The Spring Creek Project Series:
Two geology projects to be taught at the introductory level

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Senior Integrative Exercise
March 11, 2009

Submitted in partial fulfillment of the requirements for a Bachelor of Arts degree from Carleton College, Northfield, Minnesota.
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**Lyman Lakes Project**

Introduction

Research: Phosphorus cycle

Project: Make a phosphorus cycle

Readings: Phosphorus in aquatic ecosystems

   Paper 1: NPS Nutrient Pollution Assessments
   Paper 2: Eutrophication: An Ecological Vision

Reading: Lyman Lakes study

Research: Lyman Lakes system

Field work: Water testing in Lower Lyman Lake

Final Paper: Phosphate concentrations in Lower Lyman Lake

**Bell Field Project**

Introduction

Research: Nitrogen cycle

Project: Make a nitrogen cycle

Readings: Nitrogen in aquatic ecosystems

   Paper 1: NPS Nutrient Pollution Assessments
   Paper 2: Human Alteration of the Global Nitrogen Cycle

Reading: Lyman Lakes study

Research: Bell Field system

Field work: Water testing near Bell Field

Final Paper: Spring Creek nitrate concentrations near Bell Athletic Field
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Advisor:
Mary Savina, Carleton College

ABSTRACT

Carleton College, Northfield Minnesota has a long history of actively transforming the landscape to provide recreation, utility, and aesthetics to the campus. Two major projects undertaken by the college were the creations of Lyman Lakes in 1916 and Bell Athletic field in 1927. Both of these projects involved reworking the route of Spring Creek, the small creek then running through campus. The creation of Lyman Lakes required dredging a wetland and the creation of Bell Field required digging a new route for a section of the creek. Sometime after the creation of these areas, the water quality of the creek began to decline. Problems included overloading of key nutrients, increases in turbidity, and eutrophication. The reasons for this decline in water quality have been attributed to various sources, primarily: storm water runoff, septic tank leakage, and fertilizer leaching. In order to analyze the possible loading contributions of Bell Field and Lyman Lakes, two projects were created to explore their nutrient systems. Both projects include: learning about nutrient cycles, researching relevant papers, doing field work, making spatial maps of nutrient concentrations, and writing a final report on the dynamics of the system studied. The finalized course schemas for each project were placed on the Carleton College geology website for teachers and students to access.

KEYWORDS: Carleton College, Spring Creek, Lyman Lakes, Bell Field, nutrient loading, introductory geology, water quality
INTRODUCTION

In a time when traveling abroad, internships overseas, and international problems are most appealing in student researchers’ minds, we often tend to forget the land on which we live. Carleton College has an interesting and often surprising collection of historical information which some will never get the chance to see. Take a trip to the Carleton archives (located on the first floor of the library) or look through the massive amounts of data the facilities staff have collected and it is quite possible you will find more surprises then you were expecting. In order to facilitate this discovery, the Spring Creek project series was created. The Spring Creek project series is a detailed outline for two exploratory projects meant to be taught at the introductory level. These projects aim to provide an opportunity for students to explore the geology of the land around them, while concurrently learning a little bit about its anthropocentric history and usage. Appended (Appendix 3), you will find comprehensive course schemas for conducting each project. The main questions that drive the separate projects are:

1) What causes the elevated phosphorus levels near Lyman Lake shorelines?

2) How does fertilizing Bell Field affect the nitrogen levels of the nearby creek and lakes?

BACKGROUND

Spring Creek History

In 1916, Carleton College finalized plans to dredge a small wetland on campus. Back then, the area was referred to by the students as Demosthenes Hollow. Damming the wetland in two places, and using buckets, horses and hands to remove soil, two lakes were created in
its place. Using the soil removed from the new lakebeds, two islands were made in the lower of the two lakes. The Lakes became known as Upper and Lower Lyman, and the two islands as Stewsie (after the current college grounds manager) and Mai Fete (Anderson, 2007; Headley, 1966).

The small wetland that used to exist there was a part of Spring Creek, the small stream which runs from southern Northfield Minnesota, through the college, and into the Cannon River. Throughout Carleton’s history and even as currently as 1996 when Lyman Lakes were dredged most recently (Anderson, 2007) the course and water bodies of Spring Creek have been adjusted and changed. Since the creation of the lakes, there has been one other major Spring Creek alteration: The creation of Bell Field.

Sometime in the mid 20’s consideration for the construction a new athletic field began. With the growing participation of women in sports, this field was to be the women’s athletic field. A large lowland area to the east of the Margaret Evans residence hall was selected and construction began. Likely the largest difficulty in creating the field came with moving Spring Creek, which at the time ran directly through the center of what is now known as Bell Athletic Field. In order to make the field appropriately rectangular in shape, the creek was filled, and a new channel was dug at the field’s boundaries. In 1927 Bell Field was completed (Headley, 1966).

Sometime after the completion of these two major projects, the water quality of the Spring Creek system began to decline. (Berg, 1967) Levels of key nutrients including nitrogen and phosphorous began to rise. Where before, there had been no detectable amounts of these nutrients, concentrations began spiking far into the measurable region. The increase
of nutrients created algal blooms, and the once nutrient free Lyman Lakes fell into a state of eutrophication. The reasons for these nutrient loading increases have been tentatively attributed to anthropogenic sources including: increased storm water runoff, septic tank leakage, and fertilizer leaching (Berg, 1967; Grubb 1985).

**Project Background**

As a precursor to this project, water samples were taken from 15 locations throughout the Spring Creek system (Appendix 3, Fig.1). Samples were taken both during a dry period, and after a rain event. These samples, intended to locate areas of elevated nutrient concentrations displayed higher levels near areas impacted by human activity. Both Bell Athletic Field and Lyman Lake shorelines displayed nutrient levels higher than the median values (Appendix 3, fig.2). With the data from this research, these two sites were selected as the basis for the Spring Creek project series.

**Format**

The appended project outlines are formatted as though directing a participating student. In each section, readings, projects, and research will be assigned. This paper is mainly meant to be a description of these projects; if you are an instructor interested in conducting these projects, please consider using the project website as opposed to this paper. The website can be found at: [www.go.carleton.edu/SpringCreek](http://www.go.carleton.edu/SpringCreek). If you are having trouble with accessing the website, please contact the current technical director of geology. If it becomes necessary to use this paper as opposed to the project website, the Appendix pages under the “Bell Field project” and “Lyman Lakes project” sections (Appendix 3) may be used as student handouts and the instructors’ notes (Appendix 2) may be used as a guide for
instructors. Again, this paper is meant only to be a descriptive and archive-able version of the projects. For the most current version of the projects please consider the website.

For a synopsis of the work done in each project, see the following section.

**PROJECT DESCRIPTIONS**

**Shared Concepts**

Each project begins by introducing the primary nutrient students will be focusing on. The first assignment the students undertake is researching and then creating either a phosphorus or nitrogen cycle depending on which project they are following. General readings regarding the global and regional trends in aquatic nutrient levels (e.g. Dinnes, 2004; Vitousek 1977; Khan, 2002) are subsequently assigned, and questions are posed after each paper. The final shared component of the two projects involves reading and analyzing a paper (Berg, 1967) specifically written about Spring Creek and the Lyman Lakes. From there on, the papers involve specialized research and field work to form hypotheses regarding their study area.

**Lyman Lakes Project**

The Lyman Lakes have experienced various problems since their construction, the most visually prominent of these being algal blooms. Filling of the lakes from sedimentation and eutrophication of the waterways (Grubb, 1985; Jones, 1978) have set the stage perfectly for the continuance of these algal production events. Allowing the nutrient ratio for maximum algae production of 10:1 phosphate to nitrate (Carpenter, 1998) Lyman Lakes could be classified as strongly phosphorous limited (Appendix 3, fig. 2). Additionally, with
the shallowing of the lakes due to sediment infill, the lakes are able to be quickly warmed by the sun. This provides good temperature conditions for algae growth. With this in mind, the input of phosphorus to the system is likely the main factor in determining scale of algal blooms. Considering the production dependency on phosphorus, the central issue of the Lyman Lakes project revolves around a phosphorous concentration spike found near Lower Lyman shorelines. In order to learn about possible origins of this elevated phosphorous concentration, the nutrient loading properties of Canada Geese (e.g. Post, 1998; Unckless, 2007) and the elevated phosphate levels in Rice County soils (e.g. Sowles, 2005; Beck, 1996) will be studied. The related research assignments will help students form hypotheses regarding the degree and feasibility of these sources as phosphate inputs. The project concludes with the students doing field work to determine the scope of actual phosphorous levels around Lyman lake shorelines, and creating a map and final paper to display the results.

**Bell Field Project**

When Spring Creek was diverted to make Bell Field, it was reconstructed to wrap around the field’s edge. The creek now borders both the field’s north and east sides. A rough buffer zone was left between the fertilized area and the stream’s boundary, but this buffer zone is as narrow as two meters in some places (Appendix 1, fig. 3). Due to its classification as a heavy use athletic field, Bell Field receives an average yearly fertilizer loading of 11,500 pounds. Of that amount, 800 pounds can be considered to be solely nitrogen (Easley, 2009). Additionally, when doing preliminary research for this project, the sample taken near Bell Field had over two times the median level of nitrates on both sample days (Appendix 3, fig. 2). With the rising awareness of excessive nitrogen loading as a significant problem (Braun,
2007) the Bell Field project focuses researching what factors could influence the transport of nitrogen from Bell Field into the creek, and from there to Lyman Lakes. Research on leaching rates from fertilized fields (e.g. Bowman, 2002) will be combined with denitrification rates (e.g. Mulholland, 2008), and data extrapolated from the field’s topographic gradient (Appendix 3 fig. 4) to aid students in forming hypotheses regarding the Bell Field system. The project concludes with field work to determine the scope of actual nitrate levels near Bell Field, and a map and final paper to display the results.

CONCLUSIONS

These projects were designed with the hope that they might raise the Carleton Community’s interest in the great educational resources we sit upon. The Spring Creek system is a fascinating mesocosm than can provide research opportunities ranging from the historical, to the scientific. It is my hope that sometime soon, these projects are taught in an introductory geology classroom to inspire students to learn more about the Spring Creek system.

Based on the initial research for this study, and the hope that projects similar in format will continue to be developed, I would suggest the following topics/areas as subjects for future projects. In order of decreasing similarity to this project:

1) Nitrate levels before, during, and directly after the Northfield golf course
2) Nitrate levels near previously unsewered communities
3) Phosphate levels in Northfield storm sewer discharge
4) Carleton Campus soil phosphate levels
5) Stratigraphy and hydrology of bell field
ACKNOWLEDGEMENTS

First and foremost I would like to thank Tim Vick, the technical director in geology at Carleton College. I would have expected him to hide every time he saw me coming, but instead Tim was always ready to drop what he was doing and lead me around the building searching for near lost maps or other data. Even though we wouldn’t always find what I was looking for, he always had helpful tips and advice that eventually let me to the answers I was looking for. This project couldn’t have been completed without him. I would also like to thank my comprehensive thesis advisor, and advisor throughout most of Carleton: Mary Savina. Mary once gave me one of the nicest compliments I have ever received and inspired me to peruse not just a degree in geology, but as broad of an education as I could possibly grab a hold of. Without her encouragement I never would have imagined a project as pan-disciplinary as the one I finally decided to undertake.

Funding for this project was provided through the Carleton College Geology Department.

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Easley, D., 2009, Email communications with Dennis Easley, Director of grounds, Carleton College

Godfrey, S., 1981, Stratigraphy of glacial outwash filling in the Spring Creek channel near the Women's Recreation Center, Bell Field, Carleton College.

Grubb, S., 1985, Modeling Erosion and Deposition in the Lyman Lakes and the Spring Creek Watershed, Carleton College.


APPENDIX

Appendix 1: Data
Figure 1. GIS map of the Spring Creek System. Created in ARC GIS June 2008 by Dylan Linet.
### Spring Creek Nitrogen, Nitrate, and Phosphate Levels

Concentrations in mg/L

<table>
<thead>
<tr>
<th>Site Number</th>
<th>Natural Waters</th>
<th></th>
<th></th>
<th>Storm Sewers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry N</td>
<td>Wet N</td>
<td>Dry NO3</td>
<td>Wet NO3</td>
<td>Dry Po4</td>
<td>Wet P04</td>
</tr>
<tr>
<td>1 Cannon River</td>
<td>0.50</td>
<td>1.20</td>
<td>2.20</td>
<td>5.28</td>
<td>1.00</td>
<td>0.30</td>
</tr>
<tr>
<td>2 Below Lakes</td>
<td>0.40</td>
<td>2.20</td>
<td>1.76</td>
<td>9.68</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td>3 Stewsie Island</td>
<td>0.18</td>
<td>0.85</td>
<td>0.79</td>
<td>3.74</td>
<td>0.84</td>
<td>0.14</td>
</tr>
<tr>
<td>5 Upper Lyman</td>
<td>0.70</td>
<td>3.20</td>
<td>3.08</td>
<td>14.08</td>
<td>0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>6 Near Bell Field</td>
<td>5.00</td>
<td>2.20</td>
<td>22.00</td>
<td>9.68</td>
<td>0.12</td>
<td>0.16</td>
</tr>
<tr>
<td>8 Below Golf Course</td>
<td>1.30</td>
<td>0.80</td>
<td>5.72</td>
<td>3.52</td>
<td>0.10</td>
<td>0.14</td>
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<tr>
<td>10 Golf Course Pond</td>
<td>1.00</td>
<td>0.34</td>
<td>4.40</td>
<td>1.50</td>
<td>0.00</td>
<td>0.22</td>
</tr>
<tr>
<td>13 Drained Head Pond</td>
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<td>3.40</td>
<td>8.80</td>
<td>14.96</td>
<td>0.16</td>
<td>0.10</td>
</tr>
<tr>
<td>14 Storm Water Pond</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.16</td>
<td>0.00</td>
</tr>
<tr>
<td>17 East Headwater</td>
<td>0.52</td>
<td>0.60</td>
<td>2.29</td>
<td>2.64</td>
<td>0.04</td>
<td>0.18</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
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<td><strong>1.51</strong></td>
<td><strong>5.43</strong></td>
<td><strong>6.64</strong></td>
<td><strong>0.18</strong></td>
<td><strong>0.12</strong></td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td><strong>0.70</strong></td>
<td><strong>0.85</strong></td>
<td><strong>3.08</strong></td>
<td><strong>3.74</strong></td>
<td><strong>0.12</strong></td>
<td><strong>0.14</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11.10</strong></td>
<td><strong>13.59</strong></td>
<td><strong>48.84</strong></td>
<td><strong>59.80</strong></td>
<td><strong>1.64</strong></td>
<td><strong>1.10</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Storm Sewers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry NO3</td>
<td>Wet NO3</td>
<td>Dry P04</td>
</tr>
<tr>
<td>4 Lower Lyman Outfall</td>
<td>0.06</td>
<td>0.26</td>
<td>0.64</td>
</tr>
<tr>
<td>7 Second St Outfall</td>
<td>0.00</td>
<td>0.00</td>
<td>0.70</td>
</tr>
<tr>
<td>9 Seventh St Outfall</td>
<td>0.00</td>
<td>0.00</td>
<td>0.60</td>
</tr>
<tr>
<td>11 Woodley St Outfall</td>
<td>0.00</td>
<td>0.00</td>
<td>0.46</td>
</tr>
<tr>
<td>12 Mayflower Drive Outfall</td>
<td>0.20</td>
<td>0.88</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>0.05</strong></td>
<td><strong>0.23</strong></td>
<td><strong>0.52</strong></td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.00</strong></td>
<td><strong>0.60</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.26</strong></td>
<td><strong>1.14</strong></td>
<td><strong>2.62</strong></td>
</tr>
</tbody>
</table>

Figure 2. Nitrogen, nitrate, and phosphate levels found in Spring Creek. Dry samples were taken during June 2008, 12 days after the most recent rain and wet samples taken September 2008 during a rain event. Data collected and recorded in Microsoft Excel by Dylan Linet.
Proximity of Spring Creek to Bell Athletic Field
Northfield, Minnesota

Legend
- Spring Creek
- Bell Field

Figure 3. Illustration of the proximity of Bell Field to Spring Creek. Created in ARC GIS March 2009 by Dylan Linet.
Figure 4. Contour lines of Bell Athletic Field. Created in ARC GIS June 2008 by Dylan Linet.
Appendix 2: Teacher’s Notes
Teacher’s Notes

How to use this guide

First off, thanks for choosing to use my project. I’ll make this as quick and easy as possible. To use the teacher’s guide, just read it over. It will give suggestions on how to run these projects, and provide answers to the assigned questions. The suggestions and tips section provides some useful general suggestions. The projects section contains more information and the answers to the assigned questions. This guide assumes that you have already read the “Student Projects” section (Appendix 3).

Suggestions and tips

Workload

The two projects are very comparable in workload; each project could take from two weeks to over half the term depending on how extensive you would like their field research to be, and how thorough you suggest the students be with their research. I personally would want each project to last about three or four weeks. This project is meant to be done during lab time, or during class periods where the teacher provides support, but doesn’t hold formal lectures. Readings may be assigned for homework or done during class. All of the assignments are either project based, or reading based.

Materials Needed

- Two nitrate in water test kits (50 samples each). Hach catalogue # 1416100 Nitrogen, Nitrate Test Kit, Model NI-14, Color Disc, 50 tests
  Web Link
  Cost: 136.50$

- One phosphate in water test kit (100 samples). Hach catalogue # 224800 Phosphorus, Orthophosphate (reactive) Test Kit, Model PO-19, Color Disc, 100 tests
  Web Link
  Cost: 77.79$

- Two boxes of filters (100 each box). Fisher Scientific catalogue # 0987432A Whatman Gf/c glass fiber filters, 2.5 cm
  Web Link
  Cost: 110.36$

There are also some things needed that the Geology department already has plenty of:

- Whirl pack sample bags
- Sample syringes
- Filter attachments

These items can all be found in the geochemistry lab. Email: dlinet@gmail.com if you need help finding them.
The only other item you might need is extra test tubes which can be acquired from the chemistry stock room.

**How to assign the projects**

You could do one of two things with these projects: Split the class into two and have each half select a different project, or: Have the entire class pick one project and do it together. I would suggest the second option.

**Group work or independent work?**

*Project: Make a nutrient cycle*

The first assignment of both projects, meant to be done in small groups. Break up the class or have them choose partners. Groups of three would be fine.

**Readings**

All readings and questions should be read and answered by each student individually.

**Research**

Research should be done mostly during lab time. Students can work together, but the write-up assigned at the end of the section should be done individually.

**Field work**

Field work should be done in your project groups

*Concentration Mapping*

Concentration mapping can be done as a large group, or in several smaller groups. I would suggest several smaller groups.

**Final Paper**

The final paper should be done individually

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**Projects**

**Lyman Lakes Project**

**Introduction**- Introduces student to the history of Lyman Lakes. Have the students read the two introductions to help them decide which project to choose, or just so they can see what the other group is doing.

**Research: Phosphorus cycle**- Here the students use Google to research the phosphorus cycle. They can do this in the computer lab, in groups or in pairs. Or, they can do it for homework.

**Project: Make a phosphorus cycle**- Here the students will make a phosphorus cycle with the information they gathered. This should be their first graded assignment. They can do it in
groups or individually. They can use colored pencils, a computer program, paper cutouts, or another medium. Grading should be based on completeness: Do they have all of the sources/fluxes etc…

**Readings:** *Phosphorus in aquatic ecosystems* - Two readings and accompanying questions that should be done individually. The answers provided here are abbreviated. Student answers should be expected to go into further detail. Questions can be turned in and graded if desired.

**Paper 1:** NPS Nutrient Pollution Assessments…

**Questions and Answers:**

What is the difference between a point and non point source?
A- Point sources come from an easily defined specific area; diffuse sources are from larger general regions.

What are examples of point sources, of non point sources?
A- Point Sources: Storm drain, hog farm, sewage treatment plant. Diffuse sources: Phosphate containing mineral leachate, Agricultural zone.

How does runoff affect nutrient loading? What factors affect runoff?
A- As runoff increases, nutrient loading increases. Slope and area affect runoff.

What is the difference between runoff and leaching and how are they affected by soil particle size? How does precipitation play into this?
A- Runoff is surface flow from precipitation, leaching is flow into or out of the ground. Larger soil particle size means higher leaching and less runoff and vice versa.

What are the three nutrient cycles discussed? How are they similar?
A- Carbon, Nitrogen, and Phosphorous: They all are essential for life, they all can move through the soil and water, etc…

**Paper 2:** Eutrophication: An Ecological Vision

**Questions and Answers:**

What does this article site as the causes for degeneration of freshwater?
A- Overconsumption, misuse, pollution, eutrophication, and depletion of the underground water table.

What phosphorus concentrations in milligrams per liter does this paper claim can cause eutrophication?
A- .05 mg/l

In the process of eutrophication, what causes the dissolved oxygen level to decrease?
A- Decomposers using oxygen to break down dead algae

What are the phosphorus containing components of sewage?
A- Detergents and human wastes

What brings deeper water phosphorus to the surface of a water body?
A- Rain events/ turbidity

What does eutrophication do to plant diversity?
A- Decreases it

Which parts of a lake are most affected by eutrophication?
A- Shallow, warm, stagnant areas

**Reading: Lyman Lakes study** - A paper about Lyman Lakes and accompanying questions that should be done individually. The answers provided here are abbreviated. Student answers should be expected to go into further detail. Questions can be turned in and graded if desired.

Questions and Answers:

What levels of nitrogen and phosphorus are purported to initiate eutrophication in shallow lakes?
A- .01 mg/l phosphorus, .3 mg/l nitrogen

What does the paper cite as possible sources of nutrient input to Spring Creek?
A- Septic tanks, organic and inorganic fertilizer, street runoff.

What reasons were given for why the sampled nitrogen and phosphorous levels were so low?
A- There had been no rain for 2 weeks

What is the peak discharge (flow) of Spring Creek during the spring?
A- 25 cubic feet per second

What is the problem with low turnover in a water body?
A- It gives algae time to grow (eutrophication)

Why do shallow depths expedite eutrophication?
A- Sunlight can penetrate deeper

**Research: Lyman Lakes system** - Students here will be reading papers and researching their questions. Instructors should familiarize themselves with the papers in order to help answer questions. Research can be done together, but write ups should be done individually, handed in, and graded. Grading should be done regarding the quality and quantity of research, not on organization (Organization will be graded for on the final paper)
**Field work: Water testing in Lower Lyman Lake**- Here students will be performing their field experiments. I would suggest allowing each group to take about 100 samples (the budget assumed this). The students will generally be designing their own project setup, but instructors should lend support and advise proper experiment setup. Students should create an excel file with their recorded data. Either each student can have an excel file, or there can be one group file in the common folder (or on Moodle). After recording the nutrient concentrations and finalizing data, the students will make a map of the concentrations. These maps should be high quality, but do not have to be computerized (although I would suggest it).

**Final Paper: Phosphate concentrations in Lower Lyman Lake**- The final paper should be a culmination of all the work and research done. I suggest a total length of 5-7 concise pages. The papers should be graded on organization, breadth and depth of content, and display of understanding of the topics.

**Bell Field Project**

The Bell Field project should be treated in the same way as the Lyman Lakes project. Provided are the answers to the questions in the Bell Field Project specific paper:

**Paper 2: Human Alteration of the Global Nitrogen Cycle**

Questions and Answers:

What are the general effects nitrate has on soils?
A- It depletes soil minerals and acidifies them.

Why is using industrially created fertilizers worse for the environment then using natural fertilizers?
A- Industrially created fertilizers fix new nitrogen from the atmosphere, while natural fertilizers recycle nitrogen which has already been fixed.

The Mississippi river runs south through Minneapolis and St. Paul and then passes by Redwing. Since 1965 how much have nitrate levels in the river increased?
A- Levels have increased by over 2 times.

What is the safe level of nitrate mg N/L in drinking water?
A- 10 mg N/L

The answer to the above question is reported in “nitrate mg N/L”. Is this measuring nitrogen, or nitrate?
A- It is measuring nitrogen as contained in the nitrate ion.
What does the paper claim lakes in the temperate zone (like Lyman Lakes) are typically limited by, nitrogen, or phosphorus?
A- Phosphorus.

If Spring Creek were to have phosphorus concentrations of .033mg/L what would nitrogen concentrations have to be to make your answer to the previous question true?
A- Nitrogen concentrations would have to be over .53mg/L.
Appendix 3: The Projects
Lyman Lakes Project: Introduction

Between 1916 and 1917, a small wetland to the north of the main Carleton College campus was widened, dammed and dredged to create the lakes we now know as Lyman Lakes. Named Demosthenes Hollow when it was a wetland, the area provided a filtration system for Spring Creek before it merged with the cannon river. Now, the ecology of the area is much different and it is not completely known how the creation of the lakes and the removal of the wetland have affected the Spring Creek system. When testing for phosphorous levels in the areas around lower Lyman Lake, it was found that spikes in the amount of phosphorous recorded would occasionally occur. However, these peaks only occurred near shore lines, and when the sample had been disturbed during acquisition. Most interestingly, the levels of phosphorous found were highest in samples taken around the islands. In this study, you will explore this phenomenon. Using data on the types of soils in the area, the nutrient cycling properties of Canada geese, and common phosphorus sources, you will form hypotheses as to what ratio biologic and geologic systems have contributed to these nutrient spikes. In the second part of the study you will take phosphorous measurements around the lake’s shorelines to determine where the most affected areas are. Your final results will be a hypotheses paper, and a map of phosphorus concentrations around Lower Lyman Lake.
Research: Phosphorus cycle

To start, we should first know what phosphorus is, and how it cycles in the environment. Following is a short description of the basics of phosphorus, and some information which should aid you in your first assignment of making a phosphorus cycle.

So, what is phosphorous?

Phosphorus is a chemical element which is a vital nutrient for both plants and animals. In nature it is almost always found as the compound PO₄³⁻ which is called “phosphate” and mainly comes from phosphorus containing soils, and biologic processes. Phosphorous is involved in forming bones and teeth in animals, helps store and transfer energy during photosynthesis in plants, and for both plants and animals it is essential in holding DNA together. In a balanced ecosystem, phosphorous (as phosphate) moves in a relatively equilibrated cycle, passing through the environment and providing nutrition to plants and animals. Recently however, phosphorus has become a hot topic in the environmental sphere as various human activities have disrupted the phosphorus cycle creating unhealthy buildups in some areas, and famine causing deficits in others. In order to better understand how this cycle has become disrupted, we must first learn how this cycle works when in equilibrium.

The best way to find general information about the phosphorus cycle is to search Google for “Phosphorus Cycle”

Note: When reading many of the papers used in this project, both phosphate and phosphorus will be discussed repeatedly, so it is important to know the significance of both, and how they are different. While looking through your search results, keep in mind that phosphorus travels though natural systems in the form of phosphate (PO₄³⁻), yet it is still referred to as the “phosphorus” cycle because it is the phosphorus in phosphate that is of most interest.

After looking through a few of these pages and looking at a picture or two of the phosphorus cycle, you will be ready to begin your first assignment.
Project: Make a phosphorus cycle

Starting with a pencil and paper, begin by writing words like “fertilizer” and drawing arrows to where they might go. For example: an arrow from fertilizer could likely go to the words “stream” or “groundwater”. Try to include all of the sources and fluxes you can think of. A flux is something moving to somewhere else, in this case your fluxes will be the arrows. Once you have done this, you can re draw the sources and fluxes in a more organized manner. In your final drawing of the nitrogen cycle, use drawings in addition to words to help emphasize the relationships between sources. For example, set your scene on the boundary between an agricultural and rural area and draw a water body nearby.

Some questions to answer in your drawing include:

What are the major inputs of phosphorus to aquatic systems?

How does phosphorus leave aquatic systems?

What is the difference between how urban and rural areas contribute to the phosphorous cycle?

What are the differences between how natural processes and human processes contribute to the phosphorus cycle?

After completing your phosphorous cycle diagram, the next item on the agenda is to look at phosphorus and related compounds through a more specific lens: Aquatic ecosystems.
Readings: Phosphorus in aquatic ecosystems

The following papers will help you to understand how phosphorus finds its way into aquatic systems, and what effects it has. These papers provide excellent insight into the issues of human impact on phosphorous and nitrogen (a related element) levels. After reading the selected pages, answer the related questions. As mentioned before in the “make a phosphorus cycle” experiment, it is extremely important to pay attention to whether the papers are discussing movement of phosphorus or phosphate. If they are reporting in terms of phosphate, simply divide the numbers by three to get the measurements in terms of phosphorus. If you prefer understanding in terms of phosphate, and the data is regarding phosphorus, multiply by three.

**Paper 1: NPS Nutrient Pollution Assessments of Conservation Practices**


Only read pages 8-35 of this paper. If you are printing it out, note that you should select to print out pages 12-39 due to the introduction section which is lettered instead of numbered.

This excellent paper focuses on nutrient loading problems in the Midwest, specifically Iowa. After reading the paper, please type out answers to the following questions:

Questions:

What is the difference between a point and non point source?

What are examples of point sources, of non point sources?

How does runoff affect nutrient loading? What factors affect runoff?

What is the difference between runoff and leaching and how are they affected by soil particle size? How does precipitation play into this?

What are the three nutrient cycles discussed? How are they similar?

**Paper 2: Eutrophication: An Ecological Vision**


Eutrophication is a process where water bodies receive an overabundance of nutrients (like nitrogen and phosphorus) that stimulate excessive growth of algae and nuisance plants. This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water and causes all sorts of problems for an ecosystem. The following paper discusses the causes and effects of eutrophication.
Please read the following sections of this paper: Introduction and Definition (pages 450-452), Sources of Phosphorus and Phosphorus cycle (pages 458-460), Plant diversity (page 465), and Conclusions (pages 474-475). After reading the sections, please type out answers to the following questions.

Questions:

What does this article site as the causes for degeneration of freshwater?

What phosphorus concentrations in milligrams per liter does this paper claim can cause eutrophication?

In the process of eutrophication, what causes the dissolved oxygen level to decrease?

What are the phosphorus containing components of sewage?

What brings deeper water phosphorus to the surface of a water body?

What does eutrophication do to plant diversity?

Which parts of a lake are most affected by eutrophication?

When done reading these papers on general and global nutrient issues, the next step of the project will bring things closer to home. Continue on to read and analyze papers specifically about Spring Creek and Lyman Lakes.
Reading: Lyman Lakes Study

Paper: A Study on Lyman Lakes


This paper is the write up for an extensive research project done on Lyman Lakes in the late 60’s. The goal of the project was to raise awareness about the problems with the current Lyman Lakes situation and to provide information on their history and how they became as they are now. In doing so, they did an exceptional amount of literature review and research, finding information on stream flow, nutrient concentrations, and possible sources of nutrient loading. After reading the paper, please type out answers to the following questions.

Questions:

What levels of nitrogen and phosphorus are purported to initiate eutrophication in shallow lakes?

What does the paper cite as possible sources of nutrient input to Spring Creek?

What reasons were given for why the sampled nitrogen and phosphorous levels were so low?

What is the peak discharge (flow) of Spring Creek during the spring?

What is the problem with low turnover in a water body?

Why do shallow depths expedite eutrophication?

After reading this paper, you should have a good idea how nutrients like phosphorus play into our local waterway system. For the next section of the project, you will be collecting information about two specific possible phosphorus inputs to Lyman Lakes: Geese and Soil.
Research: Lyman Lakes

Thinking back to this project's introduction page, remember that when Lyman Lakes were tested for phosphorus concentrations, it was found that levels were highest near shorelines, when the water was disturbed, and specifically near the island shores. For this project, it is hypothesized that the phosphorus contributed by roosting geese, and leaching from the area's eroding banks are the primary contributors to this phenomenon.

Why Geese?

Geese can spend up to 12 hours each day eating. Considering that their favorite foods are grasses, and that they don't like to stray too far from water, most of their waking day is spent near lake shorelines. Since geese feces is high in phosphorus, this projects assumes that runoff from these near lake areas would contribute measurable levels of phosphorus to the system.

Why Soils?

Considering data collected regarding the erosion rates and total available soil phosphorus of our area, Northfield is regarded as having a mid-level range of soil phosphorus contamination. This suggests that it is likely soil phosphorus is a measurable phosphorus input.

Your job will be to analyze the following papers, graphs, and diagrams for relevant data, and to develop these hypotheses or, formulate your own hypotheses about what is happening in the Lower Lyman area. You are welcome and encouraged to look beyond the data provided and to search for new relevant articles. Keep in mind, that there is no answer yet known about the Lower Lyman phosphorus levels and that if you disagree with the hypotheses given, feel free to purport different hypotheses as long as you have supporting data. As you are researching, keep the following questions in mind:

Does the hypothesis that geese and soils are the major contributors to this phenomenon seem correct? If not, what do you believe are the major contributors?

What are the reasons behind why these sources could be major contributors of phosphorous?

Why do you believe disturbed water samples (samples taken while disturbing the lake sediment) showed higher phosphorus levels?

What might be the rate at which geese contributed phosphorous is leaching into the lakes?

What might be the rate at which soil phosphorus is leaching into the lakes?

What rate might other (if any) sources be contributing phosphorous to the system?

Based on these questions, what percent of the total lake phosphorus might each source be contributing?

To what extent might the elevated phosphorus areas exist?
Would these areas remain constant? How would rainfall affect them? How would a lack of rain?

Where might the phosphorous go once it enters the lakes? How might phosphorous leave the Lyman Lakes system?

Remember, there are no right answers known to these questions, so any guess can be valid as long as it has sources which support it. You will be doing your own research from this step onward, and the work you do could be useful for future students in interpreting the Lyman Lakes system.

In order to organize your answers to these questions, please prepare a short concise informal paper discussing what might cause the elevated levels of phosphorus found near Lower Lyman Shorelines. The paper should be between 2-4 pages, double spaced. Do not worry about proper formatting, if a compilation of bullet points or question/answer type dialog works better for you, feel free to use that style for your paper. This assignment is just to help you gather and organize data for your final paper write up.

Here are some papers to get you started:

Beck, J.F., 1996, Soil Survey of Rice County Minnesota, United states department of agriculture


Once your paper and hypotheses are formed, it will be time to start collecting some field data.
Field Project: Lower Lyman water testing

Now, with ideas in mind of what the phosphorus system might be like in the lakes, it is time to go out and collect some field data to add to your report. You will be using Hach phosphate in water test kits and the sampling methods it describes to test water samples taken from the lakes.

Step One: Testing Region and Frequency

The first thing you will want to do is to determine the region you will be testing. For this project, you will be testing water from the shorelines and across Lower Lyman Lake. The sample concentration, locations, and frequency will be up to you to decide. Here is an example plan:

- Sample 32 selections each testing day.
- Test over three days: Two days in sequence and one day after a rain event (if possible) otherwise one more day in sequence.

You may use this provided testing criteria for your field testing, or you may opt to create your own sampling method.

Step two: Sample collection and testing
You will be provided with sampling bags to take your samples in. After acquiring the samples, either keep them in a cold refrigerator or test them as soon as you get back to the lab. This instruction guide by Hach provides information on how to complete the tests (link to booklet). You will be using the instructions for 0-1 mg/L of phosphate test.

**Step three: Recording your results**

While testing, please record your results in a Microsoft Excel file.

**Step four: Creating the map**

Once you have recorded all your data, you will compile your results in the form of a spatial concentration map (see project introduction for example). You may either use a computer program like Adobe Illustrator or Google Sketch up, or draw the map by hand. The map should include sampling locations (as points) and areas of high to low concentration.

In addition to the full size map, please create a smaller key map. This map only needs to have the locations of samples taken and the sample names/numbers. This map should either be digital, or small enough to scan in to the computer. This map should be included in your final paper as a reference to where samples are located.
Final Paper: Phosphate Concentrations in Lower Lyman Lake

You have now analyzed multiple papers regarding phosphorus in aquatic systems, tested and sampled for field data, and recorded results from your testing. In a 5-7 page double spaced paper please describe the phosphorus system of Lower Lyman Lake. This paper should address all of the questions asked in the research section in a more formal context as well as relating them to the results you found in the field testing section. Also, please include the small key map you made in step four of the field project section.
Bell Field Project: Introduction

On average, Carleton College applies 800 pounds of nitrogen per year to Bell athletic field. This nitrogen is applied in the form of corn gluten in the spring, and a synthetic fertilizer in the late fall. Because Bell Field is an athletic field, more nitrogen is applied to the field than normal Carleton fields, some of which receive no fertilizer at all. Due to this continuous fertilizer application, it is possible that the nitrogen might move from the field into the bordering waterway: Spring Creek. Downstream, Lyman Lakes have experienced a number of algal blooms and other effects of nitrogen loading. In this study you will learn about the factors that affect nitrogen input to aquatic systems, and use research to estimate concentrations of nitrogen in Spring Creek. In the field work part of the project you will take water samples from the creek to measure nitrogen concentrations before, around, and after Bell Field. Using this field data, you will create a spatial map of nitrogen concentrations. For the final paper of this project, you will use the field data, and your prior research, to describe the nitrogen concentration system in the bell field area.
Research: Nitrogen cycle

To start, we should first know what nitrogen is, and how it cycles in the environment. Following is a short description of the basics of nitrogen, and some information that should aid you in your first assignment of making a nitrogen cycle.

So, what is nitrogen?

Nitrogen is a chemical element that is vital for both plant and animal health. A component in DNA, RNA, and proteins, life would not be able to function without it. There can however, be too much nitrogen which you will learn more about as the project progresses. Most of the nitrogen in the world is contained in the earth's atmosphere in the form of nitrogen gas (N2). However, this form of nitrogen is not usable by most organisms. In creating a nitrogen cycle, you will discover how this nitrogen is pulled into the biotic system. In a balanced ecosystem, nitrogen moves in a relatively equilibrated cycle, passing through different forms of nitrogen and cycling back into the atmosphere. Recently however, nitrogen has become a hot topic in the environmental sphere as various human activities have disrupted the nitrogen cycle creating unhealthy buildups in some areas, and famine causing deficits in others. In order to better understand how this cycle has become disrupted, we must first learn how this cycle works when in equilibrium.

The best way to find general information about the nitrogen cycle is to search Google for “Nitrogen Cycle”

After looking through a few of these pages and looking at a picture or two of the Nitrogen cycle, you will be ready to begin your first assignment.
Project: Make a nitrogen cycle

Starting with a pencil and paper, begin by writing words like “fertilizer” and drawing arrows to where they might go. For example: an arrow from fertilizer could likely go to the words “stream” or “groundwater”. Try to include all of the sources and fluxes you can think of (a flux is a transportation process). Once you have done this, you can re draw the sources and fluxes in a more organized manner. In your final representation of the phosphorus cycle, use drawings in addition to words to help emphasize the relationships between sources. For example, set your scene on the boundary between an agricultural and rural area and draw a water body nearby.

Some questions to answer in your drawing include:

What are the major inputs of nitrogen to aquatic systems?

How does nitrogen leave aquatic systems?

What is the difference between how urban and rural areas contribute to the nitrogen cycle?

What are the differences between how natural processes and human processes contribute to the nitrogen cycle?

After completing your nitrogen cycle diagram, the next item on the agenda is to look at nitrogen and related compounds through a more specific lens: Aquatic ecosystems.
Readings: Nitrogen in aquatic ecosystems

The following papers will help you to understand how nitrogen finds its way into aquatic systems, and what effects it has. These papers provide excellent insight into the issues of human impact on nitrogen and phosphorus (a related element) levels.

As you continue with this project, keep in mind this important distinction: When reading many of the papers used in this project, nitrogen will most frequently be referred to as “nitrate” (one of nitrogen's most important forms for aquatic systems), “nitrate nitrogen” (the amount of nitrogen as nitrate), or just “nitrogen”. Because of this, it is important to know the difference between them. When the papers report concentrations as “nitrate-N” (nitrogen in nitrate) or as “nitrate N/L” they are referring to the concentration of nitrogen present, but only nitrogen as contained in the nitrate ion. When they report in terms of just “nitrate”, they are not referring to the concentrations of nitrogen, but to the concentrations of the nitrate ion itself. In order to convert between the two, multiply nitrogen concentrations by 4.4 to get nitrate concentrations, or divide nitrate concentrations by 4.4 to get nitrogen concentrations. Simply “nitrogen” is a separate issue. In most cases it can be assumed to be nitrogen from nitrate and treated as such (ex: you can multiply it by 4.4 to get nitrate, etc…), but sometimes it is “Total nitrogen” which cannot be converted because it is a separate measurement altogether and should just be counted on its own. Total nitrogen is a measurement of the total amount of nitrogen contributed by various sources of nitrogen, not just from nitrate.

Paper 1: NPS Nutrient Pollution Assessments of Conservation Practices


Only read pages 8-35 of this paper. If you are printing it out, note that you should select to print out pages 12-39 due to the introduction section that is lettered instead of numbered.

This excellent paper focuses on nutrient loading problems in the Midwest, specifically Iowa. After reading the paper, please type out answers to the following questions:

Questions:

What is the difference between a point and non point source?

What are examples of point sources, of non point sources?

How does runoff affect nutrient loading? What factors affect runoff?

What is the difference between runoff and leaching and how are they affected by soil particle size? How does precipitation play into this?

What are the three nutrient cycles discussed? How are they similar?
Paper 2: Human Alteration of the Global Nitrogen Cycle


This paper is a helpful review paper on Human impacts to the nitrogen cycle, and how this increase in nitrogen effects the environment. It should provide you with a good understanding of some of the issues regarding overabundant nitrogen and how things have changed to bring global nitrogen levels to what they are.

You may skim, or skip entirely the sections under “Effects on the Atmosphere” and “Effects on terrestrial ecosystems.”

Terms to Know:

**Eutrophication:** A process where water bodies receive an overabundance of nutrients (like nitrogen and phosphorus) that stimulate excessive growth of algae and nuisance plants. This enhanced plant growth, often called an algal bloom, reduces dissolved oxygen in the water and causes all sorts of problems for an ecosystem.

**Limiting/controlling nutrient:** In aquatic systems, a ratio of 16:1 nitrogen to phosphorous (or 10:1 nitrate to phosphate) was found to describe which nutrient was in greater need by the system for further plant production. If nitrogen is over 16 times more abundant than phosphorus, then the system would be over saturated with nitrogen, and phosphorous would be the limiting/controlling nutrient for plant growth. If there is more than 1/16th as much phosphorous as nitrogen, then there is not enough nitrogen in the system, and nitrogen would be the limiting/controlling nutrient.

Questions:

What are the general effects nitrate has on soils?

Why is using industrially created fertilizers worse for the environment then using natural fertilizers?

The Mississippi river runs south through Minneapolis and St. Paul and then passes by Redwing. Since 1965 how much have nitrate levels in the river increased?

What is the safe level of nitrate mg N/L in drinking water?

The answer to the above question is reported in “nitrate mg N/L”. Is this measuring nitrogen, or nitrate?
What does the paper claim lakes in the temperate zone (like Lyman Lakes) are typically limited by, nitrogen, or phosphorus?

If Spring Creek were to have phosphorus concentrations of .033mg/L what would nitrogen concentrations have to be to make your answer to the previous question true?

When done reading these papers on general and global nutrient issues, the next step of the project will bring things closer to home. Continue on to read and analyze a paper specifically about Lyman Lakes and the Spring Creek system.
Reading: Lyman Lake Study

Paper: A Study on Lyman Lakes


This paper is the write up for an extensive research project done on Lyman Lakes in the late 60’s. The goal of the project was to raise awareness about the problems with the current Lyman Lakes situation and to provide information on their history and how they became as they are now. In doing so, they did an exceptional amount of literature review and research, finding information on stream flow, nutrient concentrations, and possible sources of nutrient loading. After reading the paper, please type out answers to the following questions.

Questions:

What levels of nitrogen and phosphorus are purported to initiate eutrophication in shallow lakes?

What does the paper cite as possible sources of nutrient input to Spring Creek?

What reasons were given for why the sampled nitrogen and phosphorous levels were so low?

What is the peak discharge (flow) of Spring Creek during the spring?

What is the problem with low turnover in a water body?

Why do shallow depths expedite eutrophication?

After reading this paper, you should have a good basic idea of how nutrients like phosphorus play into our local waterway system. In the next part of the project, you will begin to do research to discover why and at what rate nutrients could be leaching from Bell Field.
Research: Bell Field System

Sometime in the early 20's, plans began to be made for the creation of a new women’s athletic field. In order to construct it however, they had to re-route the path of a small creek which ran straight through the middle of the proposed area. In order to make a rectangular field, they took the course of the creek and bent it at a ninety degree angle, wrapping it around the edge of the site. By the end of 1927 the project was completed, and the Bell Field and Spring Creek that we know today were formed. Today, Bell Field's status as a heavy use athletic field earns it 2-3 fertilizer applications per year, and a total input of 800 pounds of nitrogen per year. As you have learned in the previous sections, leaching and runoff from fertilizer can be a substantial contributor to nutrient loading in aquatic systems. In the following section of the project, you will use various data sources, and some independent research to determine whether or not you think fertilizer from Bell Field could be contributing noticeable amounts to the concentration of nitrogen in Spring Creek. Please read this entire section before doing a specific part so you are aware of what type of work you will be doing and some of the questions you will want to answer.

Terms to Know:

**Topographic Gradient:** Topographic gradient is the change in elevation over the change in distance from one point on a surface, to another point. Put more simply, it is slope. When applying fertilizer, slope is important because it determines in which direction runoff will travel over the surface.

Take a look at the following diagram; it is a three dimensional elevation map of Bell Field:
In this map, we are viewing the field from an angle, and are thus able to discern relative elevations just by glancing at the map. Although these types of maps are helpful in visualizing elevation, most elevation maps are sold in the form of topographic maps. Topographic maps, although less easy to visualize are much more versatile. Angled as though looking at a landscape from directly above, topographic maps minimize distortion due to perspective, and if in the same scale can be placed next to maps of adjoining areas to display a larger area. Take a look at the following topographic map of Bell Field and see if you can visualize the elevation change it displays:

In this map, each gray line drawn represents a change in elevation of 5 feet.

Without a north arrow, or scale bar can you line these two maps up in your head just using the elevation data?

Considering that the movement of groundwater under the surface most often travels from high elevation to low elevation, which direction do you think rainwater seeping into the ground on and around Bell Field would travel?

**Leaching:** Once fertilizer is applied to a field, it begins slowly seeping into the ground. In a fully efficient system, all of this fertilizer would be assimilated by plants, however in real world scenarios some of it seeps into the ground and eventually into the groundwater. This
excess fertilizer is the amount leached. Leaching is often reported as a percent of total fertilizer leached, or as a rate of leaching. Topographic gradient is related to leaching because it determines the direction that subsurface groundwater will travel.

**Nitrogen uptake & denitrification:** After reaching the water, there are various ways that nitrate-nitrogen can come back out again. Assimilation into plant structures (uptake) and conversion back to atmospheric nitrogen (denitrification) are the biggest ones. Both processes take nitrate out of water and will end up lowering the nitrogen concentration over time. As such, they are the two main rates used to model decreases in nitrogen concentration. For this part of the project you will read a paper specifically dealing with these rates. These rates are most frequently reported in micrograms of nitrogen per area per time which is written as: “ug N area^(-2) time^(-1)” it is important to note the area and time units used so you can effectively calculate how quickly a given concentration would be depleted.

With these terms in mind, you will begin to research what factors could affect the nitrogen levels near Bell Field.

**Research:**

Using Google scholar, search for papers discussing nitrogen leaching from athletic fields (link to Google scholar search) and nitrogen uptake and denitrification rates (link to Google scholar search). Search through these papers to determine what seem to be the average ranges of nitrate leaching, uptake, and denitrification and write them down, these rates will be useful soon when you are estimating concentrations. Here are some papers to get you started:

**Bowman, D.C., 2002, Fate and transport of nitrogen applied to six warm-season turfgrasses:** Crop Science, v. 42, p. 883.

This paper is a broad study covering general rates of nitrogen leaching from high use athletic fields. In this, and many other leaching papers the amount of nitrogen leached to the soil is reported as a percent of the total nitrogen applied.


Another excellent and broad reaching paper, it reports ranges of denitrification and plant uptake across different land use areas. Note that the rates you should be looking for are reported in micrograms of nitrate lost each hour in a cubic meter.

**Concentration Calculator** (concentration calculator web site will be added here once website is up)

This calculator will handle some of the unit conversions and calculations for you. Using the variables for leaching you found, try entering them in to see how much it changes the projected concentration of nitrate in the stream. Keep in mind this model is very simple and will not necessarily represent actual levels of nitrate in the system. It does however provide a useful tool to see how different variables effect concentration. Aside from the unit conversions, all this calculator does is:
Amount of fertilizer * Leaching rate = Amount of fertilizer leached per time

Amount of fertilizer leached per time/ discharge= base concentration

Base concentration + amount of fertilizer carried by rainfall occurring= Concentration at given time.

Afterwards, try adjusting the stream discharge and recent rainfall amount to see how they affect the concentration. You can find rainfall history and data at Carleton from the Carleton weather website (link to website). Discharge of the stream changes daily depending on various factors. Try entering values between 2, 5, and 25 cubic feet per second (a slow, normal, and extremely fast day respectively). If you are modeling a particularly fast or slow day, consider raising and lowering the rainfall value to a large or small number respectively since rainfall is usually the largest contributor to stream discharge.

Once you have some possible concentration values, try applying the rates of nitrogen uptake and denitrification to determine how long the nitrogen would last before disappearing.

While you are working on your research, here are some questions you will want to address:

What does the topographic gradient of Bell Field say about which direction groundwater will flow?

What does this mean in regards to the fertilizer on the surface?

What seem to be average nitrogen leaching rates in typical athletic fields?

What are some possible reasons for the variability of these rates?

What seem to be average nitrogen uptake and nitrification rates?

What are possible reasons for the variability of these rates?

Does Bell Field seem to have a higher, lower, or normal level of fertilizer application compared to other fields?

What might be the ranges of nitrate-nitrogen concentration found in Spring Creek?

Assuming these levels, how long would it take for these levels of nitrogen to disappear due to uptake and denitrification?

How would dilution by entering the lakes affect these ranges?

Does the hypothesis that Bell Field might be one of the major contributors to the nitrogen loading of Lyman Lakes seem to stand up?

How does the data you have found and analyzed seem to support or reject this claim?

In order to organize your responses to these questions, please prepare a short concise informal paper discussing what might affect the movement of nitrogen in the Bell Field area,
what nitrogen levels might be found in the nearby regions of Spring Creek, and what factors might affect how long they would last. The paper should be between 2-4 pages, double spaced. Do not worry about proper formatting, if a compilation of bullet points or question/answer type dialog works better for you, feel free to use that style for your paper. This assignment is just to help you gather and organize data for your final paper write up. Keep in mind that exact calculated numbers are not important for this section of the project. Working with the number should help give you an idea of ranges and relative effects of different factors on these numbers and help you to understand which factors are most important. You may include projected numbers in your write up, but it is more important to note contributing factors and their relative importance.

Once your paper and hypotheses are formed, it will be time to go out into the field and see what the actual levels of nitrogen around Bell Field are.
Field Work: Water testing Near Bell Field

Now that you have learned about nitrogen, nitrate in aquatic systems, sources, draws, and a little bit about Bell Field itself, it is time to go out and test the actual levels of nitrate-nitrogen in Spring Creek. You will be using the Hach company’s nitrate-nitrogen in water test kit and the sampling methods it describes to determine the concentrations.

**Step One: Testing Region and Frequency**

The first thing you will want to do is to determine the region you will be testing. For this project, you will be testing water before, in the vicinity of, and after Bell Field. The sample concentration, locations, and frequency will be up to you to decide. Here is an example plan:

- Sample 24 selections each testing day.
- Test over four days: Two days in sequence and two days after a rain event (if possible) otherwise two more days in sequence

You may use this provided testing criteria for your field testing, or you may opt to create your own sampling method.

**Step two: Sample collection and testing**
You will be provided with sampling bags to take your samples in. After acquiring the samples, either keep them in a cold refrigerator or test them as soon as you get back to the lab. This instruction guide by Hach provides information on how to complete the tests. ([link to booklet](#)) Start by using the instructions for 1-10 mg/L of nitrate-N. If the levels are too small to detect, Switch to the 0-1 mg/L instructions.

The only difference between your methods and those described in the Hach manual is that you will first be filtering your samples through a sediment filter before testing. To do this:

1) Install a filter in the filter compartment
2) Shake your sample bag to mix the sediment
3) Draw sample water from the bag with the sample pipette
4) Attach the filter compartment to the pipette
5) You are now ready to inject this water into you test tubes
6) Change the filter if necessary

**Step three: Recording your results**

While testing, please record your results in a Microsoft Excel file.

**Step four: Creating the map**

Once you have recorded all your data, you will compile your results in the form of a spatial concentration map (see project introduction for example). You may either use a computer program like Adobe Illustrator or Google Sketch up, or draw the map by hand. The map should include sampling locations (as points) and areas of high to low concentration.

In addition to the full size map, please create a smaller key map. This map only needs to have the locations of samples taken and the sample names/numbers. This map should either be digital, or small enough to scan in to the computer. This map should be included in your final paper as a reference to where samples are located.
Final Paper: Spring Creek Nitrate Concentrations near Bell Athletic Field

You have now analyzed multiple papers regarding Nitrogen in aquatic systems, tested and sampled for field data, and recorded results from your testing. In a 5-7 page double spaced paper please describe the nitrogen system of Spring Creek near the Bell Field area. This paper should address all of the questions asked in the research section in a more formal context as well as relating them to the results you found in the field testing section. Also, please include the small key map you made in step four of the field project section.