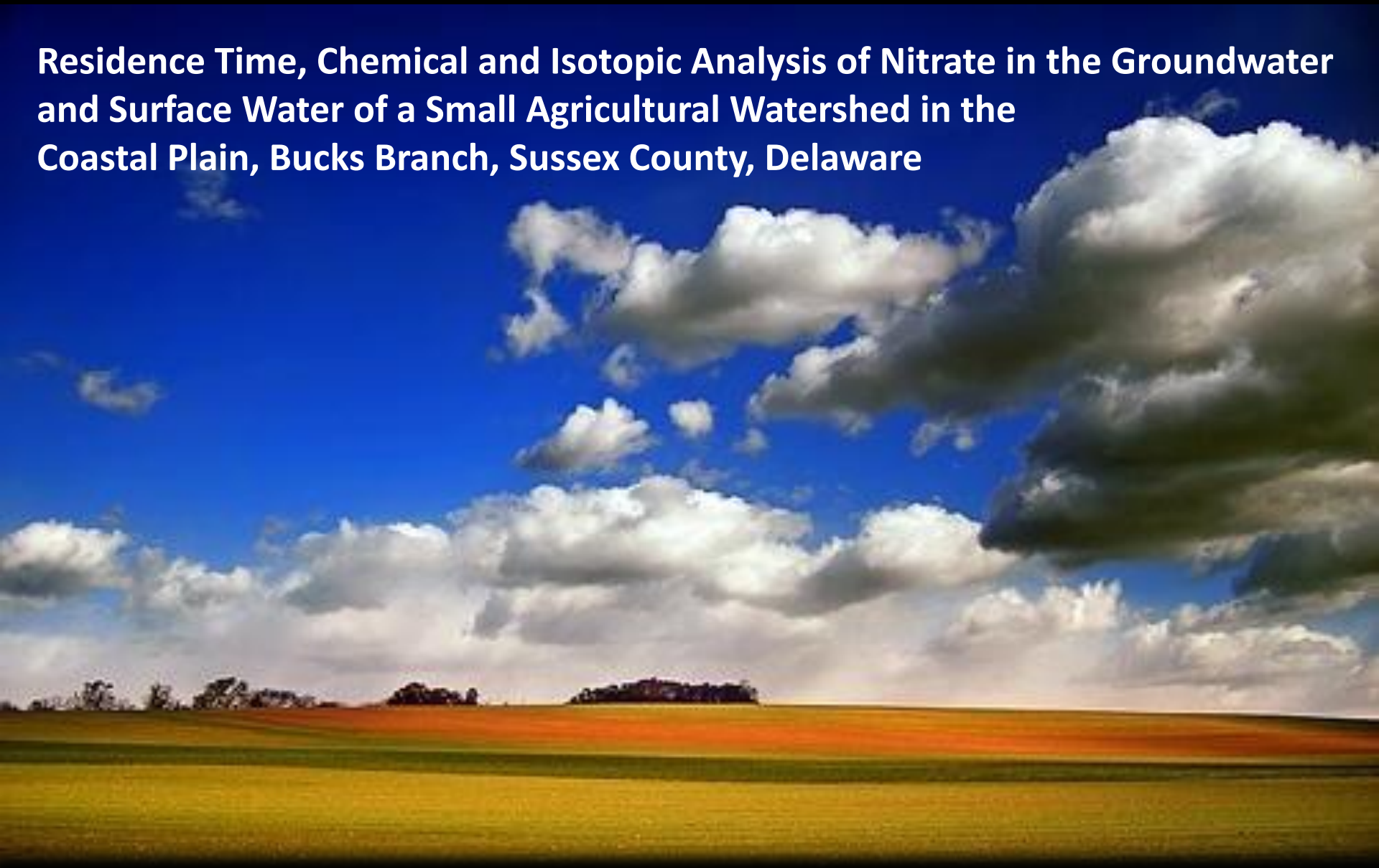
Residence Time, Chemical and Isotopic Analysis of Nitrate in the Groundwater and Surface Water of a Small Agricultural Watershed in the Coastal Plain, Bucks Branch, Sussex County, Delaware



John Clune (jclune@usgs.gov)
Judy Denver (jmdenver@usgs.gov)

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Introduction
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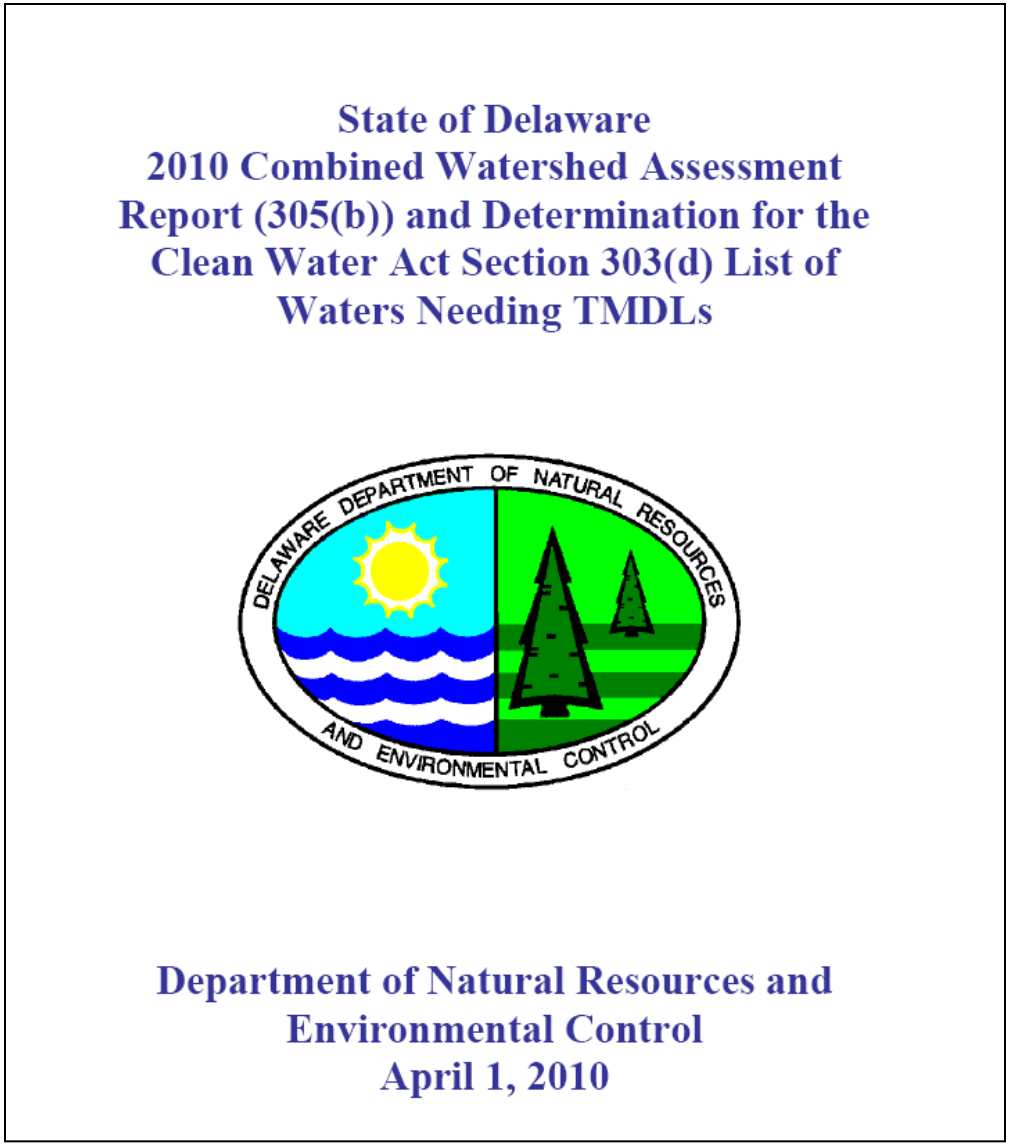
Introduction

Problem/Need

Resource managers need a practical perspective on **travel time** of groundwater to streams, detailed understanding of the sources of nitrogen for **targeting management** efforts and to better **quantify water-quality improvements**

Introduction

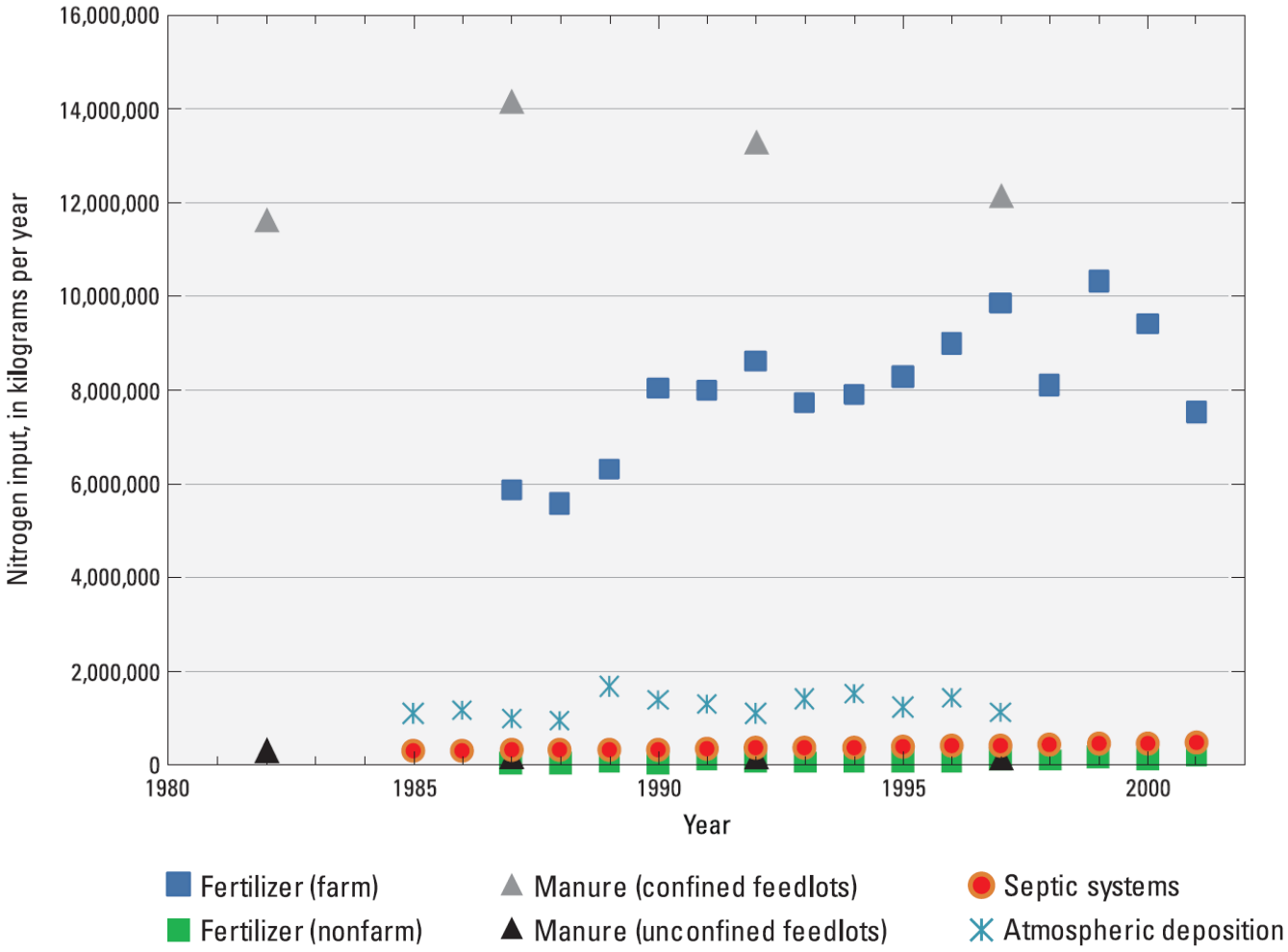
High TN



Bucks Branch has some of the **highest measured concentrations of total nitrogen** in any stream in the State (Delaware Department of Natural Resources and Environmental Control, 2010) and most of the nitrogen is in the form of nitrate.

Introduction

Sources



The vast majority of nitrogen inputs in this part of Sussex County, Delaware are from **manure** and **fertilizer**

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Purpose/Objectives

The purpose of this study was to present (1) **estimated residence times** of groundwater and (2) and provide a **chemical and isotopic analysis of nitrate** in the groundwater and surface water of the Bucks Branch watershed

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Concentrations of *sulfur hexafluoride (SF_6),* *dissolved gases* and *silica* in groundwater and surface water to determine the apparent age of groundwater in the aquifer and to estimate the average residence time of groundwater discharging to streams.

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Major-ion chemistry and the *nitrogen and oxygen isotopic composition* of nitrate in groundwater and stream water during base flow to evaluate the potential sources of nitrogen and to describe biogeochemical processes

Study Area

Location

The study area is located approximately 32 miles (mi) west of the Atlantic Ocean shoreline in Sussex County, Delaware

Bucks Branch drains 7.02 square miles (mi^2), and is a tributary to the Nanticoke River located on the Delmarva Peninsula, which eventually drains into the Chesapeake Bay.

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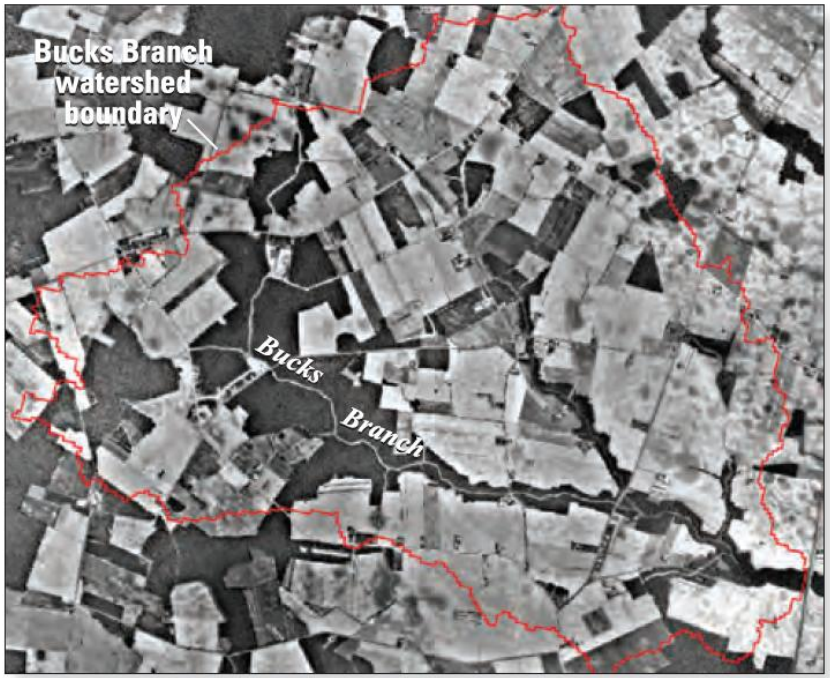
Study Area

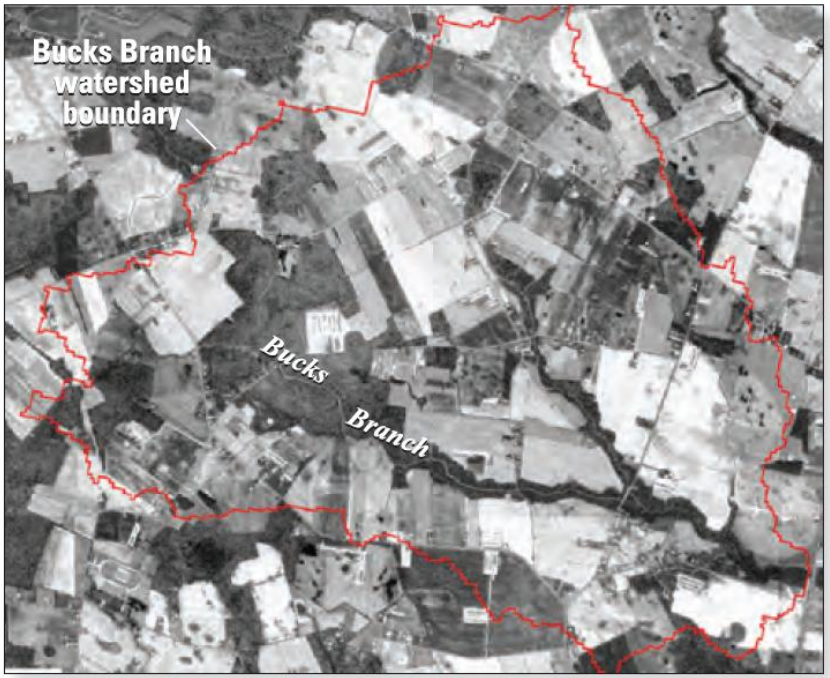
Historical

A. 1968



Aerial photograph by Agricultural Stabilization and Conservation Service, 1968

B. 1997



Aerial photograph by Earth Data (formerly PhotoScience), 1997

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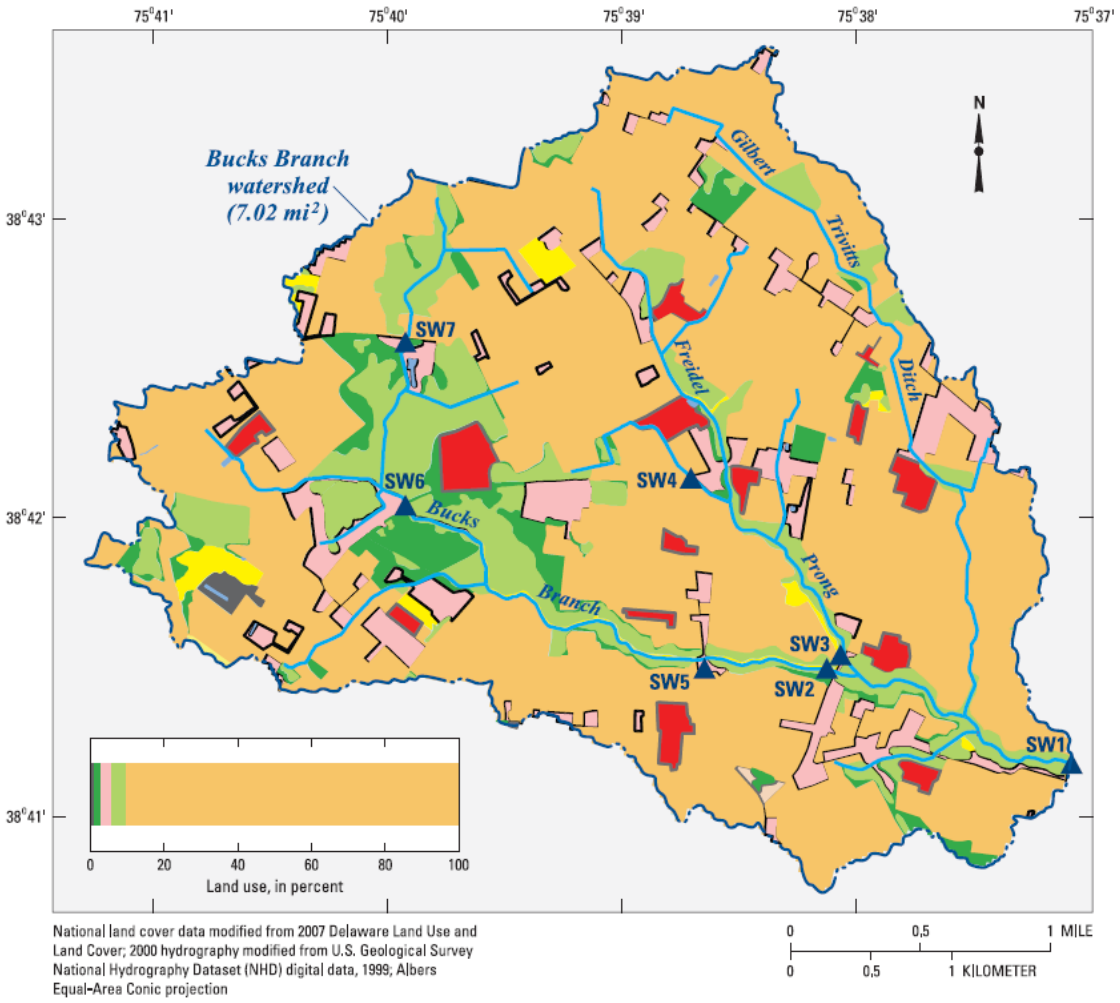
Study Area

Land Use



EXPLANATION

- Hay/pasture
- Concentrated animal feeding operations
- Cropland
- Forest
- Residential
- Water
- Wetlands
- Orchards
- SW1 Surface-water sampling site and identifier

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Study Area

Morphology




Channelization and dredging (ditching) of streams affects the nearby **water table**, impairs the functional properties of the **aquatic ecosystem**, reduces **canopy cover**

Methods

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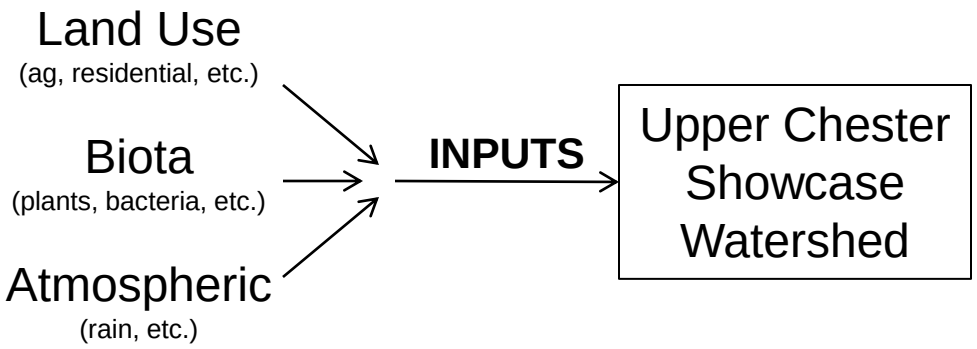
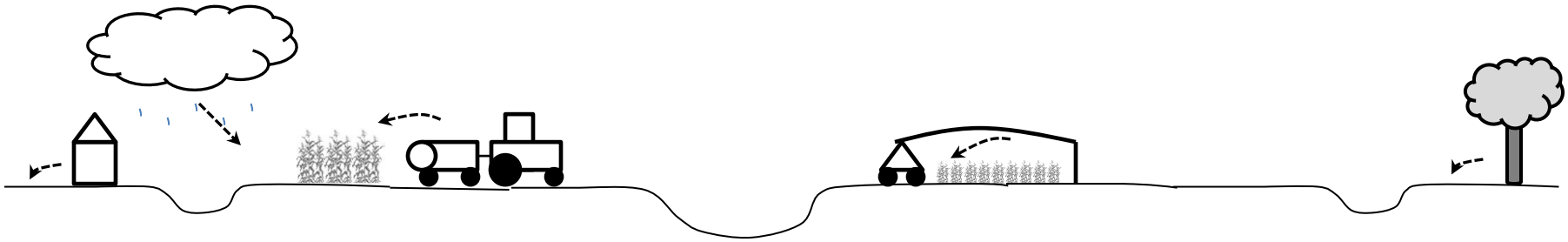
Mass Balance





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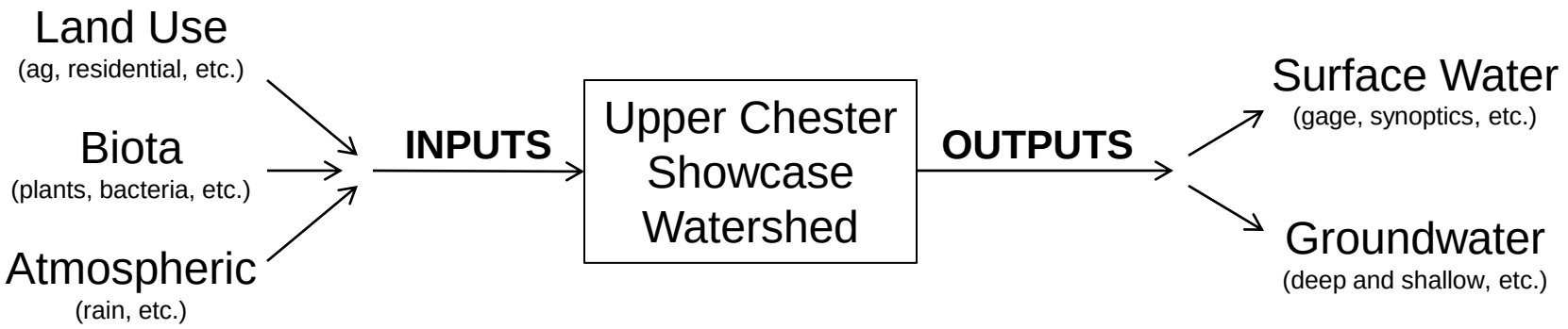

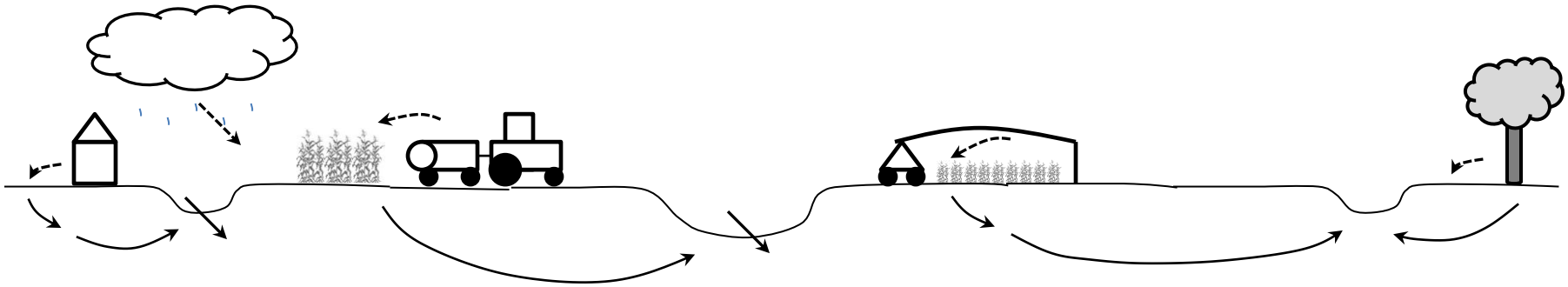

Methods

Sampling

Stream Synoptic (n =7, 5)

- High/Low Baseflow Conditions
- Field Parameters
- Major Ions (DNREC)
- N & O Isotopes (USGS)

Groundwater Synoptic (n = 10)

- Sampled Once
- Field Parameters
- Major Ions (DNREC)
- N & O Isotopes (USGS)
- Dissolved Gases (USGS)

Residence Time of Groundwater

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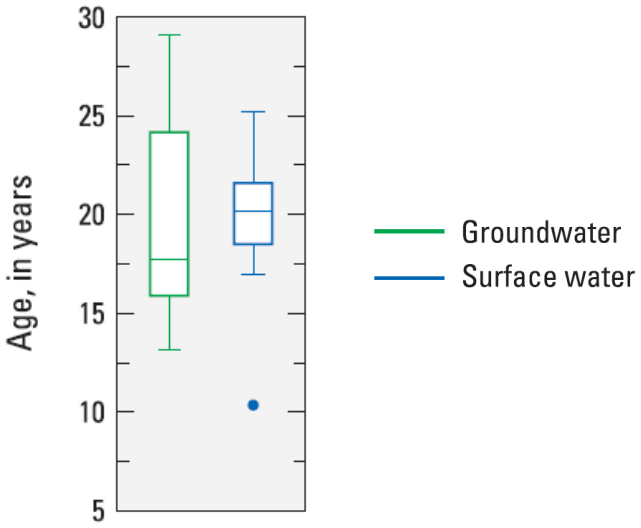
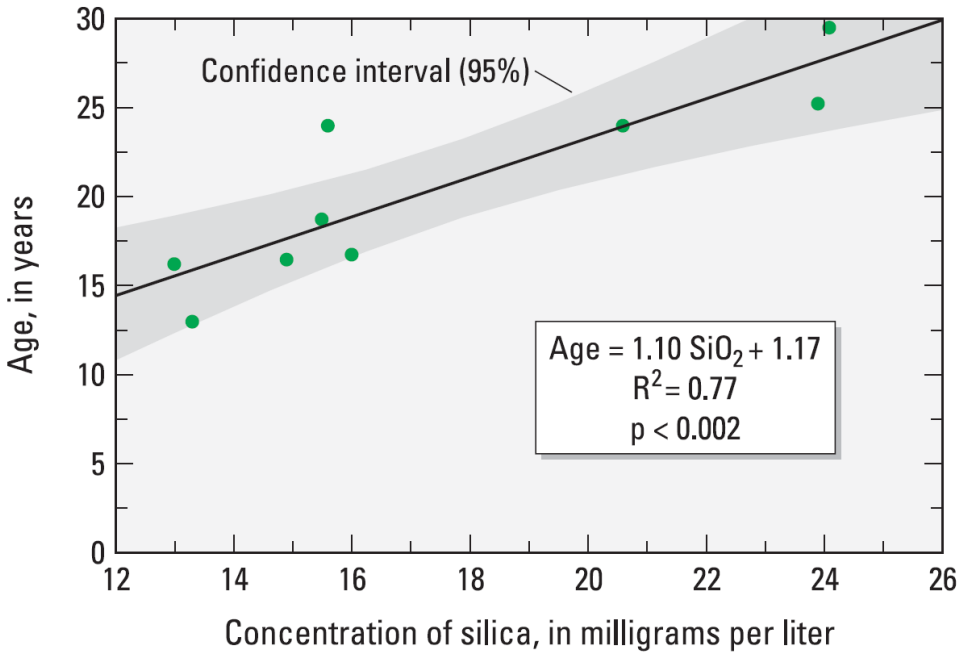
Residence Time of GW

The apparent age of groundwater sampled ranged from 13 to 30 years, with a median age of **18 years**

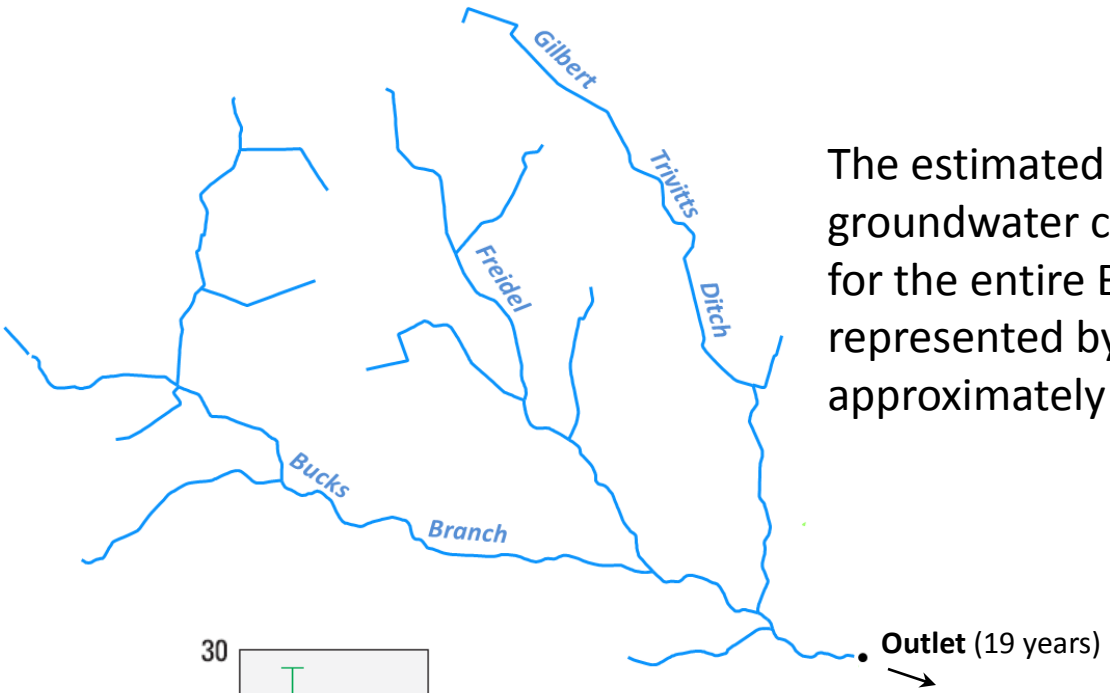




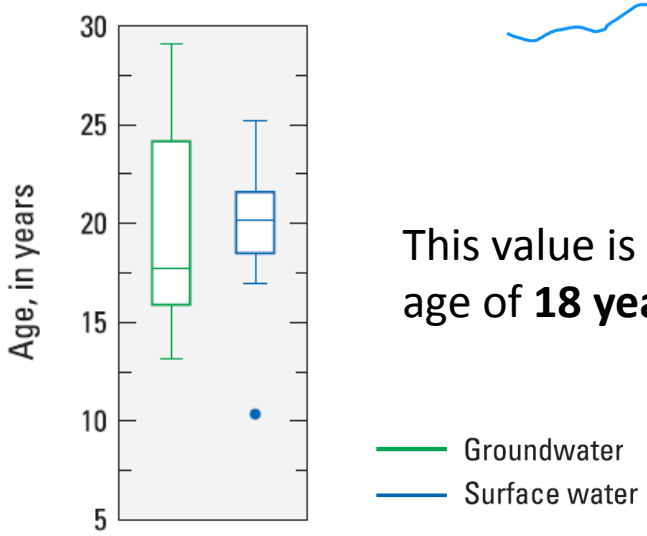
The residence time of groundwater contributing to the **stream** during base flow was based on an empirical model using simple linear regression of **groundwater ages** and **silica** concentrations in groundwater

Residence Time of GW

Outlet

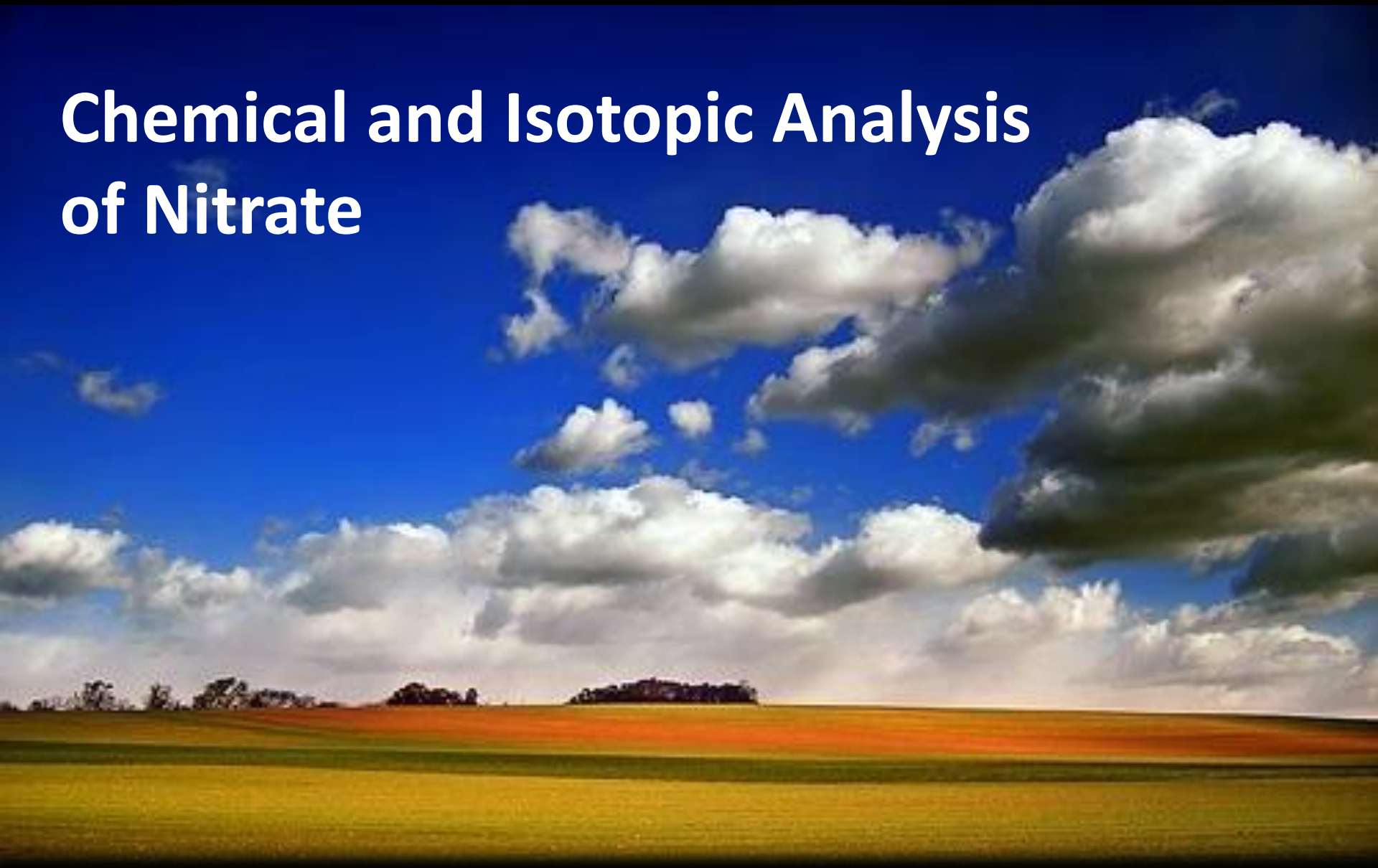


The estimated residence time of groundwater contributing to stream flow for the entire Bucks Branch watershed represented by the outlet and is approximately **19 years.**



This value is comparable to the median age of **18 years** for groundwater.

Chemical and Isotopic Analysis of Nitrate



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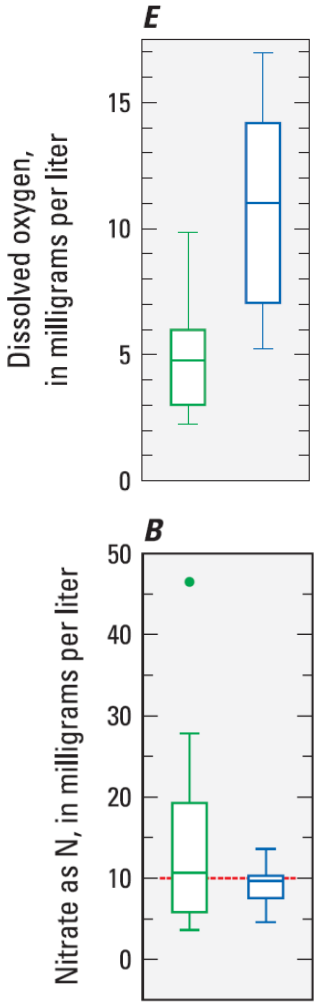
Major Ion Chemistry

Oxic Conditions



The surficial aquifer had **oxic conditions** with dissolved oxygen levels greater than 0.5 mg/L

The **lack of reducing conditions** for effective removal of nitrate by microbes coupled with the high rate of nitrogen input often leaves any effects of possible loss of nitrate indistinguishable

Nitrate exceeded the USEPA **drinking-water standard** (10 mg/L as N) in 60 percent of the groundwater wells and at 42 percent of the surface-water sites

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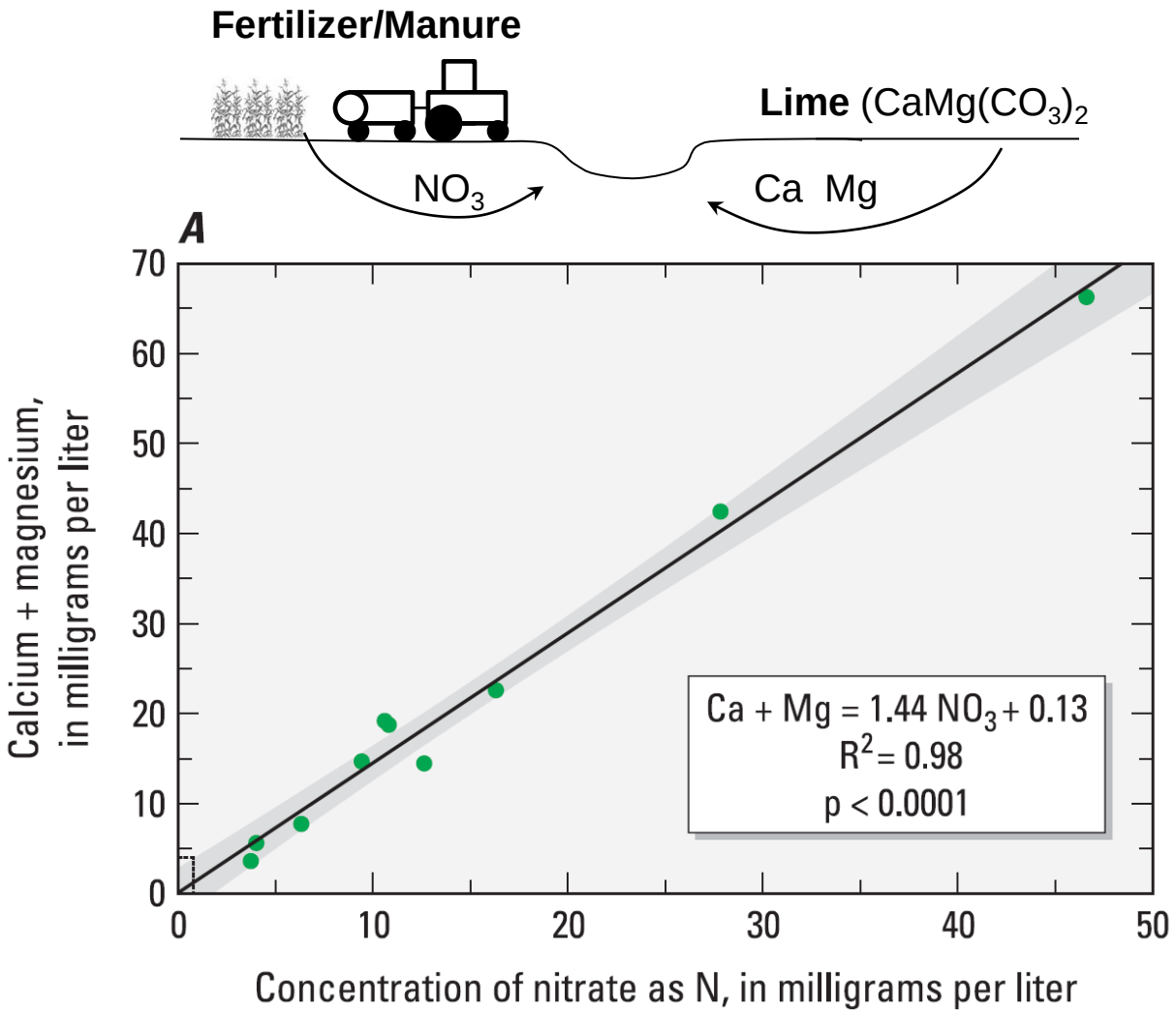
Major Ion Chemistry

Applications



Fertilizer, manure and soil organic matter produce an acidity that is often neutralized with **lime** (crushed dolomite) [$CaMg(CO_3)_2$]

A similar relation of NO_3 was found with **potash (KCl)** and **specific conductance**.

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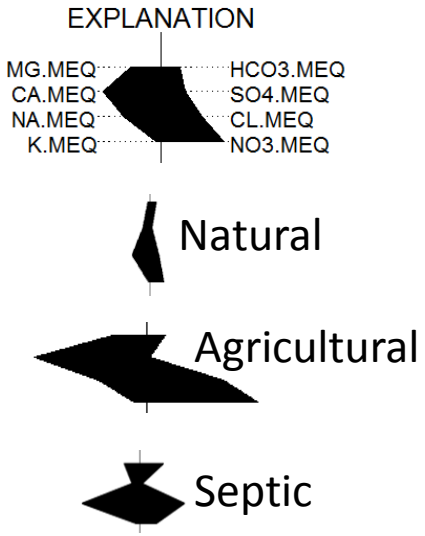
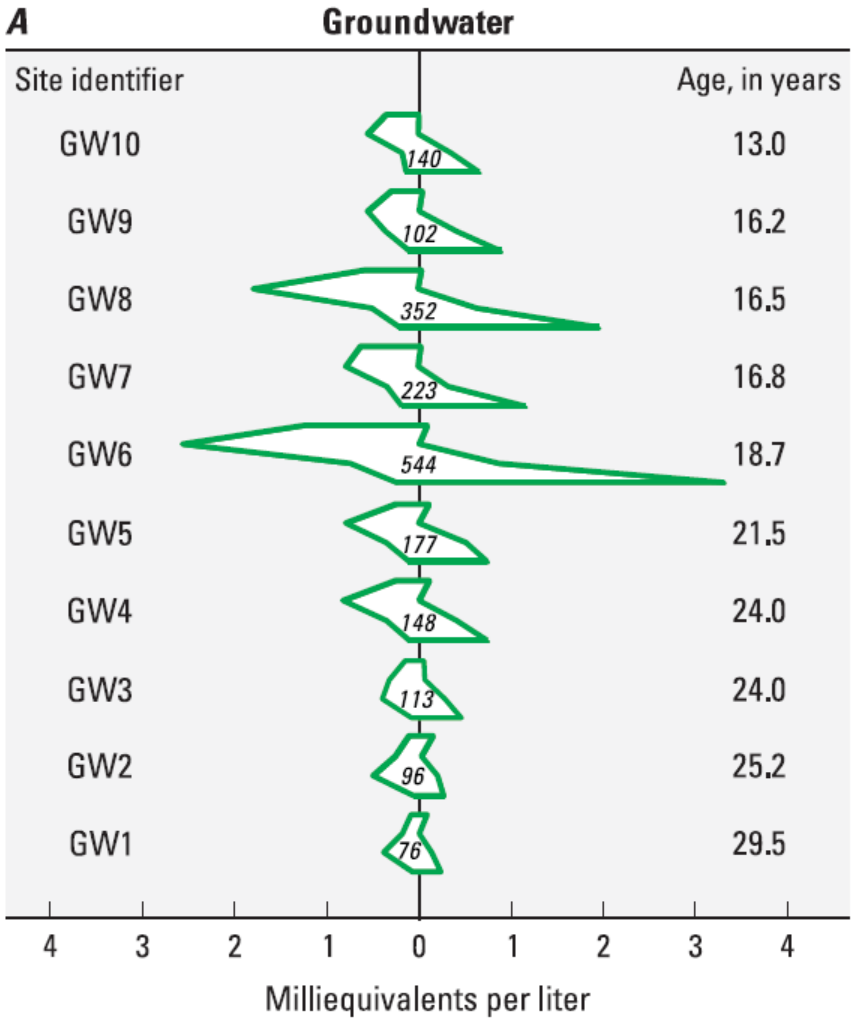
Major Ion Chemistry



The relative abundance of cations and anions in ground water present a pattern commonly seen in **water affected by agriculture**



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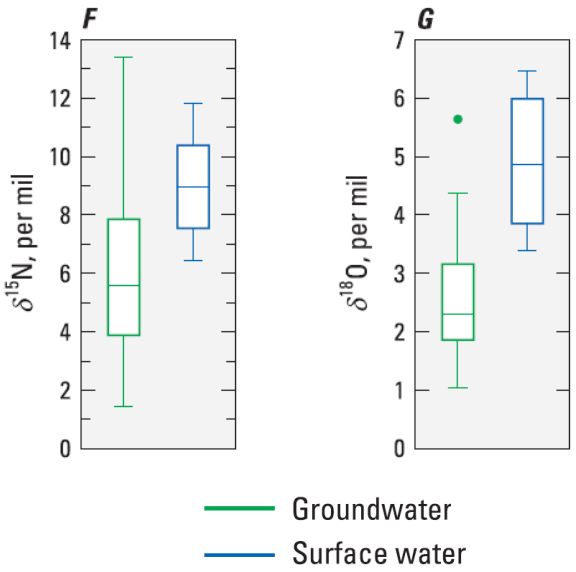
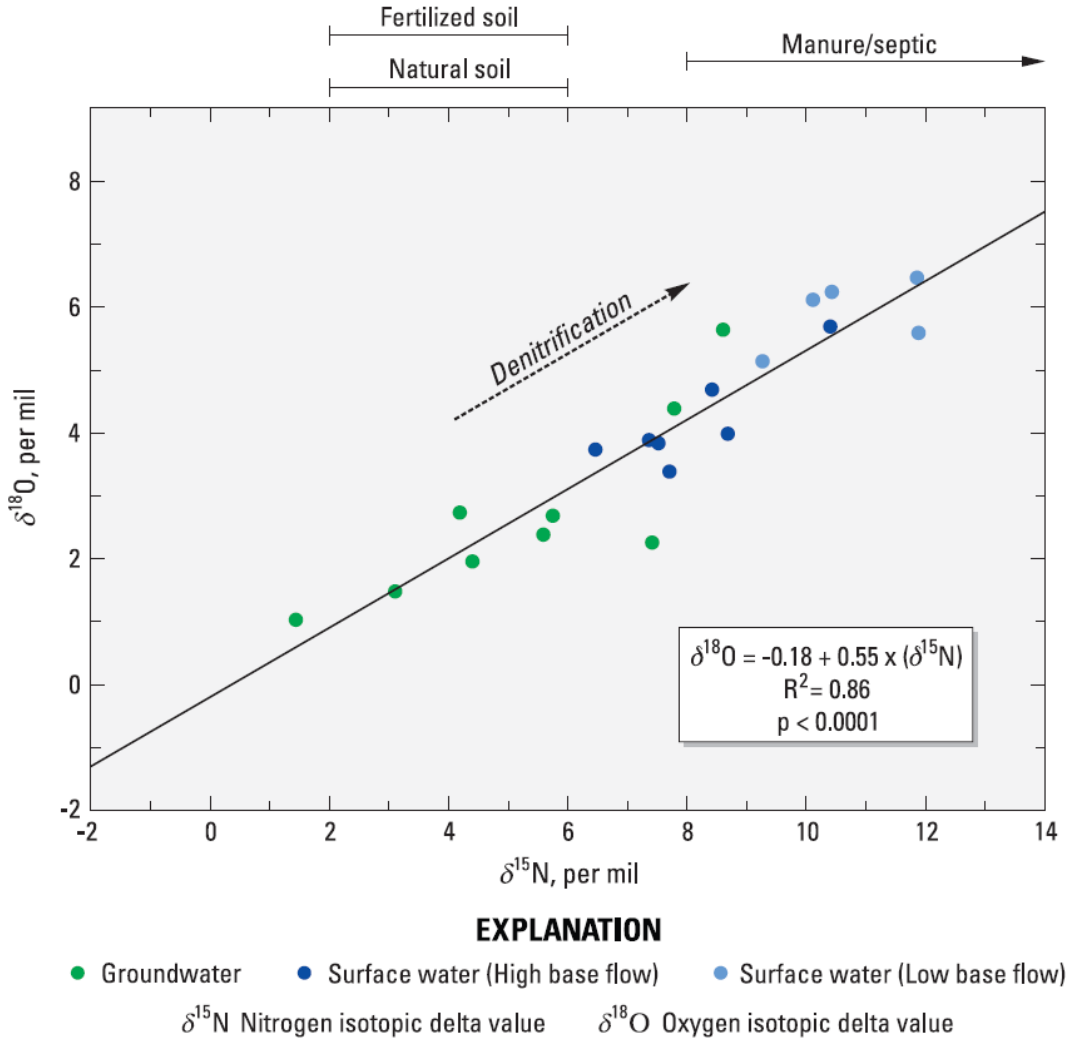
Isotopic Composition of Nitrate



This linear relation between the N and O isotopes in flow path studies has been shown to be an indication of **denitrification** in groundwater



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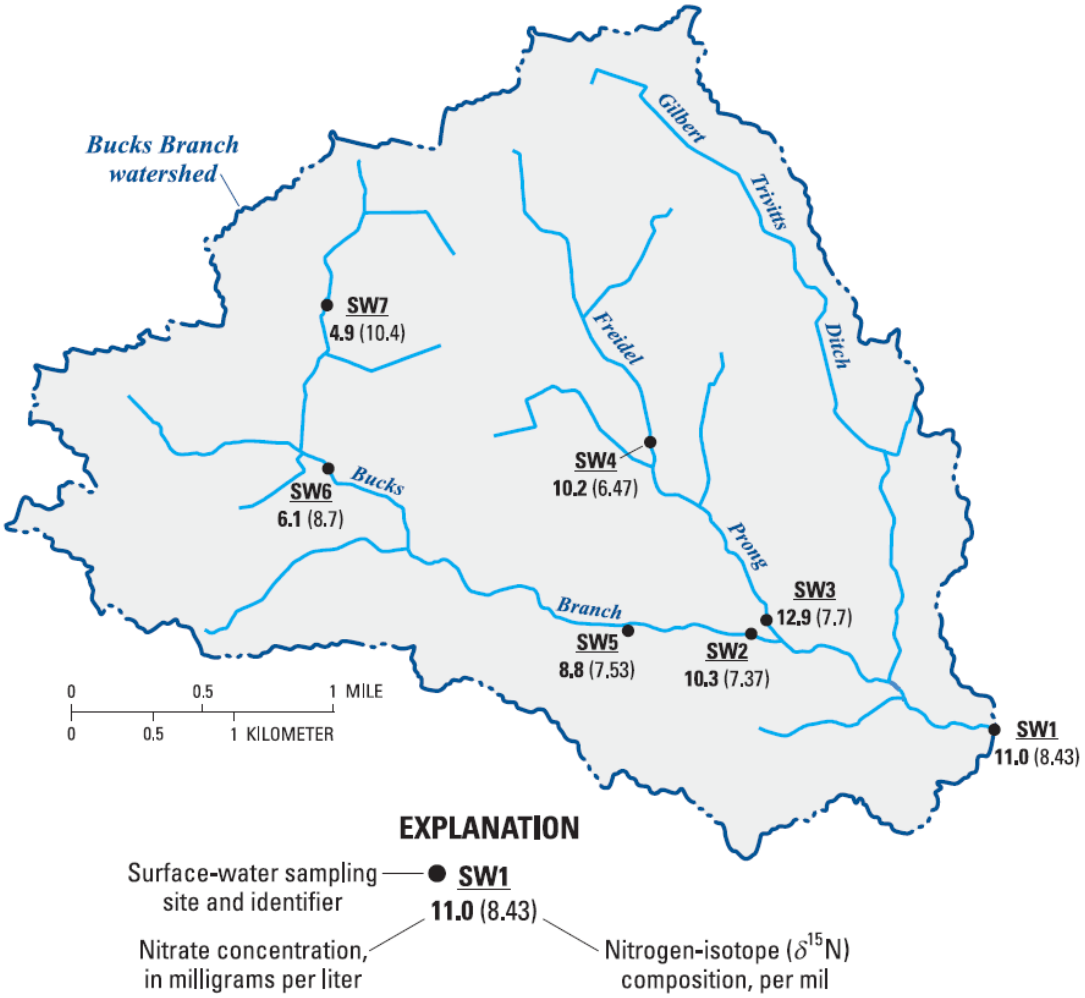

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Summary and Conclusions

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- Geochemistry indicates that **agriculture is the dominant source of nitrate** contamination and the observed patterns are similar other studies
- Nitrogen and oxygen isotopes ($\delta^{15}N$ and $\delta^{18}O$) of nitrate in groundwater and surface water indicate some **loss of nitrate through denitrification**, but this process is not sufficient to remove all of the nitrate and concentrations of nitrate remain elevated.

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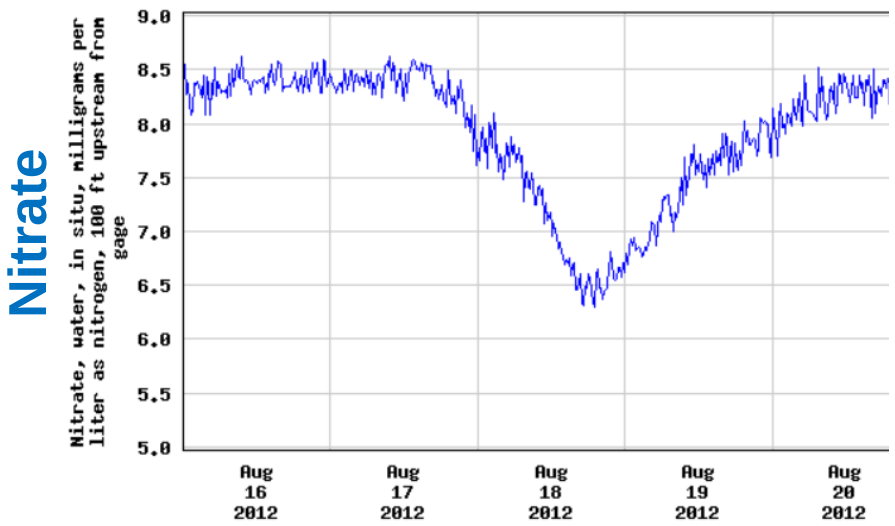
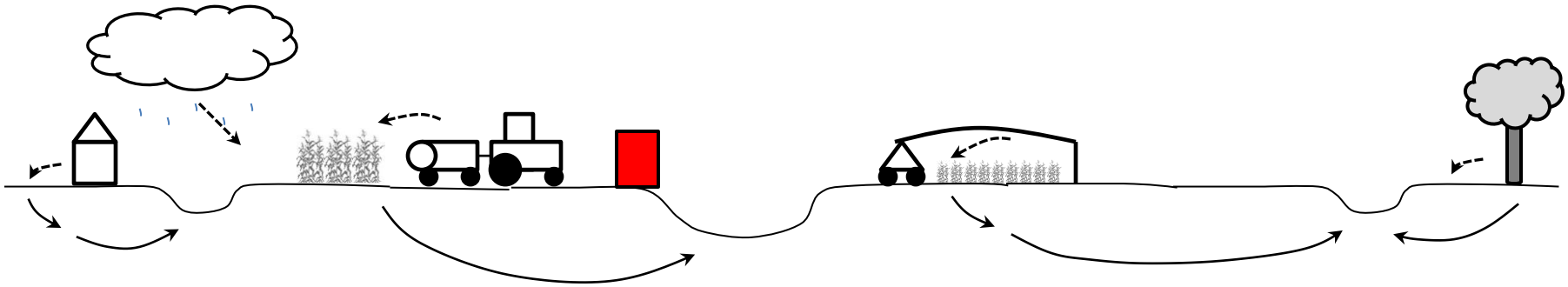
Possible Next Steps

Gage Monitoring

- Monthly (Baseflow) Sampling
- Event (Storm) Sampling
- Major Ions, Nutrients
- N & O Isotopes
- Continuous WQ (Temp, pH, SC, DO)
- Nitrate Sensor



http://waterdata.usgs.gov/usa/nwis/uv?01493112



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- High/Low Baseflow Conditions
- Field Parameters
- Major Ions, Nutrients
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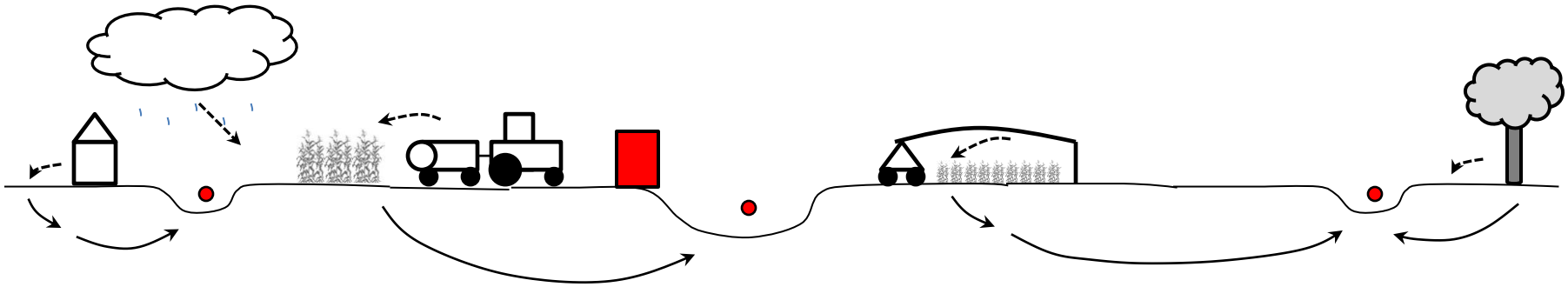
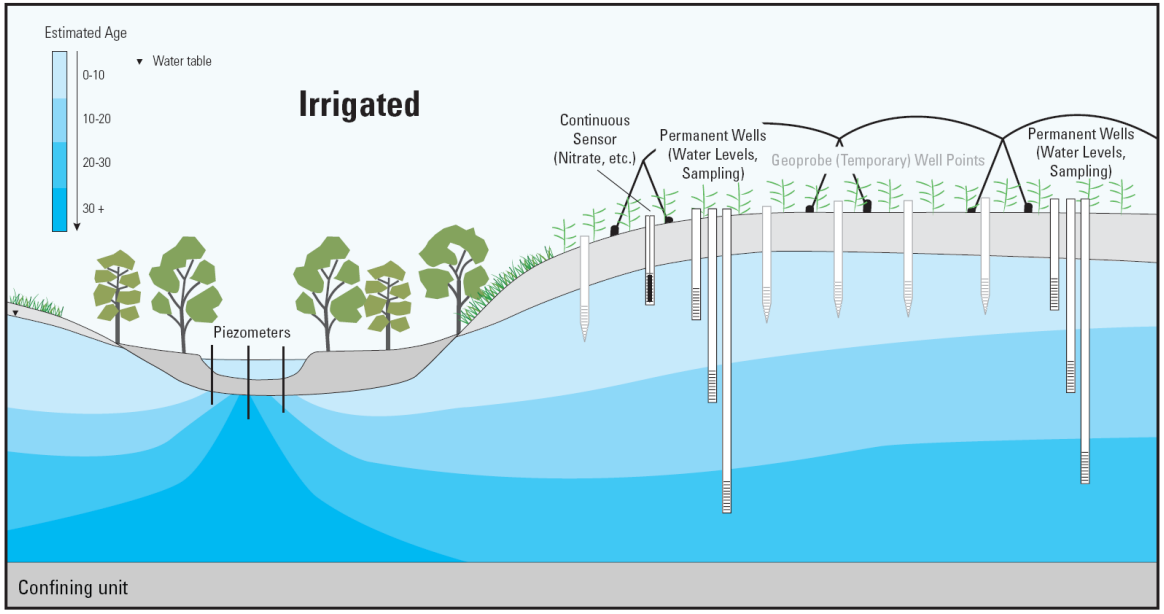
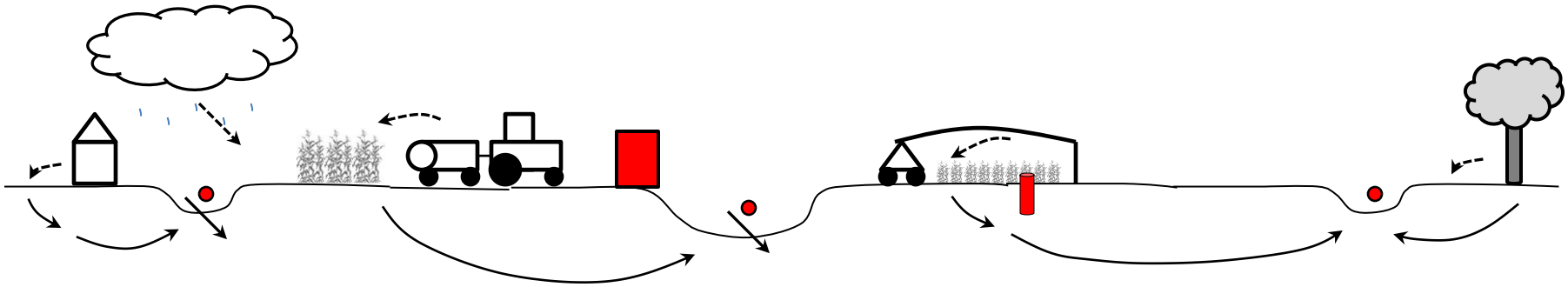


Possible Next Steps

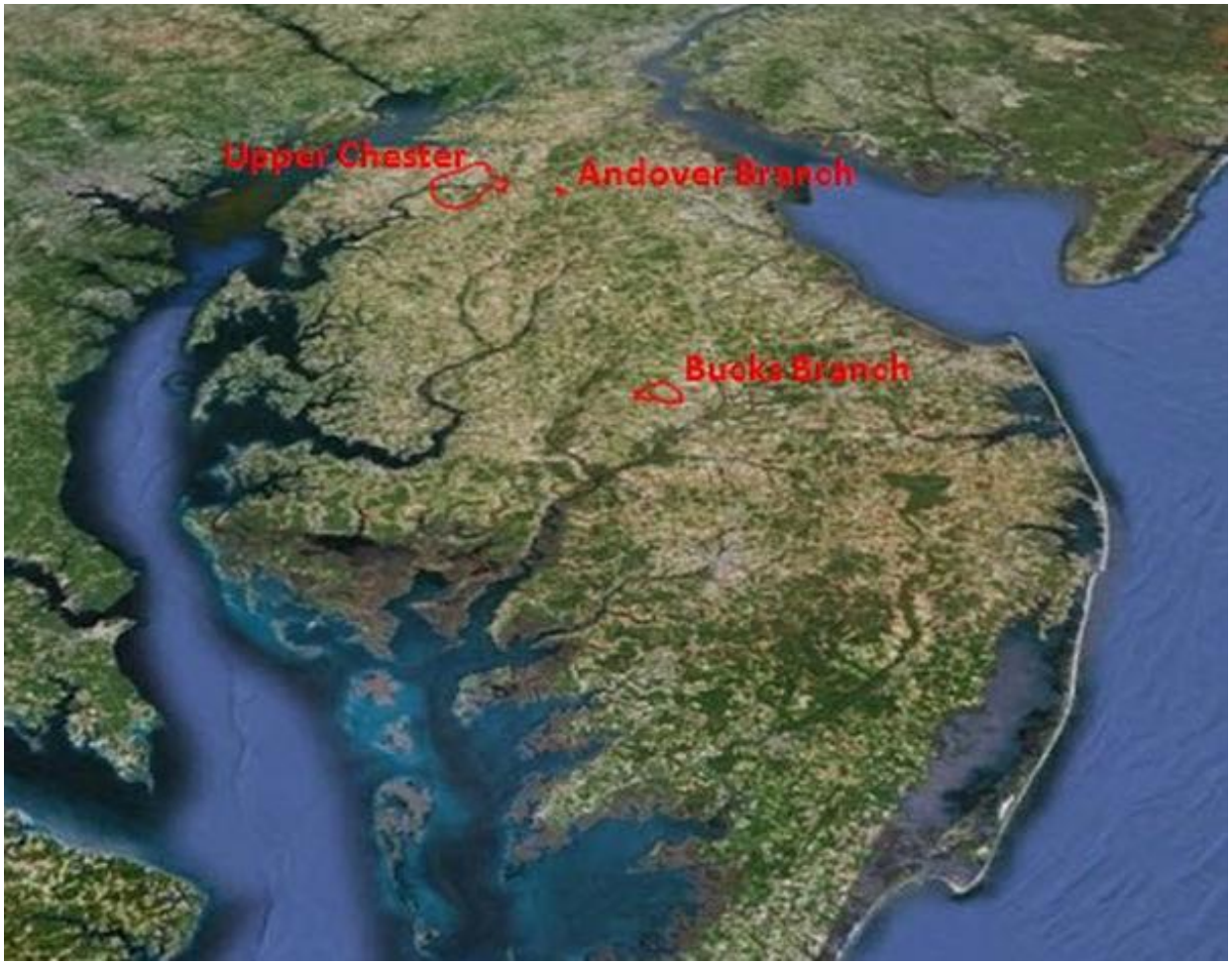
Shallow GW

- Bi-Monthly Sampling of Shallow Wells (WQ , Levels)
- Continuous Water Quality (Temp, SC, Nitrate)
- Geoprobe Synoptics
- Track Inputs





Monitoring the Water Quality Response of Conservation Practices in Small Watersheds



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Contact Info:
jclune@usgs.gov
(443) 498-5606

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