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Population Impacts On Surface Water Quality In The Little Papillion Creek Watershed.

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Population Impacts On Surface Water Quality In The Little Papillion Creek Watershed

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Steven L. Bartosh

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ABSTRACT

Population Impacts On Surface Water Quality In The Little Papillion Creek Watershed

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University of Nebraska, 2002

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This study involved monthly monitoring of water quality at 30 rural and urban sites in Douglas County, Nebraska from January 1996, to December 1996. Eight water parameters were measured or calculated for each sample and the results were then analyzed. Nitrate, potassium, chloride and sodium were the four parameters used in this thesis to display the strongest relationships between the land uses and quality of water. This thesis examines how rural and urban land uses affect the concentrations of the chemical constituents. Additionally, this thesis will correlate the number of businesses and residents with nitrate, potassium, chloride and sodium.

Rural area sample sites averaged higher concentrations of both nitrate and potassium. Urban area sample sites, however, averaged higher concentrations of sodium and chloride.

Sodium and chloride had the strongest positive correlation associated with the number of businesses and residents within an area. This

relationship may result from the use of these chemicals in mainly urban areas as de-icing agents for streets. Nitrate and potassium had some negative correlations values, but not as strong as sodium and chloride. This may be because nitrate and potassium used as fertilizers, in both rural and urban areas.

This study documents the relationship between urbanization and surface water quality. In addition, this study also provides a baseline study for future comparison. The results suggest the need to consider water quality effects when planning for urban expansion and monitoring of urban areas.

Table of Contents

Table of Figures

1. INTRODUCTION

Surface water plays an important role in our society and in the hydrologic cycle. Contamination of surface water affects the quality of recharge for ground water and overall negatively affects our environment. Over the next few years, millions of dollars will be spent in the collection of ground-water quality data. The data will be used to provide early warning of pollution events and provide information on the effectiveness of cleanup efforts (Harris, Loftis, and Montgomery 1987). Scientists and government officials are beginning to realize the importance of prevention, and not just cleaning up polluted water. "One of the most significant developments relating to water pollution in the United States was, in 1991, the implementation of a formally legislated federal pollution prevention program" (Bowlds 1992 42). This program (an amendment to section 319 of the Clean Water Act) is a shift toward pollution prevention by cutting it off at its source. It is the consensus in many literature sources that looking at the land is a logical place to start this prevention process. In 1992, the National Task Force for the Environment suggested that "environmental and land use planning need to be integrated", and the "present system of land use planning and environmental management doesn't even offer minimal environmental protection" (Alexander 1993 43). Without fundamental changes in the system of values, planners are "doomed to chase after the chaos which is always one step ahead" (Alexander 1993 43).

This study examines both a rural and urban environment in the Little Papillion Creek watershed in Omaha, Nebraska. The concentrations of potassium, nitrate, sodium and chloride will be examined in relation to urban and rural areas. In addition each of the previously mentioned chemical constituents will be correlated with the number of businesses and residents associated with each of the sample sites.

Literature pertaining to non-point source (NPS) pollution reveals a need for research that combines environmental science and aspects of urban planning to best understand and manage urban and nearby rural water resources (Harbor 1994, Bowlds 1992 45, and Tourbier 1994). This thesis will examine the relationship that exists between land use and water quality variables in an attempt to understand how urban and rural land use pollutants affect the quality of a stream used primarily to remove urban storm runoff.

The prevention part of the water pollution problem is an easy solution in theory, but not in action. It is relatively easy to target point-source pollution (pollution from a direct source such as from a pipe). However, non-point source pollution is not as easy to pinpoint. Urban non-point source pollution is a huge contributing factor. "Urban and suburban runoff is the single biggest source of water pollution, limiting the full use of 40% of the nation's waters" (www.epa.gov). Rural non-point pollution is also a large contributor due to the loss of organic rich topsoil over the years. This has resulted in farmers having to put more fertilizer on their crops to sustain their yields (Bowlds 1992). "Watershed-based approaches may be the solution to U.S. non-point source pollution for which agriculture is the main source" (Environmental Science and Technology 1995 407). The watershed approach allows for the consideration of the entire hydrological system, including surface water and ground water quality and quantity, as well as the sources of pollution. This leads to a holistic treatment, as opposed to focusing prevention efforts on the individual pollutants or pollution sources (Environmental Science and Technology 1995).

2. RESEARCH DESIGN

2.1 Scope

This study seeks to quantify the spatial and temporal patterns of selected chemical concentrations in the Little Papillion Creek in relation to the number of residents and businesses within the area. By comparing water quality variables to human related indices, the role that human activities play in water contamination can be assessed. It is not intended to be a chemistry or a urban planning study; rather, it is a geographic study that focuses on the relationship between land use and water quality within the study area.

2.1 Justification and Rationale

The United States has made tremendous advances in the past twenty-five years to clean up the aquatic environment by controlling pollution from point sources (www.epa.gov/OWOW/nps). Unfortunately, not enough was done to control pollution from diffuse, or non-point, sources (NPS). Today, NPS pollution remains the nation's largest source of water quality problems (www.epa.gov/OWOW/nps).

Until the recent addition (1987) of the Clean Water Act, an amendment under section 319, non-point source pollution was not recognized as a concern by the EPA. For example, before the late 1970's the EPA thought of street run-off as virtually clean water (Krupp, 1990). NPS pollution is of great concern and there is need for studies to examine relationships between land use and the chemicals constituents associated with the different areas. It is important to understand these trends in water quality since this surface water runoff is part of the hydrologic system.

The Little Papillion Creek watershed was selected as the study area because of its proximity to Omaha, the relatively small size of the watershed, and the rural-to-urban contrast in land use. Water samples were taken once a month at 30 sites. The number of businesses and households in portions of the Little Papillion Creek watershed were calculated and used as independent variables for correlation analysis with the water quality variables to determine the relationships between water quality and urbanization – suburbanization.

2.2 Research Questions

A. How do rural and urban land uses within the Little Papillion Creek watershed affect the concentrations of the selected chemical constituents?

B. How does the number of businesses and residents correlate with the selected chemical constituent concentrations?

2.3 Objectives

The following are objectives of this research:

A. Determine if rural areas in the Little Papillion Creek watershed are associated with higher levels of potassium and nitrate as compared to the urban areas.

B. Determine if urban areas in the Little Papillion Creek watershed are associated with higher levels of chloride and sodium as compared to the rural areas.

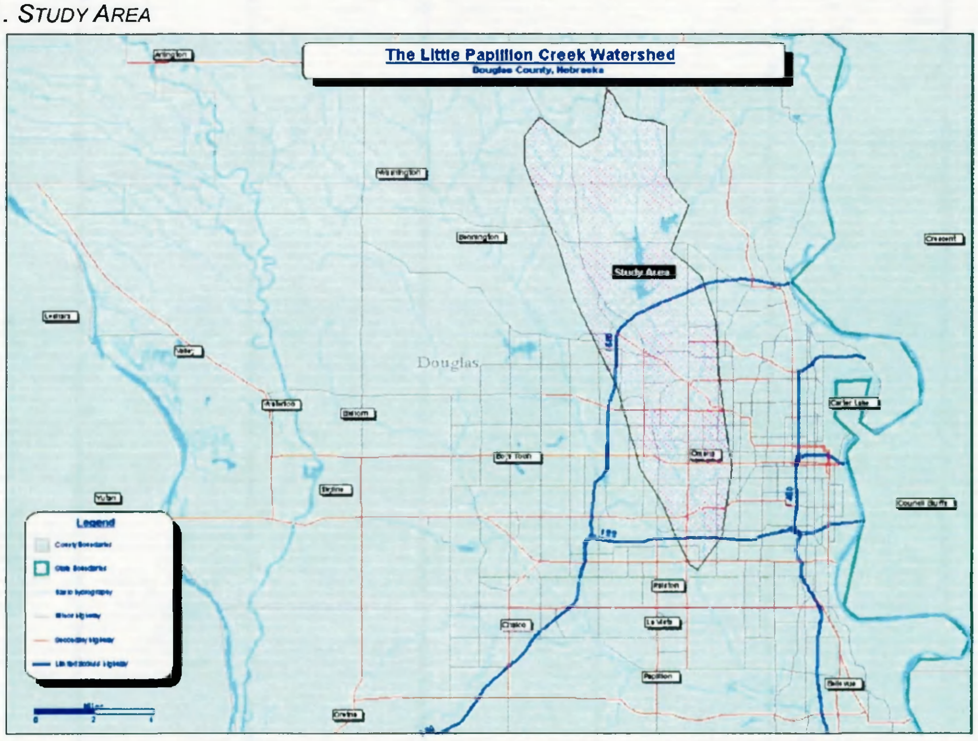
C. As a stream progresses from an agricultural area into and through an urban area, do the defined water quality variables change and if so, how do they change in relation to population density.

3. STUDY AREA

3.1 Location

The thirty sites used in this study are all located in Douglas County, Nebraska. Douglas County is in the east-central portion of Nebraska, in the Great Plains region of the United States (Bartlett 1975). Douglas County is bordered on the east by Iowa, (across the Missouri River), Sarpy County to the south, Saunders County to the west, and Dodge and Washington Counties to the north. Douglas County has a total land area of 214, 208 acres and population of 463,585. Omaha is the largest city in Nebraska and is the county seat of Douglas County (Bartlett 1975).

FIGURE 1. STUDY AREA

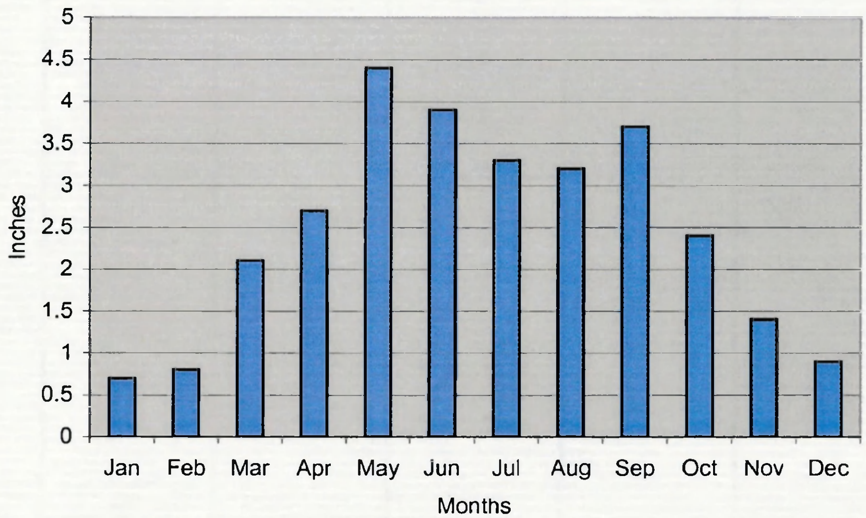


3.2 Climate

The climate of the study area is classified as *Dfa* using the Köppen Climate System (Strahler and Strahler 1994). The *Dfa* classification is associated with regions where the average temperature of the coldest month is less than -3°C, and where the average temperature of the warmest month is greater than 22°C. The region is moist, having adequate precipitation in all months, and no dry season (Strahler and Strahler 1994). Convergence of cold, dry air masses and warm, moist air masses are common in the spring resulting in intense thunderstorms. The mean annual precipitation is 71 centimeters. (Institute of Agriculture and Natural Resources 1986). The region has four distinct seasons with periods of freezing and thawing in the fall, winter, and spring.

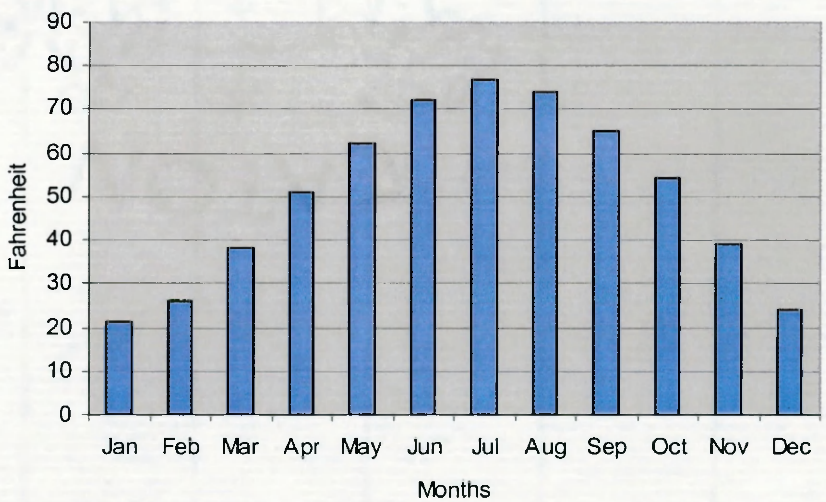
On average, the months with the highest amounts of precipitation are May, June and September (figure 2). The months with the least amount of precipitation are December, January, and February.

FIGURE 2. MEAN MONTHLY PRECIPITATION
SOURCE: THE WEATHER CHANNEL (HTTP://WWW.WEATHER.COM/WEATHER/CLIMATOLOGY/MONTHLY/68130)



Typically, the warmest months are June, July, and August. The coolest months are December, January, and February (figure 3).

FIGURE 3. MEAN MONTHLY TEMPERATURE
SOURCE: THE WEATHER CHANNEL(HTTP://WWW.WEATHER.COM/WEATHER/CLIMATOLOGY/MONTHLY/68130)



3.3 Surface Hydrology

The Little Papillion Creek watershed is one of the branches of the Papillion Creek, which is a tributary of the Missouri River. The three main tributaries of the Little Papillion are Thomas Creek, Cole Creek, and Elmwood Creek. There are eight other unnamed tributaries. Cunningham Lake is located in the northern section of the watershed. The Little Papillion drains a considerable amount of agricultural and urban land in Douglas County, along with a small portion of agricultural land in Washington County.

3.4 Soils

The soils in the Little Papillion Creek watershed are classified as the Monona-Ida association (Bartlett 1975). A typical Monona-Ida association soil is deep, well drained, and nearly level to a very steep silty soil. The soils formed in silty, wind deposited loess. Water erosion is the main hazard in the cultivated areas and in areas being developed for urban expansion (Bartlett 1975).

3.5 Topographic Region

The Ground Water Atlas of Nebraska classified the Little Papillion Watershed as Rolling Hills (Institute of Agriculture and Natural Resources 1986). This classification is associated with moderate to steep slopes formed by glaciers that were modified by erosion and recent deposition. The watershed's landscape had also been altered by anthropogenic activity. The rolling hills in the rural areas have been terraced and cultivated for agriculture, while the urban area have been developed into a city landscape by grading the hills and by channeling streams.

3.6 Geology

Most of the rock units in eastern Nebraska (the location of the study area) are classified as sedimentary rocks of Pennsylvanian age (Institute of Agriculture and Natural Resources 1986). This area was uplifted, which enhanced erosion and resulted in the exposure of the rock that dates back 286 to 320 million years. Wisconsin-aged Peoria Loess overlays Nebraska-aged glacial tills in the Little Papillion Creek watershed and these units overlie the Pennsylvanian bedrock (Institute of Agriculture and Natural Resources 1986 24).

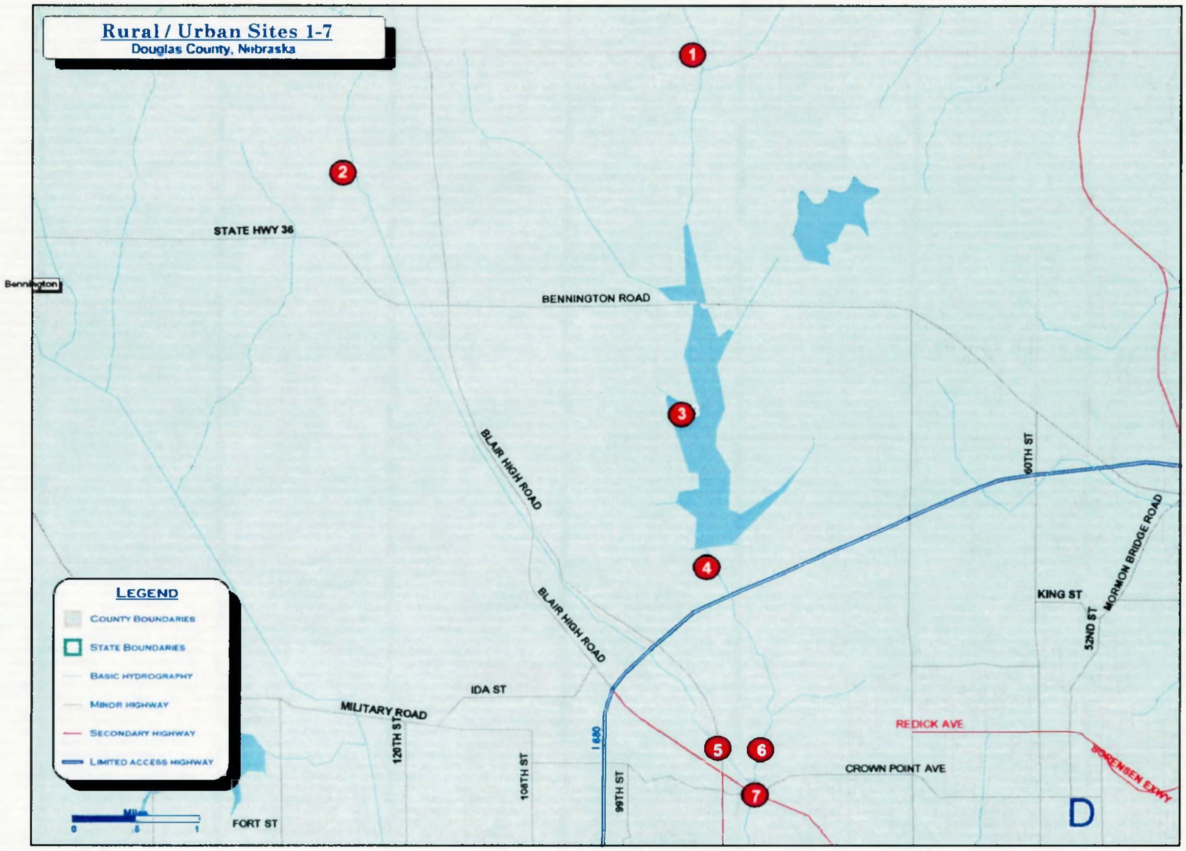
3.7 Land use

The Little Papillion Creek watershed was selected because of its proximity to Omaha and the rural-to-urban land use contrast, which it reflects. The rural portion is mostly an agricultural area with a small area dedicated to recreational uses. The main economic activity is crop agriculture (mostly corn) and cattle production. The urban area is comprised of residential neighborhoods, retail establishments, and light industry. The southern portion of the watershed is classified as industrial. Additional detailed descriptions of land use are included in the following section.

3.8 Sample Sites

3.8.1 Rural/Urban Sites 1-7

FIGURE 4. RURAL/URBAN SITES 1-7

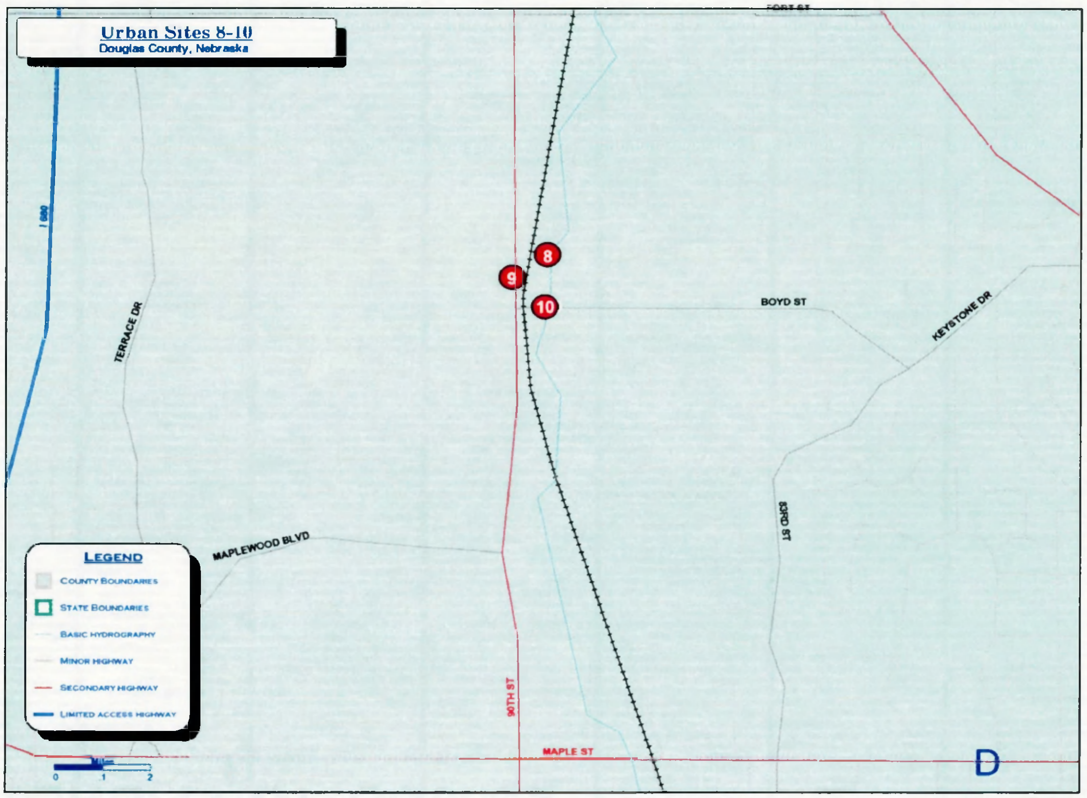


Sites 1-7 are located in generally rural areas (figure 4). Sites 1 and 2 are located in an area surrounded by agricultural land use. Approximately, 500 meters up stream from Site 1 on the Little Papillion Creek is a feedlot with fifty head of cattle. The sample site is located at a bridge along a gravel covered Dutch Hall road. Just south of Site 1 there is a wildlife area. Site 3 is at Lake Cunningham, which is fed by tributaries associated with agricultural areas. It is located at a fishing platform, approximately at the midpoint of the Lake. The lake shoreline in this area is protected from wave erosion by large rocks and broken pieces of concrete. Sample Site 4 is just below the dam site just north of State Street. The only source of water for this site is overflow from Lake Cunningham. The site is located approximately 200 meters from the dam. Open, manicured grass fields surround the site. Sample Site 5 is on the fringe of the rural area. There are residential areas near by, but not within the immediate area adjacent to the creek. Site 5 is located northwest of the Wenninghoff Road and Vernon Street intersection. To the northwest of the site, approximately 100 meters, there is a Road and Maintenance Department facility responsible for street salting.

Two sites in this portion of the study area are located along Thomas Creek (sites 2 and 6). Sample Site 2 is near the headwaters of Thomas Creek, east of the Bennington Road, Highway 133 intersection. This area has roadside garbage scattered throughout the site, including part of an automobile. Sample Site 6 is located southeast of the Vernon Avenue and Irvington Road intersection. Upstream from this site is a rural area, along with a light industrial and retail area. Sample Site 7 is located 300 meters downstream from the convergence of Thomas Creek and the Little Papillion. This site is located northwest of the Wenninghoff Road and Military Avenue intersection.

3.8.2 Urban Sites 8-10

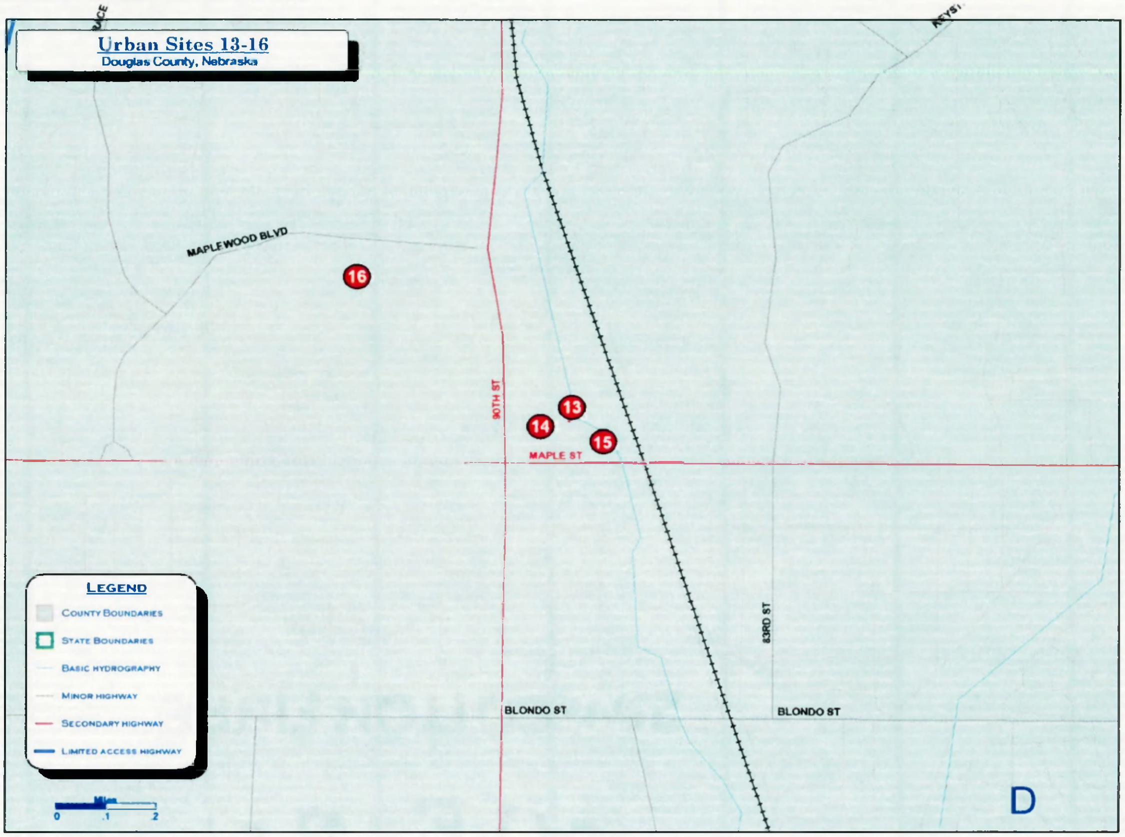
FIGURE 5. URBAN SITES 8-10



Sample Site 8 is located northeast of the Boyd and 90th Street intersection (figure 5). This site is an underground outlet for residential street runoff. Sample Site 9 is on the Little Papillion Creek upstream from the inlet at Site 8. Site 9 is southwest of the 88th Street and Fowler Avenue intersection. This area is surrounded by a park in the immediate area and retail stores upstream. Sample Site 10 is located 300 meters down stream from Site 9, and is surrounded by parkland.

3.8.3 Urban Sites 13 – 16

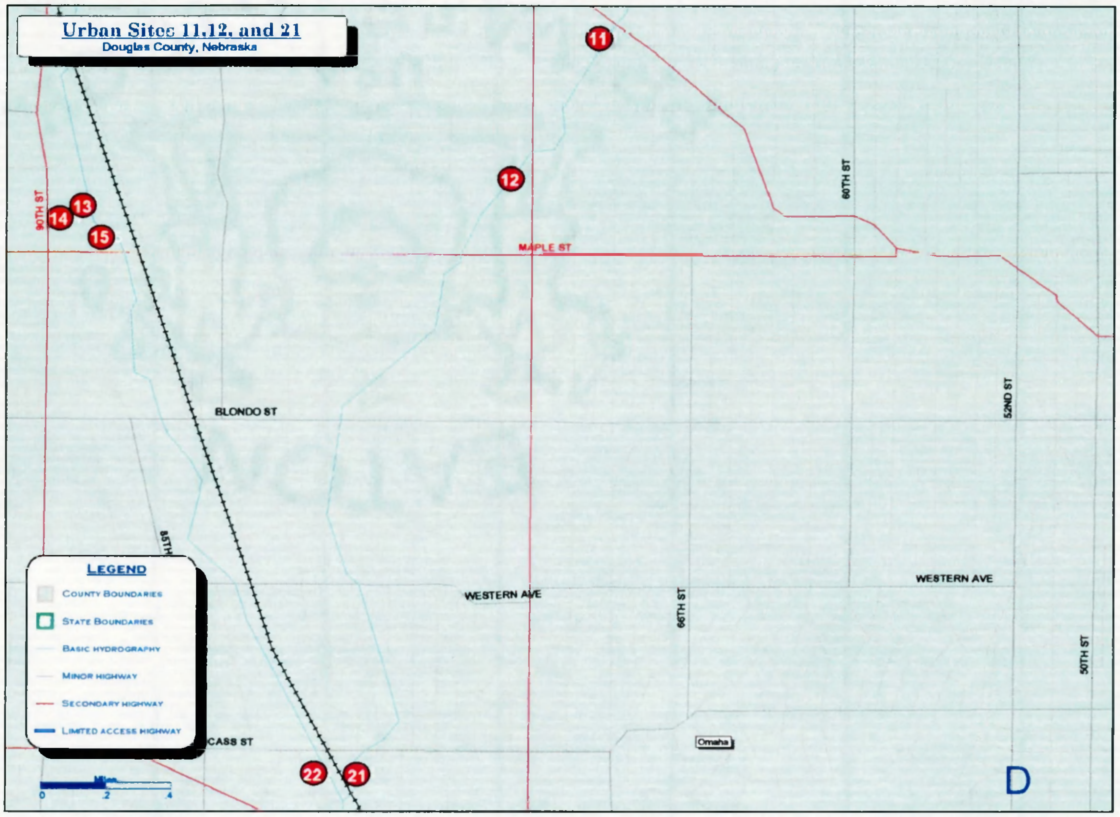
FIGURE 6. URBAN SITES 13-16



Sample Site 13 is located along the Little Papillion Creek northeast of 90th and Maple Street (figure 6). The main land uses in this area are residential, industrial, and retail. Limestone rock lines the banks for erosion control. Sample Site 14 is located in the same vicinity as 13. Site 14 is downstream from Site 16 and drains residential areas along with a small retail area. Site 15 is 300 meters down from the other two sites. Sample Site 16 is located upstream from Site 14 at the intersection of Maplewood Boulevard and 96th Street. The main land use in this area is residential.

3.8.4 Cole Creek Sites 11, 12, and 21

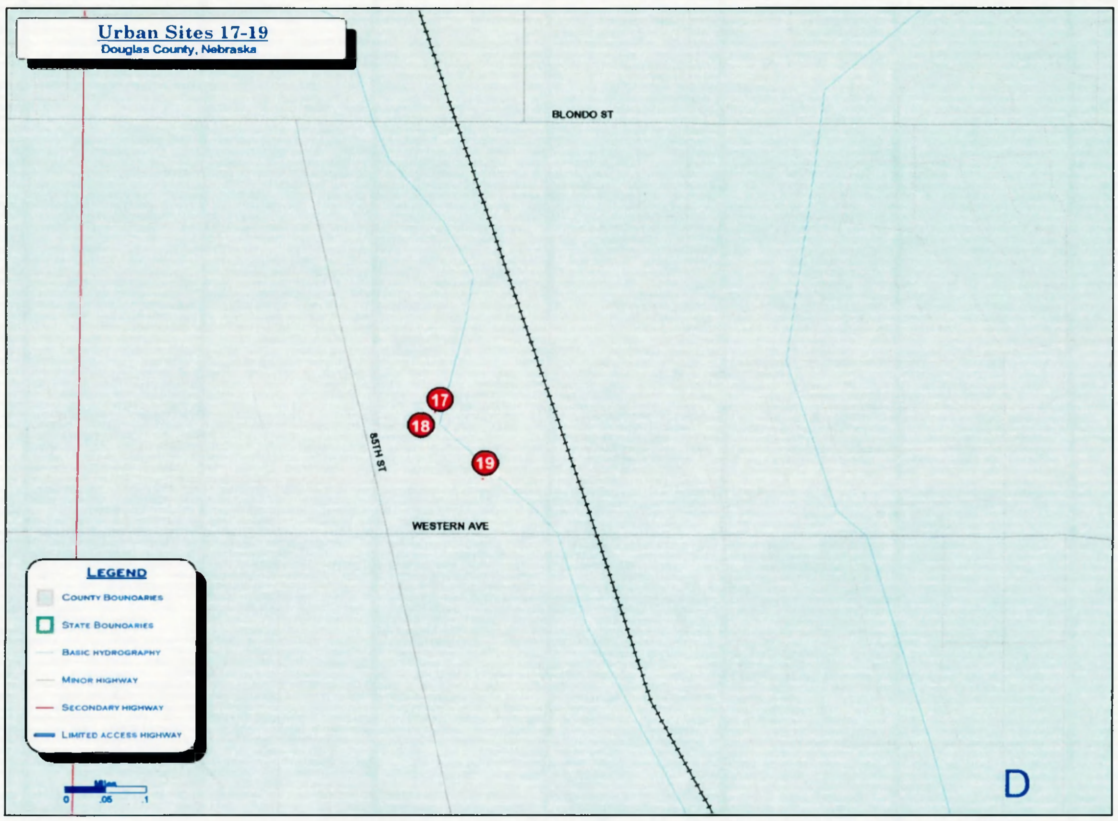
FIGURE 7. URBAN SITES 11,12, AND 21



The three sites along Cole Creek are Sites 11, 12, and 21 (figure 7). Sample Site 11 is located at the intersection of Cole Creek and Military Avenue. The land use in the area is residential and parkland. There is an abundance of garbage scattered throughout this site. Site 12 is located at the intersection of Cole Creek and Bedford Avenue. There is a small engine repair shop, open fields, and retail businesses in this area. Site 21 is at the mouth of Cole Creek, where it joins the Little Papillion Creek. The main runoff at this site is from surrounding parking lots and retail areas. Site 21 is located down stream on Cole Creek from Sites 11 and 12.

3.8.5 Urban Sites 17-19

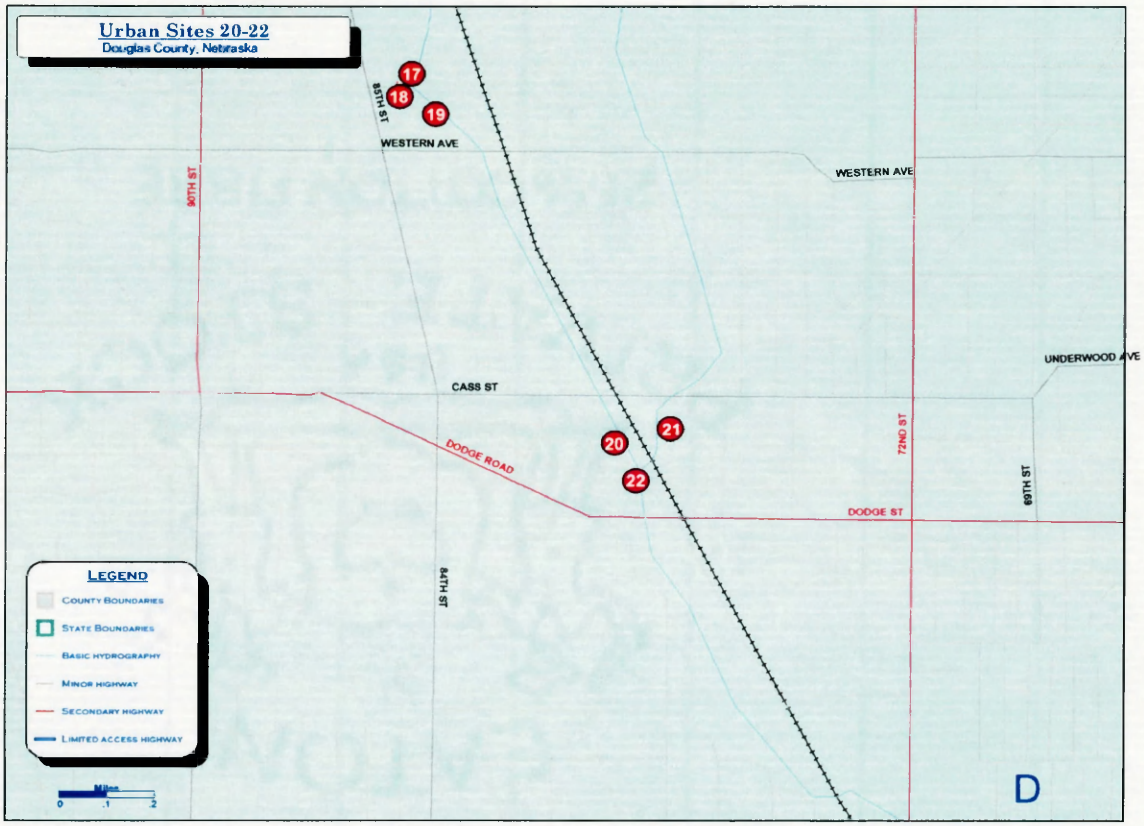
FIGURE 8. URBAN SITES 17-19



Sample Site 17, 18, and 19 are located in close proximity to each other (figure 8). These areas are on the east side of the 85th and Hamilton Street intersection. The land use in this area is residential and parkland. There are limestone rocks that are used for erosion control on the banks of the stream in this area. Site 17 is upstream from 18. Site 18 is an underground outlet for runoff from residential areas. Site 19 is located downstream 300 meters from the other two sites.

3.8.6 Urban Sites 20 – 22

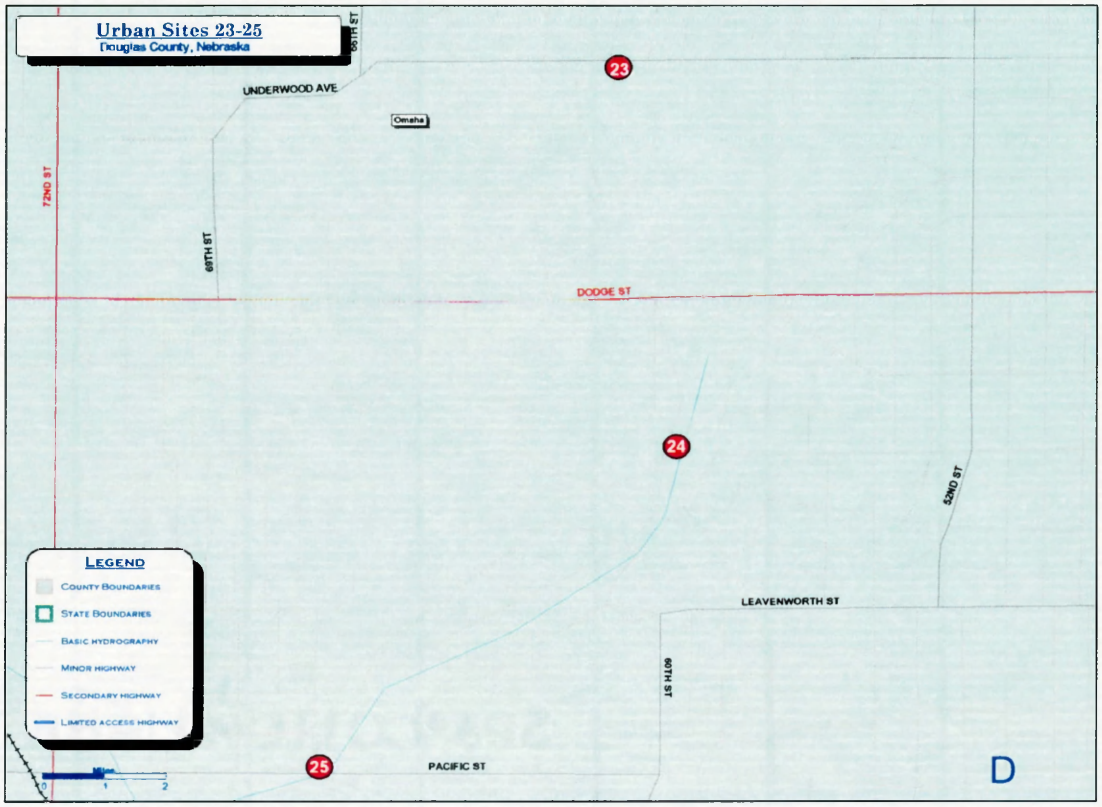
FIGURE 9. URBAN SITES 20-22



Sites 20, and 22 are located along the Little Papillion between Cass and Dodge Streets (figure 9). Land use in this area is mostly retail and light industry. The main runoff source feeding Little Papillion Creek in this area appears to be derived from area parking lots and roads. Site 20 is upstream on the Little Papillion from Site 22. Site 21 is located down stream on Cole Creek from Sites 11 and 12.

3.8.7 Elmwood Creek Sites 23-25

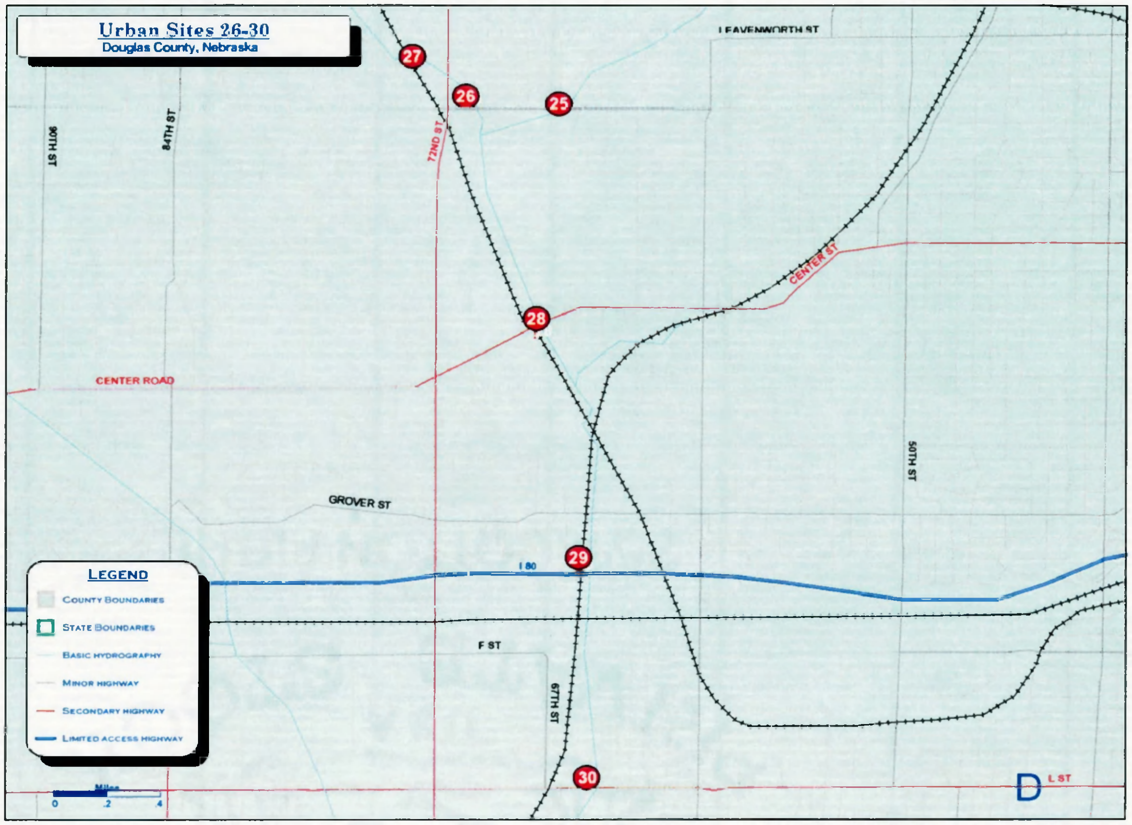
FIGURE 10. ELMWOOD CREEK SITE 23-25



The sample sites along Elmwood Creek are Sites 23 24, and 25 (figure 10). Site 23 marks the beginning of the above ground portion of Elmwood Creek. The location of site 23 is 59th Street and Underwood Boulevard. Elmwood Creek runs along the west side of Memorial Park from this site. Site 24 is located west of the Harney and Happy Hollow Street intersection. The University of Nebraska at Omaha is to the west of this site and a residential area is to the east. Site 25 is located where Pacific Street passes over Elmwood Creek near the southwest corner of Elmwood Park. A golf course and parkland are up stream from this site.

3.8.8 Urban/Industrial Sites 26-30

FIGURE 11. URBAN/INDUSTRIAL SITES 26-30



Site 26 is located east of the 72nd and Pacific Street intersection on the Little Papillion Creek (figure 11). The main land uses in this area are retail, light industrial and residential. The banks are lined with limestone for erosion control. Site 27 is located east of the Jackson and 75th Street intersection. Nebraska Furniture Mart is on the east side of the site and the main runoff appears to be from residential areas and the parking lots of retail stores. Site 28 is located at the intersection of West Center Road and the

Little Papillion Creek. The Aksarben complex is upstream and the main runoff appears to be from parking lots and streets. Site 29 is located underneath Interstate 80 and within a construction zone for the Keystone Trail. Site 30 is located at 64th and L Streets in an industrial area of Omaha.

4. LITERATURE REVIEW

4.1 Journals and Periodicals

Alexander (1993) argues for the integration of environmental protection into land use planning practices. The author states, "the present system of land use planning and environmental management doesn't even offer minimal environmental protection". The author gave a good description of why to implement more environmental regulation on land use, however, he did not describe how to do it. This article reinforces the validity of this thesis as a first step approach on how to integrate environmental analysis and land use.

Harbor (1994) discusses the impacts of urban runoff on natural ground water recharge. He provides information on how land use planners and environmental scientists work together in the assessment of runoff damage. The author discusses the importance of land use studies and regulation. This article provides an argument for land use planning and monitoring to help control increases in runoff. This is another article that expresses the importance of combining land use planning and environmental science; however, it does not explain the procedures to do so.

Soil and vegetation are known to provide a cleansing buffer for water by absorbing contaminates. Knapp (1991) discusses the recovery of soil and vegetation from severe human impacts, and the effect it has on water quality.

The article reveals the complexity and emphasizes the influence that land use has on water quality.

The EPA has made gains in monitoring point source pollution. Until the mid 1970's the EPA thought street run-off was virtually clean water. Krupp's (1990) article discusses the shift of emphasis of the organization to non-point source pollution, which again emphasizes the importance of this thesis research, and it helps to understand the factors related to shift in interest.

Well-kept golf courses may be beautiful, however certain communities are concerned about the use of pesticides and herbicides at their facilities. Kunihiro's (1990) article presents an example from Japan and explains why there is opposition to the building of golf courses in Japan. The golf courses are noted to contaminate well and surface water in some areas. This article describes environmental problems associated with golf courses in Japan, which also pertain to the courses present in the Little Papillion Creek watershed.

Likens (1991) outlines what he perceives to be the major areas people should be focusing on in terms of human impacts on environmental change. Land use changes associated with deforestation, urbanization, and transportation were on his list. He also gives inference to the impacts of toxification of the land and water, and helps explain the realm of environmental concern surrounding some land uses.

By looking at non specific point sources for runoff contaminants in urban areas, Field and Pitt (1990) determined that runoff from locations in urban areas have higher toxicity levels related to automobile-service facilities, unpaved industrial parking and storage areas, and paved industrial streets. This article targets some land uses of concern for this thesis.

Nazari and Burston (1991) conducted a study in the United Kingdom monitoring groundwater in drinking wells. The study area was once perceived to have clean drinking water, but the authors discovered contaminants in the water and directly linked them to area land use practices. This article displayed the effects of land use on the water cycle.

Almost any type of land use is a potential contributor of non-point pollution. Phillips (1988) discusses the importance of cleaning up non-point pollution sources. There are a few landscape designs and engineering structures the author introduces to help curb the pollution. This article reinforces the importance of land use regulation and the environment.

Thomas (1992) provided information about land use implications for environmental quality and agriculture sustainability. The objective of this research was to determine the effects of four land use systems (continuous alfalfa, forest, ridge-till corn, and conventional corn) on runoff, soil loss, and nutrient transport in runoff and sediment. This article reveals the spectrum of issues concerning agriculture and water quality associated with different agricultural practices.

Sutherland and McCuen (1985) discusses how urban runoff pollution directly results form debris and contaminants on streets, contaminates from open land areas, publicly used chemicals, air-deposited substances, ice control chemicals, and dirt and contaminants washed from vehicles. They also discuss what cities are doing to curb non-point pollution sources. The indicated the effectiveness of street sweeping was a significant variable. This article is directly related to the type of contaminates this proposal is targeting in the urban areas.

Wulkowicz and Saleem (1974) studied chloride concentrations within an urban basin in the Chicago area, and the relationship between chloride and the amount of urbanization in the basin, precipitation events and dilution capacity of the stream. Water quality in the basin during the study period was clearly affected by large applications of road salt. This article is also related to the expected results set forth in this thesis.

4.2 Books

Lazaro's 1990 book titled, Urban Hydrology: A Multidisciplinary Perspective, discusses many subjects pertaining to urban runoff and stream quality, with several chapters discussing land use changes. Lazaro addresses both non-point and point pollution, as well as modeling and control measures, which are topics related to the thesis.

Luken and Edward's (1977) book titled, Water Pollution Control, gave a good introduction to water pollution prevention and policies pertaining to run off. It presents background information of past water pollution control policies, water quality impacts from runoff from urban and agriculture areas, and policies and historic objectives of water pollution, all of which are topics relevant to this thesis.

Wagner's 1994 book titled, In Our Backyard, presents a general overview of many issues relevant to my study. He discusses the protection of surface waters, which includes several charts and diagrams of sources and contaminants. Also discussed are point and non-point source pollution, current management practices and other possible alternatives, and the problem of household based pollution. He also relates the problem of water pollution to land use practices, as well as presenting a list of the health effects of certain chemicals in drinking water.

The importance of correct procedures cannot be over-estimated because no matter how sophisticated the analytical equipment in the laboratory, it will only analyze the sample that is brought into the laboratory. Reeve's 1994 book titled, Environmental Analysis, discusses important issues to resolve before one ventures into the field. This information assisted in determining sampling methods used for this thesis.

5. RESEARCH METHODOLOGY

5.1 Sample Collection

To determine water quality in the Little Papillion watershed, water samples from thirty sites were collected once a month for the year 1996. The samples were analyzed within 72 hours of the time they were collected. Table 1 displays the water quality parameters tested in this study and Table 2 sample collection information.

Table 1. Water Quality Parameters

Parameter	**Method**	**Testing Location**
pH	Meter	Field
Temperature	Thermometer	Field
Total Dissolved Solids	Meter	Field
Nitrate	Reflectaquant	Laboratory
Phosphate	Reflectaquant	Laboratory
Potassium	Horiba Meter	Laboratory
Sodium	Horiba Meter	Laboratory
Chloride	Titration	Laboratory

Selection of the correct sampling methods was essential to this study. Pre-planning was accomplished by reviewing procedures outlined in the books Environmental Analysis (Reeve 1994), Environmental Chemistry (Oniel 1993), and water quality parameters and methods of analysis were selected that best fit my objectives.

TABLE 2. SAMPLE COLLECTION

Sites	30
Sampling Device	0.5 liter plastic bottle
Sampling Design	The sites were selected using a "Judgmental" approach (Keith 1991 16), meaning a visual assessment of technical judgment was used to strategically place samples throughout the Little Papillion watershed. The sample site selection was designed to aid in the assessment of an area's land use impacts on stream quality.
Sampling Procedure	The sample device was rinsed three times before the sample was taken. The water was then sampled from the center of the stream horizontally and vertically. At an area where mixing occurs (example: secondary stream flowing into main stream) the sample was taken 300 meters downstream to ensure proper mixing (Reeve 1994, 52). The sample was immediately placed in a cooler, and put in refrigerator at the conclusion of the sample collection.

5.2 Field Analysis

The hydrologic variables tested in the field include pH, Total Dissolved Solids (TDS), and Temperature (C°). All parameters were tested; using a solid-state meter, either directly from the stream or immediately after water was taken from source.

5.3 Laboratory Analysis

Collected samples were stored in a cooler during collection and immediately placed in the refrigerator in the Geography/Geology department. Stored samples were allowed to reach room temperature before they were analyzed using the methods below.

5.3.1 Nitrate (NO_3 and NO_3-N)

Nitrates were measured using the Reflectoquant meter. In this method, a reduction agent reduces Nitrate to nitrite. In the presence of an acidic buffer, the nitrite reacts with an aromatic amine to form a diazonium salt, which in turn reacts with N-(1-naphthyl)-ethylene-diamine to form a red-violet azo die, the concentration of which is determined reflect-ometrically . The results are displayed in parts per million (ppm). The NO_3 reading was reduced to NO_3-N by multiplying the obtained reading by a factor of 0.2258 (www.epa.org). NO_3-N is the amount of nitrogen in the nitrate form.

5.3.2 Phosphate (P)

Phosphate (P) was measured using the Reflectoquant meter. In this method, a solution acidified with sulfuric acid orthophosphate ion (PO43-) and molybdate ions form molybdophosphoric acid. This is reduced to phosphomolybdenum blue (PMB), the concentration of which is determined reflectometrically.

5.3.3 Potassium (K)

Potassium (K) was measured using a calibrated Horiba Ion selective meter and the results were displayed in Parts Per Million (PPM).

5.3.4 Sodium (Na)

Sodium was measured using a calibrated Horiba Ion selective meter and the results are displayed in parts per million (PPM).

5.3.5 Chloride (Cl)

Chloride was measured using the titration method according to the American Public Health Association (1980) standards. A 50-ml sample were titrated using the mercuric nitrate (Hg $(NO^3)^2$) method. 1.0 ml of acidifier and

1.0 ml of nitric acid were added to the 50-ml sample to produce a light green solution. The solution was titrated with mercuric nitrate until an endpoint (dark purple) was reached. The amount of mercuric nitrate titrant was entered into the following formula:

Chloride mg/L = (A-B) x N x 35,450/ ml sample (50 ml)

A = ml of acid solution used to achieve a pH of 4.5

B = 0.6

N = 0.0141

5.4 Land Use Parameters – Business and Residential Population Data

Business and Residential address information were attained from InfoUSA, of Omaha, Nebraska. The address data were geo-coded and displayed using ESRI's ArcView GIS. Once the data were displayed in the GIS program, the business and residential data were selected by plotting a 1000-meter buffer around each sample site. Only, data upstream from the site were selected. The number of residents and businesses associated with each sample site were used as the land use variable in the correlation analysis. The complete data sets are displayed in the Objective C portion of the Appendix displayed at RES (residential) and BUS (business).

5.5 Statistical Analysis

To determine objectives A and B, averages were computed and plotted on a graph using Microsoft Excel. Averages for both rural and urban site results where computed using the overall, tributaries, non-tributaries, spring, summer, fall and winter.

To determine objective C, Pearson's correlation coefficients were calculated using Microsoft Excel statistical package. The formula is as follows:

$$r = \frac{\Sigma XY - \frac{\Sigma X \Sigma Y}{N}}{\sqrt{(\Sigma X^2 - \frac{(\Sigma X)^2}{N}) \quad (\Sigma Y^2 - \frac{(\Sigma Y)^2}{N})}}$$

In addition, the logarithmic transformation and the reciprocal function were performed using Microsoft Excel statistical package. Then the two-tailed significance was determine by using the critical values chart the Pearson's correlation coefficient in Appendix VII of, Statistical Techniques in Geographical Analysis, (1994). Scatter plots were then generated for all values with a significance of 0.05 and 0.01. Scatter plots were generated using Microsoft Excel.

5.6 Seasonal Classification

For the purposes of this thesis the seasons were divided as follows:

Winter – December, January, February
Spring – March, April, May
Summer – June, July, August
Fall – September, October, November

6. RESULTS

The following section will discuss the compiled results pertaining to objectives stated in section 2.3 of this thesis. Not all of the values will be discussed in this section. Instead, only the values deemed to be most important in the scope of this thesis will be presented. The results for phosphate will not be discussed because the values did not produce correlations with the number of businesses and residents. The standard field tests (temperature, pH, and TDS) and phosphate values are presented in the appendix.

First, the results related to Objective A will be discussed which attempts to find the relationship between the potassium and nitrate levels of rural and urban study sites. In addition, the results related to Objective B, which examined the Chloride and Sodium levels between the rural and urban sites, will be discussed. Finally, the results of Objective C, which examined the correlation between the Chloride, Sodium, Potassium, Nitrate and the number of residents and businesses, will be discussed.

Temperature and precipitation data during 1996 are presented month-by-month and seasonally to aid in the discussion of results.

FIGURE 12. MEAN MONTHLY TEMPERATURE – 1996
SOURCE: NATIONAL WEATHER SERVICE

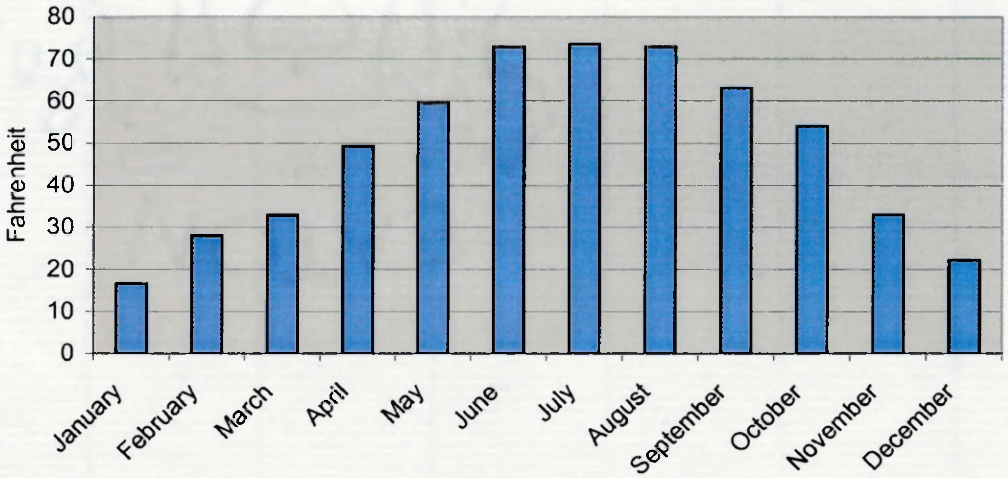


FIGURE 13. AVERAGE MONTHLY PRECIPITATION – 1996
SOUCE: NATIONAL WEATHER SERVICE

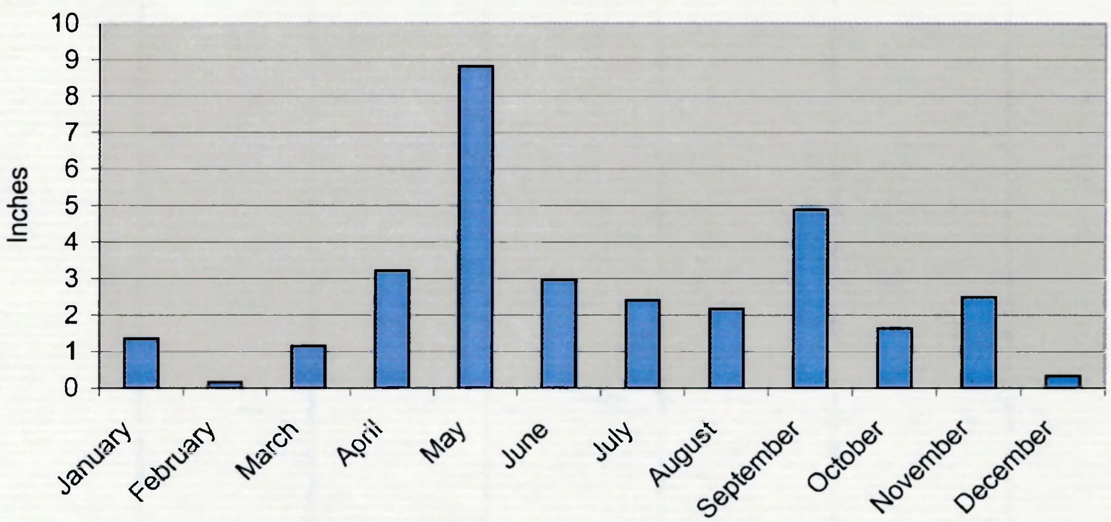


Figure 14. Seasonal Temperature Average

Source: National Weather Service

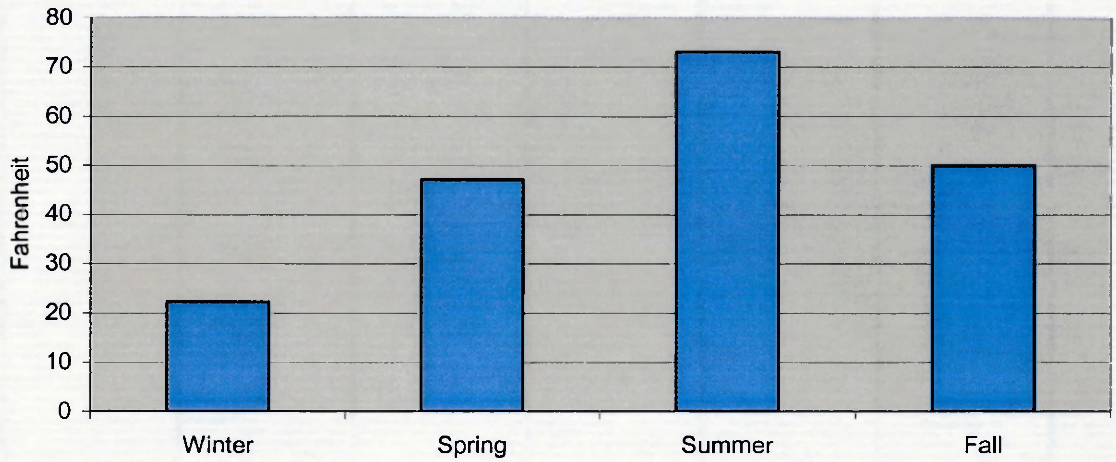
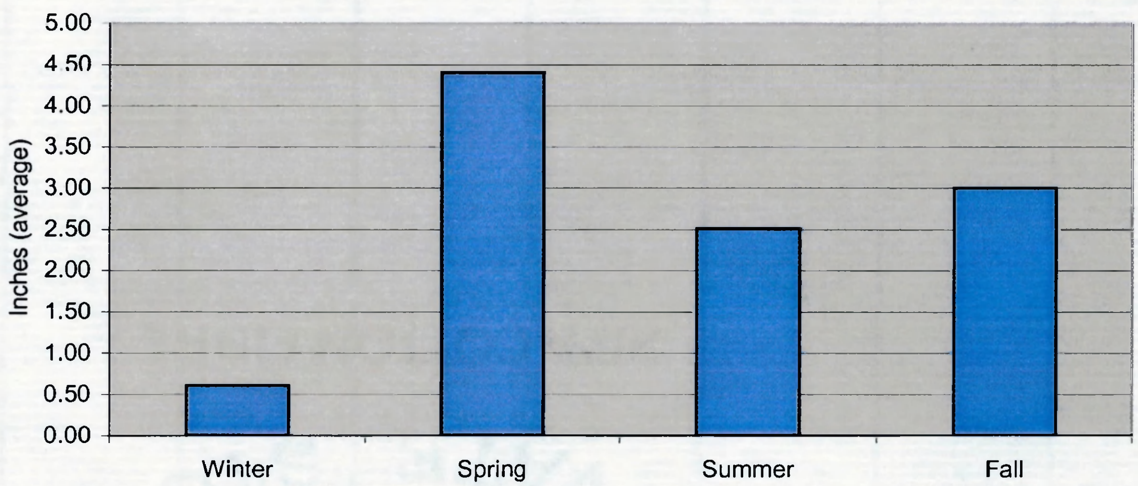


Figure 15. Seasonal Precipitation Average

Source: National Weather Service



6.1 Results of Nitrate and Potassium in the Rural and Urban Sites

The first objective of this thesis was to determine if the rural areas (sites 1-7) of this study area where associated with higher levels of nitrate and potassium. For both chemical constituents, the overall, tributary, non-tributary, and seasonal results all revealed that levels of nitrate and potassium were higher for the rural sample sites for each chemical constituent, with the exceptions being the average potassium levels in the winter and spring. These trends are depicted in figures 16 and 17, and the entire data set is in the appendix.

FIGURE 16. OBJECTIVE A – NITRATE
(SEE APPENDIX FOR COMPLETE RESULTS)

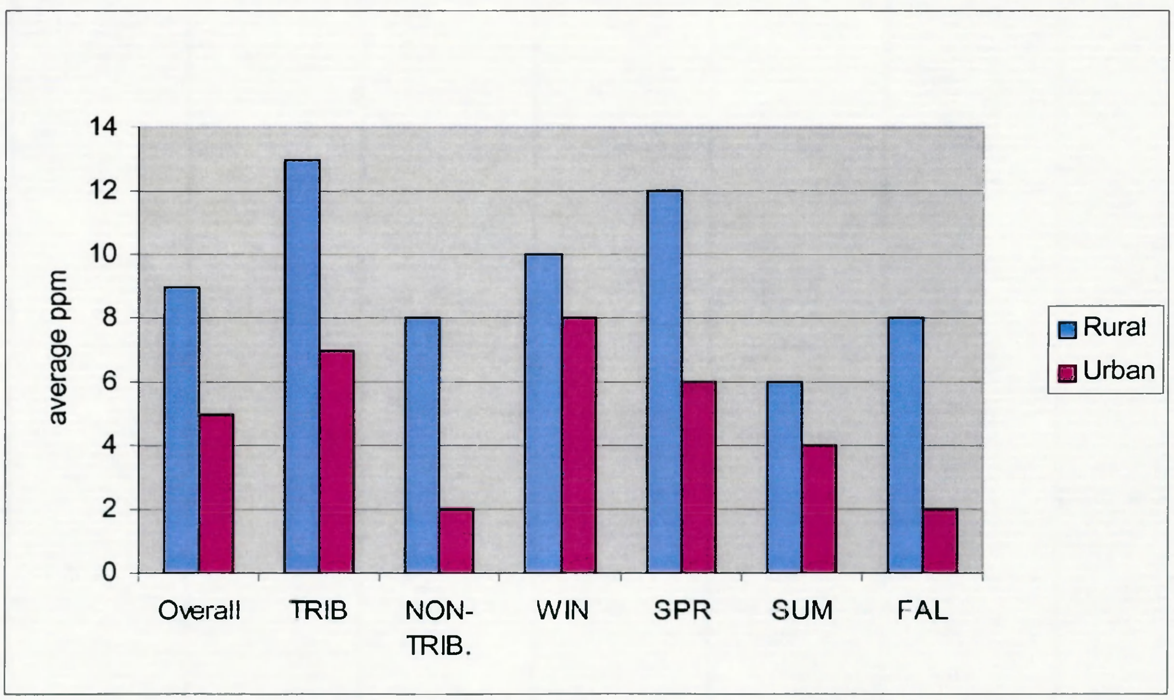
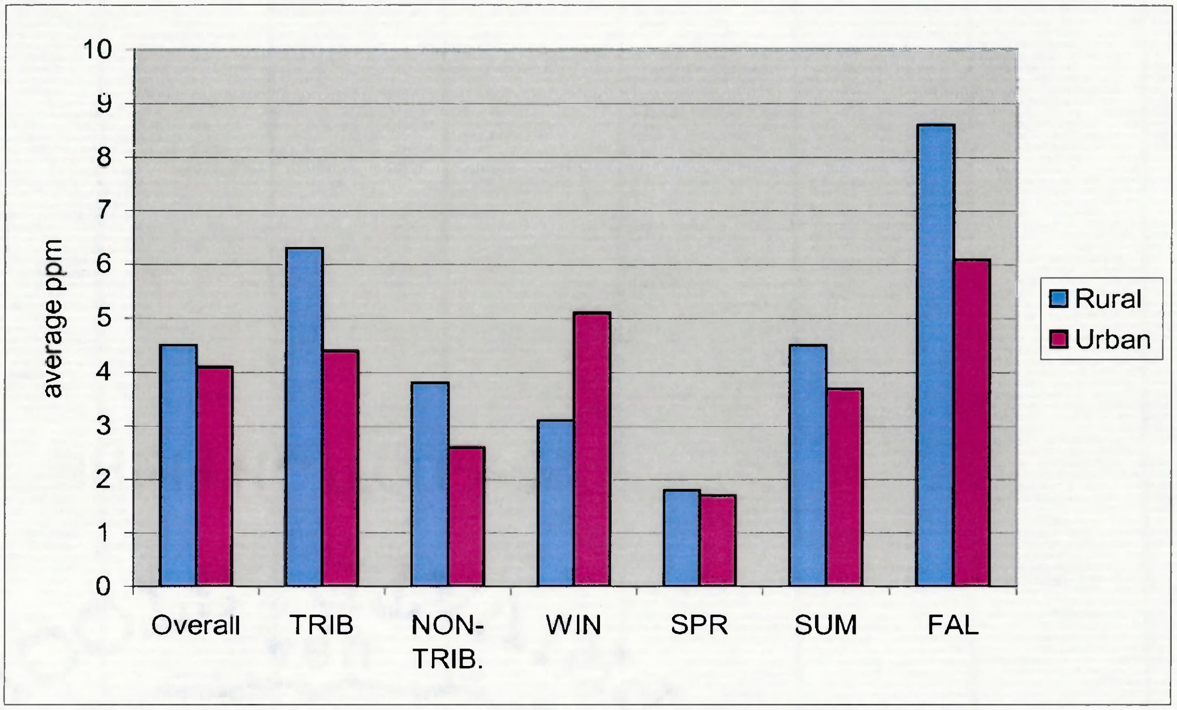


FIGURE 17. OBJECTIVE A – POTASSIUM
(SEE APPENDIX FOR COMPLETE RESULTS)



6.1.1 Overall Results

Nitrogen and potassium in the form of fertilizers are applied to fields to enhance crop production. Bacteria in the soil convert various forms of nitrogen to nitrate, a nitrogen/oxygen ion ($N0_3$). Nitrogen, when applied in excess of crop needs, can flow into aquatic ecosystems (EPA Website, 2002). In addition, "an open feedlot receives about 300 tons of manure containing 24,000 pounds of nitrogen per acre, per year (Sweeten, Baird, Manning 1991?). The seven rural sites averaged 9 ppm nitrate ($N0^3$ – N) while the twenty-three urban sites averaged 5 ppm for the entire year. Clearly, the results reveal the association of this farming practice and the higher levels of these chemicals in the rural area.

6.1.2 Tributary Results

There were several sample sites located on tributaries (sites 2, 6, 8, 11, 12, 14, 16, 18, 21, 23, 24, and 25) of the Little Papillion Creek. These sites had highest mean levels of potassium and nitrate associated with them. The rural tributaries (sites 2 and 6) had an average of 13 ppm for the entire year. This was the highest average out of the seven categories (overall, tributary, non-tributary, spring, summer, fall, and winter) that the sample set was divided into. The urban tributaries (sites 8, 11, 12, 14, 16, 18, 21, 23, 24, and 25) averaged 7 ppm, or six ppm lower than the rural. The non-tributary (which reflects samples collected along the main channels of the Little Papillion Creek) urban sites had the lowest averages of 2 ppm, while the rural sites averaged 8 ppm. Clearly the urban sites averaged lower concentrations of nitrate.

It's also important to discuss the apparent dilution process as the tributaries flow in to the main channel of the Little Papillion Creek. As the tributary water flows into the main portion of the creek it mixes with a higher volume of water that dilutes the concentration of the dissolved load in the tributary streams water. The results show this process in that the tributaries average the highest concentration of Nitrate.

6.1.3 Seasonal Results - Nitrate

The results were also categorized temporally by dividing the sample sets seasonally to reveal any seasonal trends that are associated with higher concentrations of nitrate and potassium. The rural sample sites produced higher levels of nitrate for all four seasons. The rural sites in the spring produced the highest readings averaging 12 ppm. This is typically a time when farmers fertilize their land as part of the spring planting process. The lowest average for the rural sites was in the summer at 6 ppm. Again, typically this is when precipitation volumes are decreasing (see figure 15) and spring runoff has already removed any available nitrate. The highest concentration of nitrate for the urban sites was an average of 8 ppm during the winter months, and the lowest was 2 ppm in the fall. It is unclear why the winter had the highest reading; however, it most likely has to do with the weather at that time. Typically farmers and homeowners will fertilize in the spring and fall; however, depending on the weather, this may vary by changing the their schedule earlier or later in the year (ie: winter). Also, snow melting and spring rains can have an effect when run-off into the surface water occurs which in turn affects the chemical concentration of the streams.

6.1.4 Seasonal Results – Potassium

Potassium is also a byproduct of fertilizer and is used in similar ways as nitrogen. The results for potassium revealed the rural sites averaged higher concentrations of potassium then the urban, although it was only slightly higher (see figure 17). The trends in the results were similar between the nitrate and potassium with the exception of the winter samples. The urban sites had a higher average then the rural during the winter months. This makes sense because potassium chloride is used as a de-icing agent during the winter months. The highest average for the rural sites was 8.6 ppm during the fall and the lowest was in the spring at 1.8 ppm. The highest mean for the urban sites was 6.1 ppm for the Fall and the lowest was 1.7 ppm for the Spring. The elevated potassium concentrations in the fall may reflect the application of fertilizer in both the rural and urban areas. The spring had the lowest concentrations and based on the weather data; this may be due to the high volume of precipitation during this season (see figure 15). The potassium may have already been flushed from the soil and any additional runoff will dilute its concentration in the stream.

6.2 Results of Sodium and Chloride in the Rural and Urban Sites

The second objective was to determine if the urban sites (sites 8-30) in the Little Papillion Creek watershed were associated with higher levels of chloride and sodium as compared to the rural sites.

For both constituents, the over-all, tributary, non-tributary, and seasonal results, all revealed the levels of sodium and chloride were higher in the urban sites. This data is depicted in figures 18 and 19. The temporal trend for both sodium and chloride is very similar for the entire study.

FIGURE 18. OBJECTIVE B – CHLORIDE
(SEE APPENDIX FOR COMPLETE RESULTS)

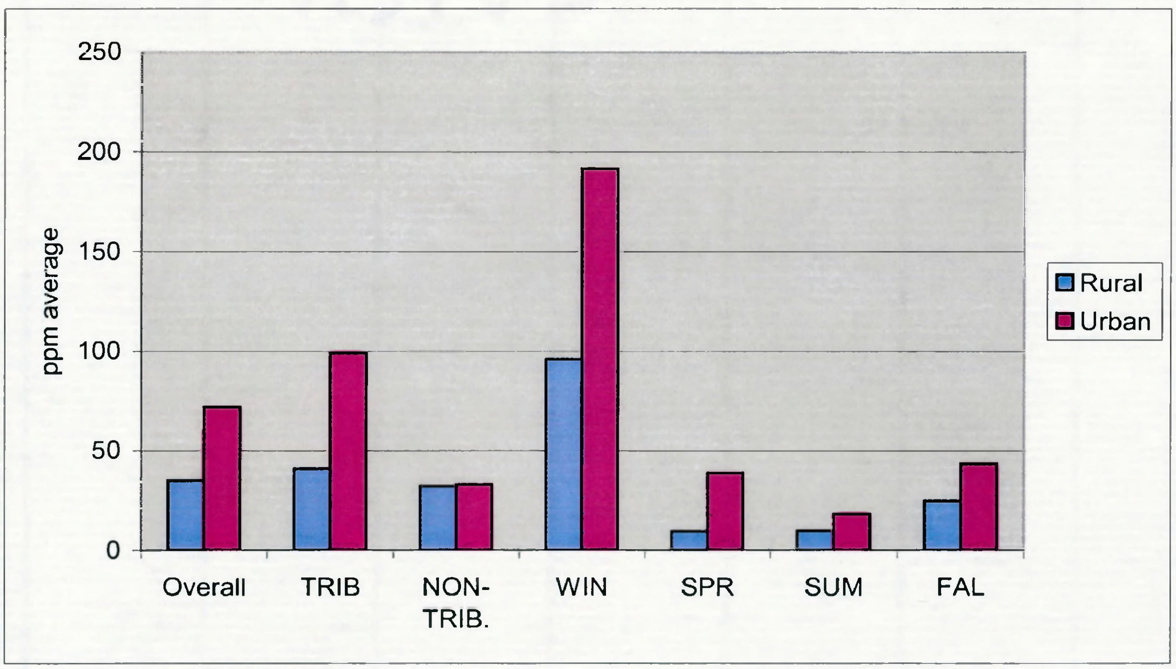
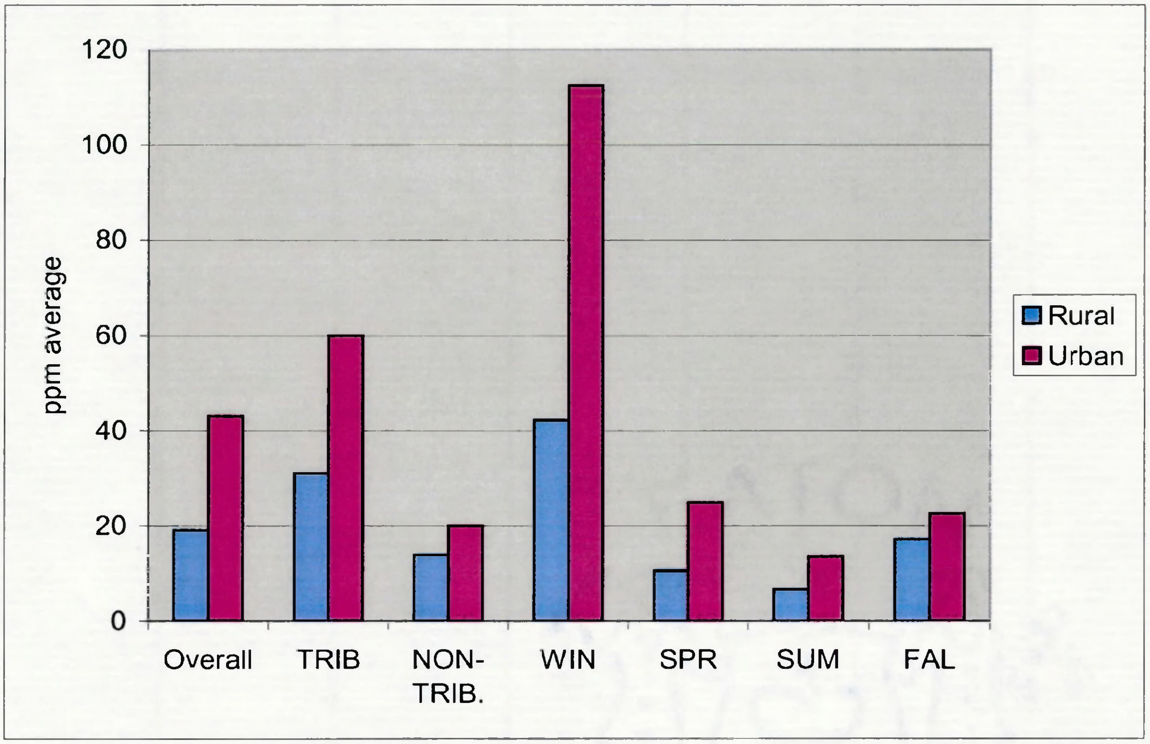


FIGURE 19. OBJECTIVE B – SODIUM
(SEE APPENDIX FOR COMPLETE RESULTS)



6.2.1 Overall Results

Chloride and Sodium are associated with urban non-point source pollution, with both of these constituents used as part of the de-icing of area streets. During this process snow melt results in run-off flowing into surface streams. The runoff during melting events results in potentially large quantities of sodium and chloride flowing into the Little Papillion Creek drainage system, which from an environmental standpoint can lead to fish kills and unbalanced water composition.

For chloride, the over-all average for the sites associated with rural areas was 35ppm. The overall average for the sites in the urban areas was 72 ppm. The overall sodium average for the sites in the rural areas was 19 ppm and 43 ppm in the urban areas.

6.2.2 Tributary Results

Similar to the nitrate and potassium results, the chloride and sodium tributaries have higher concentrations then non-tributaries. The average for the sites associated with rural tributaries for chloride was 31 ppm versus and 60 ppm for the urban. The sites associated with non-tributary areas and substantially lower, with the average for the rural area being 14 ppm, and 20 ppm for the urban sites. The urban areas are higher because of the wider use of chemical de-icing agents. In addition, the tributaries have higher concentration in both the rural and urban because of the limited amount of dilution that occurs in the tributaries compared to the main channel.

6.2.3 Seasonal Results - Sodium and Chloride

With the main source of urban non-point source pollution for both sodium and chloride being de-icing agents used in the winter, the highest averages occur therefore in the winter season for both the rural and urban area. For the winter season, chloride averaged 92 ppm for the rural sites and 192 ppm for the urban. The sodium averages for the winter season were 42 ppm for the rural sites and 112 ppm for the urban.

6.3 Correlation Analysis Results

The final objective was to determine how the water quality of the Little Papillion Creek, as it progresses from the rural area into and through an urban area, changes in relation to population density. The results were generated by correlating the selected chemical constituent data with the number of business and people within the Little Papillion Creek watershed.

Business and residential areas have certain characteristics associated with them. Both have larger amounts of impermeable surfaces like rooftops and pavement. Typically they both have some green space, or a permeable surface such as a lawn, or green space where water and nutrients infiltrate into the ground and into the hydrologic system. Furthermore, residential areas are associated with more green space than business districts. The amount of green space can influence the nitrate and potassium concentration based on levels of fertilization. The amount of pavement affects the chloride and sodium concentration levels, especially in the winter months due to the runoff of de-icing agents. In addition, impermeable surfaces affect the rate at which all the chemical constituents can be deposited into the surface water by run-off.

Pearson's correlation coefficients (*r*) were calculated to determine the strength of relationship between water quality data and business and residential data. The calculated *r* values are presented in the following tables, with the letter V representing the *r* value for data that was not transformed. The data for the reciprocal transformations *r* values are represented as the letter R, and the logarithmic transformation *r* values are represented by the letter L. These values are combined with letters representing each of the chemical constituents. The letter C represents chloride, S represents Sodium, P represents Potassium, and N represents Nitrate. Additionally, each of the seasons are represented at follows; WIN as winter, SPR as spring, SUM as summer, and FAL as fall. The significance of the correlation are presented at the 0.05 level in red and 0.01 level in blue. Scatter plots will only be provided for values with a level of significance of 0.05 or higher. A key is provided below each table for reference.

TABLE 3. OVERALL CORRELATION VALUES

	VC	LC	RC	VS	LS	RS
Business	0.0957	0.7306	-0.3041	0.0929	0.6035	-0.3478
Residential	0.3567	0.7796	0.7673	0.4087	0.7019	0.6888
	VP	LP	RP	VN	LN	RN
Business	-0.3433	-0.1860	-0.2244	-0.4453	-0.4351	-0.4267
Residential	-0.1354	-0.1414	0.0563	-0.1847	-0.3020	-0.0756

C=chloride S=Sodium P=Potassium N=Nitrate
L=Logarithmic Function R=Reciprocal Function V=Un-transformed R Value
Significance Level of .05 = RED and .01 = BLUE

Figure 20. Overall Chloride Residential Scatter Plot

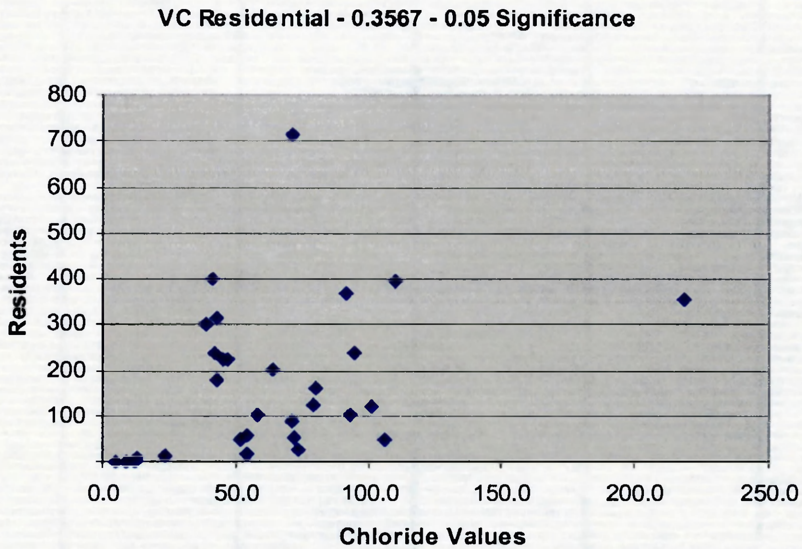


Figure 21. Overall Log Transformation for Chloride Business Scatter Plot

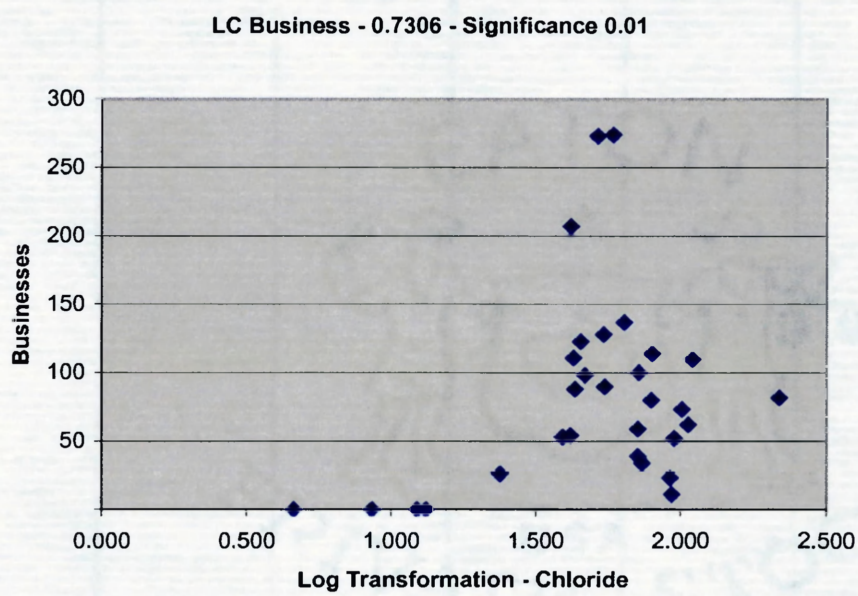


FIGURE 22. OVERALL LOG TRANSFORMATION FOR CHLORIDE RESIDENTIAL SCATTER PLOT

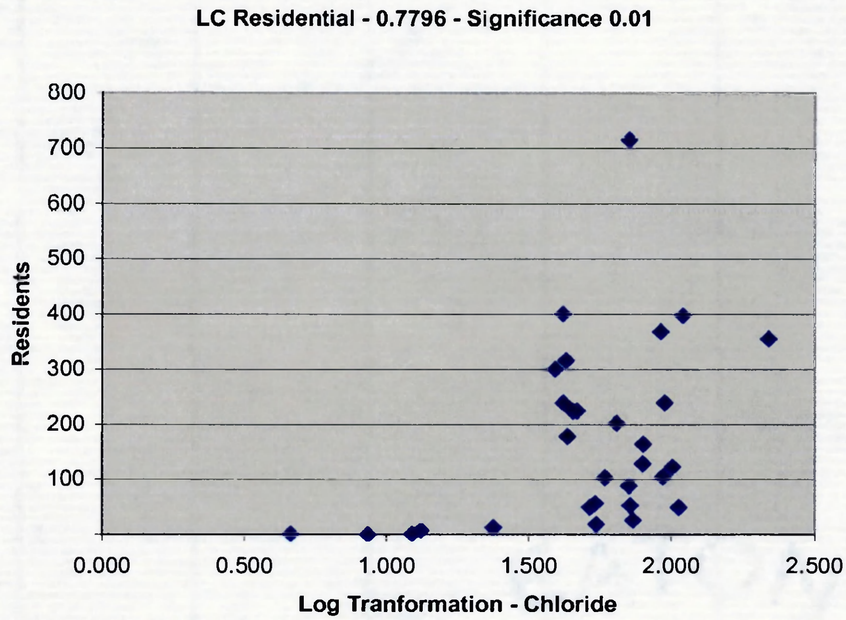


FIGURE 23. OVERALL RECIPROCAL FUNCTION FOR CHLORIDE RESIDENTIAL SCATTER PLOT

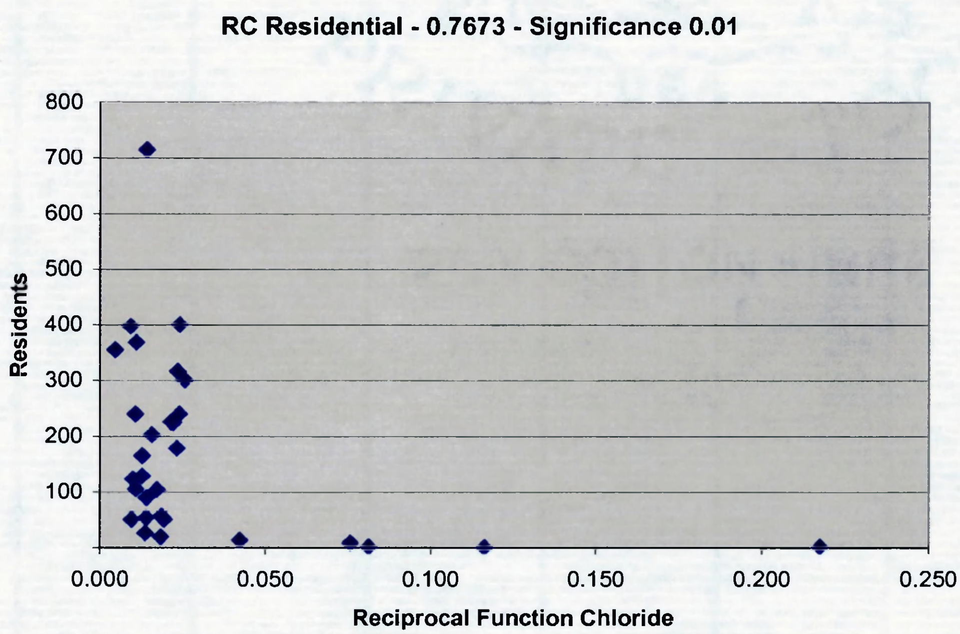


FIGURE 24. OVERALL SODIUM RESIDENTIAL SCATTER PLOT

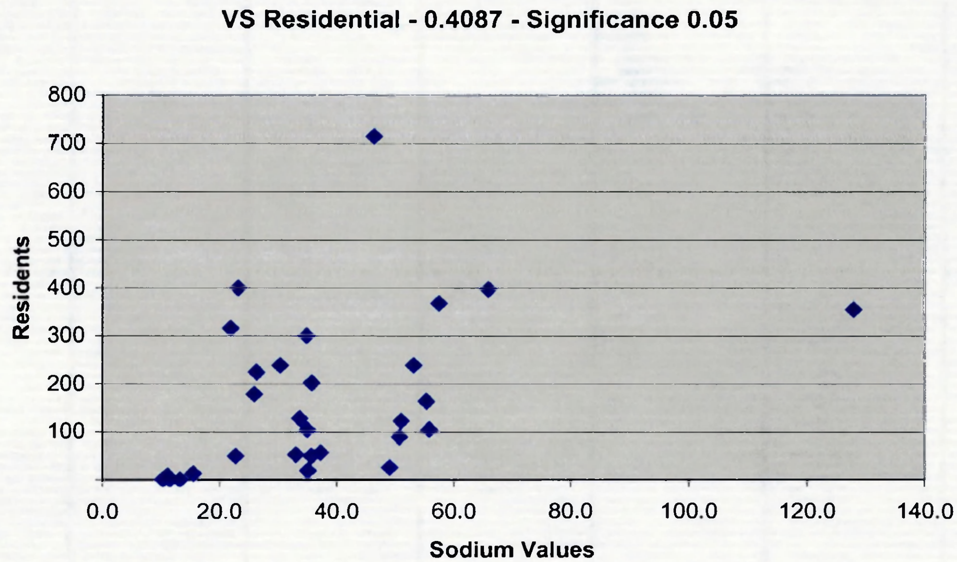


FIGURE 25. OVERALL LOG TRANSFORMATION FOR SODIUM BUSINESS SCATTER PLOT

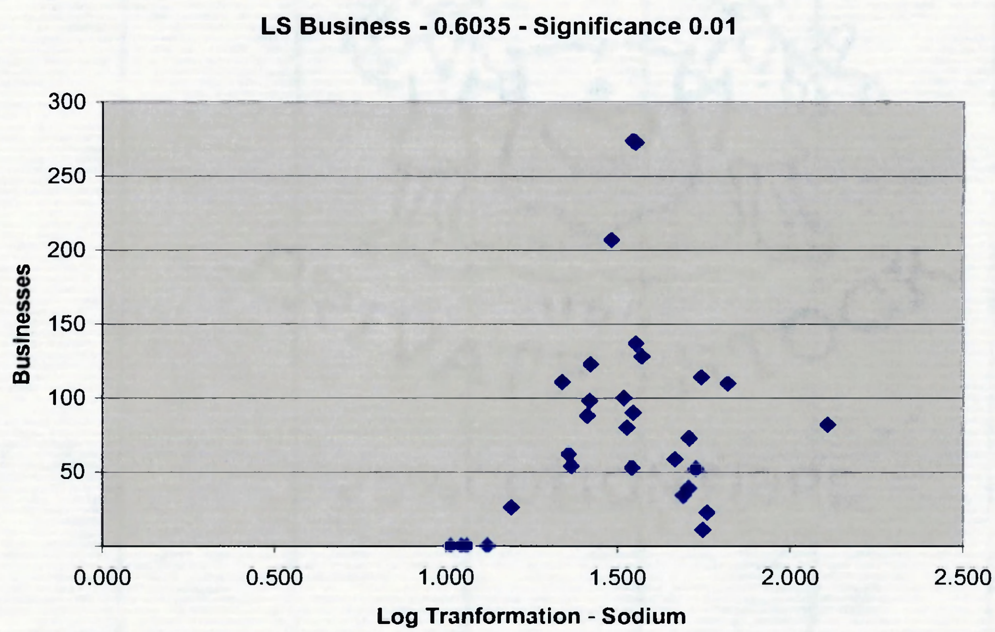


Figure 26. Overall Log Transformation for Sodium Residential Scatter Plot

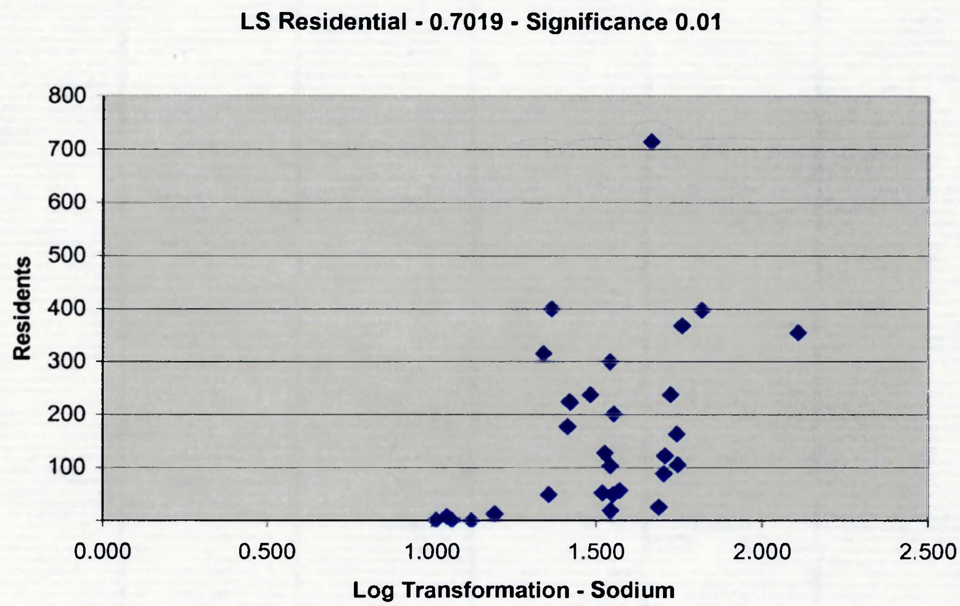


Figure 27. Overall Reciprocal Function for Sodium Residential Scatter Plot

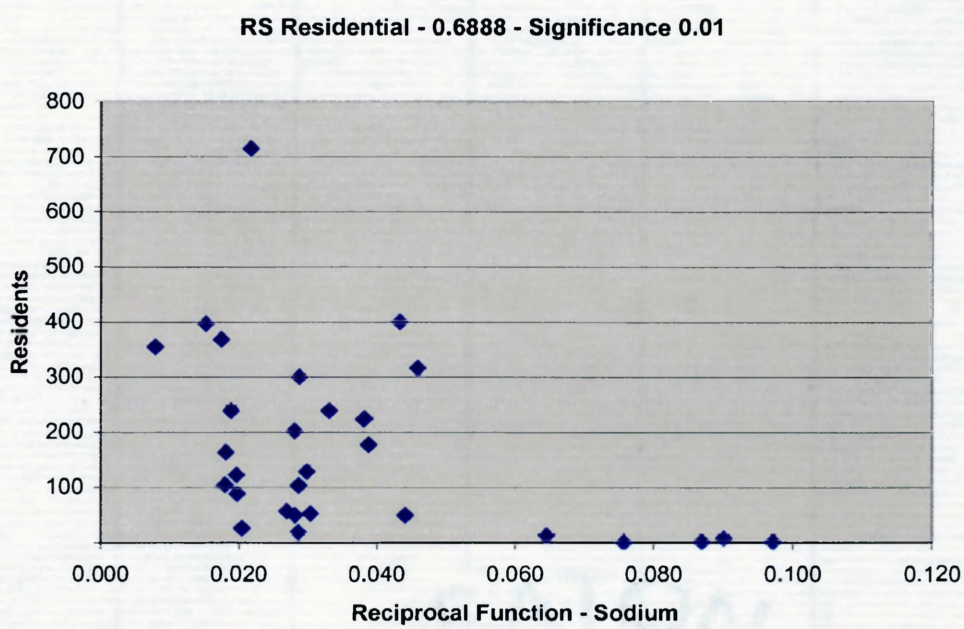


Figure 28. Overall Nitrate Business Scatter Plot

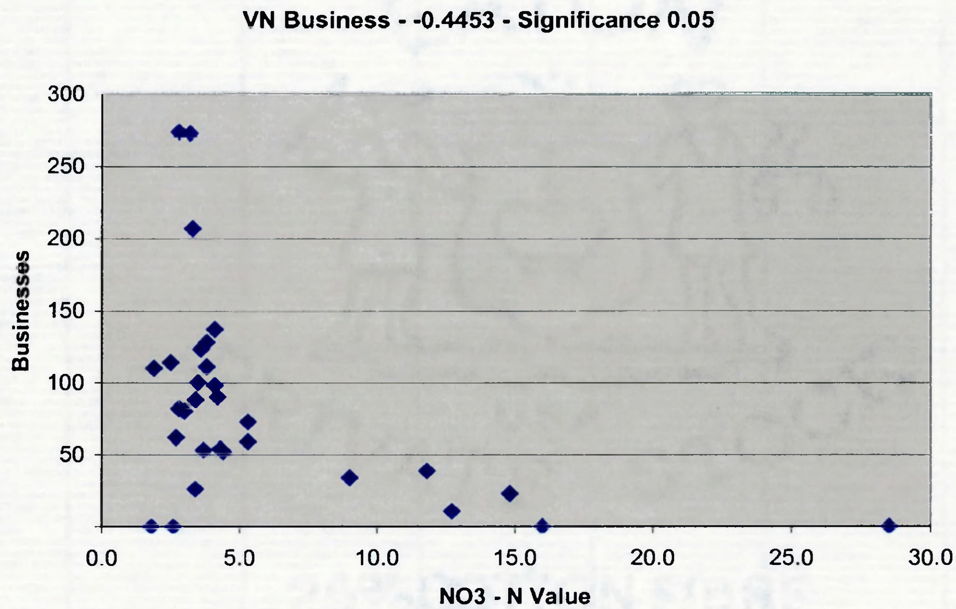


Figure 29. Overall Log Transformation for Nitrate Business Scatter Plot

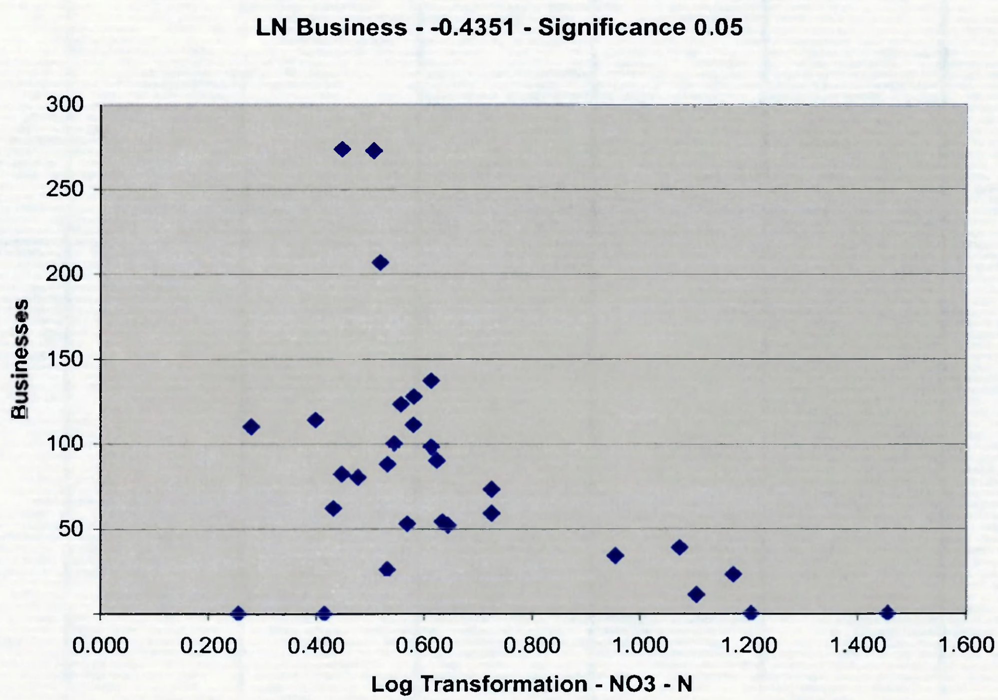
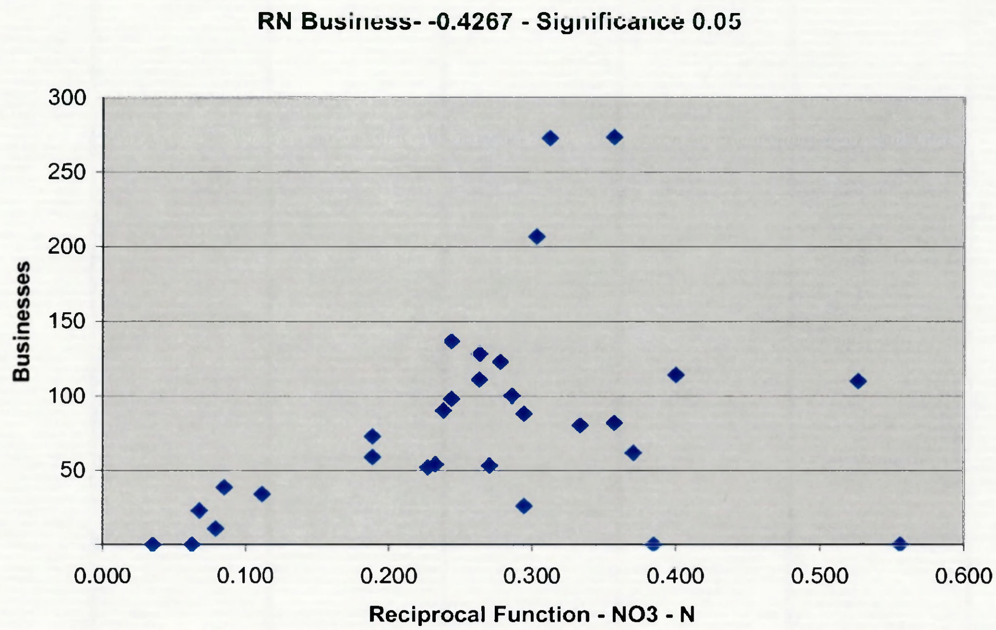


FIGURE 30. OVERALL RECIPROCAL FUNCTION FOR NITRATE RESIDENTIAL SCATTER PLOT



6.3.1 Overall Correlation Results

Examination of Table 3, and the scatter plots (Figures 20 to 27) indicates a positive correlation associated with the number of residential units and both chloride and sodium. The *r* values for each variable were significant at least at the 0.05 level. The strongest correlation was between chloride and residential population density at 0.7796, which is significant at 0.01, and which was achieved after performing a logarithmic transformation. In addition, the data transformed by the logarithmic function produced a strong positive correlation with the number of businesses and both chloride and sodium.

The strongest correlation with business and chloride was 0.7306, which is significant at the 0.01 level.

These results clearly indicate a relationship between higher numbers of residential units and businesses, and the amount of chloride and sodium in the water samples. In the winter, streets are treated with a mix of sand and salt to melt the snow and ice. During the melting process, run-off carries the chemicals into the Little Papillion Creek drainage system.

There is a negative correlation between the number of businesses and nitrate (table 3, figures 28 to 30). This means the sample sites with the least amount of surrounding businesses had higher levels of nitrate. The results are a reflection of the use of nitrogen in agricultural areas in the upper part of the drainage basin and in green spaces in the urban area.

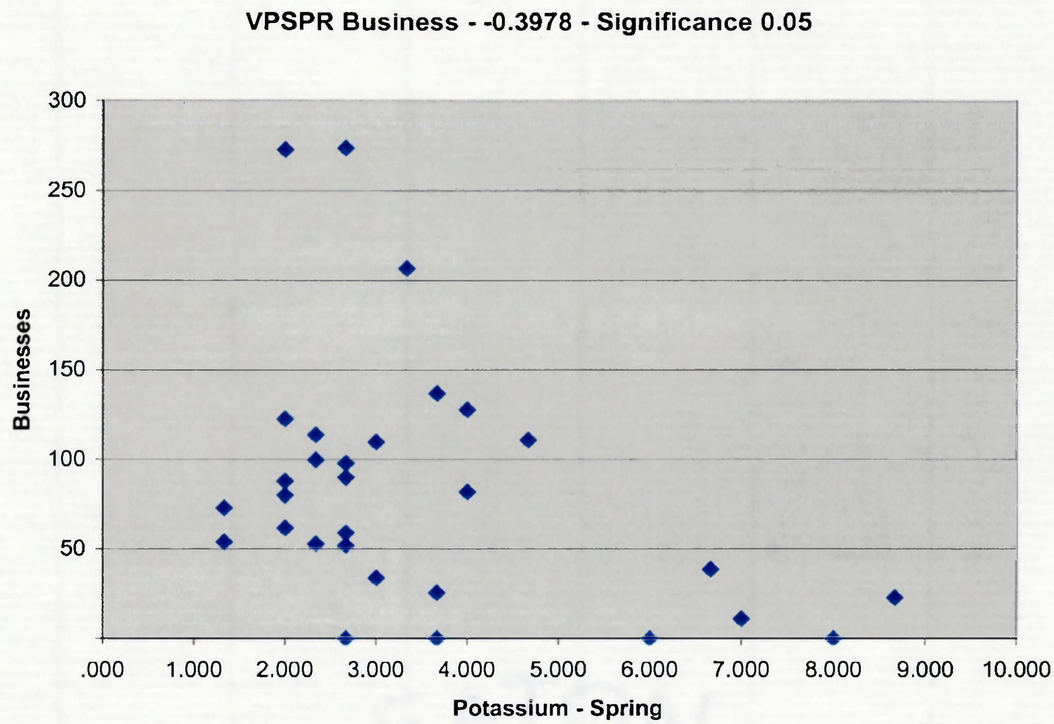
TABLE 4. SEASONAL POTASSIUM VALUES

	VPWIN	LPWIN	RPWIN	VPSPR	LPSPR	RPSPR
Business	0.0747	0.1966	0.3147	-0.3978	0.3375	-0.2478
Residential	-0.2401	-0.0663	0.0660	-0.0938	-0.3162	-0.2730
	VPSUM	LPSUM	RPSUM	VPFAL	LPFAL	RPFAL
Business	-0.3381	-0.3235	-0.3033	-0.3007	-0.1810	0.0062
Residential	-0.0241	-0.1765	-0.1335	0.1281	-0.0233	0.0811

WIN=Winter SPR=Spring SUM=Summer FAL=Fall

Significance Level of .05 = RED and .01 = BLUE

FIGURE 31. SPRING POTASSIUM BUSINESS SCATTER PLOT



6.3.2 Potassium Seasonal Correlation Values

A closer look at table 4 reveals a significant negative correlation at the 0.05 level between the number of businesses and the concentration of potassium during the spring months. The *r* value of -0.3978 reveals that the sample sites with the least number of surrounding businesses had lower concentrations of potassium. This is consistent with the agricultural use of potassium in the rural upstream portions of the drainage basin. No other *r* values for potassium were significant when the data was divided seasonally.

Table 5. Seasonal Nitrate Values

	VNWIN	LNWIN	RNWIN	VNSPR	LNSPR	RNSPR
Business	**-0.3812**	-0.0975	-0.2779	**-0.4423**	0.3142	-0.2869
Residential	-0.0758	-0.0238	0.2928	-0.2394	**-0.4303**	-0.3257
	VNSUM	LNSUM	RNSUM	VNFAL	LNFAL	RNFAL
Business	**-0.4017**	-0.3072	-0.3707	**-0.4124**	**-0.5244**	**-0.3611**
Residential	-0.1433	-0.1724	0.2048	-0.2437	**-0.3617**	-0.0086

WIN=Winter SPR=Spring SUM=Summer FAL=Fall

Significance Level of .05 = RED and .01 = BLUE

Figure 32. Winter Nitrate Business Scatter Plot

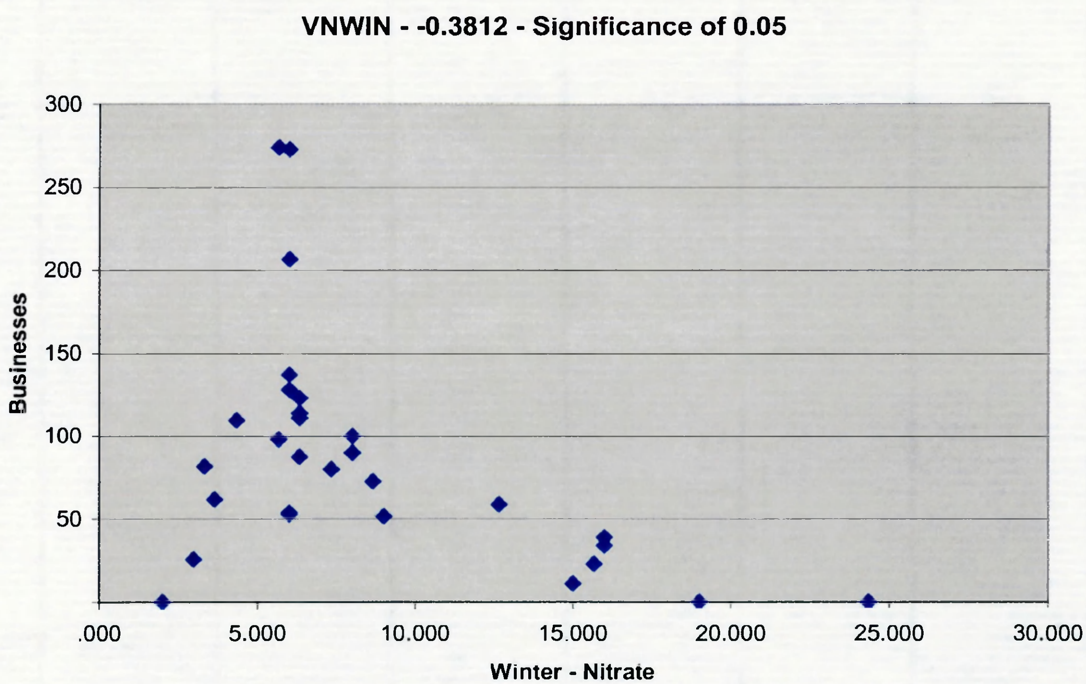


FIGURE 33. SPRING NITRATE BUSINESS SCATTER PLOT

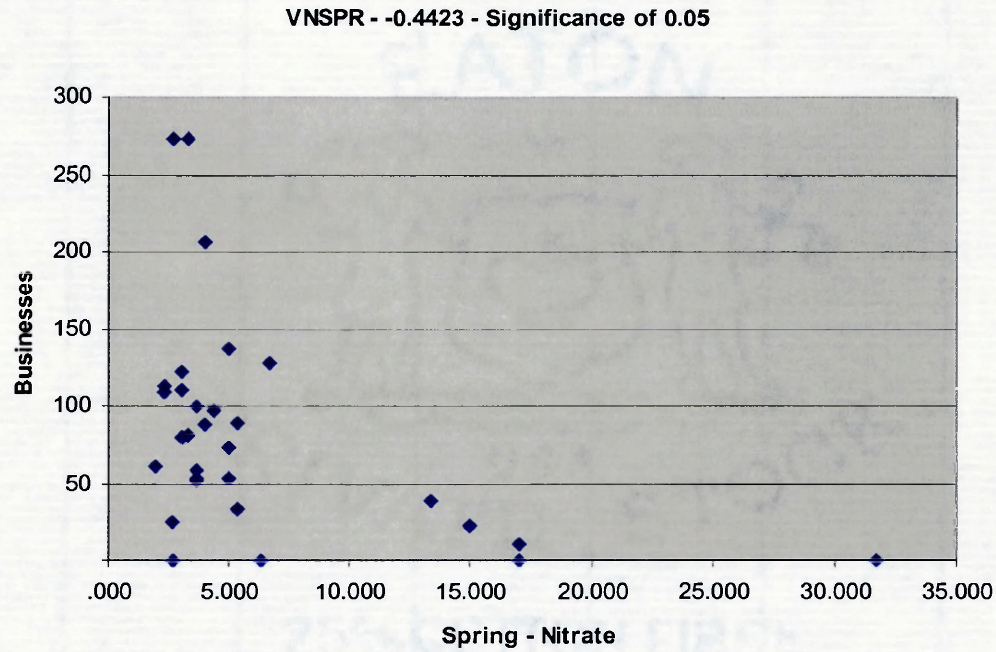


FIGURE 34. SPRING LOG TRANSFORMATION NITRATE BUSINESS SCATTER PLOT

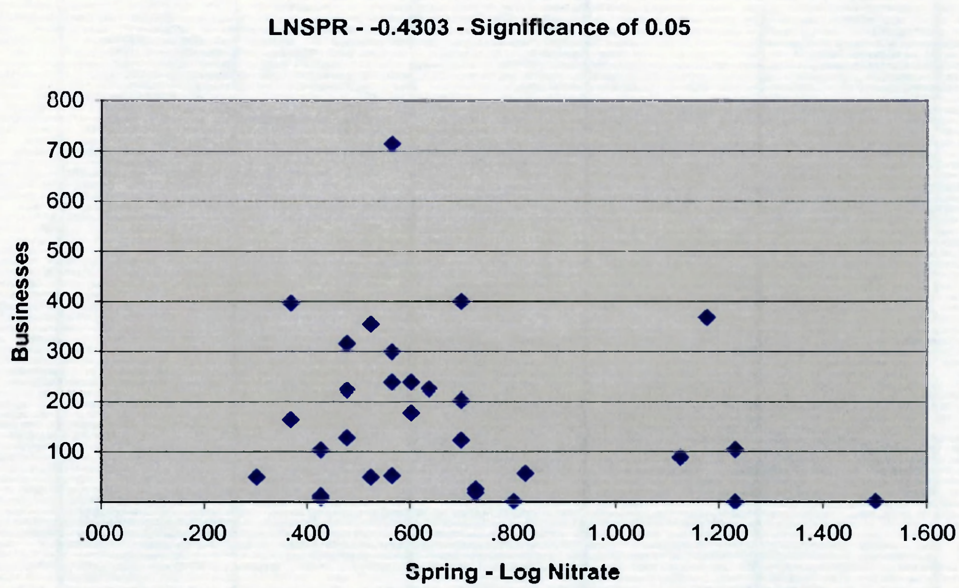


Figure 35. Summer Nitrate Business Scatter Plot

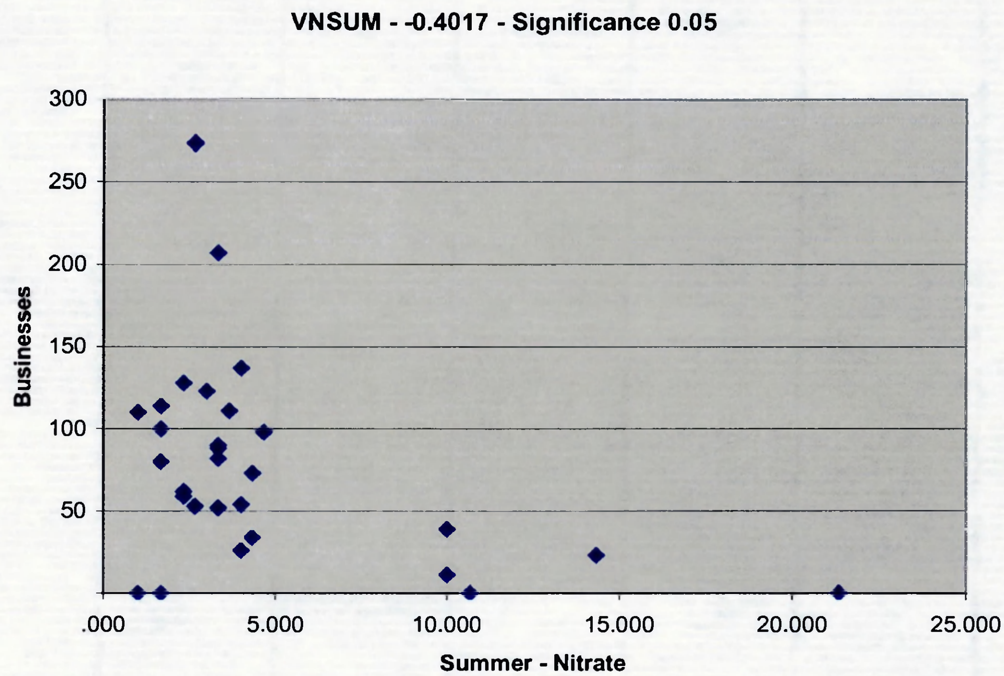


Figure 36. Fall Nitrate Business Scatter Plot

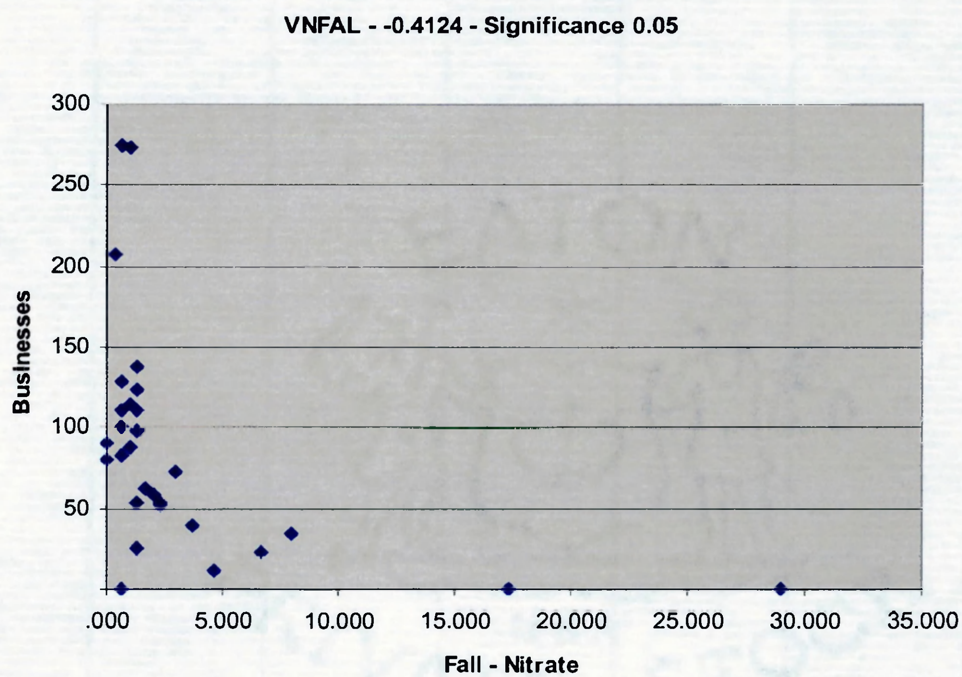


FIGURE 37. FALL LOG TRANSFORMATION NITRATE BUSINESS SCATTER PLOT

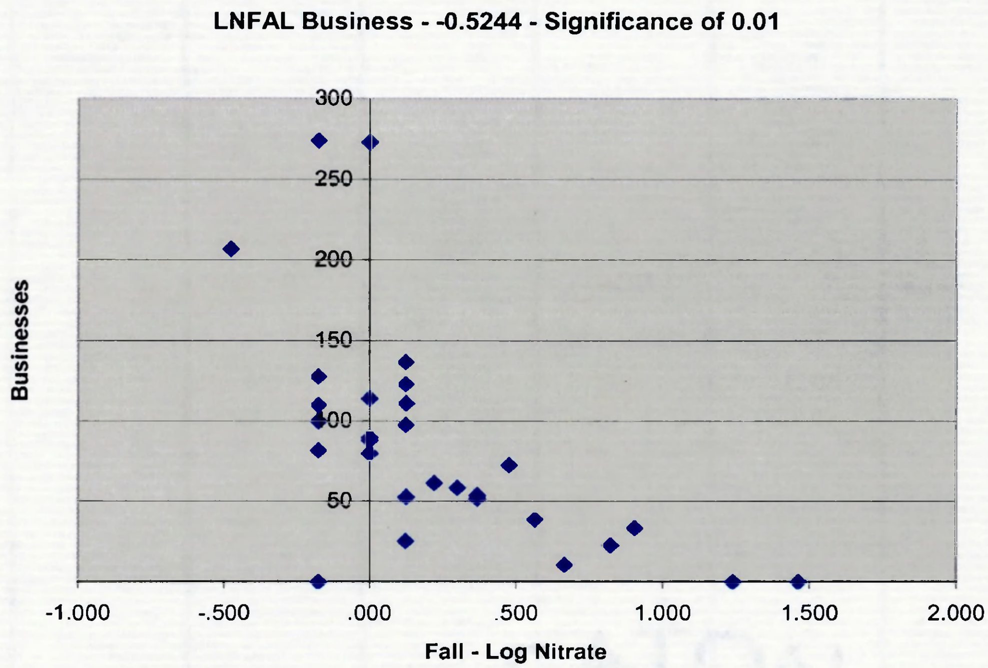


FIGURE 38. FALL LOG TRANSFORMATION NITRATE RESIDENTIAL SCATTER PLOT

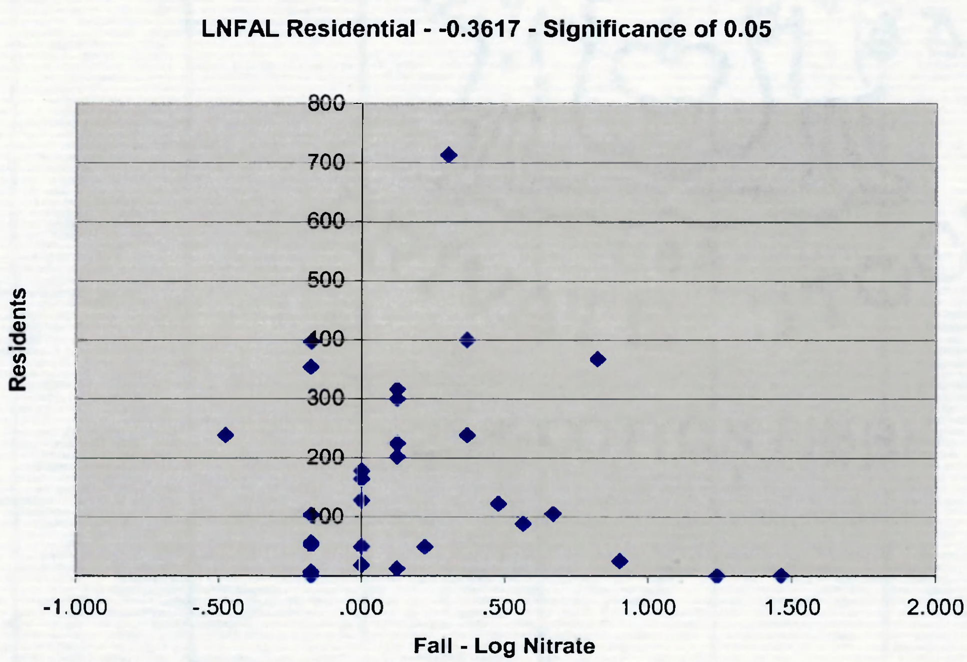
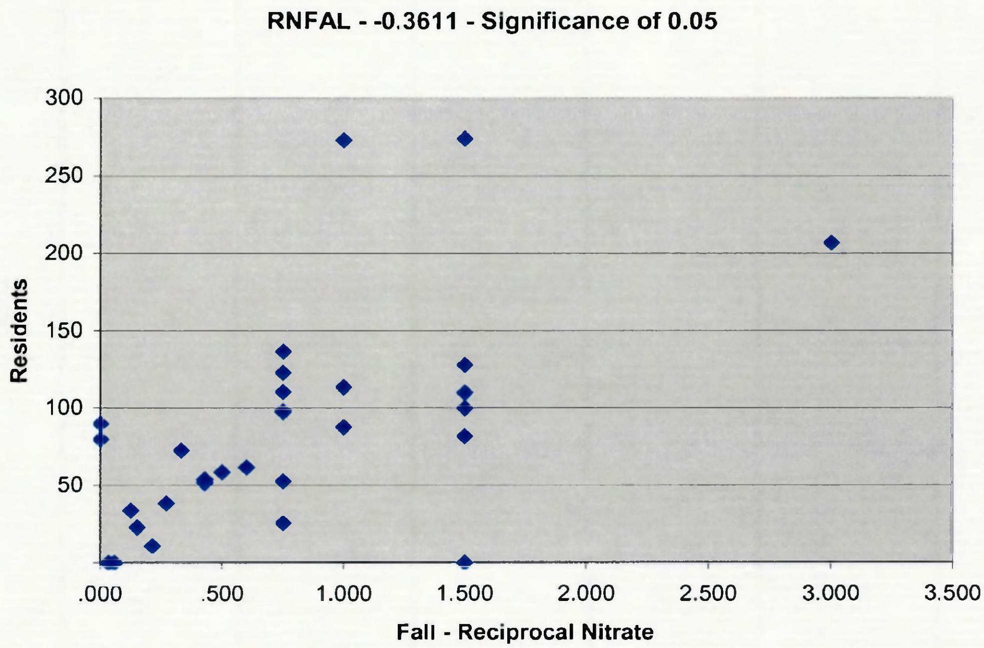


FIGURE 34. FALL RECIPROCAL FUNCTION NITRATE RESIDENTIAL SCATTER PLOT



6.3.3 Nitrate Seasonal Correlation Values

Table 5 reveals numerous significant negative correlations between the number of businesses and the concentration of nitrate in each season. This negative correlation indicates that as nitrate decreases the number of businesses increases. The results reflect the use of nitrogen in agricultural areas, with nitrate levels being lower in sites surrounded by a higher number of businesses. The strongest correlation was in the Fall. Using the logarithmic transformation the number of businesses compared to nitrate had an *r* value of -0.5244 which is significance at the 0.01 level. The sites associated with residential areas had two values that were significant at the

0.05 level, using the logarithmic transformation, in the spring and fall. The Spring had a -0.4423 value and Fall had -0.3617. Nitrate is not only a fertilizer for agricultural use, but it is used for residential lawns as well. Many lawns are fertilized throughout the year, but especially in the Spring and Fall. The negative correlation associated with residential sites could indicate that even though lawns are fertilized in residential areas with products that contain nitrate, it is still not producing high levels like the agricultural areas in this study because runoff from manicured and landscaped lawns in Omaha's residential areas is limited.

Table 6. Seasonal Chloride Values

	VCWIN	LCWIN	RCWIN	VCSPR	LCSPR	RCSPR
Business	0.0903	0.8054	-0.3165	0.0842	0.3776	-0.2772
Residential	0.2858	0.7975	0.8358	0.3872	0.7562	0.7291
	VCSUM	LCSUM	RCSUM	VCFAL	LCFAL	RCFAL
Business	-0.0083	0.3987	-0.2918	0.1229	0.6575	-0.3576
Residential	0.5146	0.6611	0.6135	0.5205	0.7877	0.7155

WIN=Winter SPR=Spring SUM=Summer FAL=Fall

Significance Level of .05 = RED and .01 = BLUE

FIGURE 40. WINTER LOG TRANSFORMATION CHLORIDE BUSINESS SCATTER PLOT

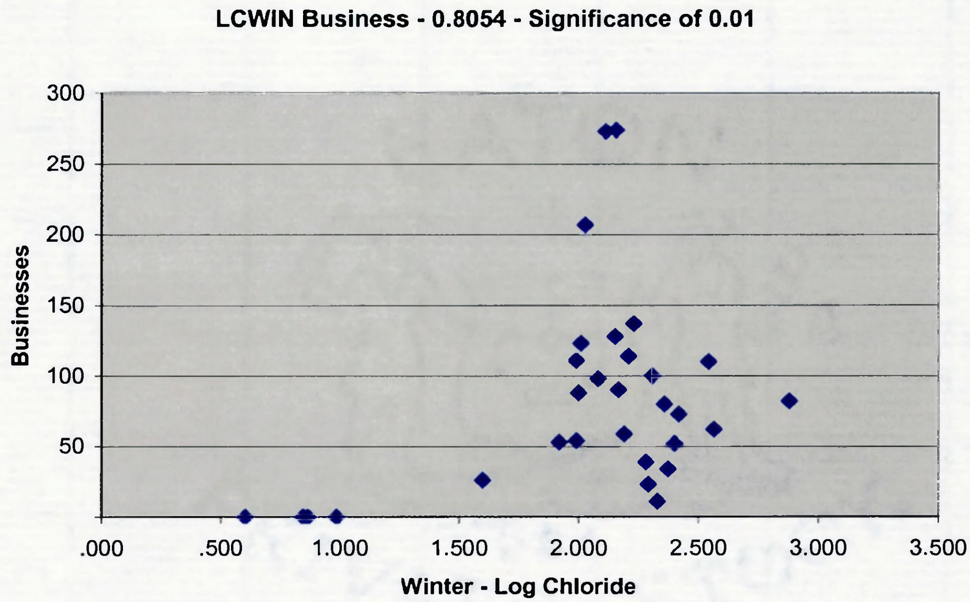


FIGURE 41. WINTER LOG TRANSFORMATION CHLORIDE RESIDENTIAL SCATTER PLOT

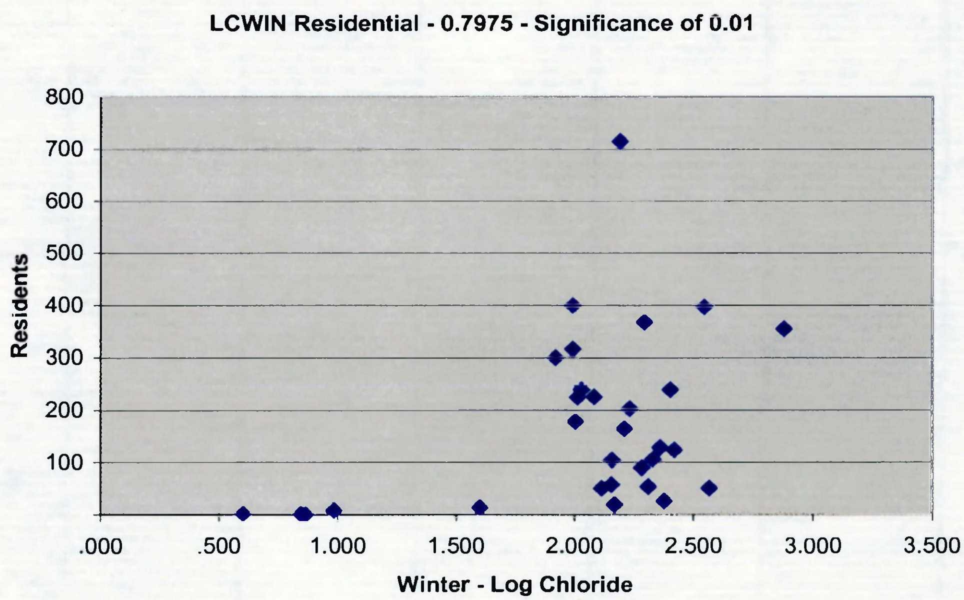


FIGURE 42. WINTER RECIPROCAL FUNCTION CHLORIDE RESIDENTIAL SCATTER PLOT

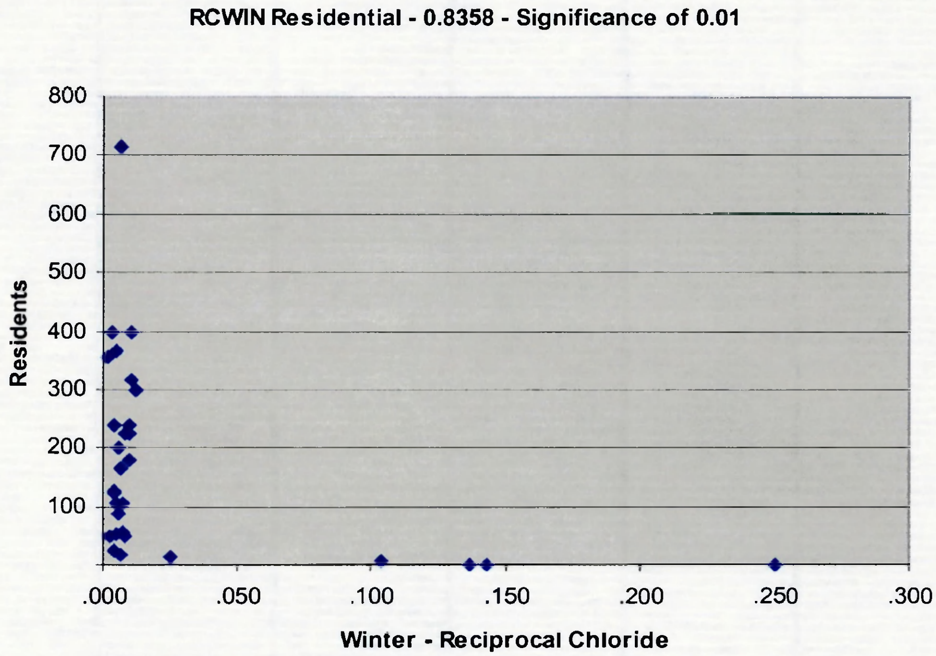


FIGURE 43. SPRING CHLORIDE RESIDENTIAL SCATTER PLOT

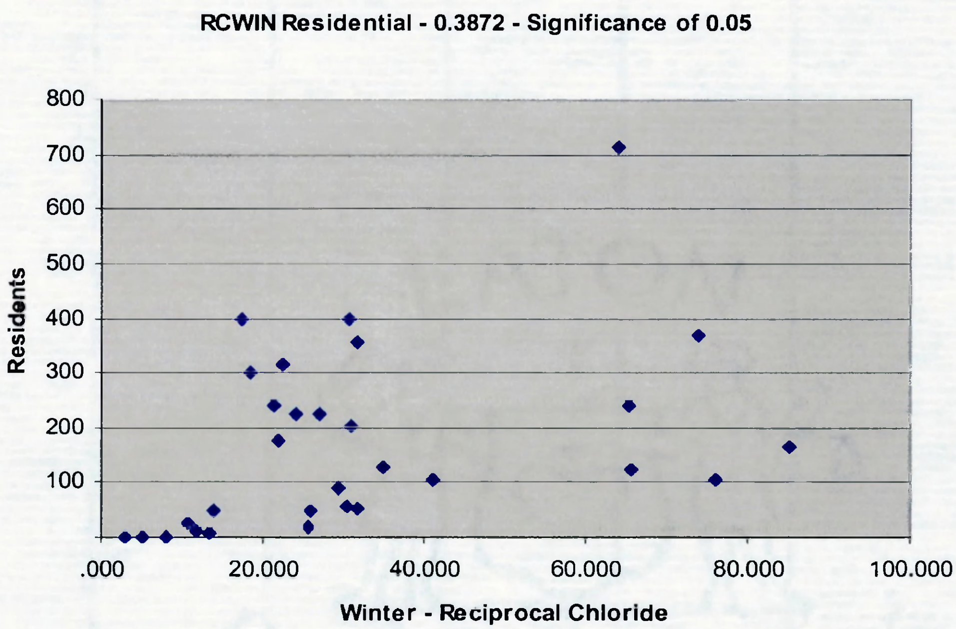


FIGURE 44. SPRING LOG TRANSFORMATION CHLORIDE BUSINESS SCATTER PLOT

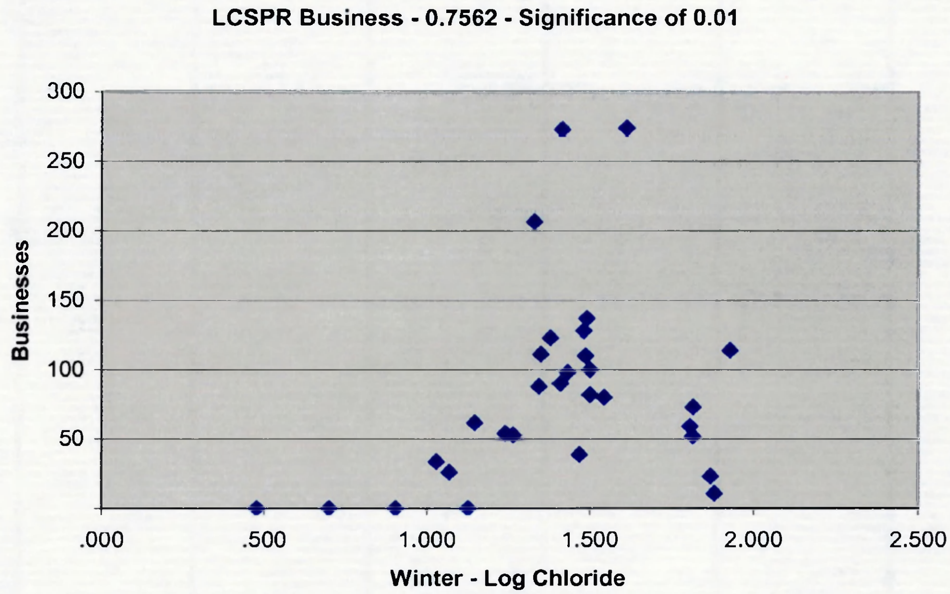


FIGURE 45. SPRING LOG TRANSFORMATION CHLORIDE RESIDENTIAL SCATTER PLOT

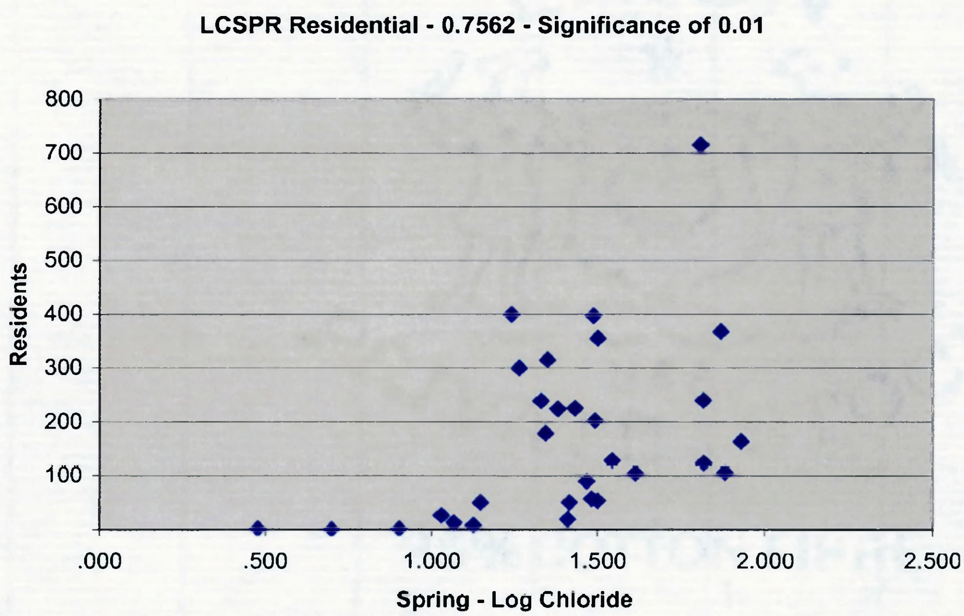


FIGURE 46. SPRING RECIPROCAL FUNCTION CHLORIDE RESIDENTIAL SCATTER PLOT

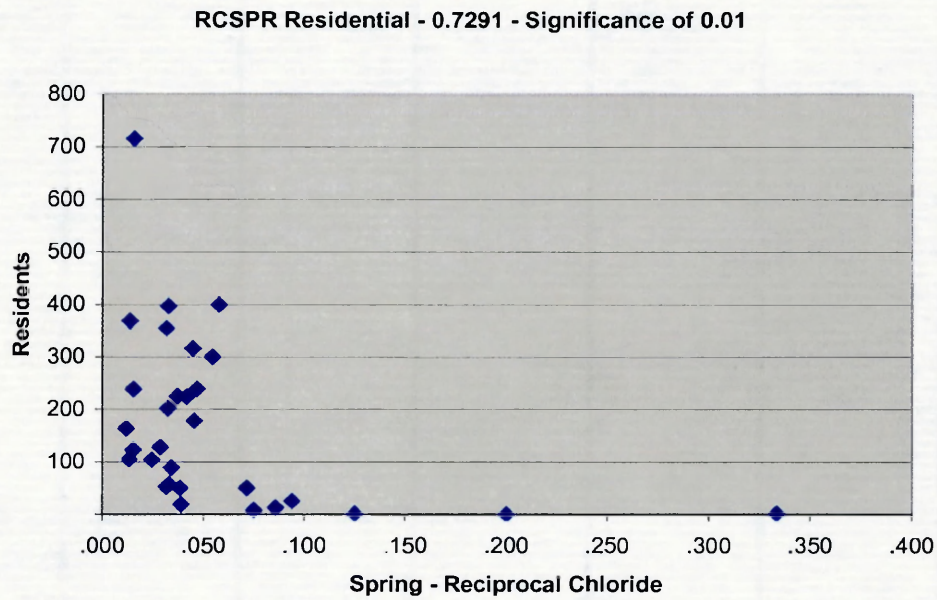


FIGURE 47. SUMMER CHLORIDE RESIDENTIAL SCATTER PLOT

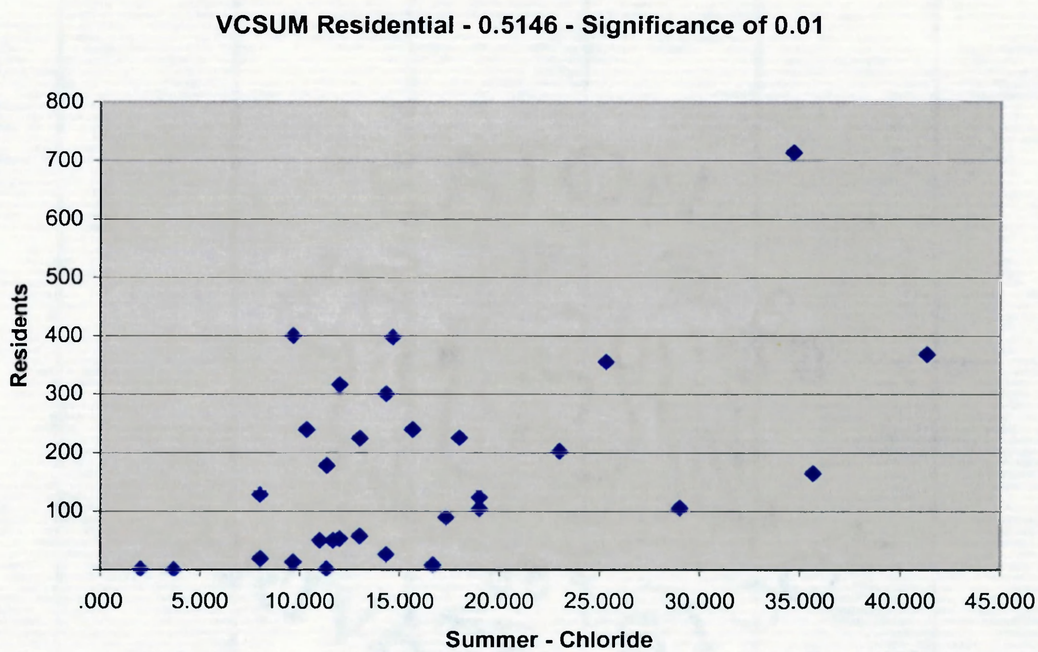


FIGURE 48. SUMMER LOG TRANSFORMATION CHLORIDE BUSINESS SCATTER PLOT

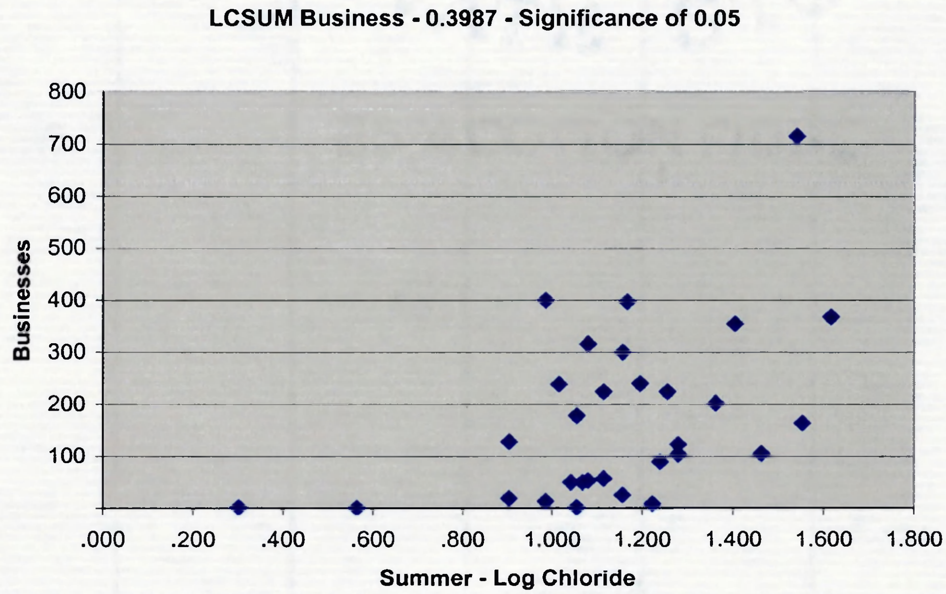


FIGURE 49. SUMMER LOG TRANSFORMATION CHLORIDE RESIDENTIAL SCATTER PLOT

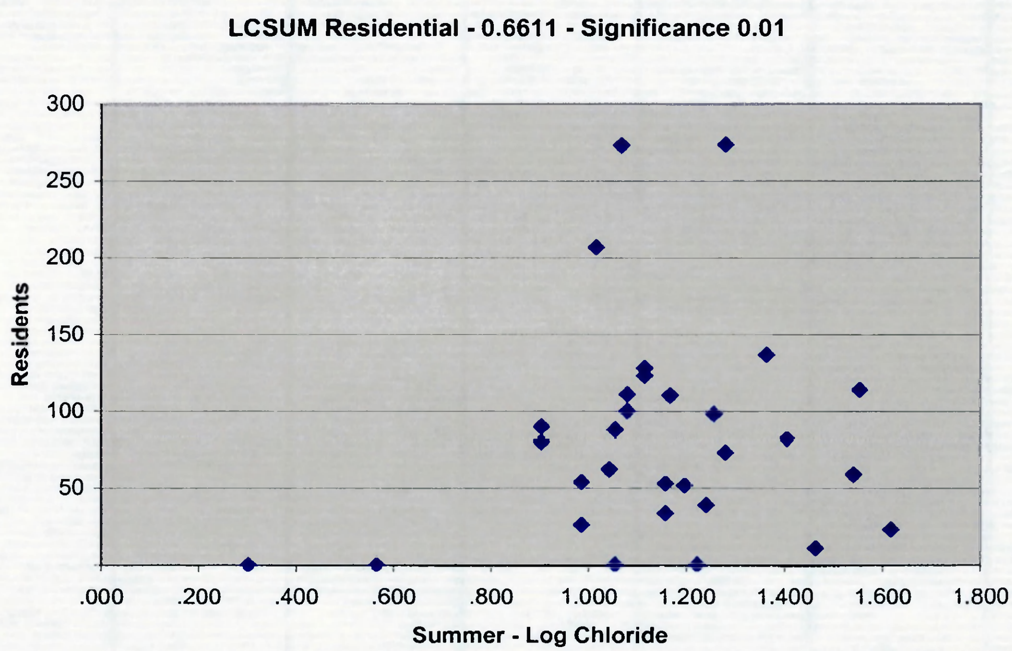


Figure 50. Summer Reciprocal Function Chloride Residential Scatter Plot

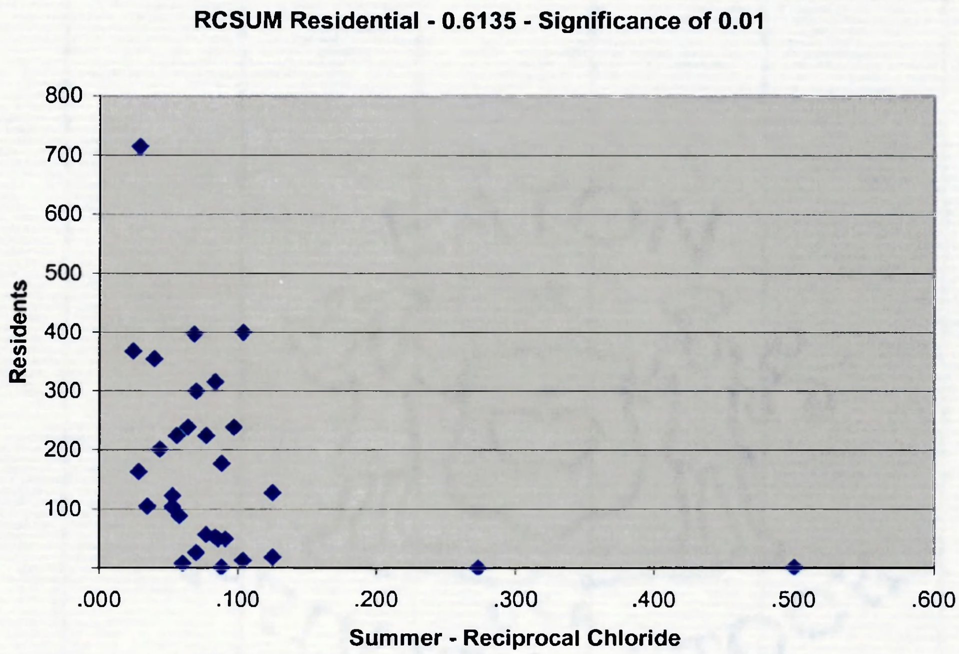


Figure 51. Fall Chloride Residential Scatter Plot

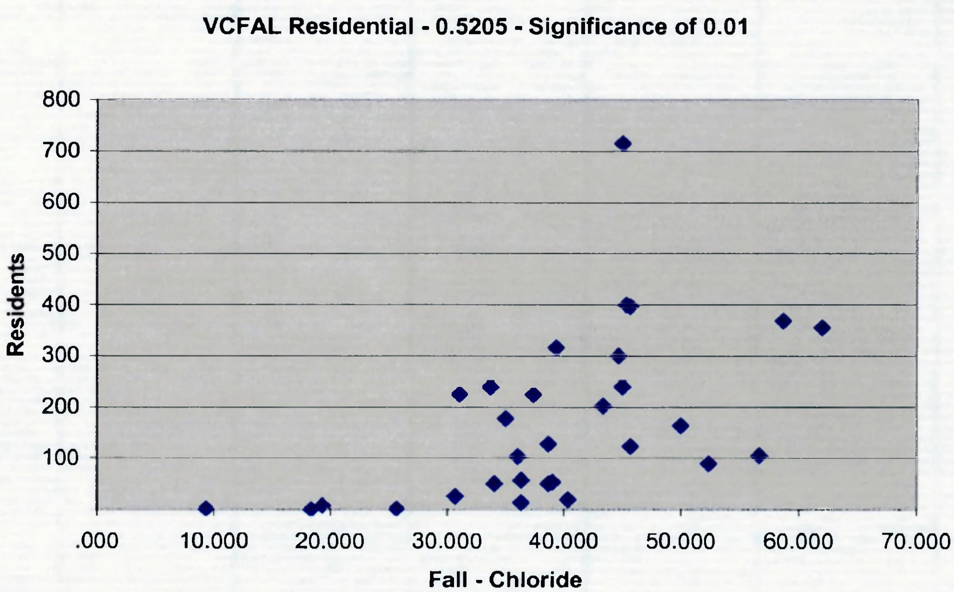


FIGURE 52. FALL LOG TRANSFORMATION CHLORIDE BUSINESS SCATTER PLOT

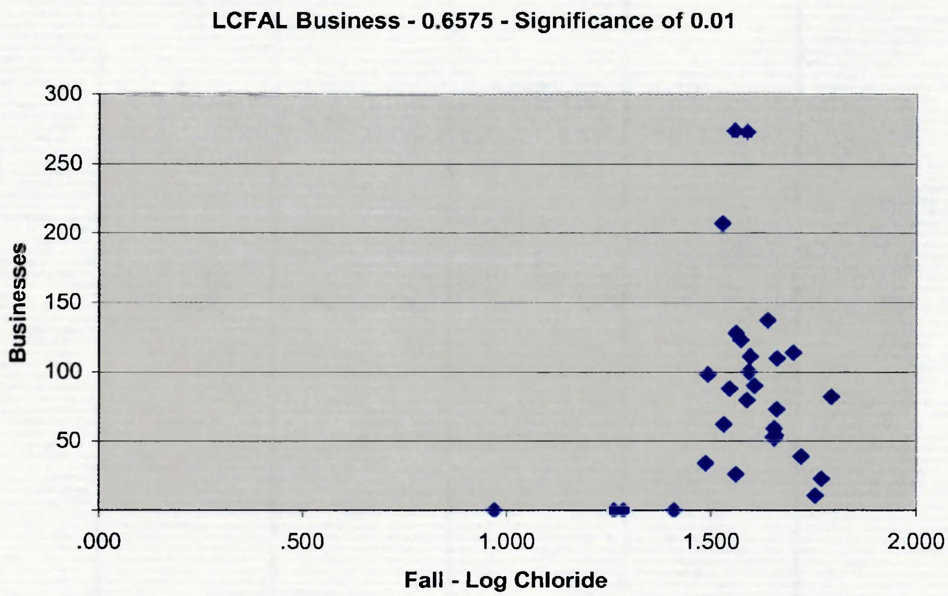


FIGURE 53. FALL LOG TRANSFORMATION CHLORIDE RESIDENTIAL SCATTER PLOT

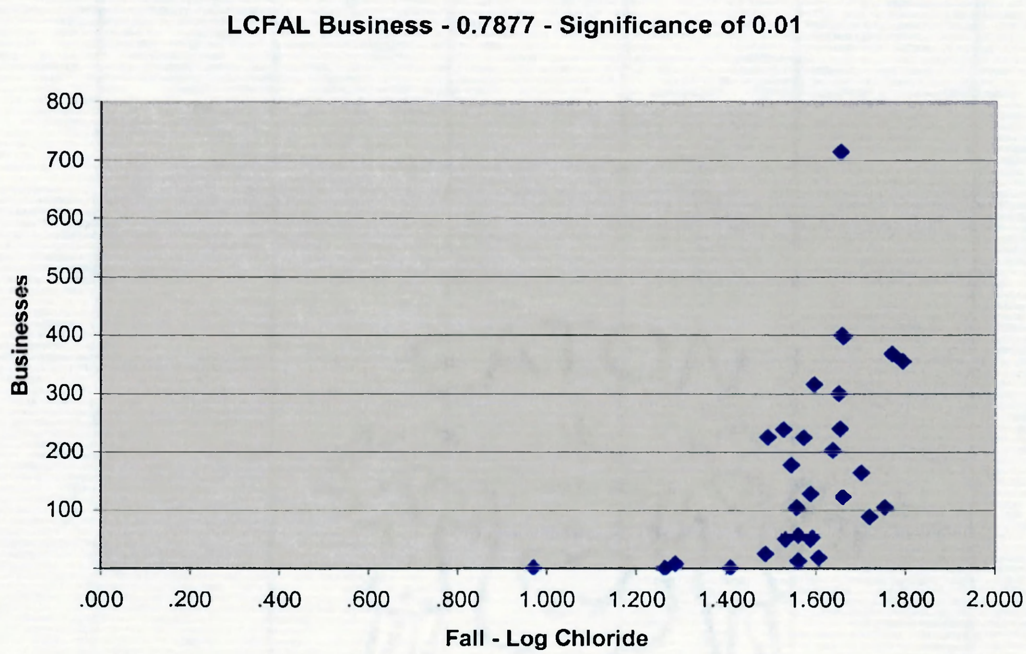


Figure 54. Fall Reciprocal Function Chloride Business Scatter Plot

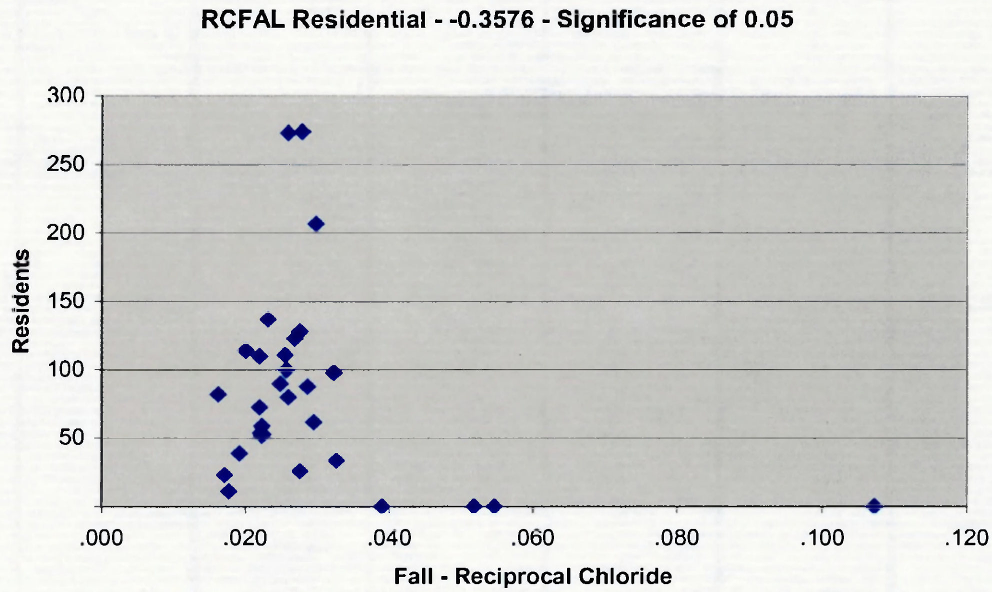
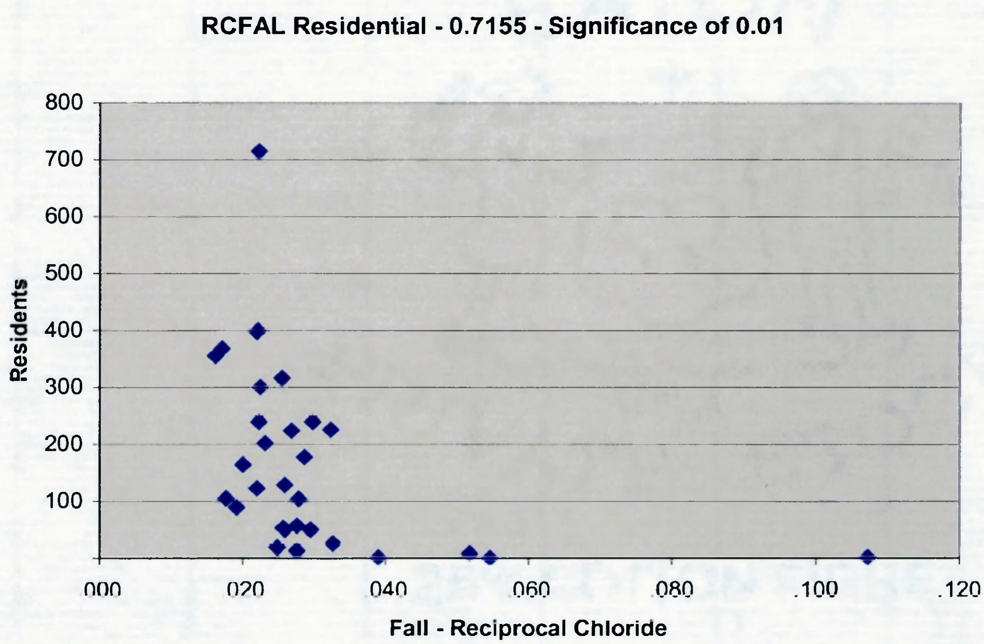


Figure 55. Fall Reciprocal Function Chloride Residential Scatter Plot



6.3.4 Chloride Seasonal Correlation Values

There are positive correlations between both business and residential sites and chloride concentrations throughout all the seasons. The residential sites have the strongest positive correlation in each of the four seasons, with the highest value being 0.8358, which was obtained using the reciprocal function, and is significant at the 0.01 level. The sites more associated with businesses have positive correlations as well, but with the exception of the *r* value of 0.8054 for winter, which was obtained using the logarithmic function, all other *r* values are only significant at the 0.05 level. One anomaly was the negative correlation for the reciprocal function in the Fall, which indicates that in the Fall of the year chloride concentration decreases as the number of businesses increases. It is unclear why this trend.

The reason for the strong correlation is the specific use of chloride for de-icing of residential streets. Parking lots associated with businesses tend to be plowed rather then have de-icing agents applied, unlike the use of Nitrate in both the agriculture and urban areas.

Table 7. Seasonal Sodium Values

	VSWIN	LSWIN	RSWIN	VSSPR	LSSPR	RSSPR
Business	0.0957	0.6844	-0.3415	0.0079	0.3727	-0.3389
Residential	0.3822	0.7425	0.7879	0.2874	0.5481	0.4799
	VSSUM	LSSUM	RSSUM	VSFAL	LSFAL	RSFAL
Business	0.1095	0.4009	-0.3119	0.1302	0.5549	-0.2537
Residential	0.4444	0.6044	0.3386	0.3611	0.6376	0.5371

WIN=Winter SPR=Spring SUM=Summer FAL=Fall

Significance Level of .05 = RED and .01 = BLUE

FIGURE 56. WINTER SODIUM RESIDENTIAL SCATTER PLOT

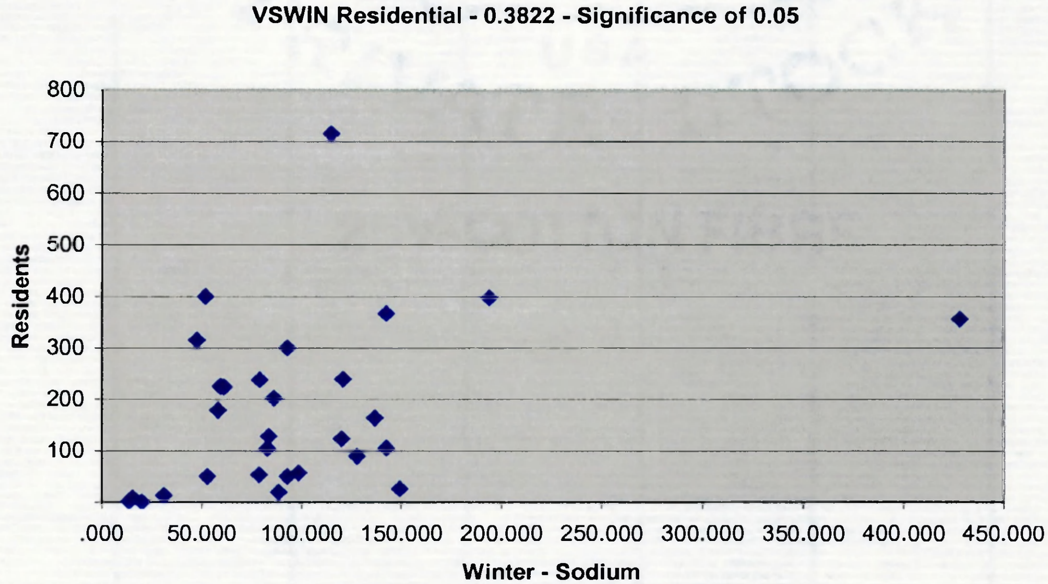


FIGURE 57. WINTER LOG TRANSFORMATION SODIUM BUSINESS SCATTER PLOT

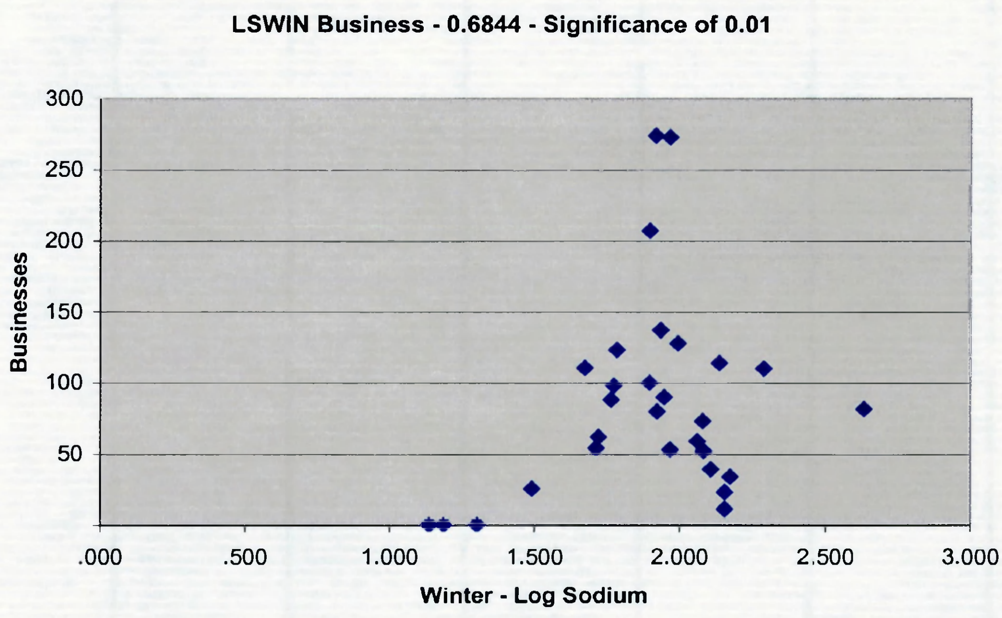


FIGURE 58. WINTER LOG TRANSFORMATION SODIUM RESIDENTIAL SCATTER PLOT

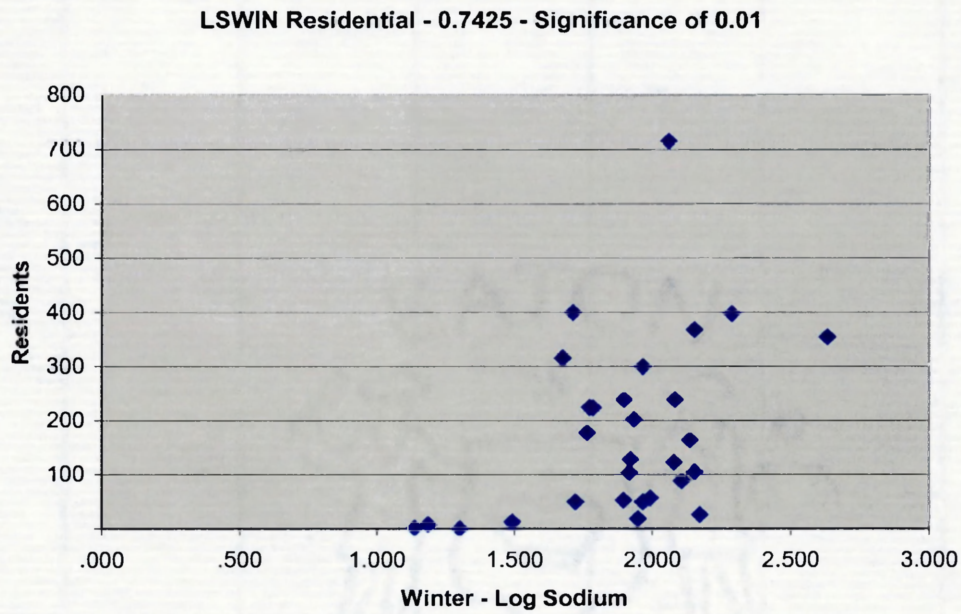


FIGURE 59. WINTER RECIPROCAL FUNCTION SODIUM RESIDENTIAL SCATTER PLOT

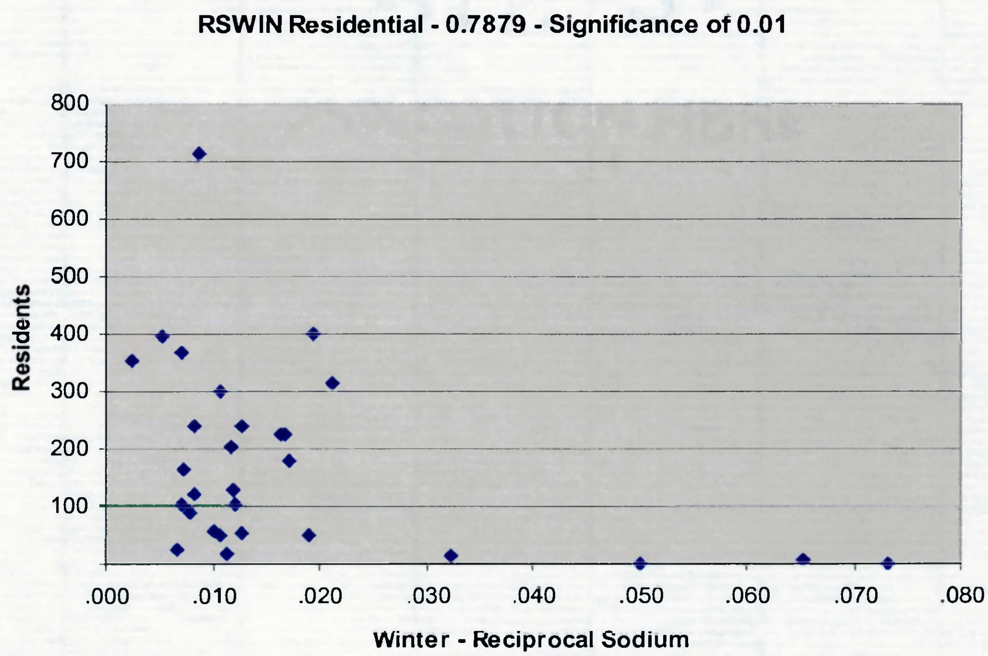


FIGURE 60. SPRING LOG TRANSFORMATION SODIUM BUSINESS SCATTER PLOT

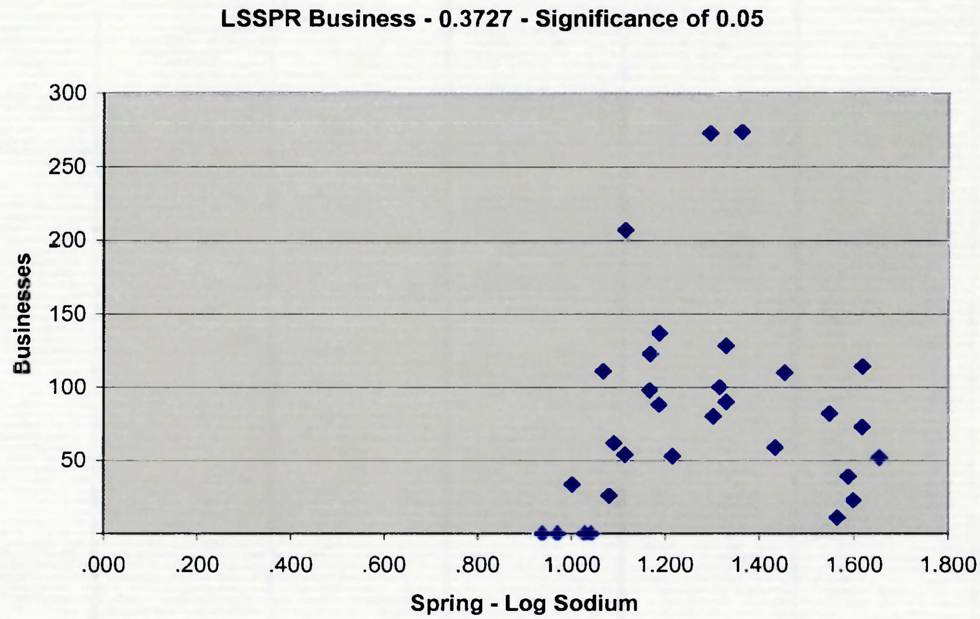


FIGURE 61. SPRING LOG TRANSFORMATION SODIUM RESIDENTIAL SCATTER PLOT

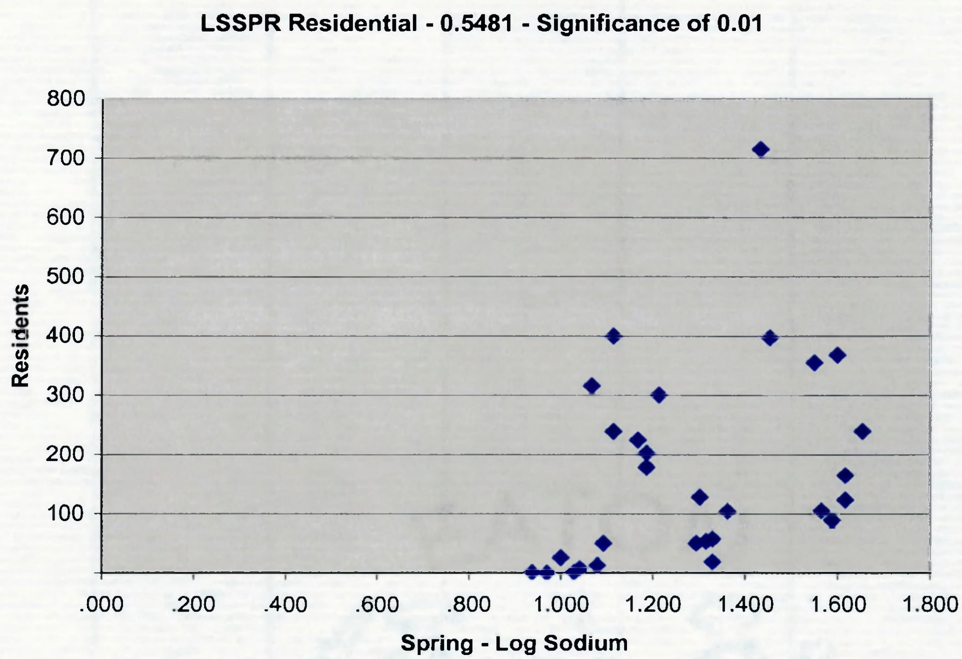


FIGURE 62. SPRING RECIPROCAL FUNCTION SODIUM RESIDENTIAL SCATTER PLOT

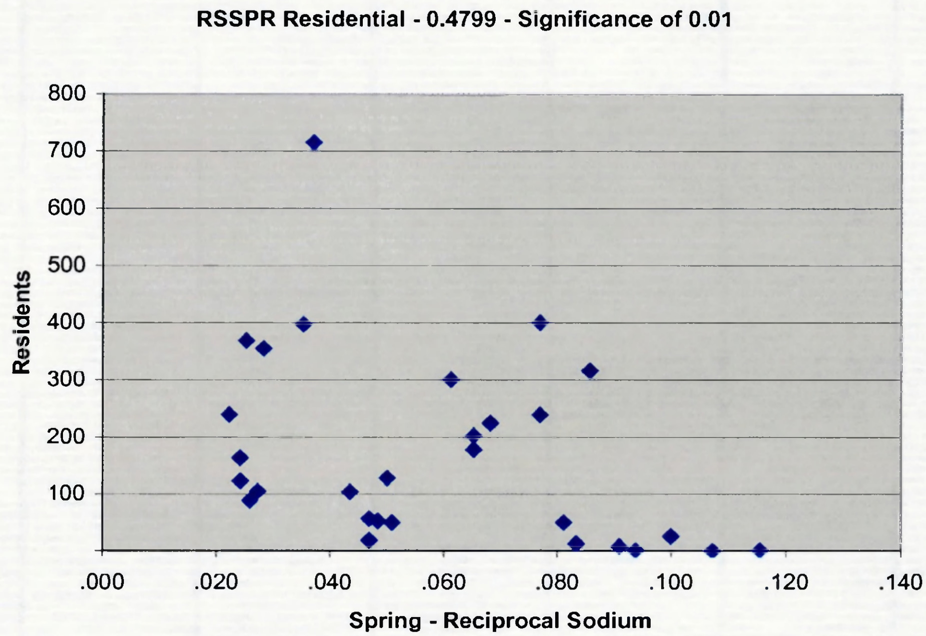


FIGURE 63. SUMMER SODIUM RESIDENTIAL SCATTER PLOT

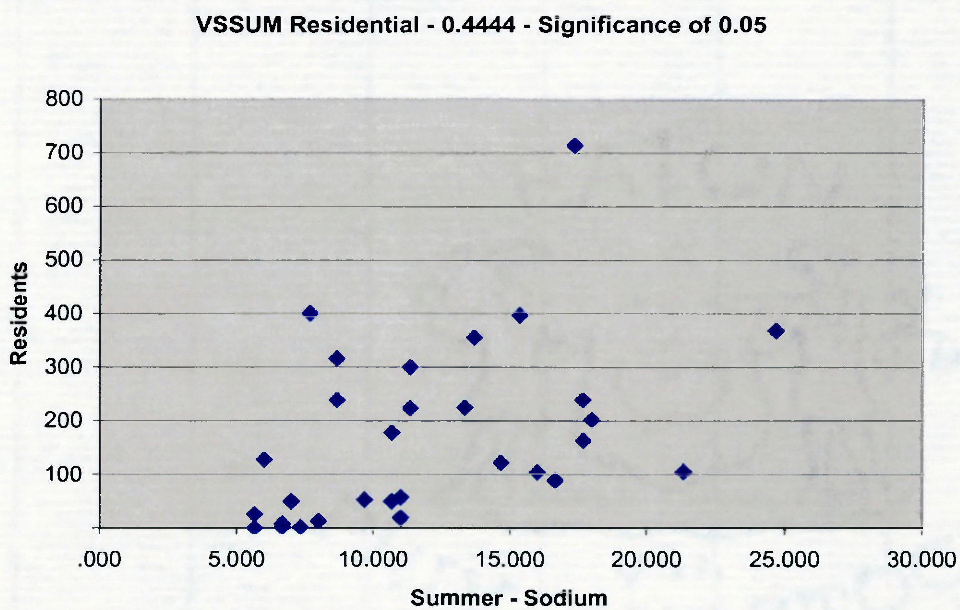


Figure 64. Summer Log Transformation Sodium Business Scatter Plot

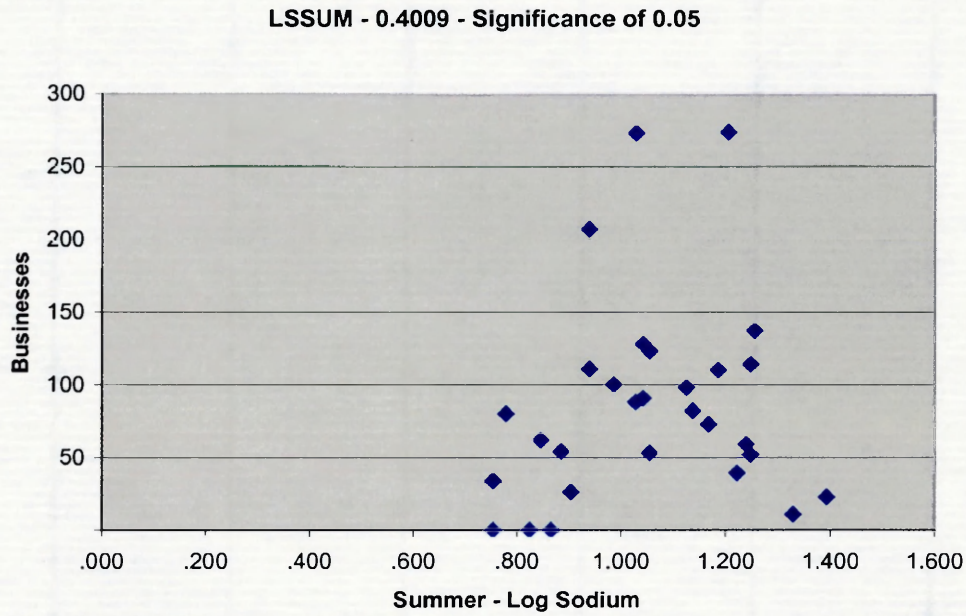


Figure 65. Summer Log Transformation Sodium Residential Scatter Plot

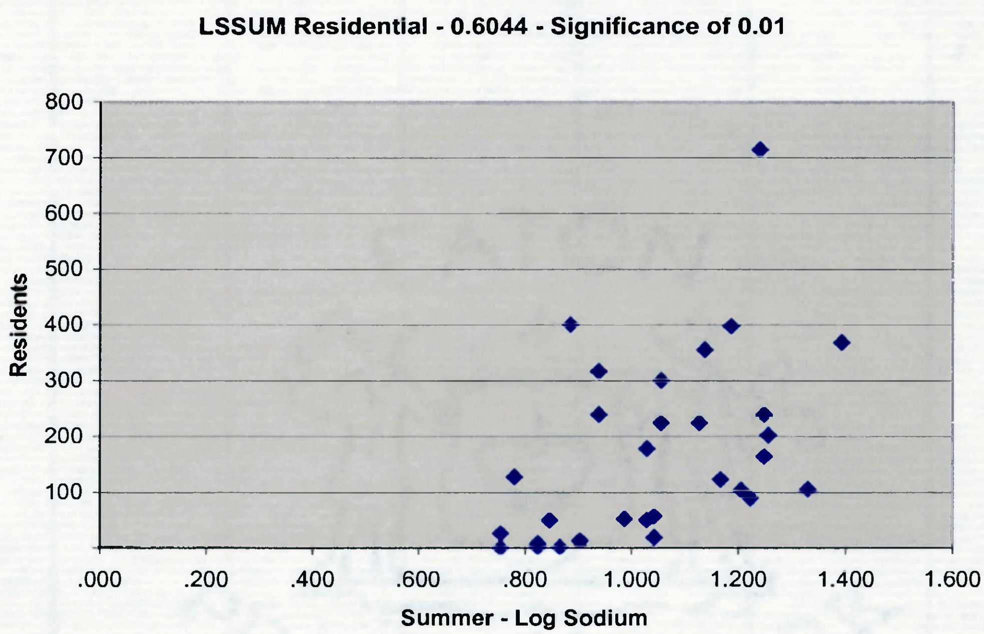


FIGURE 66. FALL SODIUM RESIDENTIAL SCATTER PLOT

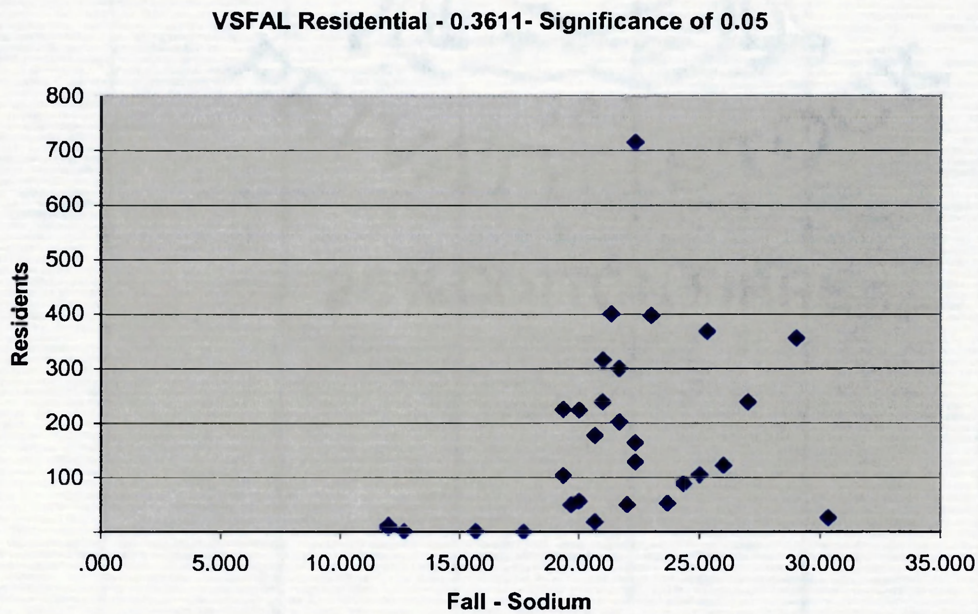


FIGURE 67. FALL LOG TRANSFORMATION SODIUM BUSINESS SCATTER PLOT

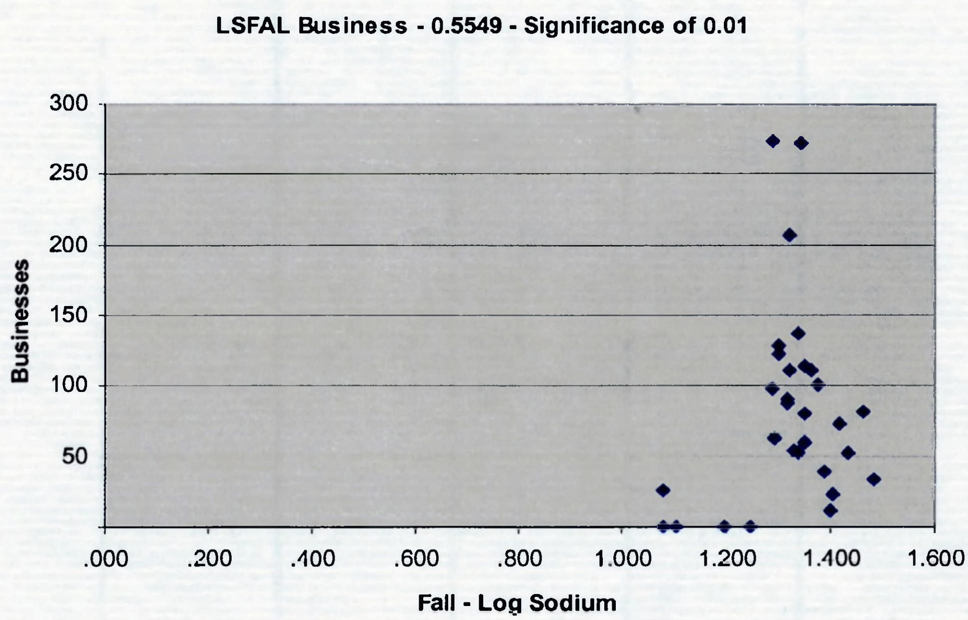


FIGURE 68. FALL LOG TRANSFORMATION SODIUM RESIDENTIAL SCATTER PLOT

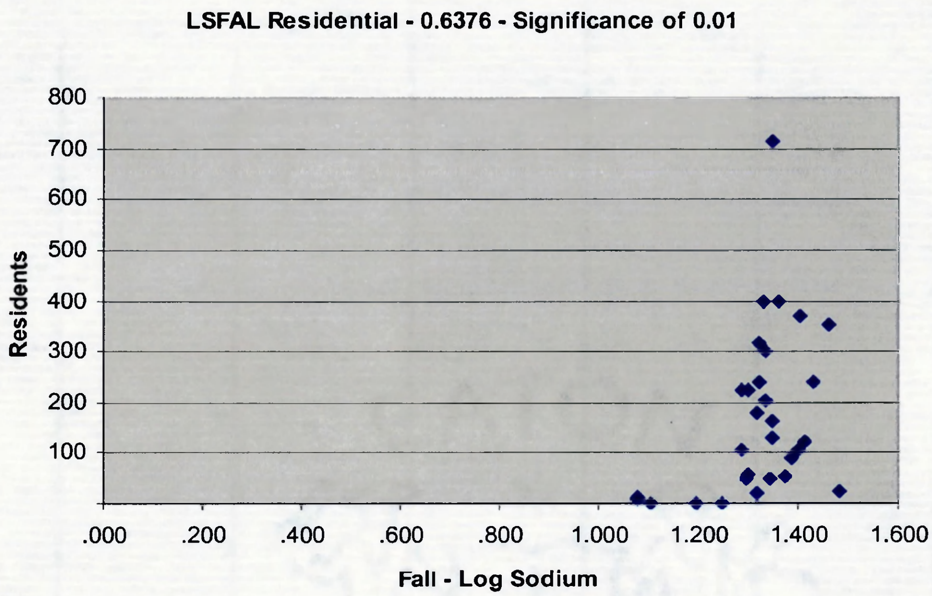
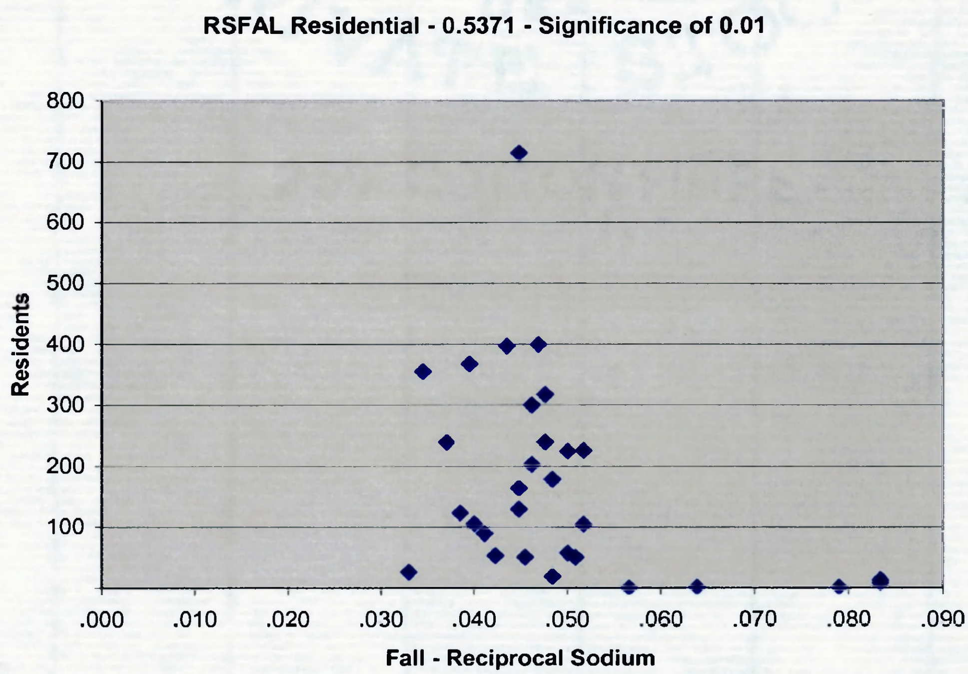


FIGURE 69. FALL RECIPROCAL FUNCTION SODIUM RESIDENTIAL SCATTER PLOT



6.3.5 Sodium Seasonal Correlation Values

Sodium is very much related to Chloride; hence the trends in the data are very similar. Both residential and business sites have positive correlations with sodium in each of the four seasons. The residential sites have the strongest correlation overall in that sodium and residential are correlated at the 0.01 level in all four seasons. The strongest correlation was produced using the reciprocal function for residential sites during winter, which had an *r* value of 0.7879. The sites associated with the number of businesses produced positive correlations in each season using the logarithmic function, with the highest value being 0.6844 during the winter season, which is significant at the 0.01 level. Similar to chloride, sodium is contained in a de-icing agent used most often in residential areas.

7. SUMMARY AND CONCLUSION

7.1 Summary and Conclusion

The United States has made significant advances in the past thirty years to clean up the aquatic environment by controlling pollution from industries, and sewage treatment plants. Over the last 15 years, our country has made headway in addressing NPS pollution by taking a watershed monitoring approach (www.epa.gov/OWOW/nps/). The fact remains that NPS is still the EPA's number one water quality concern and that NPS is responsible for 40% of our surveyed rivers, lakes and estuaries not being clean enough to meet basic requirements for fishing or swimming (www.epa.gov/OWOW/nps/).

Since NPS pollution is a relatively new water quality concern, additional research is needed to understand the relationships that exist between the uses of the land and water quality. This thesis was intended to examine only a few of the thousands of relationships that affect the NPS pollution problem. This thesis revealed some of the effects that land use has on water quality in the Little Papillion Creek in Omaha. This research can serve as a means for future research with respect to Omaha's water resources, and it can also be a model for research that can be placed in other locations.

The rural sample locations in this thesis, on average, had higher concentrations of nitrate and potassium throughout the year, at sites located both on the tributaries and non-tributaries. It appears that this is the result of the land use practices in the rural areas in the upstream parts of the drainage basin, which includes areas where both farming and feedlot operations exist. It appears that the use of fertilizers that contain potassium and nitrogen, along with nitrogen from feedlots, is the determining factors as to why higher concentrations of these chemicals are associated with the rural sample sites.

The urban sites averaged higher concentrations of sodium and chloride throughout the year at sites located on the tributaries to the Little Papillion Creek, and at sites on the non-tributaries as well. Both sodium and chloride are associated with chemical agents used to de-ice streets. Urban areas have a higher concentration of roads and therefore have a higher amount of de-icing agents applied to them. These results indicate that chemicals are entering the hydrologic system by way of street run-off, and furthermore, it indicates that the highest concentrations of both sodium and chloride occur in the winter months.

Sodium and Chloride had the strongest positive correlations associated with the number of businesses and residents. The reason for this strong correlation may be because of the specific use, and urban association, of these two chemical constituents. Nitrate and potassium had some negative correlations, but not as strong as the correlations for sodium and chloride. Perhaps the reason for this trend can be derived from how these chemicals are used. Both urban and rural land use utilize both of these nutrients in the form of fertilizer. The sites associated with urban green space areas or rural areas should have higher nitrate and potassium levels. Therefore, since both nitrate and potassium are used in both rural and urban areas, it is not strongly correlated to either business or residential land uses. Potassium was the least correlated of all the chemical constituents, which were part of this study. Even though fertilizer is used in both rural and urban areas, there is an additional source of nitrate in rural areas in the form of feedlot operations. This may be why nitrate exhibited stronger correlation compared to potassium.

7.2 Future Studies

Since NPS pollution is a relatively new issue, additional studies need to be completed to better understand the sources and dispersion of this type of pollution. There are several variables that can influences the levels of contamination, and this needs to be further explained.

Correlating the concentrations of chemicals within a stream with the number of residences and business is a start in understanding this problem but perhaps a more accurate way would be to calculate the square footage of impervious surface and correlate them with water quality data. In addition, it would be beneficial to calculate the distance the impervious surfaces are from the creek, as well as to calculate surface runoff rates. Stream discharge hydrograph analysis, and precipitation data would be another important variable to include in an expanded study. Finally, weekly sampling would provide a more conclusive database for determining spatial and temporal trends in the database.

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APPENDIX

All Data

1/21/1996

Site	Stream	Temp. F	Temp C	pH	TDS ppm	Chloride t ml	Chloride ppm	Nitrate ppm	Potassm ppm	Sodium ppm	Phosph ppm
1		32	0	7.7	240	0.9	3	32	4	16	0
2	trib	32	0	7.3	300	1.4	8	27	1	17	4
3		31	0	6.9	200	1.5	9	1	3	16	0
4		37	3	7.8	250	2	14	2	3	17	0
5		32	0	7.9	270	5	44	3	3	38	1
6	trib	31	0	7.8	1000	47.3	467	25	8	320	4
7		32	0	8.2	300	55.2	546	4	3	33	0
8	trib	32	0	8.2	2500	136.4	1358	5	10	880	1
9		32	0	7.8	380	7.7	71	9	3	100	0
10		31	0	8.2	340	6.6	60	9	3	46	2
11	cole	31	0	7.7	540	12.4	118	15	5	100	9
12	cole	31	0	7.8	540	13.5	129	12	4	100	15
13		31	0	8.2	340	4.7	41	8	3	37	3
14	trib	31	0	8.2	920	38.6	380	4	5	270	5
15		31	-1	8.2	360	6	54	8	3	77	6
16	trib	32	0	7.7	440	5.2	46	27	1	26	3
17		31	-1	8	340	5.9	53	10	3	31	4
18	trib	31	-1	8.2	370	7.8	72	8	4	44	1
19		31	0	7.9	390	8	74	8	4	48	7
20		31	-1	8.2	350	8.5	79	10	3	42	2
21	cole	31	0	7.8	710	8.5	79	10	5	150	0
22		31	-1	7.9	430	7.7	71	8	3	67	0
23	elmwd	31	0	7.6	470	9.8	92	33	2	45	2
24	"	31	0	7.5	620	7.7	71	27	2	56	5
25	"	31	0	7.6	580	9.8	92	29	3	43	1
26		31	0	8	490	7.6	70	9	3	65	5
27		31	0	8.1	480	11.2	106	9	3	54	4
28		31	0	8	560	9.8	92	12	4	71	8
29	constr.	32	0	8.1	550	19.1	185	11	3	64	6
30		32	0	8.1	520	21.1	205	10	3	64	0

2/21/1996

Site	Stream	Temp.	Temp	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		35	1	7.6	240	1.1	5	26	4	3	1
2	trib	34	1	8	230	1.4	8	17	8	8	2
3		33	0	7.8	150	1.3	7	4	2	4	0
4		40	5	8.1	210	1.4	8	3	3	4	0
5		33	1	8	250	4.5	39	5	4	10	0
6	trib	32	0	7.8	310	3.4	28	15	5	7	4
7		33	0	8.1	620	29.1	285	4	3	73	0
8	trib	34	1	8.2	500	31	304	4	4	84	1
9		34	1	7.9	400	13.4	128	8	2	28	0
10		33	1	8	390	13.4	128	7	2	34	0
11	cole	33	1	7.7	800	40.9	403	7	4	110	0
12	cole	33	1	7.9	690	34.5	339	6	1	92	1
13		33	1	8	400	15.3	147	8	2	35	0
14	trib	34	1	7.8	470	19.9	193	5	1	51	1
15		34	1	7.9	440	17.6	170	6	5	40	3
16	trib	34	1	8	570	33.3	327	6	2	88	1
17		33	1	8.1	460	18.5	179	8	3	42	1
18	trib	33	1	7.9	390	34	334	8	14	44	2
19		33	1	8	470	19.5	189	8	21	40	0
20		33	1	8.1	350	11.2	106	7	2	22	1
21	cole	33	1	8.1	410	16	154	6	4	40	2
22		33	1	8.1	400	13.9	133	8	10	31	0
23	elmwd	33	1	8	410	18.6	180	10	3	52	1
24	"	33	1	7.9	590	27.9	273	16	2	91	3
25	"	34	1	8	600	21.2	206	18	25	40	3
26		33	1	8.1	450	18.7	181	8	10	40	0
27		34	1	8.1	370	11.5	109	8	2	24	0
28		33	1	8.1	390	12.7	121	10	19	24	1
29	constr.	34	1	8	410	21.8	212	10	48	22	2
30		33	1	8	400	23.6	230	10	46	26	1

3/21/1996

Site	Stream	Temp.	Temp	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		38	4	8.1	210	1	4	36	1	15	5
2	trib	39	4	8.1	220	1.2	6	17	1	17	2
3		38	3	8.3	170	1.4	8	1	3	17	1
4		42	5	8.3	180	1.4	8	0	3	17	1
5		37	3	8.3	210	1.9	13	2	3	18	0
6	trib	37	3	8.1	260	2.5	19	11	2	19	6
7		36	2	8.3	220	2.1	15	3	1	22	2
8	trib	37	3	8.4	290	4.6	40	2	4	83	2
9		37	3	8.2	240	2.4	18	5	3	24	1
10		37	3	8.3	240	2.3	17	6	2	22	0
11	cole	37	3	7.8	450	14	134	5	2	100	4
12	cole	37	3	8.1	440	14	134	3	2	110	3
13		37	3	8.2	320	2.2	16	4	3	21	2
14	trib	37	3	8.2	240	5.8	52	2	3	66	2
15		37	3	8.2	250	3.3	27	5	2	23	3
16	trib	37	3	8	390	9.4	88	5	3	62	7
17		37	3	8.1	250	3.5	29	5	2	24	1
18	trib	37	3	8.1	260	3.3	27	6	2	24	1
19		37	3	8.1	260	2.9	23	6	3	24	1
20		37	3	8.2	260	3.5	29	5	2	26	1
21	cole	37	3	8.2	470	15.1	145	2	3	99	2
22		37	3	8.1	420	7	64	3	3	47	1
23	elmwd	37	3	8	540	8.6	80	13	4	78	8
24	"	38	3	8.1	450	12.4	118	24	3	75	3
25	"	37	3	8.3	310	1	4	18	4	81	5
26		38	3	8.3	300	5.5	49	13	3	42	1
27		38	3	8	320	5.4	48	2	2	36	1
28		37	3	8.1	300	5	44	9	3	41	1
29	constr.	37	3	8.2	330	6.1	55	6	5	45	0
30		37	3	8.3	370	7.6	70	4	3	49	10

4/21/1996

Site	Stream	Temp.	Temp	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		53	12	7	270	0.8	2	45	2	6	0
2	trib	46	8	8.1	230	0.9	3	11	0	6	0
3		45	7	8.3	220	0.95	3	1	0	7	1
4		53	12	8.2	220	0.7	1	2	0	7	2
5		51	11	8.1	240	0.8	2	8	0	8	1
6	trib	52	11	8	300	1.7	11	8	0	8	0
7		52	11	8.1	240	1.2	6	3	1	7	2
8	trib	54	12	8.1	300	3.2	26	3	0	26	3
9		52	11	8.1	260	1.4	8	4	1	10	1
10		52	11	8.1	270	1.8	12	4	0	8	1
11	cole	53	11	8	420	8.2	76	5	3	22	1
12	cole	53	12	8	420	4.2	36	2	1	26	1
13		53	12	8.2	270	3	24	4	0	7	1
14	trib	54	12	7.9	370	2.2	16	0	2	25	2
15		54	12	8.2	270	1.3	7	3	0	11	1
16	trib	54	12	7.8	420	4.2	36	3	3	29	2
17		55	13	8	290	4.3	37	4	0	10	1
18	trib	54	12	7.9	290	2.3	17	4	1	23	1
19		54	12	8.2	300	1.3	7	5	0	10	1
20		54	12	8.2	300	4.3	37	2	0	11	2
21	cole	55	13	8.3	360	5.2	46	0	2	28	2
22		54	12	8	300	2.3	17	2	1	12	3
23	elmwd	54	12	8	470	7.7	71	26	3	19	1
24	"	54	12	8.1	470	6.2	56	16	3	16	1
25	"	54	12	8	490	2	14	17	1	10	1
26		54	12	8.5	310	1.3	7	2	2	10	1
27		54	12	8.4	300	1.5	9	2	1	10	1
28		55	13	8.2	320	1.2	6	3	1	15	1
29	constr.	55	13	8.1	330	3.3	27	2	0	10	1
30		55	13	8.2	320	4.1	35	2	0	15	1

5/21/1996

Site	Stream	Temp	Temp.	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		56	13	7.4	290	0.9	3	37	5	3	3
2	trib	56	14	7.7	270	1.2	6	23	2	5	2
3		67	20	7.9	240	1	4	18	4	4	0
4		67	20	7.9	240	1.9	13	7	2	7	1
5		65	18	7.8	250	1.8	12	6	2	7	0
6	trib	59	15	7.6	220	1.1	5	4	3	6	0
7		59	15	7.6	230	2.2	16	3	2	5	1
8	trib	59	15	7.8	290	2.9	23	7	2	12	2
9		61	16	7.6	230	2.3	17	5	1	6	3
10		62	17	7.7	250	1.7	11	4	0	5	3
11	cole	60	16	7.6	240	2.6	20	6	1	8	2
12	cole	60	16	7.6	200	3.9	33	4	2	6	4
13		62	17	7.7	250	3	24	3	0	3	0
14	trib	60	16	7.7	170	2.7	21	3	0	4	0
15		59	15	7.6	270	2.2	16	2	1	3	3
16	trib	60	16	7.6	290	3.1	25	4	2	2	0
17		62	17	7.7	250	2.3	17	2	0	4	1
18	trib	61	16	7.8	250	2.4	18	5	3	4	2
19		61	16	7.8	250	2.7	21	3	0	4	3
20		61	16	7.9	230	1.7	11	2	1	5	2
21	cole	61	16	7.9	150	3	24	1	2	7	1
22		61	16	7.9	230	3.1	25	1	1	6	0
23	elmwd	56	13	7.7	400	6.8	62	28	0	15	5
24	"	59	15	7.8	370	5.5	49	23	1	12	4
25	"	61	16	7.8	380	5.8	52	18	3	11	2
26		61	16	7.7	190	2.5	19	3	1	6	0
27		62	16	7.9	210	3	24	5	0	5	0
28		61	16	7.8	220	2.7	21	4	2	4	1
29	constr.	61	16	7.7	230	2.2	16	3	0	5	0
30		61	16	7.7	250	2.5	19	3	0	4	1

6/21/1996

Site	Stream	Temp	Temp.	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		59	15	7.6	370	0.8	2	22	18	8	0
2	trib	56	14	8	360	0.9	3	11	15	6	0
3		68	20	8.1	240	1.8	12	0	4	11	2
4		68	20	8.1	260	2.5	19	1	3	9	0
5		66	19	8	280	1.6	10	0	6	11	0
6	trib	63	17	7.7	370	1.4	8	1	4	5	0
7		63	17	7.8	330	1.7	11	0	3	10	5
8	trib	66	19	7.6	370	3.8	32	1	6	11	3
9		61	16	7.7	310	2.6	20	1	3	19	2
10		64	18	7.9	310	3	24	5	2	12	2
11	cole	66	19	7.5	350	4.9	43	4	1	16	3
12	cole	66	19	7.5	350	3.5	29	4	4	19	5
13		64	18	7.5	340	3.3	27	2	11	11	4
14	trib	64	18	7.9	340	2.5	19	2	6	15	8
15		64	18	7.5	340	2.7	21	5	7	13	8
16	trib	64	18	7.9	350	8.5	79	2	3	17	2
17		64	18	7.2	360	3.2	26	2	4	16	8
18	trib	66	19	74	340	5.4	48	4	6	18	7
19		64	18	7.7	350	4.3	37	4	5	16	6
20		64	18	7.9	340	3.2	26	5	3	15	1
21	cole	66	19	8	480	9.2	86	4	2	18	3
22		63	17	7.5	470	4	34	4	4	16	6
23	elmwd	59	15	7.9	480	8.6	80	4	22	26	9
24	"	61	16	7.8	490	6.7	61	4	17	23	5
25	"	63	17	7.7	480	3.8	32	4	13	24	7
26		63	17	7.5	370	2.9	23	4	8	16	4
27		63	17	7.6	350	1.2	6	3	4	18	3
28		64	18	7.7	370	1.8	12	3	3	19	4
29	constr.	66	19	7.8	360	3	24	2	2	12	1
30		66	19	7.7	370	2.2	16	2	3	7	2

7/21/1996

Site	Stream	Temp	Temp.	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		59	15	7.8	260	0.8	2	15	11	6	2
2	trib	57	14	7.7	260	0.9	3	10	9	5	2
3		61	16	7.9	210	1.5	9	2	3	4	1
4		59	15	7.8	210	2	14	2	2	4	1
5		61	16	7.7	220	1.3	7	4	4	5	1
6	trib	61	16	7.7	280	2.1	15	4	5	4	1
7		64	18	7.7	260	1.5	9	4	5	4	1
8	trib	63	17	7.9	310	2.3	17	6	4	4	3
9		63	17	7.8	230	1.2	6	3	2	5	1
10		63	17	7.7	290	0.8	2	3	2	3	1
11	cole	64	18	7.8	410	1	4	4	2	6	1
12	cole	63	17	7.8	400	1.2	6	4	3	8	1
13		63	17	7.7	280	0.9	3	5	8	8	1
14	trib	63	17	7.8	320	1.5	9	1	4	6	2
15		64	18	7.6	270	0.9	3	2	4	5	2
16	trib	63	17	8	430	1.6	10	2	3	6	2
17		66	19	7.8	300	1.1	5	3	3	6	2
18	trib	66	19	7.7	280	1.4	8	4	4	8	2
19		63	17	7.6	300	1.3	7	5	3	7	1
20		64	18	7.8	270	1.1	5	3	2	4	1
21	cole	64	18	7.9	330	1.5	9	1	1	8	1
22		64	18	7.7	270	1.9	13	2	2	9	3
23	elmwd	63	17	7.8	420	2.3	17	13	11	12	1
24	"	61	16	7.6	390	1.8	12	10	9	8	2
25	"	61	16	7.9	400	1.5	9	9	9	7	2
26		64	18	8	330	1.5	9	1	5	6	2
27		64	18	7.9	310	2	14	3	3	5	1
28		66	19	7.7	270	1.3	7	4	2	3	1
29	constr.	64	18	7.8	280	1.1	5	1	2	4	1
30		64	18	7.8	310	0.9	3	1	2	3	2

8/21/1996

Site	Stream	Temp. F	Temp C	pH	TDS ppm	Chloride t ml	Chloride ppm	Nitrate ppm	Potassm ppm	Sodium ppm	Phosph ppm
1		59	15	7	270	0.8	2	27	2	6	0
2	trib	50	10	8.1	230	1.1	5	11	0	6	0
3		55	13	8.3	220	1.9	13	1	0	7	1
4		56	13	8.2	220	2.3	17	2	0	7	2
5		57	14	8.1	240	1.8	12	8	0	8	1
6	trib	57	14	8	300	2.6	20	8	0	8	0
7		57	14	8.1	240	1.9	13	3	1	7	2
8	trib	56	13	8.1	300	3.3	27	3	0	26	3
9		57	14	8.1	260	2.3	17	4	1	10	1
10		58	14	8.1	270	0.9	3	4	0	8	1
11	cole	58	14	8	420	1.6	10	5	3	22	1
12	cole	57	14	8	420	1.8	12	2	1	26	1
13		59	15	8.2	270	1.2	6	4	0	7	1
14	trib	60	16	7.9	370	2.2	16	0	2	25	2
15		61	16	8.2	270	1.3	7	3	0	8	1
16	trib	60	16	7.8	420	2.1	15	3	3	29	2
17		59	15	8	290	1.4	8	4	0	12	1
18	trib	61	16	7.9	290	1.9	13	4	1	28	1
19		61	16	8.2	300	1.6	10	5	0	17	1
20		62	17	8.2	300	0.9	3	2	0	13	2
21	cole	63	17	8.3	360	1.8	12	0	2	27	2
22		60	16	8	300	1.6	10	2	1	23	3
23	elmwd	58	14	8	470	3.3	27	26	3	36	1
24	"	57	14	8.1	470	2	14	16	3	33	1
25	"	60	16	8	490	1.7	11	17	1	19	1
26		59	15	8.5	310	1.3	7	2	2	11	1
27		60	16	8.4	300	2.1	15	2	1	9	1
28		60	16	8.2	320	1.1	5	3	1	11	1
29	constr.	60	16	8.1	330	1.3	7	2	0	13	1
30		61	16	8.2	320	1.1	5	2	0	8	1

9/21/1996

Site	Stream	Temp	Temp.	pH	TDS	Chloride t	Chloride	Nitrate	Potassm	Sodium	Phosph
		F	C		ppm	ml	ppm	ppm	ppm	ppm	ppm
1		54	12	7.3	300	1.3	7	23	10	11	0
2	trib	54	12	7.4	240	1.9	13	9	11	12	0
3		59	15	7.8	220	1.5	9	1	6	11	1
4		61	16	7.7	220	2	14	1	4	16	1
5		57	14	7.6	240	1.3	7	4	5	12	0
6	trib	57	14	7.5	220	1.7	11	6	5	7	0
7		59	15	7.4	240	1.9	13	2	5	8	1
8	trib	59	15	7.5	340	3.1	25	2	4	27	2
9		59	15	7.5	290	2.3	17	3	5	10	0
10		59	15	7.4	210	2.2	16	3	4	15	1
11	cole	61	16	7.6	300	4	34	8	5	29	1
12	cole	59	15	7.5	190	2.9	23	6	4	27	1
13		59	15	7.7	170	2.3	17	2	4	14	1
14	trib	59	15	7.5	210	2	14	0	4	8	3
15		61	16	7.6	180	1.9	13	1	5	6	2
16	trib	63	17	7.6	230	3	24	3	15	12	2
17		61	16	7.4	210	2.3	17	2	5	15	1
18	trib	59	15	7.7	220	1.1	5	2	5	19	2
19		59	15	7.4	190	1.3	7	2	4	16	1
20		61	16	7.6	170	1.7	11	2	8	14	2
21	cole	59	15	7.7	210	2.6	20	0	6	19	3
22		61	16	7.6	250	2.1	15	0	4	14	3
23	elmwd	57	14	7.5	440	4.3	37	18	4	28	2
24	"	59	15	7.6	390	4.2	36	12	5	24	2
25	"	59	15	7.6	370	3.6	30	11	6	20	1
26		61	16	7.4	230	1.2	6	2	4	10	1
27		61	16	7.6	270	1.3	7	2	4	11	1
28		61	16	7.7	280	1.7	11	0	3	10	1
29	constr.	59	15	7.5	250	1.3	7	1	4	13	1
30		61	16	7.5	270	1.3	7	0	6	10	1

10/21/1996

Site	Stream	Temp F	Temp. C	pH	TDS ppm	Chloride t ml	Chloride ppm	Nitrate ppm	Potassm ppm	Sodium ppm	Phosph ppm
1		46	8	6.9	260	1.3	7	48	6	17	1
2	trib	46	8	7.1	240	2.1	15	32	21	20	4
3		48	9	7.2	190	3.8	32	1	5	16	0
4		48	9	7.1	300	2.1	15	1	6	16	0
5		46	8	7.3	520	5.1	45	0	7	13	0
6	trib	45	7	7.1	420	4.1	35	10	19	24	2
7		46	8	7.2	500	4.9	43	3	11	19	1
8	trib	46	8	7.1	210	3.8	32	0	15	28	2
9		46	8	7.1	460	4.1	35	0	12	21	1
10		45	7	7.1	420	3.9	33	2	13	26	4
11	cole	46	8	7.1	380	3.2	26	1	7	29	5
12	cole	46	8	7.1	400	3.3	27	1	7	29	4
13		46	8	7.1	260	3.1	25	2	7	26	5
14	trib	46	8	7.1	350	4.3	37	1	9	29	4
15		46	8	7.1	290	3.5	29	0	8	25	4
16	trib	46	8	7.1	330	4.1	35	2	9	23	4
17		46	8	7.3	300	3.9	33	1	8	24	1
18	trib	48	9	7.3	360	4.5	39	2	7	24	3
19		46	8	7.3	320	4.3	37	1	8	25	2
20		46	8	7.2	300	4.1	35	1	8	25	3
21	cole	46	8	7.3	450	4.4	38	2	7	28	3
22		46	8	7.2	330	4.2	36	1	7	29	3
23	elmwd	52	11	7.4	540	5	44	2	6	30	5
24	"	48	9	7.2	440	5.1	45	1	5	30	5
25	"	46	8	7.3	420	4.9	43	0	5	31	4
26		46	8	7.3	380	4.2	36	0	4	27	2
27		46	8	7.2	360	4.1	35	0	3	29	3
28		46	8	7.1	300	4.3	37	0	4	26	3
29	constr.	46	8	7.1	320	4.5	39	1	5	32	2
30		46	8	7.1	310	4.1	35	0	3	29	3

11/21/1996

Site	Stream	Temp F	Temp. C	pH	TDS ppm	Chloride t ml	Chloride ppm	Nitrate ppm	Potassm ppm	Sodium ppm	Phosph ppm
1		36	2	7.1	280	2	14	16	8	11	1
2	trib	36	2	7.2	260	3.3	27	11	16	22	1
3		36	2	7.2	210	4.2	36	0	2	25	1
4		37	3	7.1	290	3.5	29	0	3	16	1
5		37	3	7.2	580	6.3	57	0	4	18	2
6	trib	36	2	7.2	410	5.2	46	8	12	62	0
7		36	2	7.3	520	5.2	46	0	15	35	1
8	trib	36	2	7.2	250	13.5	129	0	10	55	0
9		36	2	7.1	470	8.8	82	1	9	39	0
10		34	1	7.1	410	9.3	87	2	9	34	3
11	cole	36	2	7.1	390	8.3	77	0	9	44	3
12	cole	36	2	7.2	420	9.1	85	0	6	48	2
13		36	2	7.3	280	8.2	76	0	6	33	0
14	trib	36	2	7.3	325	9.2	86	1	5	36	1
15		36	2	7.2	310	6.5	59	0	6	33	1
16	trib	36	2	7.3	320	8.2	76	1	4	29	3
17		36	2	7.2	310	6.8	62	1	7	31	0
18	trib	36	2	7.3	400	9.2	86	0	6	36	1
19		36	2	7.2	350	5.5	49	1	6	29	0
20		36	2	7.2	320	6.5	59	0	6	29	1
21	cole	36	2	7.3	470	9.8	92	1	5	33	0
22		36	2	7.2	360	6.3	57	1	6	25	2
23	elmwd	39	4	7.3	520	10.1	95	0	6	42	2
24	"	37	3	7.2	470	9.5	89	1	5	40	5
25	"	36	2	7.1	420	9	84	0	6	36	3
26		36	2	7.3	390	7.3	67	0	5	29	1
27		36	2	7.2	330	8	74	1	5	33	0
28		36	2	7.1	350	7.9	73	0	4	33	0
29	constr.	36	2	7.2	330	7.7	71	0	4	35	0
30		36	2	7.2	320	8	74	0	2	32	1

12/21/1996

Site	Stream	Temp. F	Temp C	pH	TDS ppm	Chloride t ml	Chloride ppm	Nitrate ppm	Potassm ppm	Sodium ppm	Phosph ppm
1		32	0	7.5	320	1	4	15	2	22	0
2	trib	32	0	7.2	340	1.2	6	13	2	35	0
3		32	0	7.3	300	1.1	5	1	2	21	1
4		34	1	7.3	320	1.3	7	1	3	25	1
5		32	0	7.2	330	4.2	36	1	1	45	2
6	trib	32	0	7.3	640	22.3	217	8	1	120	1
7		32	0	7.5	350	27.5	269	3	1	52	1
8	trib	32	0	7.4	740	61.2	606	1	3	320	3
9		32	0	7.6	420	5.6	50	1	2	150	1
10		32	0	7.5	410	11.2	106	2	2	75	0
11	cole	32	0	7.6	620	27.2	266	4	1	150	0
12	cole	32	0	7.4	590	29.2	286	9	2	170	5
13		32	0	7.6	620	11.2	106	3	3	70	0
14	trib	34	1	7.5	520	48	474	4	1	260	1
15		32	0	7.5	470	10.2	96	4	2	120	1
16	trib	32	0	7.6	360	9.8	92	5	1	230	3
17		32	0	7.7	420	8.2	76	1	1	110	2
18	trib	32	0	7.3	410	11	104	2	1	170	0
19		34	1	7.4	450	10.5	99	1	2	90	1
20		34	1	7.5	350	12.3	117	2	1	110	1
21	cole	32	0	7.3	520	25.8	252	3	3	220	1
22		32	0	7.5	620	23.2	226	1	1	150	0
23	elmwd	34	1	7.5	570	32.2	316	4	3	330	1
24	"	32	0	7.2	580	30.1	295	2	1	280	3
25	"	34	1	7.3	490	28.2	276	1	2	300	1
26		32	0	7.2	450	18.2	176	1	2	190	3
27		34	1	7.3	620	18	174	1	2	200	1
28		34	1	7.4	660	23.3	227	2	1	170	3
29	constr.	34	1	7.5	600	22	214	3	3	150	0
30		34	1	7.4	620	25.6	250	2	1	160	0

Objective A- Nitrate

Nitrate - Objective A												
Site												
	1/26/1996	2/26/1996	3/26/1996	4/26/1996	5/26/1996	6/26/1996	7/26/1996	8/26/1996	9/26/1996	10/26/1996	11/26/1996	12/26/1996
1	32	26	36	45	37	22	15	27	23	48	16	15
2	27	17	17	11	23	11	10	11	9	32	11	13
3	1	4	1	1	18	0	2	1	1	1	0	1
4	2	3	0	2	7	1	2	2	1	1	0	1
5	3	5	2	8	6	0	4	8	4	0	0	1
6	25	15	11	8	4	1	4	8	6	10	8	8
7	4	4	3	3	3	0	4	3	2	3	0	3
8	5	4	2	3	7	1	6	3	2	0	0	1
9	9	8	5	4	5	1	3	4	3	0	1	1
10	9	7	6	4	4	5	3	4	3	2	2	2
11	15	7	5	5	6	4	4	5	8	1	0	4
12	12	6	3	2	4	4	4	2	6	1	0	9
13	8	8	4	4	3	2	5	4	2	2	0	3
14	4	5	2	0	3	2	1	0	0	1	1	4
15	8	6	5	3	2	5	2	3	1	0	0	4
16	27	6	5	3	4	2	2	3	3	2	1	5
17	10	8	5	4	2	2	3	4	2	1	1	1
18	8	8	6	4	5	4	4	4	2	2	0	2
19	8	8	6	5	3	4	5	5	2	1	1	1
20	10	7	5	2	2	5	3	2	2	1	0	2
21	10	6	2	0	1	4	1	0	0	2	1	3
22	8	8	3	2	1	4	2	2	0	1	1	1
23	33	10	13	26	28	4	13	26	18	2	0	4
24	27	16	24	16	23	4	10	16	12	1	1	2
25	29	18	18	17	18	4	9	17	11	0	0	1
26	9	8	13	2	3	4	1	2	2	0	0	1
27	9	8	2	2	5	3	3	2	2	0	1	1
28	12	10	9	3	4	3	4	3	0	0	0	2
29	11	10	6	2	3	2	1	2	1	1	0	3
30	10	10	4	2	3	2	1	2	0	0	0	2
Average	12.8	8.9	7.4	6.4	7.9	3.7	4.4	5.8	4.3	3.9	1.5	3.4
Sum	385	266	223	193	237	110	131	175	128	116	46	101

TOTAL NUMBERS				TRIBUTARIES				NON - TRIBUTARIES			
	total	num	avg		total	num	avg		total	num	avg
Rural	768	84	9	Rural	300	24	13	Rural	468	60	8
Urban	1343	276	5	Urban	787	120	7	Urban	556	240	2

Objective A - Nitrate

Nitrate Site	Average	Sum	WIN-AVG	SPG-AVG	SUM-AVG	FAL-AVG
1	28.5	342	24.33	31.67	21.33	29
2	16.0	192	19.00	17.00	10.67	17.33
3	2.6	31	2.00	6.33	1.00	0.67
4	1.8	22	2.00	2.67	1.67	0.67
5	3.4	41	3.00	2.67	4.00	1.33
6	9.0	108	16.00	5.33	4.33	8.00
7	2.7	32	3.67	2.00	2.33	1.67
8	2.8	34	3.33	3.33	3.33	0.67
9	3.7	44	6.00	3.67	2.67	1.33
10	4.3	51	6.00	5.00	4.00	2.33
11	5.3	64	8.67	5.00	4.33	3.00
12	4.4	53	9.00	3.67	3.33	2.33
13	3.8	45	6.33	3.00	3.67	1.33
14	1.9	23	4.33	2.33	1.00	0.67
15	3.3	39	6.00	4.00	3.33	0.33
16	5.3	63	12.67	3.67	2.33	2.00
17	3.6	43	6.33	3.00	3.00	1.33
18	4.1	49	6.00	5.00	4.00	1.33
19	4.1	49	5.67	4.33	4.67	1.33
20	3.4	41	6.33	4.00	3.33	1.00
21	2.5	30	6.33	2.33	1.67	1.00
22	2.8	33	5.67	2.67	2.67	0.67
23	14.8	177	15.67	15.00	14.33	6.67
24	12.7	152	15.00	17.00	10.00	4.67
25	11.8	142	16.00	13.33	10.00	3.67
26	3.8	45	6.00	6.67	2.33	0.67
27	3.2	38	6.00	3.33	2.67	1.00
28	4.2	50	8.00	5.33	3.33	0.00
29	3.5	42	8.00	3.67	1.67	0.67
30	3.0	36	7.33	3.00	1.67	0.00
		83.56	63.33	46.22	32.22	

Objective A – Potassium

Potassium - Objective A												
Site												
	1/26/1996	2/26/1996	3/26/1996	4/26/1996	5/26/1996	6/26/1996	7/26/1996	8/26/1996	9/26/1996	10/26/1996	11/26/1996	12/26/1996
1	4	4	1	2	5	18	11	2	10	6	8	2
2	1	8	1	0	2	15	9	0	11	21	16	2
3	3	2	3	0	4	4	3	0	6	5	2	2
4	3	3	3	0	2	3	2	0	4	6	3	3
5	3	4	3	0	2	6	4	0	5	7	4	1
6	8	5	2	0	3	4	5	0	5	19	12	1
7	3	3	1	1	2	3	5	1	5	11	15	1
8	10	4	4	0	2	6	4	0	4	15	10	3
9	3	2	3	1	1	3	2	1	5	12	9	2
10	3	2	2	0	0	2	2	0	4	13	9	2
11	5	4	2	3	1	1	2	3	5	7	9	1
12	4	1	2	1	2	4	3	1	4	7	6	2
13	3	2	3	0	0	11	8	0	4	7	6	3
14	5	1	3	2	0	6	4	2	4	9	5	1
15	3	5	2	0	1	7	4	0	5	8	6	2
16	1	2	3	3	2	3	3	3	15	9	4	1
17	3	3	2	0	0	4	3	0	5	8	7	1
18	4	14	2	1	3	6	4	1	5	7	6	1
19	4	21	3	0	0	5	3	0	4	8	6	2
20	3	2	2	0	1	3	2	0	8	8	6	1
21	5	4	3	2	2	2	1	2	6	7	5	3
22	3	10	3	1	1	4	2	1	4	7	6	1
23	2	3	4	3	0	22	11	3	4	6	6	3
24	2	2	3	3	1	17	9	3	5	5	5	1
25	3	25	4	1	3	13	9	1	6	5	6	2
26	3	10	3	2	1	8	5	2	4	4	5	2
27	3	2	2	1	0	4	3	1	4	3	5	2
28	4	19	3	1	2	3	2	1	3	4	4	1
29	3	48	5	0	0	2	2	0	4	5	4	3
30	3	46	3	0	0	3	2	0	6	3	2	1
Average	3.6	8.7	2.7	0.9	1.4	6.4	4.3	0.9	5.5	8.1	6.6	1.8
Sum	107	261	80	28	43	192	129	28	164	242	197	53

TOTAL NUMBERS				TRIBUTARIES				NON - TRIBUTARIES			
	total	num	avg		total	num	avg		total	num	avg
Rural	379	84	5	Rural	150	24	6	Rural	229	60	4
Urban	1145	276	4	Urban	530	120	4	Urban	615	240	3

Objective A – Potassium

Potassium						
Site						
	Average	Sum	WIN-AVG	SPG-AVG	SUM-AVG	FAL-AVG
1	6.1	73	3.33	8.00	10.33	8
2	7.2	86	3.67	6.00	8.00	16.00
3	2.0	34	2.33	3.67	2.33	4.33
4	2.7	32	3.00	2.67	1.67	4.33
5	3.3	39	2.67	3.67	3.33	5.33
6	5.3	64	4.67	3.00	3.00	12.00
7	4.3	51	2.33	2.00	3.00	10.33
8	5.2	62	5.67	4.00	3.33	9.67
9	3.7	44	2.33	2.33	2.00	8.67
10	3.3	39	2.33	1.33	1.33	8.67
11	3.6	43	3.33	1.33	2.00	7.00
12	3.1	37	2.33	2.67	2.67	5.67
13	3.9	47	2.67	4.67	6.33	5.67
14	3.5	42	2.33	3.00	4.00	6.00
15	3.6	43	3.33	3.33	3.67	6.33
16	4.1	49	1.33	2.67	3.00	9.33
17	3.0	36	2.33	2.00	2.33	6.67
18	4.5	54	6.33	3.67	3.67	6.00
19	4.7	56	9.00	2.67	2.67	6.00
20	3.0	36	2.00	2.00	1.67	7.33
21	3.5	42	4.00	2.33	1.67	6.00
22	3.6	43	4.67	2.67	2.33	5.67
23	5.6	67	2.67	8.67	12.00	5.33
24	4.7	56	1.67	7.00	9.67	5.00
25	6.5	78	10.00	6.67	7.67	5.67
26	4.1	49	5.00	4.00	5.00	4.33
27	2.5	30	2.33	2.00	2.67	4.00
28	3.9	47	8.00	2.67	2.00	3.67
29	6.3	76	18.00	2.33	1.33	4.33
30	5.8	69	16.67	2.00	1.67	3.67
		46.78	35.00	38.78	67.00	

Objective B – Sodium

Sodium - Objective B												
Site												
	1/26/1996	2/26/1996	3/26/1996	4/26/1996	5/26/1996	6/26/1996	7/26/1996	8/26/1996	9/26/1996	10/26/1996	11/26/1996	12/26/1996
1	16	3	15	6	3	8	6	6	10	17	11	22
2	17	8	17	6	5	6	5	6	11	20	22	35
3	16	4	17	7	4	11	4	7	6	16	25	21
4	17	4	17	7	7	9	4	7	4	16	16	25
5	38	10	18	8	7	11	5	8	5	13	18	45
6	320	7	19	8	6	5	4	8	5	24	62	120
7	33	73	22	7	5	10	4	7	5	19	35	52
8	880	84	83	26	12	11	4	26	4	28	55	320
9	100	28	24	10	6	19	5	10	5	21	39	150
10	46	34	22	8	5	12	3	8	4	26	34	75
11	100	110	100	22	8	16	6	22	5	29	44	150
12	100	92	110	26	6	19	8	26	4	29	48	170
13	37	35	21	7	3	11	8	7	4	26	33	70
14	270	51	66	25	4	15	6	25	4	29	36	260
15	77	40	23	11	3	13	5	8	5	25	33	120
16	26	88	62	29	2	17	6	29	15	23	29	230
17	31	42	24	10	4	16	6	12	5	24	31	110
18	44	44	24	23	4	18	8	28	5	24	36	170
19	48	40	24	10	4	16	7	17	4	25	29	90
20	42	22	26	11	5	15	4	13	8	25	29	110
21	150	40	99	28	7	18	8	27	6	28	33	220
22	67	31	47	12	6	16	9	23	4	29	25	150
23	45	52	78	19	15	26	12	36	4	30	42	330
24	56	91	75	16	12	23	8	33	5	30	40	280
25	43	40	81	10	11	24	7	19	6	31	36	300
26	65	40	42	10	6	16	6	11	4	27	29	190
27	54	24	36	10	5	18	5	9	4	29	33	200
28	71	24	41	15	4	19	3	11	3	26	33	170
29	64	22	45	10	5	12	4	13	4	32	35	150
30	64	26	49	15	4	7	3	8	6	29	32	160
Average	97.9	40.3	44.2	13.7	5.9	14.6	5.8	15.7	5.5	25.0	33.4	149.8
Sum	2937	1209	1327	412	178	437	173	470	164	750	1003	4495

TOTAL NUMBERS				TRIBUTARIES				NON - TRIBUTARIES			
	total	num	avg		total	num	avg		total	num	avg
Rural	1598	84	19	Rural	746	24	31	Rural	852	60	14
Urban	11957	276	43	Urban	7188	120	60	Urban	4769	240	20

Objective B – Sodium

Sodium						
Site						
	Average	Sum	WIN-AVG	SPG-AVG	SUM-AVG	FAL-AVG
1	10.3	123	13.67	8.67	6.67	12.67
2	13.2	158	20.00	9.33	5.67	17.67
3	11.5	138	13.67	10.67	7.33	15.67
4	11.1	133	15.33	11.00	6.67	12.00
5	15.5	186	31.00	12.00	8.00	12.00
6	49.0	588	149.00	10.00	5.67	30.33
7	22.7	272	52.67	12.33	7.00	19.67
8	127.8	1533	428.00	35.33	13.67	29.00
9	34.8	417	92.67	16.33	11.33	21.67
10	23.1	277	51.67	13.00	7.67	21.33
11	51.0	612	120.00	41.33	14.67	26.00
12	53.2	638	120.67	45.00	17.67	27.00
13	21.8	262	47.33	11.67	8.67	21.00
14	65.9	791	193.67	28.33	15.33	23.00
15	30.3	363	79.00	13.00	8.67	21.00
16	46.3	556	114.67	27.00	17.33	22.33
17	26.3	315	61.00	14.67	11.33	20.00
18	35.7	428	86.00	15.33	18.00	21.67
19	26.2	314	59.33	14.67	13.33	19.33
20	25.8	310	58.00	15.33	10.67	20.67
21	55.3	664	136.67	41.33	17.67	22.33
22	34.9	419	82.67	23.00	16.00	19.33
23	57.4	689	142.33	39.67	24.67	25.33
24	55.8	669	142.33	36.67	21.33	25.00
25	50.7	608	127.67	38.67	16.67	24.33
26	37.2	446	98.33	21.33	11.00	20.00
27	35.6	427	92.67	19.67	10.67	22.00
28	35.0	420	88.33	21.33	11.00	20.67
29	33.0	396	78.67	20.67	9.67	23.67
30	33.6	403	83.33	20.00	6.00	22.33
		960.11	215.78	120.00	213.00	
		total	295.33	74.00	47.00	120.00
		rural	42	11	7	17
		urban	112	25	14	23
		total	2585.00	573.33	313.00	519.00

Objective B – Chloride

Chloride - Objective B												
Site												
	1/26/1996	2/26/1996	3/26/1996	4/26/1996	5/26/1996	6/26/1996	7/26/1996	8/26/1996	9/26/1996	10/26/1996	11/26/1996	12/26/1996
1	3	5	4	2	3	2	2	2	7	7	14	4
2	8	8	6	3	6	3	3	5	13	15	27	6
3	9	7	8	3	4	12	9	13	9	32	36	5
4	14	8	8	1	13	19	14	17	14	15	29	7
5	44	39	13	2	12	10	7	12	7	45	57	36
6	467	28	19	11	5	8	15	20	11	35	46	217
7	546	285	15	6	16	11	9	13	13	43	46	269
8	1358	304	40	26	23	32	17	27	25	32	129	606
9	71	128	18	8	17	20	6	17	17	35	82	50
10	60	128	17	12	11	24	2	3	16	33	87	106
11	118	403	134	76	20	43	4	10	34	26	77	266
12	129	339	134	36	33	29	6	12	23	27	85	286
13	41	147	16	24	24	27	3	6	17	25	76	106
14	380	193	52	16	21	19	9	16	14	37	86	474
15	54	170	27	7	16	21	3	7	13	29	59	96
16	46	327	88	36	25	79	10	15	24	35	76	92
17	53	179	29	37	17	26	5	8	17	33	62	76
18	72	334	27	17	18	48	8	13	5	39	86	104
19	74	189	23	7	21	37	7	10	7	37	49	99
20	79	106	29	37	11	26	5	3	11	35	59	117
21	79	154	145	46	24	86	9	12	20	38	92	252
22	71	133	64	17	25	34	13	10	15	36	57	226
23	92	180	80	71	62	80	17	27	37	44	95	316
24	71	273	118	56	49	61	12	14	36	45	89	295
25	92	206	4	14	52	32	9	11	30	43	84	276
26	70	181	49	7	19	23	9	7	6	36	67	176
27	106	109	48	9	24	6	14	15	7	35	74	174
28	92	121	44	6	21	12	7	5	11	37	73	227
29	185	212	55	27	16	24	5	7	7	39	71	214
30	205	230	70	35	19	16	3	5	7	35	74	250
Average	**156.3**	**170.8**	**46.1**	**21.8**	**20.9**	**29.0**	**8.1**	**11.4**	**15.8**	**33.4**	**68.1**	**180.9**
Sum	**4688**	**5124**	**1384**	**655**	**627**	**870**	**242**	**342**	**473**	**1003**	**2043**	**5426**

TOTAL NUMBERS				TRIBUTARIES				NON - TRIBUTARIES			
	total	num	avg		total	num	avg		total	num	avg
Rural	2901.600225	84	35	Rural	984.69465	24	41	Rural	1916.905575	60	32
Urban	19974.80589	276	72	Urban	11936.2986	120	99	Urban	8038.50729	240	33

Objective B – Chloride

Chloride Site						
	Average	Sum	WIN-AVG	SPG-AVG	SUM-AVG	FAL-AVG
1	4.6	55	4.00	3.00	2.00	9.33
2	8.6	103	7.33	5.00	3.67	18.33
3	12.3	147	7.00	8.00	11.33	25.66
4	13.2	159	9.66	13.33	16.66	19.33
5	23.7	284	39.65	11.66	9.66	36.32
6	73.5	882	237.26	10.66	14.33	30.66
7	106.0	1272	366.55	14.00	11.00	33.99
8	218.2	2618	755.77	31.66	25.33	61.98
9	39.1	469	82.97	18.33	14.33	44.65
10	41.6	499	97.97	17.33	9.66	45.32
11	100.9	1211	262.25	65.65	18.99	45.65
12	94.9	1139	251.26	65.31	15.66	44.99
13	42.7	512	97.97	22.33	12.00	39.32
14	109.7	1317	348.89	30.66	14.66	45.65
15	41.8	502	106.63	21.33	10.33	33.66
16	71.1	853	154.95	63.98	34.66	44.99
17	45.2	542	102.63	23.99	13.00	37.32
18	64.2	771	169.95	30.99	22.99	43.32
19	46.7	560	120.63	26.99	17.99	30.99
20	43.2	518	100.64	21.99	11.33	34.99
21	79.7	957	161.62	84.97	35.66	49.98
22	58.4	701	143.29	40.99	18.99	35.99
23	91.7	1101	195.94	73.98	41.32	58.65
24	93.2	1119	212.93	75.98	28.99	56.65
25	71.1	853	191.27	29.32	17.33	52.32
26	54.1	650	142.29	30.32	13.00	36.32
27	51.7	621	129.63	25.99	11.66	38.65
28	54.6	656	146.62	25.66	8.00	40.32
29	71.8	862	203.60	31.66	12.00	38.99
30	79.1	949	228.26	34.99	8.00	38.65
		1693.14	320.01	161.51	390.99	
		total	671.46	65.65	68.65	173.61
		rural	96	9	10	25
		urban	192	39	18	43
		total	4407.97	894.39	415.87	999.36

Objective C - Overall

	C	LC	RC	S	LS	RS	P	LP	RP	N	LN	RN	BUS	LBUS	RBUS	RES	LRES	RRES
1	4.6	0.663	0.217	10.3	1.013	0.097	6.1	0.785	0.164	28.5	1.455	0.035		.000	.000	1	.000	1.000
2	8.6	0.934	0.116	13.2	1.121	0.076	7.2	0.857	0.139	16.0	1.204	0.063		.000	.000		.000	.000
3	12.3	1.090	0.081	11.5	1.061	0.087	2.8	0.447	0.357	2.6	0.415	0.385		.000	.000	1	.000	1.000
4	13.2	1.121	0.076	11.1	1.045	0.090	2.7	0.431	0.370	1.8	0.255	0.556		.000	.000	8	.903	.125
5	23.7	1.375	0.042	15.5	1.190	0.065	3.3	0.519	0.303	3.4	0.531	0.294	26	1.415	.038	13	1.114	.077
6	73.5	1.866	0.014	49.0	1.690	0.020	5.3	0.724	0.189	9.0	0.954	0.111	34	1.531	.029	26	1.415	.038
7	106.0	2.025	0.009	22.7	1.356	0.044	4.3	0.633	0.233	2.7	0.431	0.370	62	1.792	.016	50	1.699	.020
8	218.2	2.339	0.005	127.8	2.107	0.008	5.2	0.716	0.192	2.8	0.447	0.357	82	1.914	.012	355	2.550	.003
9	39.1	1.592	0.026	34.8	1.542	0.029	3.7	0.568	0.270	3.7	0.568	0.270	53	1.724	.019	300	2.477	.003
10	41.6	1.619	0.024	23.1	1.364	0.043	3.3	0.519	0.303	4.3	0.633	0.233	54	1.732	.019	400	2.602	.003
11	100.9	2.004	0.010	51.0	1.708	0.020	3.6	0.556	0.278	5.3	0.724	0.189	73	1.863	.014	123	2.090	.008
12	94.9	1.977	0.011	53.2	1.726	0.019	3.1	0.491	0.323	4.4	0.643	0.227	52	1.716	.019	239	2.378	.004
13	42.7	1.630	0.023	21.8	1.338	0.046	3.9	0.591	0.256	3.8	0.580	0.263	111	2.045	.009	316	2.500	.003
14	109.7	2.040	0.009	65.9	1.819	0.015	3.5	0.544	0.286	1.9	0.279	0.526	110	2.041	.009	397	2.599	.003
15	41.8	1.621	0.024	30.3	1.481	0.033	3.6	0.556	0.278	3.3	0.519	0.303	207	2.316	.005	239	2.378	.004
16	71.1	1.852	0.014	46.3	1.666	0.022	4.1	0.613	0.244	5.3	0.724	0.189	59	1.771	.017	715	2.854	.001
17	45.2	1.655	0.022	26.3	1.420	0.038	3.0	0.477	0.333	3.6	0.556	0.278	123	2.090	.008	224	2.350	.004
18	64.2	1.808	0.016	35.7	1.553	0.028	4.5	0.653	0.222	4.1	0.613	0.244	137	2.137	.007	202	2.305	.005
19	46.7	1.669	0.021	26.2	1.418	0.038	4.7	0.672	0.213	4.1	0.613	0.244	98	1.991	.010	225	2.352	.004
20	43.2	1.635	0.023	25.8	1.412	0.039	3.0	0.477	0.333	3.4	0.531	0.294	88	1.944	.011	178	2.250	.006
21	79.7	1.901	0.013	55.3	1.743	0.018	3.5	0.544	0.286	2.5	0.398	0.400	114	2.057	.009	164	2.215	.006
22	58.4	1.766	0.017	34.9	1.543	0.029	3.6	0.556	0.278	2.8	0.447	0.357	274	2.438	.004	104	2.017	.010
23	91.7	1.962	0.011	57.4	1.759	0.017	5.6	0.748	0.179	14.8	1.170	0.068	23	1.362	.043	368	2.566	.003
24	93.2	1.969	0.011	55.8	1.747	0.018	4.7	0.672	0.213	12.7	1.104	0.079	11	1.041	.091	105	2.021	.010
25	71.1	1.852	0.014	50.7	1.705	0.020	6.5	0.813	0.154	11.8	1.072	0.085	39	1.591	.026	89	1.949	.011
26	54.1	1.733	0.018	37.2	1.571	0.027	4.1	0.613	0.244	3.8	0.580	0.263	128	2.107	.008	57	1.756	.018
27	51.7	1.713	0.019	35.6	1.551	0.028	2.5	0.398	0.400	3.2	0.505	0.313	273	2.436	.004	50	1.699	.020
28	54.6	1.737	0.018	35.0	1.544	0.029	3.9	0.591	0.256	4.2	0.623	0.238	90	1.954	.011	19	1.279	.053
29	71.8	1.856	0.014	33.0	1.519	0.030	6.3	0.799	0.159	3.5	0.544	0.286	100	2.000	.010	53	1.724	.019
30	79.1	1.898	0.013	33.6	1.526	0.030	5.8	0.763	0.172	3.0	0.477	0.333	80	1.903	.013	128	2.107	.008
r value biz	0.0957	0.7306	-0.3041	0.0929	0.6035	-0.3478	-0.3433	-0.1860	-0.2244	-0.4453	-0.4351	-0.4267						
r value res	0.3567	0.7796	0.7673	0.4087	0.7019	0.6888	-0.1354	-0.1414	0.0563	-0.1847	-0.3020	-0.0756						

	C	LC	RC	S	LS	RS
Business	0.0957	0.7306	-0.3041	0.0929	0.6035	-0.3478
Residential	**0.3567**	0.7796	0.7673	**0.4087**	0.7019	0.6888

0.05	0.349
0.01	0.449

	P	LP	RP	N	LN	RN
Business	-0.3433	-0.1860	-0.2244	**-0.4453**	**-0.4351**	**-0.4267**
Residential	-0.1354	-0.1414	0.0563	-0.1847	-0.3020	-0.0756

Objective C – Potassium

	PWIN	LPWIN	RPWIN	PSPR	LPSPR	RPSPR	PSUM	LPSUM	RPSUM	PFAL	LPFAL	RPFAL	BUS	LBUS	RBUS	RES	LRES	RRES
1	3.333	.523	.300	8.000	.903	.125	10.333	1.014	.097	8.000	.903	.125		.000	.000	1	.000	1.000
2	3.667	.564	.273	6.000	.778	.167	8.000	.903	.125	16.000	1.204	.063		.000	.000		.000	.000
3	2.333	.368	.429	3.667	.564	.273	2.333	.368	.429	4.333	.637	.231		.000	.000	1	.000	1.000
4	3.000	.477	.333	2.667	.426	.375	1.667	.222	.600	4.333	.637	.231		.000	.000	8	.903	.125
5	2.667	.426	.375	3.667	.564	.273	3.333	.523	.300	5.333	.727	.188	26	1.415	.038	13	1.114	.077
6	4.667	.669	.214	3.000	.477	.333	3.000	.477	.333	12.000	1.079	.083	34	1.531	.029	26	1.415	.038
7	2.333	.368	.429	2.000	.301	.500	3.000	.477	.333	10.333	1.014	.097	62	1.792	.016	50	1.699	.020
8	5.667	.753	.176	4.000	.602	.250	3.333	.523	.300	9.667	.985	.103	82	1.914	.012	355	2.550	.003
9	2.333	.368	.429	2.333	.368	.429	2.000	.301	.500	8.667	.938	.115	53	1.724	.019	300	2.477	.003
10	2.333	.368	.429	1.333	.125	.750	1.333	.125	.750	8.667	.938	.115	54	1.732	.019	400	2.602	.003
11	3.333	.523	.300	1.333	.125	.750	2.000	.301	.500	7.000	.845	.143	73	1.863	.014	123	2.090	.008
12	2.333	.368	.429	2.667	.426	.375	2.667	.426	.375	5.667	.753	.176	52	1.716	.019	239	2.378	.004
13	2.667	.426	.375	4.667	.669	.214	6.333	.802	.158	5.667	.753	.176	111	2.045	.009	316	2.500	.003
14	2.333	.368	.429	3.000	.477	.333	4.000	.602	.250	6.000	.778	.167	110	2.041	.009	397	2.599	.003
15	3.333	.523	.300	3.333	.523	.300	3.667	.564	.273	6.333	.802	.158	207	2.316	.005	239	2.378	.004
16	1.333	.125	.750	2.667	.426	.375	3.000	.477	.333	9.333	.970	.107	59	1.771	.017	715	2.854	.001
17	2.333	.368	.429	2.000	.301	.500	2.333	.368	.429	6.667	.824	.150	123	2.090	.008	224	2.350	.004
18	6.333	.802	.158	3.667	.564	.273	3.667	.564	.273	6.000	.778	.167	137	2.137	.007	202	2.305	.005
19	9.000	.954	.111	2.667	.426	.375	2.667	.426	.375	6.000	.778	.167	98	1.991	.010	225	2.352	.004
20	2.000	.301	.500	2.000	.301	.500	1.667	.222	.600	7.333	.865	.136	88	1.944	.011	178	2.250	.006
21	4.000	.602	.250	2.333	.368	.429	1.667	.222	.600	6.000	.778	.167	114	2.057	.009	164	2.215	.006
22	4.667	.669	.214	2.667	.426	.375	2.333	.368	.429	5.667	.753	.176	274	2.438	.004	104	2.017	.010
23	2.667	.426	.375	8.667	.938	.115	12.000	1.079	.083	5.333	.727	.188	23	1.362	.043	368	2.566	.003
24	1.667	.222	.600	7.000	.845	.143	9.667	.985	.103	5.000	.699	.200	11	1.041	.091	105	2.021	.010
25	10.000	1.000	.100	6.667	.824	.150	7.667	.885	.130	5.667	.753	.176	39	1.591	.026	89	1.949	.011
26	5.000	.699	.200	4.000	.602	.250	5.000	.699	.200	4.333	.637	.231	128	2.107	.008	57	1.756	.018
27	2.333	.368	.429	2.000	.301	.500	2.667	.426	.375	4.000	.602	.250	273	2.436	.004	50	1.699	.020
28	8.000	.903	.125	2.667	.426	.375	2.000	.301	.500	3.667	.564	.273	90	1.954	.011	19	1.279	.053
29	18.000	1.255	.056	2.333	.368	.429	1.333	.125	.750	4.333	.637	.231	100	2.000	.010	53	1.724	.019
30	16.667	1.222	.060	2.000	.301	.500	1.667	.222	.600	3.667	.564	.273	80	1.903	.013	128	2.107	.008
r value biz	.075	.197	.315	-.398	.338	-.248	-.338	-.323	-.303	-.301	-.181	.006						
r value res	-.240	-.066	.066	-.094	-.316	-.273	-.024	-.176	-.134	.128	-.023	.081						

	PWIN	LPWIN	RPWIN	PSPR	LPSPR	RPSPR
Business	0.0747	0.1966	0.3147	**-0.3978**	0.3375	-0.2478
Residential	-0.2401	-0.0663	0.0660	-0.0938	-0.3162	-0.2730

0.05	0.349
0.01	0.449

	PSUM	LPSUM	RPSUM	PFAL	LPFAL	RPFAL
Business	-0.3381	-0.3235	-0.3033	-0.3007	-0.1810	0.0062
Residential	-0.0241	-0.1765	-0.1335	0.1281	-0.0233	0.0811

Objective C – Nitrate

	NWIN	LNWIN	RNWIN	NSPR	LNSPR	RNSPR	NSUM	LNSUM	RNSUM	NFAL	LNFAL	RNFAL	BUS	LBUS	RBUS	RES	LRES	RRES
1	24.333	1.386	.041	31.667	1.501	.032	21.333	1.329	.047	29.000	1.462	.034		.000	.000	1	.000	1.000
2	19.000	1.279	.053	17.000	1.230	.059	10.667	1.028	.094	17.333	1.239	.058		.000	.000		.000	.000
3	2.000	.301	.500	6.333	.802	.158	1.000	.000	1.000	.667	-.176	1.500		.000	.000	1	.000	1.000
4	2.000	.301	.500	2.667	.426	.375	1.667	.222	.600	.667	-.176	1.500		.000	.000	8	.903	.125
5	3.000	.477	.333	2.667	.426	.375	4.000	.602	.250	1.333	.125	.750	26	1.415	.038	13	1.114	.077
6	16.000	1.204	.063	5.333	.727	.188	4.333	.637	.231	8.000	.903	.125	34	1.531	.029	26	1.415	.038
7	3.667	.564	.273	2.000	.301	.500	2.333	.368	.429	1.667	.222	.600	62	1.792	.016	50	1.699	.020
8	3.333	.523	.300	3.333	.523	.300	3.333	.523	.300	.667	-.176	1.500	82	1.914	.012	355	2.550	.003
9	6.000	.778	.167	3.667	.564	.273	2.667	.426	.375	1.333	.125	.750	53	1.724	.019	300	2.477	.003
10	6.000	.778	.167	5.000	.699	.200	4.000	.602	.250	2.333	.368	.429	54	1.732	.019	400	2.602	.003
11	8.667	.938	.115	5.000	.699	.200	4.333	.637	.231	3.000	.477	.333	73	1.863	.014	123	2.090	.008
12	9.000	.954	.111	3.667	.564	.273	3.333	.523	.300	2.333	.368	.429	52	1.716	.019	239	2.378	.004
13	6.333	.802	.158	3.000	.477	.333	3.667	.564	.273	1.333	.125	.750	111	2.045	.009	316	2.500	.003
14	4.333	.637	.231	2.333	.368	.429	1.000	.000	1.000	.667	-.176	1.500	110	2.041	.009	397	2.599	.003
15	6.000	.778	.167	4.000	.602	.250	3.333	.523	.300	.333	-.477	3.000	207	2.316	.005	239	2.378	.004
16	12.667	1.103	.079	3.667	.564	.273	2.333	.368	.429	2.000	.301	.500	59	1.771	.017	715	2.854	.001
17	6.333	.802	.158	3.000	.477	.333	3.000	.477	.333	1.333	.125	.750	123	2.090	.008	224	2.350	.004
18	6.000	.778	.167	5.000	.699	.200	4.000	.602	.250	1.333	.125	.750	137	2.137	.007	202	2.305	.005
19	5.667	.753	.176	4.333	.637	.231	4.667	.669	.214	1.333	.125	.750	98	1.991	.010	225	2.352	.004
20	6.333	.802	.158	4.000	.602	.250	3.333	.523	.300	1.000	.000	1.000	88	1.944	.011	178	2.250	.006
21	6.333	.802	.158	2.333	.368	.429	1.667	.222	.600	1.000	.000	1.000	114	2.057	.009	164	2.215	.006
22	5.667	.753	.176	2.667	.426	.375	2.667	.426	.375	.667	-.176	1.500	274	2.438	.004	104	2.017	.010
23	15.667	1.195	.064	15.000	1.176	.067	14.333	1.156	.070	6.667	.824	.150	23	1.362	.043	368	2.566	.003
24	15.000	1.176	.067	17.000	1.230	.059	10.000	1.000	.100	4.667	.669	.214	11	1.041	.091	105	2.021	.010
25	16.000	1.204	.063	13.333	1.125	.075	10.000	1.000	.100	3.667	.564	.273	39	1.591	.026	89	1.949	.011
26	6.000	.778	.167	6.667	.824	.150	2.333	.368	.429	.667	-.176	1.500	128	2.107	.008	57	1.756	.018
27	6.000	.778	.167	3.333	.523	.300	2.667	.426	.375	1.000	.000	1.000	273	2.436	.004	50	1.699	.020
28	8.000	.903	.125	5.333	.727	.188	3.333	.523	.300	.000	.000	.000	90	1.954	.011	19	1.279	.053
29	8.000	.903	.125	3.667	.564	.273	1.667	.222	.600	.667	-.176	1.500	100	2.000	.010	53	1.724	.019
30	7.333	.865	.136	3.000	.477	.333	1.667	.222	.600	.000	.000	.000	80	1.903	.013	128	2.107	.008
r value biz	-.381	-.097	-.278	-.442	.314	-.287	-.402	-.307	-.371	-.412	-.524	-.361						
r value res	-.076	-.024	.293	-.239	-.430	-.326	-.143	-.172	.205	-.244	-.362	-.009						

	NWIN	LNWIN	RNWIN	NSPR	LNSPR	RNSPR		
Business	**-0.3812**	-0.0975	-0.2779	**-0.4423**	0.3142	-0.2869	**0.05**	0.349
Residential	-0.0758	-0.0238	0.2928	-0.2394	**-0.4303**	**-0.3257**	0.01	0.449

	NSUM	LNSUM	RNSUM	NFAL	LNFAL	RNFAL
Business	**-0.4017**	-0.3072	-0.3707	**-0.4124**	**-0.5244**	**-0.3611**
Residential	-0.1433	-0.1724	0.2048	-0.2437	**-0.3617**	-0.0086

Objective C – Chloride

	CWIN	LCWIN	RCWIN	CSPR	LCSPR	RCSPR	CSUM	LCSUM	RCSUM	CFAL	LCFAL	RCFAL	BUS	LBUS	RBUS	RES	LRES	RRES
1	3.999	.602	.250	2.999	.477	.333	1.999	.301	.500	9.330	.970	.107		.000	.000	1	.000	1.000
2	7.331	.865	.136	4.998	.699	.200	3.666	.564	.273	18.328	1.263	.055		.000	.000		.000	.000
3	6.998	.845	.143	7.998	.903	.125	11.330	1.054	.088	25.659	1.409	.039		.000	.000	1	.000	1.000
4	9.664	.985	.103	13.329	1.125	.075	16.662	1.222	.060	19.327	1.286	.052		.000	.000	8	.903	.125
5	39.654	1.598	.025	11.663	1.067	.086	9.664	.985	.103	36.322	1.560	.028	26	1.415	.038	13	1.114	.077
6	237.260	2.375	.004	10.663	1.028	.094	14.329	1.156	.070	30.657	1.487	.033	34	1.531	.029	26	1.415	.038
7	366.553	2.564	.003	13.996	1.146	.071	10.997	1.041	.091	33.989	1.531	.029	62	1.792	.016	50	1.699	.020
8	755.766	2.878	.001	31.657	1.500	.032	25.325	1.404	.039	61.981	1.792	.016	82	1.914	.012	355	2.550	.003
9	82.974	1.919	.012	18.328	1.263	.055	14.329	1.156	.070	44.653	1.650	.022	53	1.724	.019	300	2.477	.003
10	97.970	1.991	.010	17.328	1.239	.058	9.664	.985	.103	45.319	1.656	.022	54	1.732	.019	400	2.602	.003
11	262.252	2.419	.004	65.646	1.817	.015	18.994	1.279	.053	45.653	1.659	.022	73	1.863	.014	123	2.090	.008
12	251.255	2.400	.004	65.313	1.815	.015	15.662	1.195	.064	44.986	1.653	.022	52	1.716	.019	239	2.378	.004
13	97.970	1.991	.010	22.326	1.349	.045	11.996	1.079	.083	39.321	1.595	.025	111	2.045	.009	316	2.500	.003
14	348.892	2.543	.003	30.657	1.487	.033	14.662	1.166	.068	45.653	1.659	.022	110	2.041	.009	397	2.599	.003
15	106.634	2.028	.009	21.327	1.329	.047	10.330	1.014	.097	33.656	1.527	.030	207	2.316	.005	239	2.378	.004
16	154.952	2.190	.006	63.980	1.806	.016	34.656	1.540	.029	44.986	1.653	.022	59	1.771	.017	715	2.854	.001
17	102.635	2.011	.010	23.993	1.380	.042	12.996	1.114	.077	37.322	1.572	.027	123	2.090	.008	224	2.350	.004
18	169.947	2.230	.006	30.990	1.491	.032	22.993	1.362	.043	43.320	1.637	.023	137	2.137	.007	202	2.305	.005
19	120.629	2.081	.008	26.992	1.431	.037	17.994	1.255	.056	30.990	1.491	.032	98	1.991	.010	225	2.352	.004
20	100.635	2.003	.010	21.993	1.342	.045	11.330	1.054	.088	34.989	1.544	.029	88	1.944	.011	178	2.250	.006
21	161.617	2.208	.006	84.974	1.929	.012	35.656	1.552	.028	49.985	1.699	.020	114	2.057	.009	164	2.215	.006
22	143.289	2.156	.007	40.987	1.613	.024	18.994	1.279	.053	35.989	1.556	.028	274	2.438	.004	104	2.017	.010
23	195.939	2.292	.005	73.977	1.869	.014	41.321	1.616	.024	58.648	1.768	.017	23	1.362	.043	368	2.566	.003
24	212.934	2.328	.005	75.976	1.881	.013	28.991	1.462	.034	56.649	1.753	.018	11	1.041	.091	105	2.021	.010
25	191.274	2.282	.005	29.324	1.467	.034	17.328	1.239	.058	52.317	1.719	.019	39	1.591	.026	89	1.949	.011
26	142.289	2.153	.007	30.324	1.482	.033	12.996	1.114	.077	36.322	1.560	.028	128	2.107	.008	57	1.756	.018
27	129.626	2.113	.008	25.992	1.415	.038	11.663	1.067	.086	38.655	1.587	.026	273	2.436	.004	50	1.699	.020
28	146.621	2.166	.007	25.659	1.409	.039	7.998	.903	.125	40.321	1.606	.025	90	1.954	.011	19	1.279	.053
29	203.604	2.309	.005	31.657	1.500	.032	11.996	1.079	.083	38.988	1.591	.026	100	2.000	.010	53	1.724	.019
30	228.263	2.358	.004	34.989	1.544	.029	7.998	.903	.125	38.655	1.587	.026	80	1.903	.013	128	2.107	.008
r value biz	.090	.805	-.317	.084	.378	-.277	-.008	.399	-.292	.123	.658	-.358						
r value res	.286	.797	.836	.387	.756	.729	.515	.661	.613	.521	.788	.716						

	CWIN	LCWIN	RCWIN	CSPR	LCSPR	RCSPR		
Business	0.0903	0.8054	-0.3165	0.0842	**0.3776**	-0.2772	0.05	0.349
Residential	0.2858	0.7975	0.8358	0.3872	0.7562	0.7291	0.01	0.449

	CSUM	LCSUM	RCSUM	CFAL	LCFAL	RCFAL
Business	-0.0083	**0.3987**	-0.2918	0.1229	0.6575	**-0.3576**
Residential	0.5146	0.6611	0.6135	0.5205	0.7877	0.7155

Objective C – Sodium

	SWIN	LSWIN	RSWIN	SSPR	LSSPR	RSSPR	SSUM	LSSUM	RSSUM	SFAL	LSFAL	RSFAL	BUS	LBUS	RBUS	RES	LRES	RRES
1	13.667	1.136	.073	8.667	.938	.115	6.667	.824	.150	12.667	1.103	.079		.000	.000	1	.000	1.000
2	20.000	1.301	.050	9.333	.970	.107	5.667	.753	.176	17.667	1.247	.057		.000	.000		.000	.000
3	13.667	1.136	.073	10.667	1.028	.094	7.333	.865	.136	15.667	1.195	.064		.000	.000	1	.000	1.000
4	15.333	1.186	.065	11.000	1.041	.091	6.667	.824	.150	12.000	1.079	.083		.000	.000	8	.903	.125
5	31.000	1.491	.032	12.000	1.079	.083	8.000	.903	.125	12.000	1.079	.083	26	1.415	.038	13	1.114	.077
6	149.000	2.173	.007	10.000	1.000	.100	5.667	.753	.176	30.333	1.482	.033	34	1.531	.029	26	1.415	.038
7	52.667	1.722	.019	12.333	1.091	.081	7.000	.845	.143	19.667	1.294	.051	62	1.792	.016	50	1.699	.020
8	428.000	2.631	.002	35.333	1.548	.028	13.667	1.136	.073	29.000	1.462	.034	82	1.914	.012	355	2.550	.003
9	92.667	1.967	.011	16.333	1.213	.061	11.333	1.054	.088	21.667	1.336	.046	53	1.724	.019	300	2.477	.003
10	51.667	1.713	.019	13.000	1.114	.077	7.667	.885	.130	21.333	1.329	.047	54	1.732	.019	400	2.602	.003
11	120.000	2.079	.008	41.333	1.616	.024	14.667	1.166	.068	26.000	1.415	.038	73	1.863	.014	123	2.090	.008
12	120.667	2.082	.008	45.000	1.653	.022	17.667	1.247	.057	27.000	1.431	.037	52	1.716	.019	239	2.378	.004
13	47.333	1.675	.021	11.667	1.067	.086	8.667	.938	.115	21.000	1.322	.048	111	2.045	.009	316	2.500	.003
14	193.667	2.287	.005	28.333	1.452	.035	15.333	1.186	.065	23.000	1.362	.043	110	2.041	.009	397	2.599	.003
15	79.000	1.898	.013	13.000	1.114	.077	8.667	.938	.115	21.000	1.322	.048	207	2.316	.005	239	2.378	.004
16	114.667	2.059	.009	27.000	1.431	.037	17.333	1.239	.058	22.333	1.349	.045	59	1.771	.017	715	2.854	.001
17	61.000	1.785	.016	14.667	1.166	.068	11.333	1.054	.088	20.000	1.301	.050	123	2.090	.008	224	2.350	.004
18	86.000	1.934	.012	15.333	1.186	.065	18.000	1.255	.056	21.667	1.336	.046	137	2.137	.007	202	2.305	.005
19	59.333	1.773	.017	14.667	1.166	.068	13.333	1.125	.075	19.333	1.286	.052	98	1.991	.010	225	2.352	.004
20	58.000	1.763	.017	15.333	1.186	.065	10.667	1.028	.094	20.667	1.315	.048	88	1.944	.011	178	2.250	.006
21	136.667	2.136	.007	41.333	1.616	.024	17.667	1.247	.057	22.333	1.349	.045	114	2.057	.009	164	2.215	.006
22	82.667	1.917	.012	23.000	1.362	.043	16.000	1.204	.063	19.333	1.286	.052	274	2.438	.004	104	2.017	.010
23	142.333	2.153	.007	39.667	1.598	.025	24.667	1.392	.041	25.333	1.404	.039	23	1.362	.043	368	2.566	.003
24	142.333	2.153	.007	36.667	1.564	.027	21.333	1.329	.047	25.000	1.398	.040	11	1.041	.091	105	2.021	.010
25	127.667	2.106	.008	38.667	1.587	.026	16.667	1.222	.060	24.333	1.386	.041	39	1.591	.026	89	1.949	.011
26	98.333	1.993	.010	21.333	1.329	.047	11.000	1.041	.091	20.000	1.301	.050	128	2.107	.008	57	1.756	.018
27	92.667	1.967	.011	19.667	1.294	.051	10.667	1.028	.094	22.000	1.342	.045	273	2.436	.004	50	1.699	.020
28	88.333	1.946	.011	21.333	1.329	.047	11.000	1.041	.091	20.667	1.315	.048	90	1.954	.011	19	1.279	.053
29	78.667	1.896	.013	20.667	1.315	.048	9.667	.985	.103	23.667	1.374	.042	100	2.000	.010	53	1.724	.019
30	83.333	1.921	.012	20.000	1.301	.050	6.000	.778	.167	22.333	1.349	.045	80	1.903	.013	128	2.107	.008
r value biz	.096	.684	-.342	.008	.373	-.339	.110	.401	-.312	.130	.555	-.254						
r value res	.382	.742	.788	.287	.548	.480	.444	.604	.339	.361	.638	.537						

	SWIN	LSWIN	RSWIN	SSPR	LSSPR	RSSPR
Business	0.0957	0.6844	-0.3415	0.0079	**0.3727**	-0.3389
Residential	**0.3822**	0.7425	0.7879	0.2874	0.5481	0.4799

0.05	0.349
0.01	0.449

	SSUM	LSSUM	RSSUM	SFAL	LSFAL	RSFAL
Business	0.1095	**0.4009**	-0.3119	0.1302	0.5549	-0.2537
Residential	**0.4444**	0.6044	0.3386	**0.3611**	0.6376	0.5371