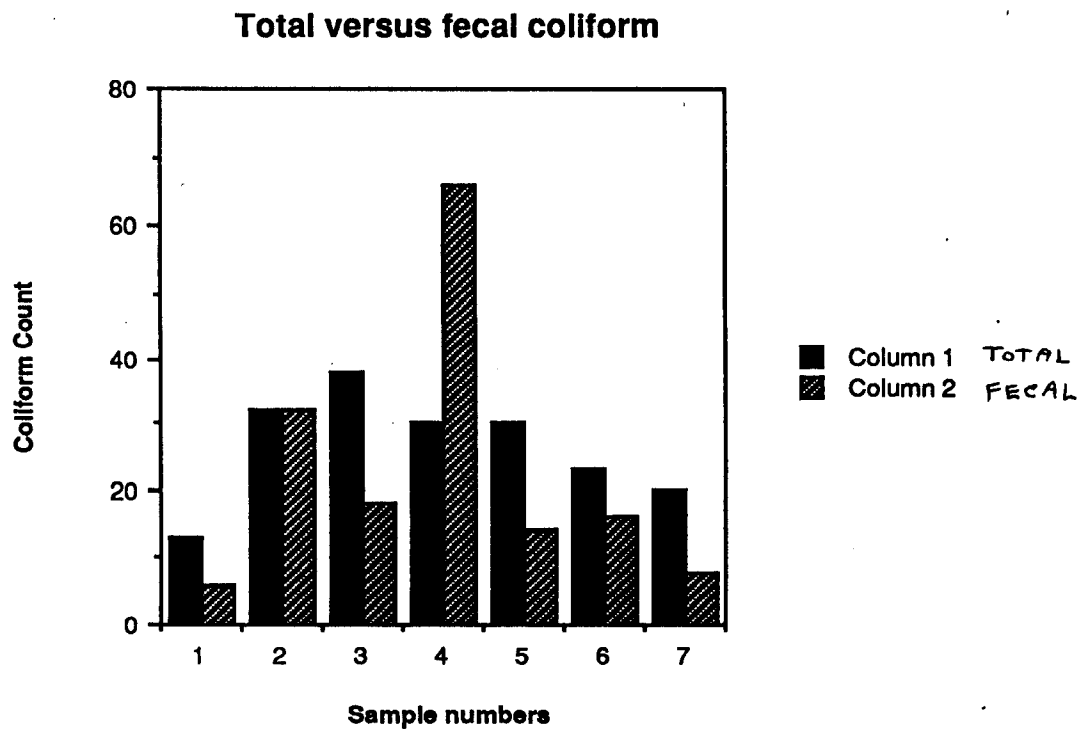


Figure 3

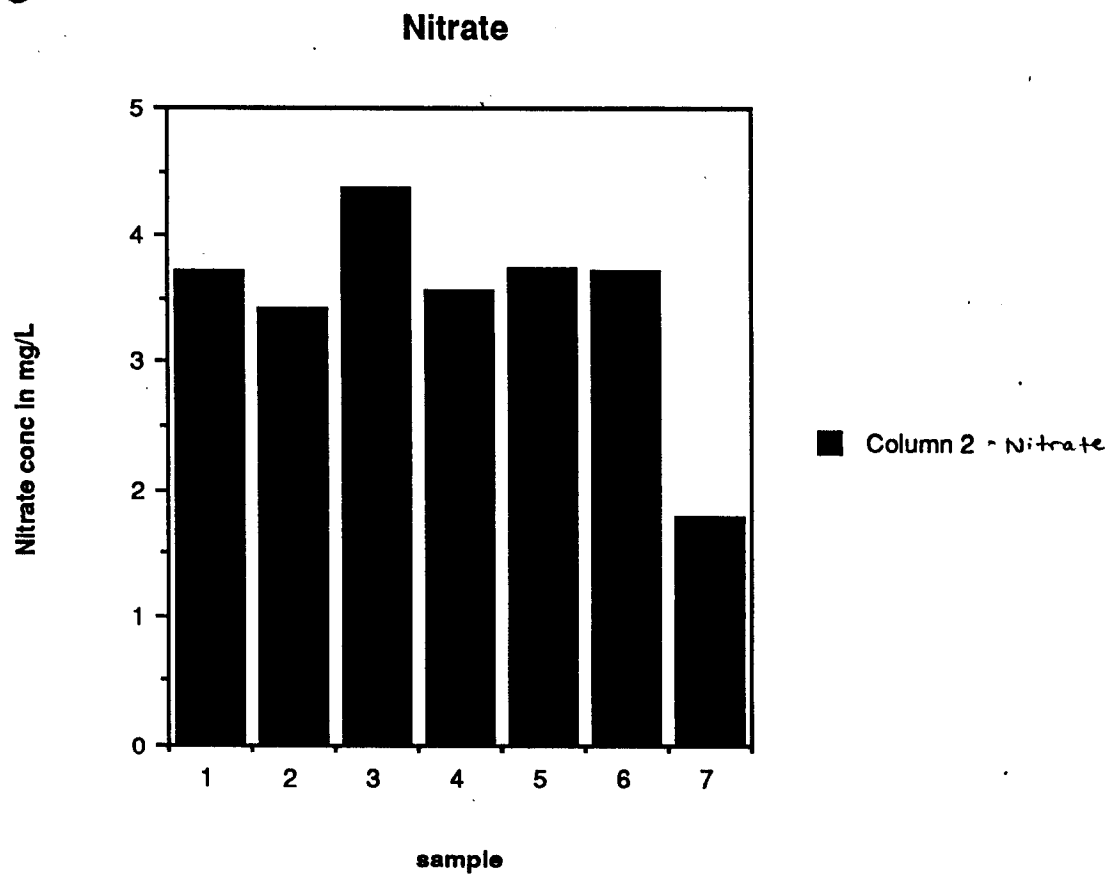


Figure 4

Sulfate Data

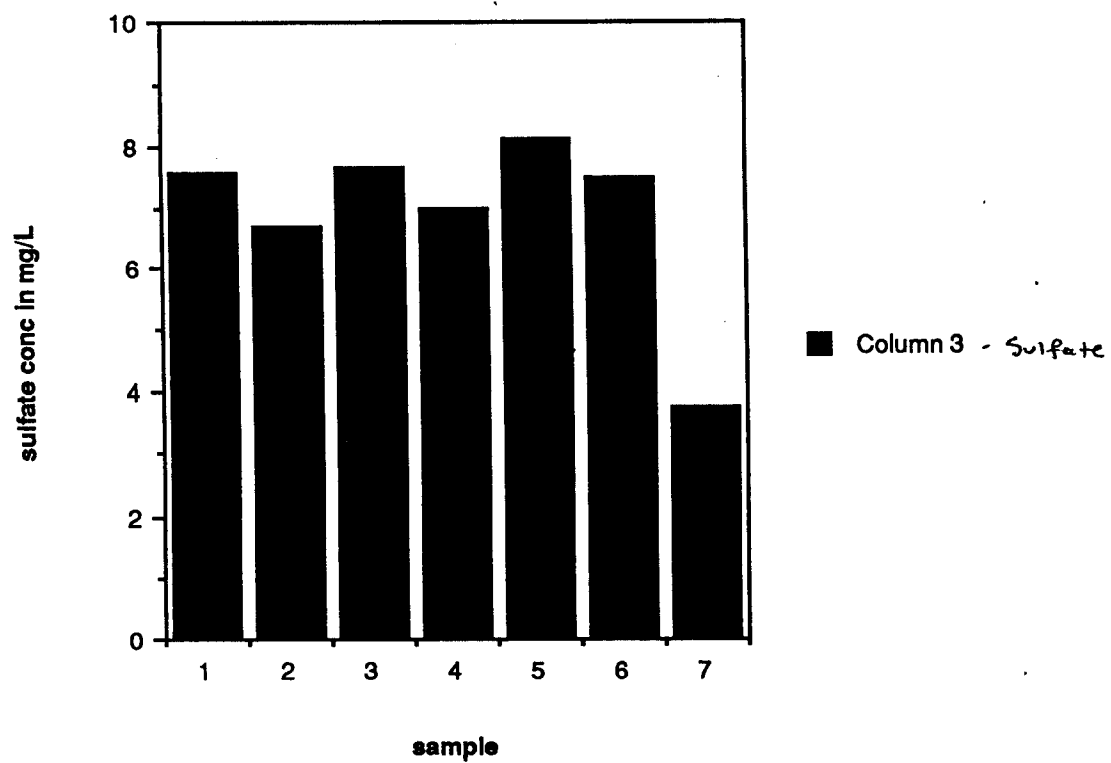
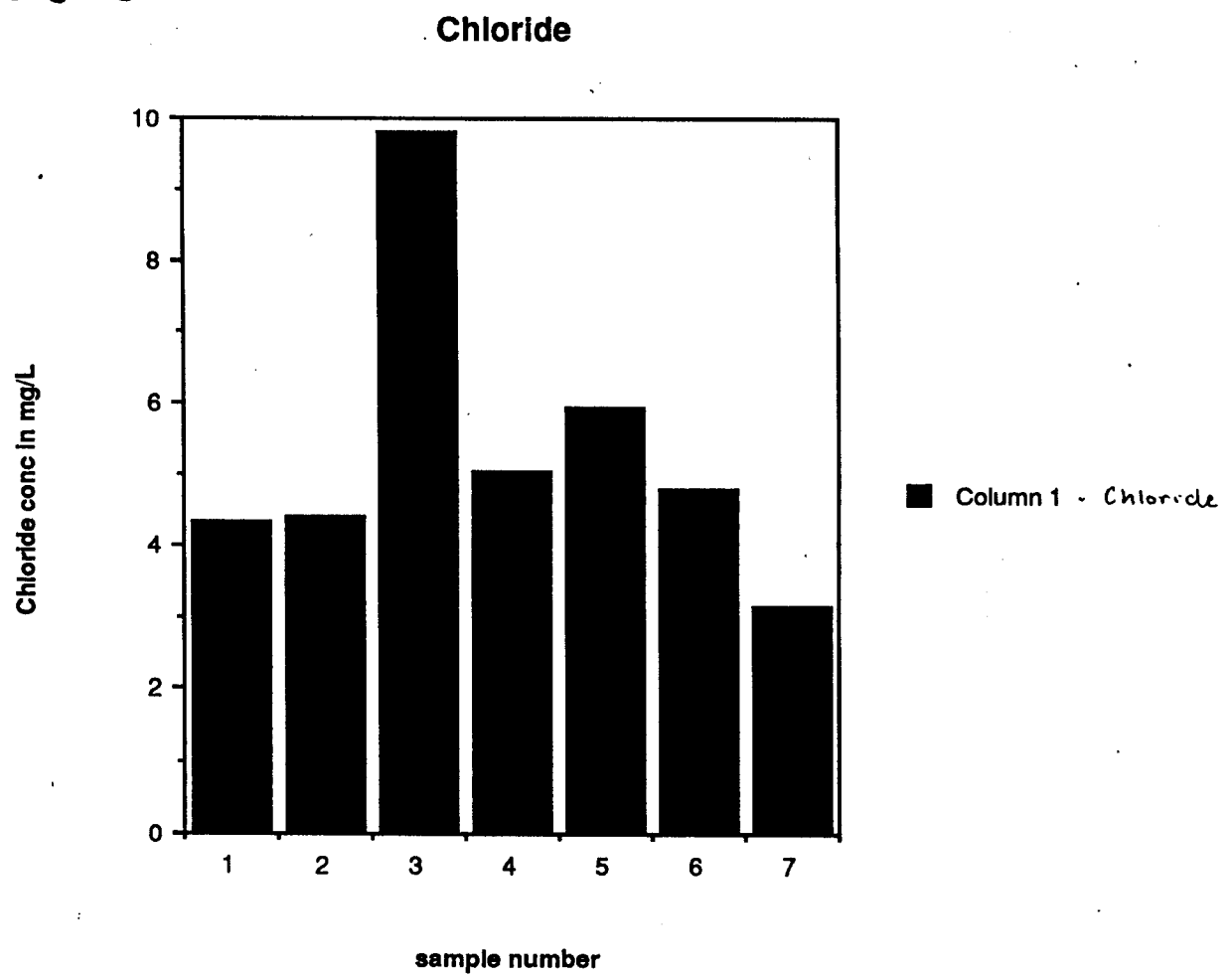


Figure 5

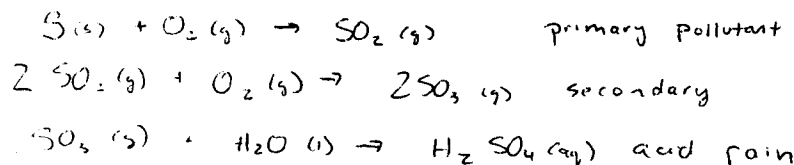


Discussion of Results:

A. Background Research:

Sulfuric acid (73.6 billion lbs.) and nitrogen (48.6 billion lbs.) are the two largest industrial chemicals produced annually in the United States. (Joeston)

Sulfate is produced in the combustion of coal and oil in automobiles and industry. The largest amount of pollution comes from sulfur dioxide emissions from electric power plants. Also, industrial processes such as the smelting of sulfide ores which produce sulfur oxides cause emissions into the atmosphere. (Held p113) Sulfur also occurs naturally in the environment. Sulfur is widely distributed in igneous and sedimentary rocks. Volcanic reactions, geothermal water, bacterial decay of some organic matter, and erosion all contribute to high sulfate concentrations in the air and water. The chemical process in which sulfur turns into water soluble sulfate ion is the following:



The best known effect of sulfate contamination is acid rain. Acidified water decreases fish populations, kills organic matter in lakes, damages trees, and can eventually work its way up the food chain damaging the entire ecosystem. Acidified water also erodes the soil more easily and corrodes metal and buildings in cities. There is ongoing debate as to the extent of human health ailments, such as breathing problems, which are believed to be caused by acid

rain. Threat to human health is not a serious threat in the case of the Green River because Federal Water Pollution Quality Criteria of the Department of the Interior sets 250 mg/L as the safety standard. The highest level in the Green River is 8.15 mg/L (Appendix 1). ⇒ Full ref?

Nitrate contamination from excessive use of nitrogen fertilizer, organic decomposition, and factory emissions threaten rural drinking water supplies. Agriculture has a two-fold contribution to nitrate levels. The amount of nitrogen fertilizer increases each year in order to keep up with productivity standards. Much of it ~~ex~~rodes into water supplies. Also, factory farming methods concentrate large numbers of animals and thus their wastes in a small area. The waste cannot decompose naturally so it ~~ex~~rodes, polluting the water supply. Sewage from leaking septic tanks or even garbage dumping also increases nitrate concentration in run-off water. Nitrogen from organic material is converted into nitrate ion in a biochemical process which begins with bacterial action. Also, a number of species of algae are able to use atmospheric nitrogen directly, thereby providing more nitrogen for the water environment. (Spiro p227) Nitrogen oxides are also present in the atmosphere from both natural sources and the combustion of fossil fuel. Car exhaust is a major source of nitrates which make up a kind of air pollution known as photochemcial smog. Air pollution contaminates rivers and lakes through acid precipitation. The primary damage caused by excessive concentrations of nitrates is methemoglobinemia, a disease which ~~a~~ffects small children. Safety standards

for nitrate are set by the Department of the Interior at less than 10 mg/L.

B. Nitrate Contamination:

Figure 3 shows relatively consistent levels of nitrate in the water samples one through six which are clustered around the junction of Route 7 and Route 43. The steady level of contamination despite the different factors (agricultural land use, construction, the golf course) implies that the source is non-point rather than point pollution. If the nitrate level were due primarily to one source such as a storm drainage pipe which emptied sewage water into the river, the level of nitrate would be significantly higher near the pipe.

The data shows that the ion's presence must be due primarily to air pollution either through acid precipitation or leaching of soils which contained nitrates from the air. According to figure 3 the level of contamination is

} Good
Hard to say this
with certainty.
Possibly a farm
upstream

could be dilution effects { consistent in the six samples taken near the junction, but significantly lower

downstream, away from Route 43. This shows that the nitrate is largely due to incomplete combustion of coal and oil in car exhaust. Much higher traffic levels at the intersection of two major highways probably caused the local high nitrate levels. Also the general human use in the area from housing, recreation, and agriculture significantly increased the contamination in the area.

} Not necessarily

Further evidence, such as the acid rain data from Hopkin's Forest, also shows that the acid levels have localized sources. For example, the road has a greater impact on air pollution than general sources such as the emissions

from industry. Nitrate levels in rainwater collected in the weather station (see Appendix 3) were approximately 2.26 mg/L during the period from February to April. Although the conditions were not precisely the same as when I sampled on April 25, the average level over a two month period indicated that only half the nitrate in the river came from acid precipitation which fell in the forest. This implies that there must be some localized source of contamination. The two primary possibilities are a localized source of air pollution or an organic source entering the water through a shallow aquifer contaminated by leaky septic tanks or soil erosion.

Although acid precipitation from car exhaust accounts for much of the nitrate found in the river, there are several other significant sources. Decomposition of organic matter probably from sewage contributes. Figure 1 shows a cluster of high fecal coliform counts in samples 2-6. This implies that a greater portion of that nitrate is due to organic sources like human or animal waste in those areas. In the area where samples 2-6 were taken there was more organic matter entering the river. In sample 6 waste from the dairy farm and in 2-5 possible erosion of soils containing sewage from the incomplete septic tanks which were replaced last winter. A more in-depth analysis of the coliform data will occur later in the report. The equally high level of nitrate in the first sample is probably not due to organic decomposition (as the low fecal count in fig 1 shows). This is consistent with the fact that the first sample was taken before the Store At Five Corners area where the sewage

dumping is thought to have occurred. The nitrate may be due to the use of nitrogen fertilizer on the golf course. Nitrogen fertilizer, used extensively in agriculture, is also one of the major sources of water contamination.

One of the most optimistic results of my lab work was that the data showed that the river has strong self-cleansing abilities. Figure 3 shows that one and a half miles down the river the level of contamination ^{by ??} had significantly dropped. This shows the river's natural ability to dilute and in effect de-toxify concentrated contaminants. The lower level of coliform bacteria in the seventh sample (Appendix 2) indicates cleaner water downstream. Finally, Sample 3, which was taken in a low velocity segment of the river had the highest nitrate concentration. Because the water was blocked by a sand bar and stagnated, it could not disperse the nitrate to less harmful concentrations. This also shows that when the river is flowing at its normal rate it is able to either disperse or break down harmful levels of nitrate. *↳ depends on season*

C. Sulfate

The trends in the sulfate data are similar to those in the nitrate data. Many of the sources of nitrate and sulfate contamination are the same. (please see Section A - Research) Also, Figure 4 shows the large decrease in sulfate concentration in sample 7. Although more research would be necessary to identify precisely what mechanism is used, clearly the river somehow cleanses itself on its course downstream. There is slightly more variability in the levels

of sulfate concentration between the different samples. This might be accounted for by natural sources. Sulfur naturally occurs and is widely distributed in igneous and sedimentary rocks so perhaps these vacillations are due to sulfur from erosion of the nearby soils and rocks.

D. Chloride

Although chloride is not one of the cations that this project focuses on, the presence of chloride can give information as to the general sources of contamination in the river. First, Figure 5 shows that the level of chloride in samples 1, 2, and 7 are relatively consistent. This supports my previous contention that most of the contamination comes from localized air pollution centered at the highway junction. Because chloride is not a major source of contamination, we would expect the levels to be consistent at both the junction and downstream. The extremely high level of chloride in sample 3 also suggests that the velocity of the river is tied to its ability to cleanse itself. Just as the nitrate concentration in sample 3 was higher because of the water stagnation, so was the chloride concentration intensified.

E. Bacteria

Comparison of total and fecal coliform results indicates ^{whether} ~~if~~ contamination is from organic or non-organic sources. Coliform data from the Enterobacteriaceae family fall into two categories. Bacteria like *E. coli* and

Salmonella which inhabit the intestines of mammals and bacteria like *Proteus* and *Aerobacter* exist in colder temperatures and thus survive in soil and water.

By growing two colonies of bacteria from the same sample, one at 35 degrees and one at 44.5 degrees, you can isolate the bacteria from ^{?? not really} organic sources since

they survive at the higher temperature. The relation between fecal and total coliform (figure 2) is a good indicator of sewage pollution. Samples 2, 4, and 6 had more than 50% fecal coliform, (Appendix 1) therefore they contained the highest level of organic pollution. Site 2 was directly downstream of a drainage pipe; site 4 was located closest to the unidentified brown, foul-smelling sludge;

site 6 was just downstream of an active dairy farm. Each site had the largest ^{contradiction} potential for the presence of organic material. These figures however, do not

seem to be tied to any variation in the level of sulfate or nitrate contamination.

Perhaps some other contaminant, not identified in the scope of this project, is responsible for the organic contamination. More testing would be necessary to identify and quantify the source. In any case, because the method of counting coliforms was so subjective (as demonstrated by the fact that I identified more fecal than total coliforms in sample 4), the data holds less weight in my conclusions.

The main use of the bacteria analysis is to generally show where the pollution was primarily organic in relation to other places on the river.

Although the comparison between the number of coliforms for total and fecal have little weight because they are counted differently, the comparison

between fecal counts in different samples is still valid. This is because the method of counting may have been subjective, but was equally flawed in each sample and thus holds value as a point of comparison. Figure 1 shows that samples 2-6 clearly had the higher level of organic components. This supports the idea that organic decomposition was part of the source of nitrate and sulfate contamination in those areas. Surprisingly, sample 6, taken near an active dairy farm, did not have noticeably higher organic bacterial levels. Perhaps this is because the natural (as opposed to factory) farming techniques allow for the waste material to decompose and naturally fertilize the soil. This decreases the need for nitrogen fertilizer and prevents excessive run-off into the water supply.

F. Sources of Error:

In my sampling technique, a possible source of error is sampling in a disturbed environment. After sampling at the first site, I proceeded to take successive samples downstream. Water I had disturbed by human contact upstream could possibly be collected in a sample downstream. I see no evidence in the data to suggest that is true however.

In ion chromatography there are few possible sources of error outside instrument error. There is always the possibility of some sort of human error or contamination, but I found no anomalies in the data to suggest this.

There are two sources of error in the bacteria test which may have affected

my results. The first, mentioned above, is the subjective method of counting the fecal coliform. It was very difficult to distinguish the greenish-tinted bacteria from the numerous pink ones. Because I was hoping to find higher concentrations of fecal bacteria in samples 2-6, I could have been more lenient in my interpretation of the color green. The second source of error occurred in filtration. I only rinsed the sides of the filtration apparatus completely in samples 2,3, and 4. Incomplete rinsing in the other samples means some bacteria colonies may have stuck to the sides of the flask. This may account for higher coliform counts in samples 2,3, and 4.

Conclusions: My research has resulted in the following five conclusions-

1. Air pollution, which enters the water in the form of precipitation directly and indirectly through soil erosion, is the main cause of sulfate and nitrate contamination of the Green River. Both regional and localized pollution contribute.
2. Organic sources of pollution, possibly sewage from Five Corners and nitrogen fertilizer also contribute to high nitrate levels.
3. Local agriculture has comparatively little effect on ion concentration because farming methods are ecologically efficient and reuse the nutrients.
4. More testing is necessary to identify other contaminants which the coliform tests and field observations indicate are present.
5. Optimistically, the Green River has strong cleansing capabilities and if sewage dumping ceases and ecologically efficient construction increases, the health of the river will be insured.

Appendix 2

#1

Sec.	Delta	Std#	Area	Group	Name	Amount
48.4	12.0	2	41854E0	2	CL	4.31
95.1	18.0	4	18377E0	4	N03	3.72
129.3	19.0	6	50760E0	6	S04	7.58

Total Area = 110994 %Identified %Total
 Area Of Group 2 = 41854 37.71 37.71
 Area Of Group 4 = 18377 16.56 16.56
 Area Of Group 6 = 50760 45.73 45.73
 Total Identified Area 110993 100.00 100.00
 Time of report: 16:24:47 Date of report: 04-26-1989

Channel 0 Run 16
 Run name: P2
 Method name: AUTOAN File: AUTO
 Date created: 8/10/88 Time created: 11:35
 Operator: S. BROWN
 Conditions: NORMAL

Sec	Type	Width	Skew	Height	%Height	Area	%Area
48.3	BV	4.7	1.34	3899	45.25	21333E0	40.87
95.4	VH	5.7	1.18	1329	15.42	8477E0	16.24
129.7	BB	6.0	1.18	3389	39.33	22392E0	42.89
Total Height		%Height	Total area		%Area		
8617		100.00	52202		100.00		

#2

Sec.	Delta	Std#	Area	Group	Name	Amount
48.3	11.0	2	21333E0	2	CL	2.20
95.4	21.0	4	8477E0	4	N03	1.71
129.7	23.0	6	22392E0	6	S04	3.34

Total Area = 52202 %Identified %Total
 Area Of Group 2 = 21333 40.87 40.87
 Area Of Group 4 = 8477 16.24 16.24
 Area Of Group 6 = 22392 42.89 42.89
 Total Identified Area 52202 100.00 100.00
 Time of report: 16:31:48 Date of report: 04-26-1989

Channel 0 Run 17
 Run name: P3
 Method name: AUTOAN File: AUTO
 Date created: 8/10/88 Time created: 11:35
 Operator: S. BROWN
 Conditions: NORMAL

Sec	Type	Width	Skew	Height	%Height	Area	%Area
48.3	BV	4.5	1.32	9106	61.95	47624E0	56.61
95.2	VH	5.7	1.18	1684	11.46	10800E0	12.84
129.5	BB	5.9	1.18	3908	26.59	25708E0	30.56
Total Height		%Height	Total area		%Area		
14698		100.00	84132		100.01		

#3

Sec.	Delta	Std#	Area	Group	Name	Amount
48.3	11.0	2	47624E0	2	CL	4.91
95.2	19.0	4	10800E0	4	N03	2.18
129.5	21.0	6	25708E0	6	S04	3.84

Total Area = 84132 %Identified %Total
 Area Of Group 2 = 47624 56.61 56.61
 Area Of Group 4 = 10800 12.84 12.84
 Area Of Group 6 = 25708 30.56 30.56
 Total Identified Area 84132 100.00 100.00
 Time of report: 16:38:48 Date of report: 04-26-1989

Channel 0 Run 18
 Run name: P4
 Method name: AUTOAN File: AUTO
 Date created: 8/10/88 Time created: 11:35
 Operator: S. BROWN
 Conditions: NORMAL

Sec	Type	Width	Skew	Height	%Height	Area	%Area
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Sec	Type	Width	Skew	Height	%Height	Area	%Area
68.2	BV	4.5	1.31	4500	47.67	24466E0	43.17
95.2	VB	5.7	1.18	1379	14.61	8799E0	15.53
129.4	BB	5.9	1.15	3560	37.72	23403E0	41.30

Total Height	%Height	Total area	%Area
9489	100.00	56668	100.00

Sec.	Delta	Std#	Area	Group	Name	Amount
68.2	10.0	2	24466E0	2	CL	2.52
95.2	19.0	4	8799E0	4	N03	1.78
129.4	20.0	6	23403E0	6	S04	3.49

Total Area = 56668 %Identified %Total

Area Of Group 2 =	24466	43.17	43.17
Area Of Group 4 =	8799	15.53	15.53
Area Of Group 6 =	23403	41.30	41.30
Total Identified Area	56668	100.00	100.00

Time of report: 16:45:49 Date of report: 04-26-1989

Channel 0 Run 19

Run name: P5

Method name: AUTOAN File: AUTO

Date created: 8/10/88 Time created: 11:35

Operator: S. BROWN

Conditions: NORMAL

Sec	Type	Width	Skew	Height	%Height	Area	%Area
68.2	BV	4.5	1.29	10965	49.40	57693E0	44.12
94.7	VB	5.7	1.20	2899	13.06	18440E0	14.10
128.8	BB	5.9	1.18	8335	37.55	54622E0	41.77

Total Height	%Height	Total area	%Area
22198	100.01	130754	99.99

Sec.	Delta	Std#	Area	Group	Name	Amount
68.2	10.0	2	57693E0	2	CL	5.95
94.7	14.0	4	18440E0	4	N03	3.73
128.8	14.0	6	54622E0	6	S04	8.15

Total Area = 130754 %Identified %Total

Area Of Group 2 =	57693	44.12	44.12
Area Of Group 4 =	18440	14.10	14.10
Area Of Group 6 =	54622	41.77	41.77
Total Identified Area	130755	100.00	100.00

Time of report: 16:52:49 Date of report: 04-26-1989

Channel 0 Run 20

Run name: P6

Method name: AUTOAN File: AUTO

Date created: 8/10/88 Time created: 11:35

Operator: S. BROWN

Conditions: NORMAL

Sec	Type	Width	Skew	Height	%Height	Area	%Area
68.2	BV	4.5	1.27	8691	45.10	46362E0	40.29
94.7	VB	5.7	1.25	2887	14.98	18344E0	15.94
128.2	BB	5.9	1.20	7694	39.92	50347E0	42.77

Total Height	%Height	Total area	%Area
19268	100.00	115773	100.00

Sec.	Delta	Std#	Area	Group	Name	Amount
48.2	10.0	2	46362E0	2	CL	4.78
94.7	14.0	4	18344E0	4	N03	3.71
128.9	15.0	6	50367E0	6	S04	7.52

Total Area = 115073 %Identified %Total
 Area Of Group 2 = 46362 40.29 40.29
 Area Of Group 4 = 18344 15.94 15.94
 Area Of Group 6 = 50367 43.77 43.77
 Total Identified Area 115073 100.00 100.00
 Time of report: 16:59:50 Date of report: 04-26-1989

Channel 0 Run 21

Run name:

Method name: AUTOAN File: AUTO

Date created: 8/10/88 Time created: 11:35

Operator: S. BROWN

Conditions: NORMAL

Sec	Type	Width	Skew	Height	%Height	Area	%Area
48.3	BV	4.4	1.34	5618	52.10	30815E0	47.70
95.2	VR	5.8	1.18	1374	12.74	8861E0	13.72
129.5	BB	5.9	1.18	3791	35.16	24928E0	38.59
Total Height.		%Height	Total area		%Area		
10783		100.00	64604		100.01		

Sec.	Delta	Std#	Area	Group	Name	Amount
48.3	11.0	2	30815E0	2	CL	3.18
95.2	19.0	4	8861E0	4	N03	1.79
129.5	21.0	6	24928E0	6	S04	3.72

Total Area = 64604 %Identified %Total
 Area Of Group 2 = 30815 47.70 47.70
 Area Of Group 4 = 8861 13.72 13.72
 Area Of Group 6 = 24928 38.59 38.59
 Total Identified Area 64604 100.00 100.00

X indicates multiple by 2 because of 50% dilute

Appendix 2 -
Coliform data

total	fecal
13	6
32	32
38	18
30	66
30	14
23	16
20	8

Appendix 3 - Weather Station Data from February to Apri
recorded in mg/L

Sample #	Nit	Sul
141	1.73	0.80
142	1.80	1.68
143	1.99	3.29
144	.90	0.56
145	2.72	2.42
146	1.26	1.36
147	.74	0.62
148	6.94	7.73
average	2.26	2.31