# Red River Basin River Watch Program Annual Report

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Contents

# INTRODUCTION

This report fulfills the evaluation requirement of the River Watch Program from December 2009 through December 2010. The purpose of this report is to provide the program managers and stakeholders with data and feedback related to the program's goals and objectives, especially as they relate to the implementation of the project in the schools and meeting the overall project objectives. Findings from this report are intended to be used to modify the program as needed to better meet the program objectives.

## Project Description

The River Watch Program was developed to produce an effective transferable model, which engages and educates watershed residents and stakeholders to better understand and protect watershed ecosystems through environmental monitoring, training, and formal and informal education programs. The primary objectives of the program include the following:

1. Coordinate project planning and sustainability for watershed science development efforts through the Strategic Leadership Team (SLT) and its affiliated partners and working groups.
2. Develop strong student leadership for River Watch teams and community engagement activities.
3. Develop interdisciplinary education modules across all grades, which address the impacts and causes of flooding and flood prevention strategies in the Red River Basin.
4. Contribute to the understanding of watershed science by developing structure for effective watershed science applied research partnerships involving River Watch students as part of a multi-disciplinary team to address relevant local resource management issues.

During 2009-2010, the program engaged in three main activities: 1) curriculum integration and teacher training, 2) youth leadership and civic engagement, and 3) applied research collaboration and watershed science skills building. Approximately twenty-five (25) Minnesota schools are currently involved in River Watch; the number fluctuates due primarily to teacher turnover. Generally, there are 6-8 students per school on a River Watch team. The program encourages schools to monitor the river monthly during open water season but some do not monitor during the months of June-August. Data is entered and accessed at http://riverwatch.umn.edu/.

# METHODOLOGY

This report describes the evaluation of the River Watch Program from December 2009 through December 2010. Data was collected according to the evaluation plan shown in Appendix A in an effort to address each of the four project objectives and subsidiary questions. Data from the Student Leader Teams was unavailable due to the meeting being cancelled. The evaluation plan for this project was based on Guskey's levels of evaluation (Guskey, 2000). Table 1 shows the relationship between the levels of evaluation, the program objectives, and data sources utilized in the evaluation.

Table 1

*Relationship between Evaluation levels, Program Objectives, and Data Sources*

| Evaluation Level (Guskey, 2000) | Program Objectives | Data Sources |
|---|---|---|
| 1. Quality of Implementation | 1. Coordinate project planning and sustainability for watershed science development efforts through the Strategic Leadership Team (SLT) and its affiliated partners and working groups.<br>2. Develop strong student leadership for River Watch teams and community engagement activities. | • River Watch Forum, March 17, 2010, agenda<br>• River Watch websites<br>• Student produced materials, March 17 |
| 2. Change in Teachers' Instruction – Use of New Knowledge and Skills | 3. Develop interdisciplinary education modules across all grades, which address the impacts and causes of flooding and flood prevention strategies in the Red River Basin. | • Syllabus of River Watch Boot Camp, June 24, 2010<br>• River Watch Evaluation Survey<br>• Teacher Focus Group Protocol<br>• Transcript of Focus Group Meeting<br>• River Watch Teacher Survey<br>• Teacher Designed Lesson Plans |
| 3. Student Learning Outcomes | 4. Contribute to the understanding of watershed science by developing structure for effective watershed science applied research partnerships involving River Watch students as part of a multi-disciplinary team to address relevant local resource management issues. | • WSKIA (Watershed Science Knowledge Interest Attitude survey)<br>• The Scientific Attitude Inventory: (SAI II) |

Data Sources and Analysis

A variety of data sources were used to get a more complete view of the impacts of the program. In addition to an existing quantitative instrument, the WSKIA, several others were developed to better target the objectives of the River Watch Program. In addition, qualitative data were collected from several different contexts.

## *Student Related Data*

*Quantitative Data*

*WSKIA (Watershed Science Knowledge Interest Attitude)*

The WSKIA (Watershed Science Knowledge Interest Attitude) survey was developed by Joe Courneya and David DeMuth to obtain baseline data on knowledge, interest, and attitude of students participating in the River Watch Program. It was designed to serve as a pre/posttest of students' content knowledge and attitudes toward science. Thirteen (13) multiple-choice questions relate to watershed science knowledge. Seven additional questions relate to students interest and attitude in science, technology, engineering, and mathematic (STEM) fields. A copy of the survey is included in Appendix B of this report.

In addition to the content, interest, and attitude items, several demographic items were included at the end of the survey. Demographics items include gender, ethnicity, time involved with River Watch, name of school and grade.

As of January 22, 2011, the posttest WSKIA had not been administered. Therefore, data from the post survey is not included in this report and only data from the spring 2010 administration of the survey will be reported. Once the posttest is administered, the responses will be matched, analyzed, and discussed in subsequent reports.

*The Scientific Attitude Inventory (SAI II)*

The Scientific Attitude Inventory (SAI II) was used to measure students' interest in science, their attitudes toward science, their views of scientist, and their desire to become scientist. Designed by Moore and Foy (1997), the SAI II was revised from the original SAI to improve the readability and to eliminate gender-biased language. The instrument consists of forty multi-choice questions related to students' attitudes toward science. The instrument was field tested, by Moore and Foy (1997), in grades 6, 9, and 12 and was found to have a split-half reliability coefficient of .805 and a Cronbach's alpha reliability coefficient of .781 making this a very reliable instrument. *Note: The data presented in this section of the report are based on the* *work of Moore and Foy. These data DO NOT represent the actual data collected from the participants in this study.*

In addition to the content, interest, and attitude items, several demographic items were included at the end of the survey. Demographics items include gender, ethnicity, time involved with River Watch, name of school and grade. A copy of the survey is included in Appendix C of this report. *Note: Data collection using The Scientific Attitude Inventory (SAI II) began in January 2011; therefore, results from the SAI II was not included in this report but will be included in subsequent evaluations.*

*Quantitative Data Analysis*

The results reported below are based on analysis of the WSKIA using the statistical software SPSS v. 18. The WSKIA was administered to students between December 11, 2009 and April 12, 2010. Students were provided the option to complete the survey electronically, via Survey Monkey, or in hard-copy format. If students completed the survey in hard-copy format, the data was entered into Survey Monkey by Grit May. Survey Monkey randomizes the responses on each survey, thus reducing the effect of "first item response bias." *Note: This also accounts for any difference between the correct responses and the order of the items in the copy of the WSKIA shown in the Appendix.* Demographic information is provided below.

Of the 327 students, 214 reported they did not participate in the River Watch Program, 109 reported participating in River Watch activities, and four did not respond to the question. Table 1 lists the reporting schools and comparison of student participation in River Watch.

Table 1 Reporting Schools and Comparison of Student Participation

| | Non-River Watch Students | River Watch Students |
|---|---|---|
| Campbell-Tintah | 16 | 4 |
| Climax | 8 | 11 |
| Clinton-Graceville-Beardsley | 40 | 7 |
| Crookston | 12 | 9 |
| East Grand Forks | 0 | 10 |
| Fosston | 4 | 7 |
| Hawley | 0 | 1 |
| Mahnomen | 5 | 12 |
| Marshall County Central | 12 | 4 |
| Red Lake | 2 | 1 |
| Red Lake County Central | 5 | 4 |
| Roseau | 18 | 7 |
| Sacred Heart | 0 | 10 |
| Stephen-Argyle Central | 49 | 6 |
| Warren-Alvarado-Oslo | 6 | 2 |
| Wheaton | 29 | 7 |
| Win-E-Mac | 5 | 6 |
| Missing (non-reporting) | 3 | 1 |
| Total | 214 | 109 |

On the 109 students who reported participation in the River Watch Program, participation time ranged from 4 months (one semester) to 4 years. The results are shown in Table 2.

Table 2 Amount of Time Participating in River Watch

| | Frequency | Percent |
|---|---|---|
| 4 months | 32 | 29.4 |
| 9 months | 23 | 21.1 |
| 2 years | 30 | 27.5 |
| 3 years | 12 | 11.0 |
| 4 years | 12 | 11.0 |
| Total | 109 | 100.0 |

Tables 3 and 4 show the demographics of the non-River Watch students and students participating in River Watch based on gender and ethnicity.

Table 3 Gender

| | Non-River Watch Students | | River Watch Students | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| Female | 120 | 56.1 | 56 | 51.4 |
| Male | 89 | 41.6 | 47 | 43.1 |
| Prefer not to disclose | 4 | 1.9 | 6 | 5.5 |
| Missing | 1 | .5 | 0 | 0 |
| Total | 214 | 100.0 | 109 | 100.0 |

Table 4 Ethnicity

| | Non-River Watch Students | | River Watch Students | |
|---|---|---|---|---|
| | Frequency | Percent | Frequency | Percent |
| African American | 2 | .9 | 1 | .9 |
| American Indian | 6 | 2.8 | 7 | 6.4 |
| Asian/Pacific Islander | 1 | .5 | 0 | 0 |
| Caucasian (white) | 187 | 87.4 | 93 | 85.3 |
| Hispanic | 6 | 2.8 | 2 | 1.8 |
| Other | 6 | 2.8 | 5 | 4.6 |
| Prefer not to disclose | 6 | 2.8 | 1 | .9 |
| Total | 214 | 100.0 | 109 | 100.0 |

Leven's Test for Equality of Variances was conducted to determine if differences existed between the River Watch students and the non-River Watch students. The variances were equal based on ethnicity, $F(1, 320) = .274$, *ns,* but for gender the variances were significantly different in the two groups, $F(1, 320) = 4.596$, $p < .01$; therefore, based on gender, the two groups are statistically different. *Note: This is important because comparisons between the two groups should not be made based on gender, but comparisons within the two groups can be made once more data is collected. When data from the post survey is complete, comparisons within the two groups will be conducted. For the purposes of this report, data from both groups will be presented to serve as a starting point for each.*

Total scores were calculated including the total number of content related items correctly answered (questions 2-14) and a comparison of responses was made between River Watch participants and non-River Watch participants. Independent sample *t*-tests and ANOVAs were computed to determine whether differences existed by gender, grade-level, time associated with River Watch, and school (respectively) in students' responses to content related questions 2-14 and are discussed in the Results section.

The thirteen content related questions 2-14, were found to had a low reliability, Cronbach's $\alpha = .028$. Poor reliabilities on the science content items is not surprising given that the questions were designed to cover a wide range of content and therefore would not be expected to target a single science content construct.

*Qualitative Data and Analysis*

The quality of implementation of the River Watch Program was evaluated, in part, through data collected from The River Watch Forum, which was held March 17, 2010, at the University of Minnesota-Crookston campus. This daylong event included four concurrent sessions, team presentations/displays, presentations on national and regional topics, and awards and recognition of schools and partners. Student brochures included information about their monitoring sites, photos, and pH, turbidity, dissolved oxygen, water temperature, and transparency tube measurements. A copy of the agenda for the forum and student produced materials are included in the Appendix of this report.

## *Teacher Related Data*

*Quantitative Data and Analysis*

*River Watch Evaluation Survey*

The River Watch Evaluation Survey was developed by the author of this report to assess the effectiveness of the River Watch Program in terms of development of educational resources, training opportunities, and outreach participation related to the River Watch Program. These items reflect several of the objectives of the River Watch Program. The survey contains four multiple-choice questions. Five additional open-ended statements solicit responses related to what works best and what needs improvement in relation to the River Watch project. The survey was administered during the River Watch Boot Camp, held in Crookston, MN, June 20-24, 2010. A copy of the survey is included in Appendix F of this report.

*River Watch Teacher Survey*

The River Watch Teacher Survey was developed by the author of this report to assess teachers' perceptions of the effectiveness of the River Watch Program in terms of development of educational resources, training opportunities, and mentor contact related to the River Watch Program. These items reflect several of the objectives of the River Watch Program. The survey contained nine 5-point Likert- scaled items with responses ranging from strongly disagree to strongly agree. Three additional open-ended statements asked for responses related to what works best and what needs improvement in relation to the River Watch Program. The survey was sent electronically via Survey Monkey in early January 2011 to teachers identified as currently participating in the River Watch Program. A copy of the survey is included in Appendix G of this report.

*Qualitative Data and Analysis*

*Boot Camp Focus Group*

The five-day boot camp event provided participants the opportunity to gain hands-on experience with river monitoring practices and to learn about ecological and sustainability principles. A copy of the syllabus of the event is included in Appendix H of this report. A 90 minute audiotaped focus group was held with during the last day of the camp. A protocol containing ten questions to be asked during the focus group was created by the evaluator. A copy of the protocol is included in Appendix I of this report.

The focus group discussion allowed for the examination of issues that were important to the participants of the camp. The first step in the analysis consisted of listening to the audio recording of the focus group. The audio recording was then transcribed in full. A copy of the transcription is included in Appendix J of this report. The transcribed audio was then inductively coded to identify issues related to the River Watch Program and its objectives (Patton, 2002). The coding resulted in the identification of common areas of concern and success.

## *Instructional and Informational Related Data*

### *Qualitative Data and Analysis*

#### *Teacher Designed Lesson Plans*

As part of participation in the River Watch Boot Camp, teachers were encouraged to design lesson plans for their classes using the ideas presented in the camp. Lesson plans were designed on topics ranging from groundwater analysis, an introduction to watersheds, geology of the Red River Basin, and natural selection.

Two levels of analysis were conducted. The first level of analysis consisted of examining the lesson plans as they related to the pedagogical strategies of designing a standards-based lesson plan (Wiggins and McTighe, 1998; McMahon, et. al, 2006). This examination looked for the presences of the following elements within each lesson: purpose statement, standards addressed, essential question students should be able to answer, assessment criteria to determine what students learned, description of activities, and lesson extension and modifications plans.

The second level of analysis involved the identification of the specific types of assessment items that were used by the teachers in the lesson plans. This included both formative and summative items, formal and informal in nature. This analysis also looked for the presence of scoring rubrics for the assessment items. Copies of the lesson plans are included in Appendix K of this report.

#### *River Watch Related Websites*

Several websites are used by teachers and students as part of the River watch project. Table 5 provides a brief description of each.

Table 5 Summary of Websites related to the River Watch Project

| Name of Site and Web Address | Summary of Contents |
|---|---|
| International River Watch Institute<br>http://www.internationalwaterinstitute.org/riverwatchforum.htm | Links include Red River Center for Watershed Education, Projects & Activities, Teacher Information, and Resource Links. |
| U of M Crookston data site<br>https://riverwatch.umn.edu/ | Designed and maintained by UMC as data storage and analysis site for data by RW teams and other monitoring partners in RR Basin. |
| River Watch Teacher<br>http://riverwatchteacher.org/moodle/ | Designed and maintained by one of the teachers participating in River Watch. |
| Red River of the North River Watch (Facebook)<br>http://www.facebook.com/#!/group.php?gid=114412341377&ref=ts | A Facebook site with fifty-nine (59) members. |

The International River Watch Institute website appears not to have been updated recently. The most recent lesson plans, from teachers who attend previous teacher training sessions, are dated 2006. They are organized by title, not by grade or standard, so searching is very difficult. Under the *Project* link is a link to River Watch that does have more current information relating to training sessions and database info, but does not contain lesson plans. Lesson plans being developed through the current project will be added to the Moodle site noted below.

The U of M Crookston data site is the central data depository for all data collected by River Watch schools. Schools can upload their data to the sire and have access to download any data from other schools from the site. Other agency monitoring partners in the Red River Basin also have data on the site, thus the data is also available to schools for analysis. Various display features are built into the site that allows users to view data graphically and customize graphs in a variety of ways.

The River Watch Teacher site was designed, and is maintained, by one of the teachers participating in the program. The site contains lesson plans and related resources and serves as a platform for collaboration among teachers. The site is user-friendly, but it is not clear how many of the River Watch teachers know of the site and are enrolled as users.

The Red River of the North River Watch (Facebook) site lists 59 members, seven of which are administrators of the site. The description of the site states:

> This group is for any river watch volunteers and alumni of the Red River of the North Basin (Minnesota, North Dakota, and Manitoba) to keep all teams in touch and on base with activities and projects that are either in progress or just starting.

The site is well designed and user friendly. There are concerns over safety of minors, as some appear to provide the name of their school and the site is open to the public. As of January 27, 2011, the last posting to the site was made on October 26, 2010.

# RESULTS AND DISCUSSION

## Quality of Implementation

The River Watch Forum agenda, student produced materials, and River Watch websites were used to examine the quality of the implementation of the River Watch program. These data sources were used formatively to provide project staff with information that could be used to improve each subsequent student related activities as they relate to the following program objectives: 1) coordinate project planning and sustainability for watershed science development efforts through the Strategic Leadership Team (SLT) and its affiliated partners and working groups, and 2) develop strong student leadership for River Watch teams and community engagement activities.

Based on personal observations made during the River Watch Forum, students were actively engaged during the forum. Concurrent sessions on topics relating to data collection, toxicity, and robotics, allowed students the opportunity to interact with professionals in these areas. Team displays allowed the students to showcase their work. The displays included photos, data tables, and analysis of their results.

A summer Youth Leadership camp that was to be held in June was cancelled due to low registration. This may have been the result of poor publicity of the event, other conflicting school/family events, personal financial reasons, or other unknown causes. Due to the lack of opportunity to survey students at this event, youth survey data is still needed.

The U of M Crookston data site and the Red River of the North River Watch (Facebook) site are primarily intended to be used by students. Other than data listed on the U of M site, both sites appear to have very little activity. This is especially odd on the Facebook site, given that Facebook is one of the primary social media platforms used for communication by middle and high school students.

## Change in Teachers' Instruction – Use of New Knowledge and Skills

The syllabus of the River Watch Boot Camp, River Watch Evaluation Survey, Focus Group transcript and River Watch Teacher Survey were used to examine changes in teachers' instruction as they relate the program goal to develop interdisciplinary education modules across all grades, which address the impacts and causes of flooding and flood prevention strategies in the Red River Basin.

The River Watch Boot Camp provided teachers with an opportunity experience first-hand the natural environment of the Red River and work with experts in the field. The five-day, residential camp was open for K-12 teachers, educators and natural resource manages. The goals of the camp, as stated in the syllabus, included the following:

- Understand the historical, climatic, geologic, soils, vegetation, and animal communities of the Red River basin landscape region and how they have changed over time due to human land use.
- Understand the interactions and impacts of land uses on the natural ecology and sustainability of the region.
- Develop improved skills of field and laboratory instruction in watershed science which can be adapted to local settings
- Acquire an expanded network of resources which support the above goals including personal contacts and instructional materials, both hard copy and electronic.
- Develop a better understanding of the array of governmental and other organizations that related to watershed management and can be of assistance to watershed educational program.
- Become more comfortable in grant writing process and more knowledgeable about funding sources.

Participants in the camp participated in numerous field trips related to river conservation and analysis techniques. Only two items on the agenda related directly to the development of lesson plans for their classrooms.

During the last day of the camp, a focus group was conducted with eight teachers and one non-teacher volunteer. Participants responded to a short survey, the River Watch Evaluation Survey, (Appendix F) prior to the beginning of the focus group meeting. When asked about the usefulness of the educational resources which were made available to them through the River Watch Program during the year, 66.7% agreed that the materials were useful (Table 6).

Table 6 Educational Resources Useful in Classroom Instruction

| | Frequency | Percent |
|---|---|---|
| agree | 6 | 66.7 |
| neutral | 1 | 11.1 |
| disagree | 1 | 11.1 |
| Total | 8 | 88.9 |
| Missing | 1 | 11.1 |
| Total | 9 | 100.0 |

Three of the respondents recorded that they were not currently involved with outreach projects related to River Watch, such as Adopt-A-River, Summer Science Camp, or public presentations.

Three themes emerged from an analysis of the open-ended statements of the River Watch Evaluation Survey and the transcript of the focus group meeting: time, real-world opportunity, and coordination of the program. The lack of time to conduct River Watch activities with their students was by far the greatest challenge identified by the teachers to their ability to effectively participate in the program. Teachers stated the following:

- Time constraints; it's hard to get into the field during the summer months when school is out of session.
- The biggest challenge is time, when that, when September 1st comes around, you don't wear the River Watch hat, you have a hundred other hats you have to trade off and if you could devote all your time to River Watch you could stay busy, but there are a hundred other things to do, and you just, there's just not enough days, days in the week, not enough hours in the day.
- This is a project that on a teacher's level does take hundreds of hours per year, and it's something that most of us volunteer to do, and so I agree, I think time is the biggest issue.

Teachers stated that the greatest benefit of participation in River Watch was the real-world science conducted by the students:

- I think it's good that students get to us real science equipment, because our schools can't always afford to buy the heavy-duty science equipment, and for them to be able to use things that scientists actually use is good.
- They get to do real world science and they get to present it to people who can make a difference.
- This program teaches the kids to be environmentally aware, environmental education, I just don't think we have enough of that in schools, and I don't think it should start when they're River Watch kids, this stuff should start way down in elementary school, so if anything, this program hopefully will grow into that.

Coordination of the program, both within their own schools and with the River Watch administrators, was found to be the greatest challenge to teachers:

- I think the other thing is you better have good administrators that are going to support it because if you don't, it's not going to, I don't think it will work, you can't be fighting to get out of school to go test or to get vehicles or get subs, I mean, administrators have to be behind you with this at least to a pretty good extent.
- Sometimes with collaboration, we seem to have a lot of thought and tossing of ideas back and forth without deciding on things as efficiently as we could.
- I think the geographical isolation of the program is an issue because I don't live close enough to the Red River to take part in this particular program itself, but if it were expanded to include service waters or other rivers or something like that, then I, you know, I'd be there and the kids would be there to, to, you know, do the stuff (couldn't understand) program.

When asked how River Watch could be improved, concern about increased implementation of the program was a mentioned by several teachers, as well as the lack of communication between teachers:

- One of the goals, you know, is to be able to take this and be able to implement it around the state, but there's going to be a lot of work to get it to there you need to have people like we have here that are in charge and are willing to do a lot to help the teachers, and I think they do, but like has been said, it is an incredibly time consuming thing that for all of us is just an add-on, it's just additional things, it's great opportunities for the kids, but it's a lot of work.

- It's hard for us to be able to talk to each other, not necessarily like communication is difficult or anything, but the time it takes or um, you know, to have just conversations about how does this work in your class, how do you choose your students, what...you know, like all that kind of stuff is, you don't always get enough time to just talk to each other about how it, like logistically works, sometimes.
- Adapt it to other situations and then you'd have to go through the same process of advertising in some way, having groups like this meet in other locations and set up a program, so it's going to be similar to River Watch but adapt it to your particular locale.

A follow-up survey, the River Watch Teacher Survey, was sent in early January 2011 to all teachers who currently participate in the program. The River Watch Teacher Survey was developed by the author of this report to assess teachers' perceptions of the effectiveness of the River Watch Program in terms of development of educational resources, training opportunities, and mentor contact related to the River Watch Program. Twelve teachers responded and their responses to the multiple-choice items are shown in Table 7.

Table 7 Frequency Table for the River Watch Teacher Survey (N = 12)

| | Strongly Disagree (1) | Disagree (2) | Neither Agree or Disagree (3) | Agree (4) | Strongly Agree (5) | No Modules were developed (6) | Mean | Std. Deviation |
|---|---|---|---|---|---|---|---|---|
| The River Watch Project has developed watershed science education modules for use in my classroom. | 0 | 1 | 3 | 4 | 2 | 2 | 4.08 | 1.240 |
| The modules connect watershed science skills with academic standards across grade and subject levels. | 0 | 1 | 2 | 5 | 2 | 2 | 4.17 | 1.193 |
| The River Watch project has developed teacher-training options for watershed science education modules and related watershed science topics including one summer teacher training session. | 0 | 2 | 2 | 8 | 0 | 0 | 3.50 | .798 |
| Training and internship options related to watershed science for pre-service teachers have been developed and are available. | 0 | 2 | 5 | 5 | 0 | 0 | 3.25 | .754 |
| I am aware of post-secondary/dual credit options related to watershed science offered by participating school | 1 | 5 | 2 | 3 | 1 | 0 | 2.83 | 1.193 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| districts and institutes of higher education. | | | | | | | | |
| The curriculum/education work group members meet regularly to share additional resources and advance the goals of the River Watch Project. | 1 | 2 | 3 | 6 | 0 | 0 | 3.08 | 1.240 |
| The watershed science education modules incorporate topics specific to flood impacts, causes, and prevention strategies that can be readily incorporated into high school curriculum. | 0 | 2 | 3 | 6 | 1 | 0 | 3.50 | .905 |
| Teacher training options have been developed which include training on the use of modules related to flooding issues and impacts in the Red River Basin. | 0 | 2 | 4 | 6 | 0 | 0 | 3.33 | .778 |
| I have had the opportunity to work with resource experts and watershed scientists as part of the River Watch Project. | 0 | 1 | 2 | 6 | 3 | 0 | 3.92 | .900 |

The results of the survey indicate that the teachers mildly agree as a whole with the effectiveness of the River Watch Program in terms of development of educational resources, training opportunities, and mentor contact related to the River Watch Program.

Four lesson plans were evaluated for the presence of research based pedagogical strategies of designing standards-based lesson plans and for the various types of assessment strategies and scoring rubrics. Table 8 shows a summary of the analysis.

Table 8 Lesson Plan Analysis

(np = not present; p = present; v = vague/unclear)

| Lesson Plan Title | Grade Level | Purpose Statement | List of Standards Addressed | Essential Question(s) | Assessment Criteria | Type of Assessment | Description of Activities | Lesson Extension and Modifications |
|---|---|---|---|---|---|---|---|---|
| Groundwater | 8 | p | p | np | v | v | p | v |
| Watersheds | 9 | p | p | np | v | p | p | v |
| Red River Geology | 8 | np | p | np | np | np | p | v |
| Natural Selection | 10 | p | p | np | p | p | p | np |

The *Groundwater* lesson plan was designed for 8$^{th}$ grade students. It contains a detailed discussion of the topic, materials required, and instructions for the activities. It lacks identification of an essential question. Although there are sections that state, "have students answer the following questions," it is unclear if the responses are written or oral, individual or group, or how they will be assessed. The lesson plan lacks clear assessment criteria and rubrics. Limited extension material was provided and no modifications for special needs students was present.

The *Watershed* lesson plan was designed for 9$^{th}$ grade students. It contains a detailed discussion of the topic, materials required, and instructions for the activities. It lacks identification of an essential question. Several formative assessment items are included, but there are no specific assessment criteria. The lesson plans does mention the science binder could be used as an evaluation tool, but does not provide a scoring rubric or other details. Limited extension material was provided and no modifications for special needs students were present.

The *Red River Geology* lesson plan was designed for 8th grade students. It contains a detailed discussion of the topic, materials required, and instructions for the activities. It lacks identification of an essential question. It contains no assessment items or criteria, although it does state students could be assessed on class discussion and participation. No rubrics are included. An extension activity is suggested in the form of a presentation of various landforms, but not details as to the criteria for the presentation are provided. No modifications for special needs students were present.

The *Natural Selection by Species Interactions* lesson plan was designed for 10th grade. It provides both national and state standards and benchmarks. It contains a detailed discussion of the topic, materials required, and instructions of the activities. It lacks identification of an essential question. No extension material was provided and no modifications for special needs students were present.

## Student Leaning Outcomes

### *Results from WSKIA*

Correct responses to questions 2-14 of the WSKIA were tabulated for both students in River Watch and non-River Watch students and are shown in Table 9.

Table 9 Frequency of Correct Responses to Questions #2-14

| | Non-River Watch Students | | River Watch Students | |
|---|---|---|---|---|
| Question Number | Frequency | Percent | Frequency | Percent |
| 2. land area whose water drains into a major river or lake system | 152 | 71.0 | 77 | 70.6 |
| 3. Red River of the North Basin | 107 | 50.0 | 73 | 67.0 |
| 4. 5.2 mg/L | 49 | 22.9 | 32 | 29.4 |
| 5. neutral | 104 | 48.6 | 81 | 74.3 |
| 6. the depth you can see down to in the water | 33 | 15.4 | 16 | 14.7 |
| 7. It is low in nutrients. | 63 | 29.4 | 34 | 31.2 |
| 8. Surface water running off years, streets, and farm fields. | 124 | 57.9 | 65 | 59.6 |
| 9. They help filter and storm water before it enters lakes or streams. | 154 | 72.0 | 85 | 78.0 |
| 10. It promotes excessive plant and algae growth in rivers & lakes. | 52 | 24.3 | 32 | 29.4 |
| 11. B1 + B2 + ...+B53 | 52 | 24.3 | 40 | 36.7 |
| 12. To show percent composition of data | 152 | 71.0 | 83 | 76.1 |
| 13. To compare your data to conditions we are trying to achieve for water quality. | 77 | 36.0 | 55 | 50.5 |
| 14. Formulate a question that can be answered by an investigation. | 130 | 60.7 | 72 | 66.1 |

A comparison of the total number of correct responses found that students in the River Watch Program answered more questions correctly, as shown in Table 10.

Table 10 Total Number of Correct Responses to Questions 2-14

| | N | Mean | Std. Dev. |
|---|---|---|---|
| River Watch Students | 109 | 6.83 | 2.276 |
| Non-River Watch Students | 214 | 5.76 | 2.077 |

Students participating in River Watch do have a higher mean score than those who do not, although this must be viewed with caution given those students self-select to participate in River Watch and therefore have a propensity towards the topic. In addition, other factors such as the number of and type of previous science courses may affect their responses on the WSKIA.

A closer examination of the scores on the WSKIA from the students participating in River Watch was conducted sorting the responses by the length of time the students had participated in the program. The results are shown in Table 11.

Table 11 Correct Responses Correlated by Time in River Watch

| Question | Length of Time | N | Number of Correct Responses | % of Correct Responses | Mean | Std. Dev. |
|---|---|---|---|---|---|---|
| 2. A watershed is generally defined as | 4 months (one semester) | 32 | 20 | 62.5 | .63 | .492 |
| | 9 months (one year) | 23 | 14 | 60.9 | .61 | .499 |
| | 2 years | 30 | 22 | 73.3 | .73 | .450 |
| | 3 years | 12 | 11 | 91.7 | .92 | .289 |
| | 4 years | 12 | 10 | 83.3 | .83 | .389 |
| | Total | 109 | 77 | 70.6 | .71 | .458 |
| 3. What is the name of the major watershed your school is located in? | 4 months (one semester) | 32 | 24 | 75.0 | .75 | .440 |
| | 9 months (one year) | 23 | 15 | 65.2 | .65 | .487 |
| | 2 years | 30 | 18 | 60.0 | .60 | .498 |
| | 3 years | 12 | 7 | 58.3 | .58 | .515 |
| | 4 years | 12 | 9 | 75.0 | .75 | .452 |
| | Total | 109 | 73 | 67.0 | .67 | .472 |
| 4. Stonefly larvae require a healthy aquatic ecosystem to thrive in. Which dissolved oxygen level would be considered adequate for stonefly and similar aquatic life? | 4 months (one semester) | 32 | 13 | 40.6 | .41 | .499 |
| | 9 months (one year) | 23 | 7 | 30.4 | .30 | .470 |
| | 2 years | 29* | 7 | 23.3 | .24 | .435 |
| | 3 years | 12 | 1 | 8.3 | .08 | .289 |
| | 4 years | 12 | 4 | 33.3 | .33 | .492 |
| | Total | 108* | 32 | 29.4 | .30 | .459 |
| 5. A sample with a pH of 7 is considered | 4 months (one semester) | 32 | 19 | 59.4 | .59 | .499 |
| | 9 months (one year) | 23 | 18 | 78.3 | .78 | .422 |
| | 2 years | 30 | 24 | 80.0 | .80 | .407 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 3 years | 12 | 12 | 100.0 | 1.00 | .000 |
| | 4 years | 12 | 8 | 66.7 | .67 | .492 |
| | Total | 109 | 81 | 74.3 | .74 | .439 |
| 6. Transparency is | 4 months (one semester) | 32 | 4 | 12.5 | .13 | .336 |
| | 9 months (one year) | 23 | 5 | 21.7 | .22 | .422 |
| | 2 years | 30 | 4 | 13.3 | .13 | .346 |
| | 3 years | 12 | 1 | 8.3 | .08 | .289 |
| | 4 years | 12 | 2 | 16.7 | .17 | .389 |
| | Total | 109 | 16 | 14.7 | .15 | .356 |
| 7. Which of the following is NOT true of a eutrophic lake/river? | 4 months (one semester) | 32 | 9 | 28.1 | .28 | .457 |
| | 9 months (one year) | 23 | 4 | 17.4 | .17 | .388 |
| | 2 years | 30 | 6 | 20.0 | .20 | .407 |
| | 3 years | 12 | 8 | 66.7 | .67 | .492 |
| | 4 years | 11* | 7 | 58.3 | .64 | .505 |
| | Total | 108* | 34 | 31.2 | .31 | .467 |
| 8. What is an example of non-point source pollution? | 4 months (one semester) | 32 | 19 | 59.4 | .59 | .499 |
| | 9 months (one year) | 23 | 12 | 52.2 | .52 | .511 |
| | 2 years | 30 | 19 | 63.3 | .63 | .490 |
| | 3 years | 12 | 9 | 75.0 | .75 | .452 |
| | 4 years | 12 | 6 | 50.0 | .50 | .522 |
| | Total | 109 | 65 | 59.6 | .60 | .493 |
| 9. One main benefit of wetlands is | 4 months (one semester) | 32 | 21 | 65.6 | .66 | .483 |
| | 9 months (one year) | 23 | 16 | 69.6 | .70 | .470 |
| | 2 years | 30 | 25 | 83.3 | .83 | .379 |
| | 3 years | 12 | 12 | 100.0 | 1.00 | .000 |
| | 4 years | 12 | 11 | 91.7 | .92 | .289 |
| | Total | 109 | 85 | 78.0 | .78 | .416 |
| 10. Fertilizers and detergents may contain phosphorous which can be damaging to the environment. Which of the following is the major environmental impact of phosphorus? | 4 months (one semester) | 32 | 8 | 25.0 | .25 | .440 |
| | 9 months (one year) | 22* | 3 | 13.0 | .14 | .351 |
| | 2 years | 29* | 11 | 36.7 | .38 | .494 |
| | 3 years | 12 | 6 | 50.0 | .50 | .522 |
| | 4 years | 12 | 4 | 33.3 | .33 | .492 |
| | Total | 107* | 32 | 29.4 | .30 | .460 |
| 11. The command =sum(B1:B53) - as stated in the program MS Excel - represents which of the following mathematical processes? | 4 months (one semester) | 32 | 4 | 12.5 | .13 | .336 |
| | 9 months (one year) | 23 | 11 | 47.8 | .48 | .511 |
| | 2 years | 30 | 15 | 50.0 | .50 | .509 |
| | 3 years | 12 | 6 | 50.0 | .50 | .522 |
| | 4 years | 12 | 4 | 33.3 | .33 | .492 |
| | Total | 109 | 40 | 36.7 | .37 | .484 |
| 12. When are pie charts most commonly used? | 4 months (one semester) | 32 | 24 | 75.0 | .75 | .440 |
| | 9 months (one year) | 23 | 17 | 73.9 | .74 | .449 |
| | 2 years | 30 | 26 | 86.7 | .87 | .346 |
| | 3 years | 12 | 7 | 58.3 | .58 | .515 |
| | 4 years | 12 | 9 | 75.0 | .75 | .452 |
| | | 109 | 83 | 76.1 | .76 | .428 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Total | | | | | |
| 13. Why would you compare your data to benchmarks? | 4 months (one semester) | 32 | 21 | 65.6 | .66 | .483 |
| | 9 months (one year) | 23 | 4 | 17.4 | .17 | .388 |
| | 2 years | 30 | 14 | 46.7 | .47 | .507 |
| | 3 years | 12 | 8 | 66.7 | .67 | .492 |
| | 4 years | 12 | 8 | 66.7 | .67 | .492 |
| | Total | 109 | 55 | 50.5 | .50 | .502 |
| 14. Which of the following is the first step in a scientific method of conducting research? | 4 months (one semester) | 32 | 22 | 68.8 | .69 | .471 |
| | 9 months (one year) | 23 | 11 | 47.8 | .48 | .511 |
| | 2 years | 30 | 22 | 73.3 | .73 | .450 |
| | 3 years | 12 | 7 | 58.3 | .58 | .515 |
| | 4 years | 12 | 10 | 83.3 | .83 | .389 |
| | Total | 109 | 72 | 66.1 | .66 | .476 |

*Missing response

A one-way ANOVA was computed to determine whether differences in the total number of correct reposes given by students in River Watch existed by based on their gender and ethnicity. There was no significance difference based on gender, $F(10, 108) = 1.038$, $p = .418$, indicating that gender does not effect the total number of correct responses. In addition, there was no significance difference based on ethnicity, $F(10, 108) = .853$, $p = .580$, indicating that ethnicity does not effect the total number of correct responses. *Note: the total N associated with the variable of name of school in students' responses to content related questions 2-14 was not large enough to provide meaningful results and therefore is not reported.*

## SUMMARY AND CONCLUSIONS

Results from the various data sources reported herein provide consistent evidence to suggest that the River Watch Program is making substantial progress towards its goals of developing interdisciplinary education modules across all grades, which address the impacts and causes of flooding and flood prevention strategies in the Red River Basin and to contribute to the understanding of watershed science by developing structure for effective watershed science applied research partnership involving River Watch students as part of a multi-disciplinary team to address relevant local resource management issues.

Overall, the teachers involved with the project are very positive about the opportunities for themselves and their students and its related activities, although they are greatly concerned about the scheduling of activities during summer and conflicts with other school events. Teachers also expressed the challenge they and the students have in performing some of the projects during the summer and over spring break.

In addition, concerns exist over alignment of activities with curriculum science standards. Based on conversations with the teachers at the Boot Camp, they were obtaining information and skills related to the Red River Basin, but need more opportunities to develop lesson plans. They were also very pleased with the interaction with experts in the field. The River Watch administrators have been actively seeking to hire a professional with a background in K-12 science; it is anticipate that this person will assist in the development of lesson plans aligned to state standards with meaningful assessment items related to the River Watch Project. Challenges exist in the collection of student data related to the effectiveness of the program. Given that students generally change teachers at the end of every semester, it is recommended that greater measures be made to conduct a pre-assessment in the first three weeks of each semester and a post assessment during the final three weeks of each semester.

Communication between the River Watch administrators and teachers was also seen as a challenge. Teachers do use email and other forms of electronic communication, but expressed a desire for more effective and timely communication. In addition, there are several websites related to River Watch, although they are confusing and some of the information is dated. The presence of student names and location on the Facebook site is a bit concerning and should be reviewed. Efforts to revise these issues are currently being developed.

Challenges also exist for the River Watch Program in the areas of development and effective use of the Strategic Leadership Team and its affiliated partners and the development and sustainability of student leadership for River Watch teams and community activities.

The River Watch Project is making progress towards its goals and is making a positive impact with students and their communities. It is important to note that student participation in the program is voluntary and that students have numerous opportunities to participate in a wide variety of afterschool activities. Their participation in River Watch shows their positive attitude and dedication towards science and the goals of the project.

*LIMITATIONS OF THIS REPORT*

- This report only covers only a one-year period.
- More data directly from students needs to be collected regarding participation in the program.
- "Post" content test was not administered.

*RECOMMENDATIONS*

- Administer pre/posttests every semester.
- Increase the number of students taking the pre and post WSKIA or other assessment items.
- Obtain student/parent permission slips early in the semester and send out information for surveys, assessment items to teachers promptly. Follow-up with teachers as needed.
- Form a group of project administrators and teachers to design project timeline for student projects, data collect, student and teacher training.
- Work with classroom teachers to align assessment items (WSKIA or other assessment items), lessons, and activities with state and local standards.
- Construct pre and post content knowledge assessment items (WSKIA or other assessment items) to achieve higher reliability.
- Work with schools regarding Internet privacy policies regarding the Facebook site.
- Work with teachers and schools to coordinate dates for teacher and student training sessions and meetings to avoid conflicts as much as possible.

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# APPENDICES

Appendix A: Program Evaluation Schedule

Appendix B: Watershed Science Knowledge-Interest-Attitude (WSKIA) Survey

Appendix C: The Scientific Attitude Inventory

Appendix D: 15th Annual Red River Basin River Watch Forum Agenda

Appendix E: Student Brochures

Appendix F: River Watch Evaluation Survey

Appendix G: River Watch Teacher Survey

Appendix H: River Watch Boot Camp Syllabus

Appendix I: Focus Group Protocol

Appendix J: Transcript of Focus Group Meeting

Appendix K: Teacher Designed Lesson Plans

Appendix A: Program Evaluation Schedule

**Objective #1: Coordinate project planning and sustainability for watershed science development efforts through the Strategic Leadership Team (SLT) and its affiliated partners and working groups.**

| Sub-questions | Data Collection Method | Targeted Respondents | Data Collection Schedule |
|---|---|---|---|
| 1a. Does the SLT and affiliated meet to share information and resource effectively to advance the project goals? | Focus group discussion* (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 1b. How does the one-day leadership development session effects the working relationship of the SLT and its affiliates? | Questionnaire | Attendees of the session | End of leadership development meeting day |
| 1c. Does the SLT create working partnerships to build program sustainability? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 1d. Do the materials produced by the project educate and inform Red River Basin resident, River Watch students and teachers?? | Focus group discussion (Evaluator led)<br><br>Questionnaire<br><br>Copies of materials produced, including Power Points, brochures, and website screen shots | SLT and affiliates<br><br>Attendees of presentations<br><br>Third party experts in science education. | Near the end of each award year<br><br>Following the end of each presentation<br><br>Near the end of each award year. |
| 1e. Does the SLT schedule presentations to River Watch teams and other public audiences and provide training on the use of its educational materials? | Focus group discussion (Evaluator led)<br><br>Questionnaire | SLT and affiliates<br><br>SLT and affiliates and attendees of presentations | Near the end of each award year<br><br>Following the end of each presentation |
| 1f. During the one-day leadership development session, were strategies for raising awareness of the causes of flooding, flood prevention, and the | Questionnaire | Attendees of the session | End of leadership development meeting day |

| | | | |
|---|---|---|---|
| impacts of flooding on land and water resources discussed and defined? | | | |

* During all focus group discussions, artifacts, such as meeting agendas, flyers, photos, etc., will also be collected and assessed as part of the evaluation process.

**Objective #2: Develop strong student leadership for River Watch teams and community engagement activities.**

| Sub-questions | Data Collection Method | Targeted Respondents | Data Collection Schedule |
|---|---|---|---|
| 2a. Has the structure of the Youth leadership team (YLT), and its related activities, been finalized in such a way as to effectively advance project goals? | Focus group discussion (Evaluator led) | SLT and affiliates | Near end of each award year |
| 2b. Have youth leadership development strategies been identified and implemented? | Focus group discussion (Evaluator led) | SLT and affiliates | Near end of each award year |
| 2c. Were student to peer communication systems developed and activities implemented to facilitate River Watch team building and connections between river Watch teams and watersheds? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 2d. Were River Watch "team-to-team" connections developed within and between watersheds? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 2e. Were school and community engagement strategies identified and implemented? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 2f. Did River Watch teams assist with annual River watch Forum, summer science camps, | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates | Near the end of each award year |

| | | | |
|---|---|---|---|
| and community river clean-up activities? | | SLT and affiliates | Near the end of each award year |
| 2f. Did River Watch team incorporate messages during outreach activities that include causes of flooding and flood impacts? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 2f. Did River Watch teams include flooding as a topic for youth leadership summer camps to discuss and identify awareness strategies? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |

**Objective #3: Develop interdisciplinary education modules across all grades, which address the impacts and causes of flooding and flood prevention strategies in the Red River Basin.**

| Sub-questions | Data Collection Method | Targeted Respondents | Data Collection Schedule |
|---|---|---|---|
| 3a. Has the project developed watershed science education modules for teachers, students, and citizens in the Red River Basin? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 3b.Do the modules connect watershed science skills with academic standards across grade and subject levels? | Examination of all modules | Third party experts in science education. | Near the end of each award year |
| 3c. Has the project developed teacher training options for watershed science education modules and related watershed science topics including one summer teacher training session? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 3d. Have training/internship options related to watershed science for pre-service teachers been developed? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |

| | | | |
|---|---|---|---|
| 3e. Has a curriculum with watershed science components that provides post-Secondary Enrollment Option/dual credit been developed and approved by participating school districts and institutes of higher education? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 3f. Do the curriculum/education work group members meet regularly to share additional resources and advance the goals of the project? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 3g. Do the watershed science education modules incorporate topics specific to flood impacts, causes, and prevention strategies that can be readily incorporated into high school curriculum? | Examination of all modules<br><br>Survey | Third party experts in science education.<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 3h. Have teacher training options been developed which include training on the use of modules related to flooding issues and impacts in the red river Basin? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |

**Objective #4: Contribute to the understanding of watershed science by developing structure for effective watershed science applied research partnerships involving River Watch students as part of a multi-disciplinary team to address relevant local resource management issues.**

| Sub-questions | Data Collection Method | Targeted Respondents | Data Collection Schedule |
|---|---|---|---|
| 4a. Has the project established a working relationship with resource experts and watershed scientists to assist with the goals of the project? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 4b. Has the project implemented two comprehensive | Focus group discussion (Evaluator led) | SLT and affiliates | Near the end of each award year |

| | | | |
|---|---|---|---|
| collaborative watershed research projects addressing current watershed research needs? | Survey | SLT and affiliates | Near the end of each award year |
| 4c. Have online tools and tutorials been developed to enable more thorough understanding and analysis of water quality and related data? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 4d. Does the SLT facilitate access to current scientific literature related to watershed topics using University e-library resources prompting local research appropriate to all River Watch schools? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 4e. Does the SLT provide ongoing opportunities for the applied research work group to meet and gather /share information and resources to effectively advance project goals? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |
| 4f. Does the SLT provide training in the use of online flood forecasting tools for Red River Basin to enable River watch teams to assist citizens and community leaders in future flood planning and awareness efforts? | Focus group discussion (Evaluator led)<br><br>Survey | SLT and affiliates<br><br>SLT and affiliates | Near the end of each award year<br><br>Near the end of each award year |

# Appendix B: Watershed Science Knowledge-Interest-Attitude (WSKIA) Survey

## 1. WSKIA Survey Introduction

Welcome to the 2009 Watershed Science Knowledge-Interest-Attitude (WSKIA) Survey.
You are invited to participate in this survey. Your participation is entirely voluntary. However, your assistance would be greatly appreciated in making this a meaningful survey.

Your answers will remain confidential, not even your teacher will know what you said. Your answers will enable us to assess the current strengths and weaknesses of the River Watch program.

This survey is not a test!
*Please answer all the questions to the best of your ability.
*You are asked to work alone and not consult another student or teacher during the survey.

The survey will take about 10 - 15 minutes.
All answers are anonymous so individuals cannot be identified or tracked. Once you start the survey, please finish it. If you choose not to take the survey, please let your teacher know.

If you have any questions about watershed science or River Watch projects, please call Wayne Goeken at 218-574 2622.

If you have questions about the rights of human participation in University of Minnesota research projects, or to report a problem, you should contact Joe Courneya at courn003@umn.edu or 218-790-0706.

If you would like to receive a copy of the research results, please send an e-mail request to Grit May at: grit.may@ndsu.edu.

Thank you very much!

## 2. Watershed Science Knowledge

* 1. In the textbox below, please PRINT your 3 initials and 4 digits for the month and day of your birth! No year needed. Please don't use spaces.
For example, Eric A. Norson, born on June 2, would be:
EAN0602

[ ]

2. A watershed is generally defined as

- ◯ a shed that stores bottled water.
- ◯ land area whose water drains into a major river or lake system.
- ◯ water running off farmland, streets, house roofs, and parking lots.
- ◯ the governing body of a local environmental agency.

3. What is the name of the major watershed your school is located in?

- ◯ Minnesota River Basin
- ◯ Lake Agassiz Basin
- ◯ Red River of the North Basin
- ◯ Missouri River Basin

4. Stonefly larvae require a healthy aquatic ecosystem to thrive in. Which dissolved oxygen level would be considered adaquate for stonefly and similar aquatic life?

- ◯ 5.2 mg/L
- ◯ 2.5 mg/L
- ◯ 3.9 mg/L
- ◯ 1.7 mg/L

5. A sample with a pH of 7 is considered

- ◯ basic.
- ◯ acidic.
- ◯ neutral.

6. Transparency is

- ◯ how well light passes through a sample of water.
- ◯ the amount of sediment in a sample of water.
- ◯ the depth you can see down to in the water.
- ◯ how clear a river looks from the center point of a bridge.

**7. Which of the following is NOT true of a *eutrophic* lake/river?**

- ◯ It causes suffocation of fish and macroinvertebrates.
- ◯ It has a proliferation of plant life especially algae.
- ◯ It is low in dissolved oxygen.
- ◯ It is low in nutrients.

**8. What is an example of non-point source pollution?**

- ◯ Dumping of garbage in local landfills.
- ◯ Waste water from factories.
- ◯ Harmful chemicals flushed down toilets in homes and businesses.
- ◯ Surface water running off yards, streets, and farm fields.

**9. One main benefit of wetlands is**

- ◯ They prevent the spread of undesireable plants and animals.
- ◯ They help to control global climate change.
- ◯ They provide good sites for landfills and other municipal garbage disposal.
- ◯ They help filter and store water before it enters lakes or streams.

**10. Fertilizers and detergents may contain phosphorous which can be damaging to the environment. Which of the following is the major environmental impact of phosphorus?**

- ◯ It has an unpleasant smell.
- ◯ It is poisonous to fish, insects, mussels, and other aquatic life.
- ◯ It pollutes ground water through soil infiltration.
- ◯ It promotes excessive plant and algae growth in rivers & lakes.

**11. The command =Sum(B1:B53) - as stated in the program MS Excel - represents which of the following mathematical processes?**

- ◯ B1 + B2 + ... + B53
- ◯ B1 x B2 x ... x B53
- ◯ Comparison of B1 and B53
- ◯ B1 + B53

**12. When are pie charts most commonly used?**

- ◯ To show percent composition of data.
- ◯ To report findings of data.
- ◯ To help understand what your data means.
- ◯ To put raw data in a more visual form.

**13. Why would you compare your data to benchmarks?**

- ◯ To compare your data to conditions we are trying to achieve for water quality.
- ◯ To show if your River Watch sites contain pollution.
- ◯ To create summaries that allow you to make statements about data.
- ◯ To show that your collection quality standards are accurate and reliable.

**14. Which of the following is the first step in a scientific method of conducting research?**

- ◯ Perform a scientific investigation to initiate the solution process.
- ◯ Draw conclusions from a research investigation.
- ◯ Formulate a question that can be answered by an investigation.
- ◯ Develop an educated guess on your expected findings.

## 3. Interest & Attitude in Science/Technology/Engineering/Math

**15. What media sources do you use to learn about science? (Please check all that apply.)**

- [ ] Internet
- [ ] Magazines
- [ ] Newspapers
- [ ] Radio
- [ ] Textbooks (or other nonfiction reading)
- [ ] TV/Videos/DVD's

Other Media Sources

**16. What are your top three favorite science-related shows? Please list below.**

**17. Which of the following activities have you or are planning to participate in during the 2009-2010 school year, including the summers of 2009 and 2010? (Please check all that apply.)**

- [ ] 4-H Program
- [ ] Adopt A River
- [ ] BEST/FIRST/LEGO Robotics
- [ ] Enviro-thon
- [ ] FFA Program
- [ ] Game Design Camp
- [ ] Knowledge Bowl
- [ ] River Watch
- [ ] Science Camp
- [ ] Science Club
- [ ] Science Fair
- [ ] Science Field Trips

Other science-related activities you participate in:

**18. Please rate your attitude about the following ideas.**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Conducting Watershed Science Research | ○ | ○ | ○ | ○ | ○ |
| Connecting Science and Technology | ○ | ○ | ○ | ○ | ○ |
| Connecting Science and Engineering | ○ | ○ | ○ | ○ | ○ |
| Exploring Human Interaction with Living Systems | ○ | ○ | ○ | ○ | ○ |

**19. Please indicate your interest in the following research-related activities.**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Building experimental equipment | ○ | ○ | ○ | ○ | ○ |
| Data analysis | ○ | ○ | ○ | ○ | ○ |
| Data gathering | ○ | ○ | ○ | ○ | ○ |
| Explaining observations (communicating/reporting) | ○ | ○ | ○ | ○ | ○ |
| Investigation/Discovery | ○ | ○ | ○ | ○ | ○ |
| Testing current theories or conclusions | ○ | ○ | ○ | ○ | ○ |

**20. How much interest do you have in the following before graduating from high school?**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Receiving college credit for River Watch | ○ | ○ | ○ | ○ | ○ |
| Taking advanced science classes | ○ | ○ | ○ | ○ | ○ |

**21. Please specify your interest in exploring a job or career in any of the following scientific fields.**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Agriculture | ○ | ○ | ○ | ○ | ○ |
| Biological Sciences | ○ | ○ | ○ | ○ | ○ |
| Computer Sciences | ○ | ○ | ○ | ○ | ○ |
| Earth Sciences | ○ | ○ | ○ | ○ | ○ |
| Education | ○ | ○ | ○ | ○ | ○ |
| Environmental Sciences | ○ | ○ | ○ | ○ | ○ |
| Health Sciences | ○ | ○ | ○ | ○ | ○ |
| Information Technology | ○ | ○ | ○ | ○ | ○ |
| Mathematics | ○ | ○ | ○ | ○ | ○ |
| Physical Sciences | ○ | ○ | ○ | ○ | ○ |

## 4. Demographics

**22. Gender**

- ◯ Female
- ◯ Male
- ◯ Prefer not to disclose

**23. Ethnicity (Race)**

- ◯ American Indian
- ◯ Asian/Pacific Islander
- ◯ Hispanic
- ◯ African American
- ◯ Caucasian (White)
- ◯ Prefer not to disclose
- ◯ Other, including more than one race (please specify)

**24. Time you have been in the River Watch program**

- ◯ 0 - not participating in the River Watch program
- ◯ 4 month (or a semester class)
- ◯ 9 month (or a year class)
- ◯ 2 years
- ◯ 3 years
- ◯ 4 years

**25. What school do you attend?**

- ◯ Bagley H.S.
- ◯ Barnesville H.S.
- ◯ Campbell-Tintah H.S.
- ◯ Clearbrook-Gonvick H.S.
- ◯ Climax H.S.
- ◯ Clinton-Graceville-Beardsley H.S.
- ◯ Crookston H.S.
- ◯ East Grand Forks H.S.
- ◯ Fosston H.S.
- ◯ Grygla-Gatzke H.S.
- ◯ Hawley H.S.
- ◯ Herman-Norcross H.S.
- ◯ Kittson Central H.S.
- ◯ Mahnomen H.S.
- ◯ Marshall County Central H.S.
- ◯ Norman County East H.S.
- ◯ Perham H.S.
- ◯ Red Lake County Central H.S.
- ◯ Red Lake Falls H.S.
- ◯ Red Lake H.S.
- ◯ Roseau H.S.
- ◯ Sacred Heart H.S.
- ◯ Stephen-Argyle Central H.S.
- ◯ Thief River Falls H.S.
- ◯ Tri-County H.S.
- ◯ Ulen-Hitterdal H.S.
- ◯ Warren-Alvarado-Oslo H.S.
- ◯ Waubun H.S.
- ◯ Wheaton H.S.
- ◯ Win-E-Mac H.S.

**26. What grade are you currently enrolled in?**

- ◯ 8th
- ◯ 9th
- ◯ 10th
- ◯ 11th
- ◯ 12th

## Appendix C: The Scientific Attitude Inventory

### 1. The Scientific Attitude Inventory

Thank you for taking your time to complete this inventory.

Your participation is entirely voluntary; however, your assistance is greatly appreciated.

Your responses to this inventory will be used to further improve the River Watch Program.

Your responses to each question will remain confidential - not even your teacher will know your responses. Your answers will enable us to assess the strengths and weaknesses of the River Watch Program.

The survey will take about 5-10 minutes. Please answer all the required questions.

Thank you again for your cooperation.

## 2. The Scientific Attitude Inventory

*** In the textbox below, please PRINT your 3 initials and 4 digits for the month and day of your birth! No year needed. Please don't use spaces.**
**For example, Eric A. Norson, born on June 2, would be:**
**EAN0602**

There are some statements about science on the next several screens. Some statements are about the nature of science. Some are about how scientists work. Some of these statements describe how you might feel about science. You may agree with some of the statements and you may disagree with others. That is exactly what you are asked to do. By doing this, you will show your attitudes toward science.

After you have carefully read a statement, decide whether or not you agree with it. If you agree, decide whether you agree mildly or strongly. If you disagree, decide whether you disagree mildly or strongly. You may decide that you are uncertain or cannot decide. Then, click on the appropriate button.

*** 1. I would enjoy studying science.**

- ○ Agree strongly
- ○ Agree mildly
- ○ Uncertain or cannot decide
- ○ Disagree mildly
- ○ Disagree strongly

*** 2. Anything we need to know can be found out through science.**

- ○ Agree strongly
- ○ Agree mildly
- ○ Uncertain or cannot decide
- ○ Disagree mildly
- ○ Disagree strongly

*** 3. It is useless to listen to a new idea unless everybody agrees with it.**

- ○ Agree strongly
- ○ Agree mildly
- ○ Uncertain or cannot decide
- ○ Disagree mildly
- ○ Disagree strongly

*** 4. Scientists are always interested in better explanations of things.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 5. If one scientists says an idea is true, all other scientists will believe it.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 6. Only highly trained scientists can understand science.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 7. We can always get answers to our questions by asking a scientist.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 8. Most people are not able to understand science.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 9. Electronics are examples of the really valuable products of science.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 10. Scientists cannot always find the answers to their questions.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 11. When scientists have a good explanation, they do not try to make it better.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 12. Most people can understand science.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 13. The search for scientific knowledge would be boring.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 14. Scientific work would be too hard for me.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 15. Scientists discover laws which tell us exactly what is going on in nature.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 16. Scientific ideas can be changed.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 17. Scientific questions are answered by observing things.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 18. Good scientists are willing to change their ideas.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

* 19. Some questions cannot be answered by science.

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

* 20. A scientist must have a good imagination to create new ideas.

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

* 21. Ideas are the most important result of science.

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

* 22. I do not want to be a scientist.

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 23. People must understand science because it affects their lives.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 24. A major purpose of science is to produce new drugs and save lives.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 25. Scientists must report exactly what they observe.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 26. If a scientist cannot answer a question, another scientist can.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 27. I would like to work with other scientists to solve scientific problems.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 28. Science tries to explain how things happen.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 29. Every citizen should understand science.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 30. I may not make great discoveries, but working in science would be fun.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 31. A major purpose of science is to help people live better.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 32. Scientists should not criticize each other's work.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 33. The senses are one of the most important tools a scientist has.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 34. Scientists believe that nothing is known to be true for sure.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 35. Scientific laws have been proven beyond all possible doubt.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 36. I would like to be a scientist.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 37. Scientists do not have enough time for their families or for fun.**

- ◯ Agree strongly
- ◯ Agree mildly
- ◯ Uncertain or cannot decide
- ◯ Disagree mildly
- ◯ Disagree strongly

*** 38. Scientific work is useful only to scientists.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 39. Scientists have to study too much.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

*** 40. Working in a science laboratory would be fun.**

- Agree strongly
- Agree mildly
- Uncertain or cannot decide
- Disagree mildly
- Disagree strongly

## 3. Interest & Attitude in Science/Technology/Engineering/Math

*** 41. What media sources do you use to learn about science? (Please check all that apply.)**

- [ ] Internet
- [ ] Magazines
- [ ] Newspapers
- [ ] Radio
- [ ] Textbooks (or other nonfiction reading)
- [ ] TV/videos/DVD's

Other Media Sources

**42. What are your top three favorite science-related shows? Please list below.**

**43. Which of the following activities have you or are planning to participate in during the 2009-2010 school year, including the summers of 2009 and 2010? (Please check all that apply.)**

- [ ] 4-H Program
- [ ] Adopt A River
- [ ] BEST/FIRST/LEGO Robotics
- [ ] Enviro-thon
- [ ] FFA Program
- [ ] Game Design Camp
- [ ] Knowledge Bowl
- [ ] River Watch
- [ ] Science Camp
- [ ] Science Club
- [ ] Science Fair
- [ ] Science Field Trips

Other science-related activities you participate in:

**44. Please rate your attitude about the following ideas.**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Conducting Watershed Science Research | ○ | ○ | ○ | ○ | ○ |
| Connecting Science and Technology | ○ | ○ | ○ | ○ | ○ |
| Connecting Science and Engineering | ○ | ○ | ○ | ○ | ○ |
| Exploring Human Interaction with Living Systems | ○ | ○ | ○ | ○ | ○ |

**45. Please indicate your interest in the following research-related activities.**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Building experimental equipment | ◯ | ◯ | ◯ | ◯ | ◯ |
| Data analysis | ◯ | ◯ | ◯ | ◯ | ◯ |
| Data gathering | ◯ | ◯ | ◯ | ◯ | ◯ |
| Explaining observations (communicating/reporting) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Investigation/Discovery | ◯ | ◯ | ◯ | ◯ | ◯ |
| Testing current theories or conclusions | ◯ | ◯ | ◯ | ◯ | ◯ |

**46. How much interest do you have in the following before graduating from high school?**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Receiving college credit for River Watch | ◯ | ◯ | ◯ | ◯ | ◯ |
| Taking advanced science classes | ◯ | ◯ | ◯ | ◯ | ◯ |

**47. Please specify your interest in exploring a job or career in any of the following scientific fields.**

| | None | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| Agriculture | ◯ | ◯ | ◯ | ◯ | ◯ |
| Biological Sciences | ◯ | ◯ | ◯ | ◯ | ◯ |
| Computer Sciences | ◯ | ◯ | ◯ | ◯ | ◯ |
| Earth Sciences | ◯ | ◯ | ◯ | ◯ | ◯ |
| Education | ◯ | ◯ | ◯ | ◯ | ◯ |
| Environmental Sciences | ◯ | ◯ | ◯ | ◯ | ◯ |
| Health Sciences | ◯ | ◯ | ◯ | ◯ | ◯ |
| Information Technology | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mathematics | ◯ | ◯ | ◯ | ◯ | ◯ |
| Physical Sciences | ◯ | ◯ | ◯ | ◯ | ◯ |

## 4. Demographics

*** 48. Gender**

- Female
- Male
- Prefer not to disclose

**49. Ethnicity (Race)**

- American Indian
- Asian/Pacific Islander
- Hispanic
- African American
- Caucasian (White)
- Prefer not to disclose
- Other, including more than one race (please specify)

**50. Time you have been in the River Watch program**

- 0 - not participating in the River Watch program
- 2 years
- 4 month (or a semester class)
- 3 years
- 9 month (or a year class)
- 4 years

**51. What school do you attend?**

- Bagley H.S.
- Hawley H.S.
- Sacred Heart H.S.
- Barnesville H.S.
- Herman-Norcross H.S.
- Stephen-Argyle Central H.S.
- Campbell-Tintah H.S.
- Kittson Central H.S.
- Thief River Falls H.S.
- Clearbrook-Gonvick H.S.
- Mahnomen H.S.
- Tri-County H.S.
- Climax H.S.
- Marshall County Central H.S.
- Ulen-Hitterdal H.S.
- Clinton-Graceville-Beardsley H.S.
- Norman County East H.S.
- Warren-Alvarado-Oslo H.S.
- Crookston H.S.
- Perham H.S.
- Waubun H.S.
- East Grand Forks H.S.
- Red Lake County Central H.S.
- Wheaton H.S.
- Fertile Home School
- Red Lake Falls H.S.
- Win-E-Mac H.S.
- Fosston H.S.
- Red Lake H.S.
- Grygla-Gatzke H.S.
- Roseau H.S.

**52. What grade are you currently enrolled in?**

- 8th
- 11th
- 9th
- 12th
- 10th

Appendix D: 15th Annual Red River Basin River Watch Forum Agenda

## Red River Basin River Watch Forum ~ 2010

### Wednesday, March 17th, 2010

### University of Minnesota-Crookston Campus

8:30 Registration. Set-up Displays. Continental Breakfast. (Bede Conference Center)

Displays from each River Watch team set up for viewing in Bede Conference Center throughout day

9:30 Welcome-Bede Conference Center: Chuck Fritz ~ IWI Executive Director

Announcements ~ Keelee Emanuel and Kellee Koenig, River Watch Youth Leader Emcees

9:45-11:45 Four Concurrent sessions at half hour intervals – Dowell Hall and Bede Conf. Center

Session 1: Data-Making Connections~ Henry VanOffelen, MN Ctr for Environmental Advocacy

Session 2: Rotifers as Toxicity Indicators ~ Brian Dingmann and Katy Smith-UMC Biology Profs

Session 3: Sea Perch-Aquatic Robotics Demo ~ Joe Courneya & Pat Jirik, MN Extension and Clearbrook-Gonvick 4-H Robotics Team

Session 4: River Watch Jeopardy ~ Dan Olson, MN Pollution Control Agency

***~Public welcome for any part of the day ~ Below is best opportunity to view River Watch assembly ~***

**11:45 Lunch-Brown Dining Hall ~ River Watch Displays can be viewed in Bede Conf. Center**

**12:45 Afternoon Session-Kiehle Auditorium: Welcome**

**Why We Flood-What Can Be Done? ~ Chuck Fritz, International Water Institute**

**LiDAR & Other Tech Tools for Flood Planning ~ Chuck Fritz, International Water Institute**

**Flood Forecasting and 2010 Outlook ~ Mark Ewens, National Weather Service**

**Citizen Science-Snow Water Equivalency ~ Mark Ewens, National Weather Service**

**Flooding Solutions-Every Project Helps ~ Nate Dalager, HDR Engineering**

**1:50 River Watch Presentations**

- **Tile Drainage Impacts ~ Campbell-Tintah RW**
- **School Research Partnerships ~ RW Research Discovery Team**
- **Summer RW Boot Camp for Teachers ~ Curriculum Integration Team**
- **Facebook to Flashdrives-Youth Take Charge ~ Youth Leadership Team**
- **River Watch-Looking Back and Looking Forward after 15 Years ~ Wayne Goeken**

**2:20 Awards – Recognition of Excellence for Schools and Partners**

**Forum Summary ~ Youth Perspectives and Parting Thoughts ~ Joe Courneya**

**2:45 Adjournment**

InternationalWaterInstitute
Flood research and watershed education for the Red River Basin

**Red River Watershed Management Board**

Appendix E: Student Brochures

Bagley High School

**Investigating Impairments on the Clearwater and Lost Rivers**

Purpose:
- To determine whether our water quality testing methods can detect impairment trends, and
- If so, if the trends persist.

School Year 2009—2010

Fosston River Watch

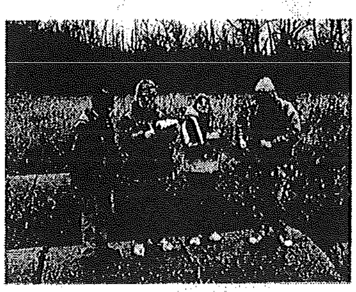
2009-2010

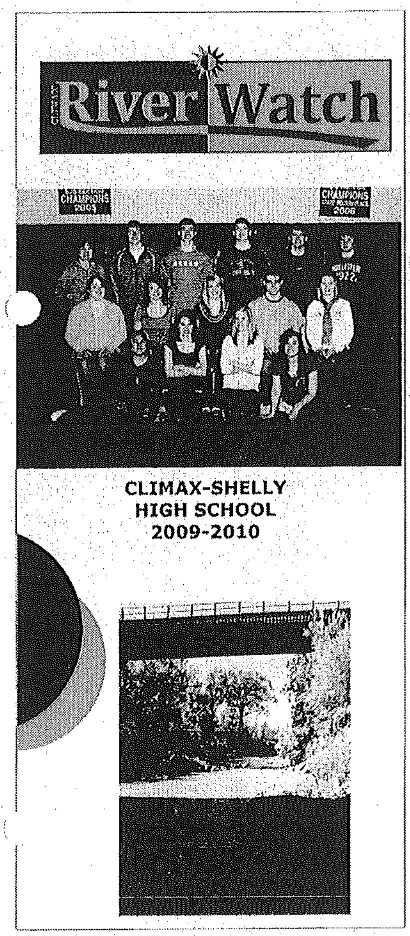
Fosston High School

WEM 10

Water Quality Report

Red Lake Falls River Watch





Appendix F: River Watch Evaluation Survey

## River Watch Evaluation Survey

***Please provide responses to the following questions/statement. Your honest responses will help to further develop the River Watch Project. Record your answers in the space provided. Use the back of the pages for more space, if needed. Please number your responses. Thank you.***

______ 1. **Describe your involvement with the River Watch Project.**
   a. **Classroom teacher**
   b. **Parent**
   c. **Volunteer (non-parent/teacher)**

______ 2. **I am involved with outreach projects related to the River Watch Project.**
   a. **Yes**
   b. **No**

3. **If you responded with "yes" above, please describe the types of outreach projects.**

______ 4. **The modules and educational resources related to the River Watch Project are useful in my classroom instruction.**
   a. **Strongly agree**
   b. **Agree**
   c. **Neutral**
   d. **Disagree**
   e. **Strongly disagree**

5. **Describe the types of modules and educational resources you have used.**

6. **What are the challenges of the River Watch Project?**

7. **What are the benefits of the River Watch Project?**

8. **What could be improved related to the River Watch Project?**

9. **Why are you involved with the River Watch Project?**

**Thank you for your cooperation. If you have any questions or additional comments, please contact, Dr. Anita Welch at anita.welch@ndsu.edu or at 701.231.5498.**

# Appendix G: River Watch Teacher Survey

## 1. Default Section

Please response to each of the following questions as they relate to your experience with the River Watch Project.
Thank you for your participation.

*** 1. The River Watch Project has developed watershed science education modules for use in my classroom.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree
- ◯ No modules were developed.

**2. The modules connect watershed science skills with academic standards across grade and subject levels.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree
- ◯ No modules were developed.

**3. The River Watch project has developed teacher training options for watershed science education modules and related watershed science topics including one summer teacher training session.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**4. Training and internship options related to watershed science for pre-service teachers have been developed and are available.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**5. I am aware of post secondary/dual credit options related to watershed science offered by participating school districts and institutes of higher education.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**6. The curriculum/education work group members meet regularly to share additional resources and advance the goals of the River Watch Project.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**7. The watershed science education modules incorporate topics specific to flood impacts, causes, and prevention strategies that can be readily incorporated into high school curriculum.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**8. Teacher training options have been developed which include training on the use of modules related to flooding issues and impacts in the Red River Basin.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**9. I have had the opportunity to work with resource experts and watershed scientists as part of the River Watch Project.**

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

**10. Describe what works best in the River Watch Project.**

**11. Describe what needs improvement within the River Watch project.**

**12. Please add any additional comments related to the River Watch Project.**

Appendix H: River Watch Boot Camp Syllabus

## River Watch Boot Camp – A Field Experience in Watershed Science

River Watch Citizen Monitoring Program

**When**: Sunday, June 20 through Thursday, June 24, 2010
**Where**: University of Minnesota, Crookston

**Sponsors and collaborations**: Center for Sustainability, U of MN, Crookston; Agriculture and Natural Resources Department; Northwest Research and Outreach Center, U of MN; Red River Watershed Management Board; International Water Institute; Northwest Regional Sustainable Development Partnership; U of MN Extension; Water Resources Center, U of MN, St. Paul; College of Education and Human Development's Curriculum and Instruction Department, U of MN, Minneapolis.

**Registration Cost**: $500.00 per participant. Partial scholarships available to Minnesota River Watch teachers—contact Wayne Goeken for information at wrg@gvtel.com or call 218-574-2622..

Optional costs (includes registration):

- 3 undergraduate credits through UMC = $1,350.00
- 3 graduate credits through the UMC, College of Education and Human Development = $2,015.00

For details on credit options contact David DeMuth at UMC, 800-862-6466.

**Summary**: A five-day, residential camp for K-12 teachers, educators, and natural resource managers to gain an understanding of the natural and human-built environment of the Red River Basin of the U. S. and Canada with special reference to watershed dynamics and river monitoring. Emphasis will be placed on gaining an understanding of ecological and sustainability principles as they interact with various land uses. Lecture, laboratory, and field instruction by professionals representing universities, agencies, and conservation organizations will provide an in-depth exposure to a theoretical and practical understanding of the landscape which can be transferred to young learners in watershed science programs. Sessions will be structured for participants to learn from each other as well as from professionals. The Red River Basin is ideally suited for such instruction with its variety of rivers and streams in a diverse setting of prairie, deciduous forest, and coniferous forest biomes containing a broad spectrum of land uses.

**Learning outcomes:**

After this session, participants will be better able to:

- Understand the historical, climatic, geologic, soils, vegetation, and animal communities of the Red River Basin landscape region and how they have changed over time due to human land use.
- Understand the interactions and impacts of land uses on the natural ecology and sustainability of the region.
- Develop improved skills of field and laboratory instruction in watershed science which can be adapted to local settings.
- Acquire an expanded network of resources which support the above goals including personal contacts and instructional materials, both hard copy and electronic.
- Develop a better understanding of the array of governmental and other organizations which related to watershed management and can be of assistance to watershed educational programs.
- Become more comfortable in the grant writing process and more knowledgeable about funding sources.

**Learning expectations:**

- Participants will create a five-day unit on one of the topics presented during the week. Submission deadline for unit lesson plans is July 20, 2010. Participants will receive all submitted lesson plans electronically or on CD in August.
- A laptop computer will be issued to each participant at registration. Participants will be expected to electronically journal their experiences throughout the week.

# Topical outline

**SUNDAY, JUNE 20**

| | |
|---|---|
| **2:00-2:45** | **Registration and check-in to dorm rooms** – Evergreen Dorm<br>**Evergreen Dorm** -laptop distribution/basic instruction |
| **2:45** | **LEED certified dorm tour.** Chris Waltz – Evergreen Lobby |
| **3:00** | **Welcome**: Wayne Goeken, International Water Institute **-** Evergreen Court |
| **3:10** | **Camp logistics -** Dave DeMuth and Dan Svedarsky, UMC – Evergreen Court |
| **3:20** | **Introductions and Boot Camp Expectations** –Evergreen Court<br>Participants share expectations<br>River Watch Curriculum Committee share lesson plan guidelines<br>"Tools" Overview – brief tutorial for laptop and digital camera |
| **4:30** | **Case Study Reports by River Watch practitioners.** Science Instructors: Garry Kotts-Stephen/Argyle, Karen Thoreson-Climax/Shelly, and Jill Bakken-Bagley – Evergreen Court |

*Journal prompt...*

Which RW program options might best work for you to utilize?
What additional information would you like to know?
What resources do you feel you need to begin or enhance existing RW program?

**5:30-6:30** **Cook out at Nature Nook, UMC campus**

**7:00** **Natural History of the Red River Valley** – Dan Svedarsky, Director, Center for Sustainability-UMC Bergland Lab

**Environmental education opportunities on campus – Butterfly gardens, Monarch tagging, and rain gardens.** Laura Bell and Eric Castle, UMC – Bergland Lab

**Overview of Monday ~ Sign up for Bird Banding**

*Journal prompt…*

What new insights about the Red River Valley did you learn?
What information from today's session would you find of most interest to share with your students?
What additional information or resources would you need to create a "nature space" at/near your school?

**8:30** **Social Time** – Evergreen Dorm

## MONDAY , JUNE 21

**6:00** **Optional early morning bird banding experience at Red River Valley Natural History Center.** Jeff Bell **Meet in lobby of Evergreen Dorm**

**7:30 – 8:00** **Breakfast at Nature Nook**

**8:00 – 9:00** **Introduction to aquatic plant identification and field identification.** Dan Svedarsky, UMC- Bergland Lab

**9:15 – 11:45** **Sedimentation, Turbidity, and Microinvertebrate Relationships as Water Quality Indicators**—Brian Dingmann, Associate Professor of Biology, UMC and Katy Smith, Assistant Professor of Biology, UMC – Bergland Lab

*Journal prompt…*

How did these sessions help you understand more about comprehensive health of our river systems vs just doing existing RW activities?
What might you be able to use from these sessions in your classes?

**12:00** **Lunch in Brown Dining Hall**

**1:00** **Field trip to Fertile.**
Load vans at Evergreen Dorm
Prairie stop at Trail Shack along Hwy 102 – Reload vans for Fertile at 1:30 p.m.

**2:00 – 4:30** **Aquatic macroinvertebrates as water quality indicators.**
**River macroinvertebrates field experience—site selection, collection and identification.**
Andre DeLorme, Associate Professor of Biology, Valley City State University
**Field site: Sand Hill River at Agassiz Environmental Learning Center, Fertile**
Reload vans for UMC at 4:45 p.m.

*Journal prompt…*

How did this session help you understand more about comprehensive health of our river systems vs just doing existing RW activities?

What might you be able to use from this session in your classes?How did the morning and afternoon sessions compliment each other to help you gain an understanding of the role of biological monitoring for water quality?

**5:30** **Dinner at Brown Dining Hall**

**6:30 – 7:30** **Fundamentals of river and stream geomorphology and ecology**. Amy Childers, River Ecologist/Outreach Specialist, MN DNR Stream Habitat Program –Bergland Lab

**7:30** **Identification of plants and invertebrates collected during the day**. –Bergland Lab

*Journal prompt...*
What information from today's sessions would you find of most interest to share with your students? What additional information or resources would you need to incorporate any of these topics into your curriculum?

**TUESDAY, JUNE 22**

**5:00** **Leave for Canoe Trip along Red Lake River from Red Lake Falls to Huot**. Breakfast enroute. Luther Aadland, Stream Habitat Program Consultant, MN DNR
Load vans at Evergreen Dorm, arriving in Red Lake Falls, Sportsman's Park approximately 5:30 a.m.
Canoe trip scheduled from approximately 6:00 – 11:00 a.m.

**11:00** **Assemble gear at Huot Old Treaty Crossing Park.**
**Cook out at Picnic Area.**
**Historic presentation**. Virgil Benoit, Associate Professor of Languages-French, UND
Vans leave for UMC at 1:00 p.m. (Return to Bergland Lab for afternoon sessions.)

*Journal prompt...*
How did last night's session on river geomorphology compliment what you experienced on the river today? (or how did today's session on the river reinforce what was covered in last night's session?)
What applications of applying historical contexts to rivers, resource management and sustainability in your classes or with other teachers/classes in your school would you consider (might work?)?

**2:00 – 3:00** **TMDLs and water policy relationships. Watershed Specialist development. U of MN Water Resources Center.** Faye Sleeper, Co-Director UofM Water Resources Center

**3:00 – 5:00** **Agricultural connections to watersheds, wetland restoration, and remediation**. Rob Sip, MN Dept of Ag, Environmental Policy Specialist
**Tour UTOC livestock facility**

**5:00** **Dinner at Brown Dining Hall**

**6:00** **Historical geology of the Red River Basin. Overview of Wednesday Field Trip,** Phil Gerla, Associate Professor of Geology, UND –Bergland Lab

**7:30** **Lesson Plan Development Opportunity**

*Journal prompt...*
What information from today's sessions would you find of most interest to share with your students?

What additional information or resources would you need to incorporate any of these topics into your curriculum?

**WEDNESDAY, JUNE 23**

**7:00** **Breakfast in Prairie Lounge**

**7:30** **Field trip to Glacial Ridge Project east of Crookston to view prairie and wetland restoration, groundwater hydrology research.** Phil Gerla, UND/Nature Conservancy

**10:00 – 11:30** **Beach ridge hydrology and calcareous fens.** Dan Svedarsky, UMC
**Wetland soil characteristics** – Katy Smith, Assistant Professor of Biology, UMC

*Journal prompt…*
Into what part of your curriculum do you think you could incorporate information learned related to the Glacial Ridge sessions? Explain what you would incorporate and how.

**12:00** **Lunch in Brown Dining Hall**

**1:00 – 1:45** **Overview of the Red River Basin as a watershed. Flooding history, flood damage reduction case studies, recommended solutions from IFMI and IJC reports**. Chuck Fritz, Executive Director, International Water Institute – Bergland Lab

*Journal prompt…*
What new perspectives did you gain as to why flooding is an issue in the Red River Basin?
How might you apply various aspects of flooding into your lessons?

**1:45 – 2:45** **Soils in connection to healthy landscapes, carbon sequestration, and climate change dynamics. Wetland soil characteristics.** Katy Smith, UMC – Bergland Lab

**2:45 - 3:00** **Break**

**3:00 – 3:45** **Functions and values of natural and constructed wetlands. Rules and Regs**. Dan Svedarsky, UMC – Bergland Lab

**3:45 – 5:00** **Integrating applied research into lesson plan development for watershed education.** Jack Norland-NDSU, Christina Hargiss-NDSU, Katy Smith-UMC, and Brian Dingman-UMC–**Bergland**

**5:00** **Dinner at Brown Dining Hall.**

**6:00 – 7:00** **Contemporary learning styles, Inquiry based learning, and examples of innovative delivery modes.** Joe Courneya, Extension Educator 4-H, Assistant Professor, UofMN Extension – Bergland

**7:00 – 8:00** **Applied research , data access, analysis and understanding.** David DeMuth, Assistant Professor-Math and Physics, UMC and Andrew Sheppard, Grad student-computer science, UofMN – Bergland

**8:00 – 8:15** **Travel to Nature Center at Red River Valley Natural History Area.**
Load vans at Evergreen Dorm.

**8:15 – 9:00** **Fundamentals of grant writing.** Wayne Goeken, IWI and David DeMuth, UMC

**10:00** **Bonfire and marshmallows. Star-gazing at dark.**
Lesson plans and grant writing discussions

*Journal prompt...*
What information from today's sessions would you find of most interest to share with your students? What additional information or resources would you need to incorporate any of these topics into your curriculum?

## THURSDAY, JUNE 24

**7:00** **Breakfast in Prairie Lounge**

**7:30** **Teacher Evaluation Focus Group – Minnesota Room**

**8:15-10:00** **Watershed Science ~ Opportunities for Engaging in Sustainable Futures**
Emphasis on using sound science to engage citizens, students, resource mgrs in critical thinking, informed decision making, and taking action to effect sustainable watersheds and the communities that depend on them.

**How River Watch and watershed science in general can help address watershed issues and awareness needs. River Watch teams as partners.** Chuck Fritz, IWI and Dan Wilkens, Administrator-Sand Hill Watershed District – Bergland Lab

**River Watch and watershed science as part of public engagement to foster discussion of conditions and desired futures. MPCA public engagement and Study Circles.** Molly Macgregor, Red River Basin Planner-MPCA, and Linda Kingery, Executive Director-Northwest Regional Sustainable Development Partnership

**10:00 – 10:10** **Break**

**10:10 – 11:00** **Watershed science as foundation for personal understanding and making case to decision-makers for support of sustainable choices.** Henry VanOffelen, Natural Resource Scientist, Minnesota Center for Environmental Advocacy

**11:00 – 12:00** **Productive Partnerships for Action—case studies such as Burnham Creek, UMC Climate Neutrality Plan, UMC Sustainability Center, Lake Winnipeg Research Consortium, and other examples.** DanSvedarsky, Wayne Goeken, Joe Courneya, and others in open discussion

*Journal prompt...*
How did these sessions help you think of ways to engage your RW teams in helping advance environmental sustainability in your community and watershed?
What information from today's sessions would you find of most interest to share with your students?
What additional information or resources would you need to incorporate any of these topics into your curriculum?

**12:00** **Lunch in Brown Dining Hall**

**1:00** **Lesson Plan Discussions and Next Steps.**
Example lesson plan with supplements for participants to view in creating their own units for submission. Presentations and ideas among participants regarding their Boot Camp topic and next steps for expanded watershed science education.

**2:30 – 3:00 Evaluation, wrap-up and safe trip home.**

**Presenters:**

**Dan Svedarsky**, Director, Center for Sustainability and Research Biologist, Northwest Research and Outreach Center, U of MN, Crookston, MN (Lead Instructor)

**David DeMuth**, Associate Professor of Physics and Math, U of MN, Crookston, MN

**Phil Gerla**, Associate Professor of Geology, UND, Grand Forks, ND. Watershed Hydrologist - Glacial Ridge, The Nature Conservancy

**Andre DeLorme**, Associate Professor, Biology, Valley City State University, Valley City, ND. Director of VCSU Macro-invertebrate Lab

**Katy Smith**, Assistant Professor of Biology, U of Mn, Crookston, MN

**Brian Dingmann**, Associate Professor of Biology, U of MN, Crookston, MN

**Jack Norland,** Research Specialist, Range Science, NDSU, Fargo, ND

**Christina Hargiss,** Adjunct Professor, Range Science at NDSU, Fargo, ND

**Luther Aadland**, River Ecologist, MN DNR Ecological Services Unit, Fergus Falls, MN

**Amy Childers**, River Ecologist/Outreach Specialist, MN DNR Stream Habitat Program, Fergus Falls, MN

**Virgil Benoit,** Professor of Languages-French, UND, Grand Forks, ND and President-Association of French of the North (AFRAN)

**Chuck Fritz**, Executive Director, International Water Institute, Fargo

**Rob Sip**, Environmental Policy Specialist, Minnesota Department of Agriculture, St. Paul, MN

**Faye Sleeper**, Co-Director, U of MN Water Resources Center, St. Paul, and former manager of MPCA TMDL program

**Linda Kingery**, Exec. Director, NW Regional Sustainable Development Partnership, U of MN, Crookston, MN

**Molly MacGregor**, Red River Basin Planner, MN Pollution Control Agency, NW Regional Office, Detroit Lakes, MN

**Henry Van Offelen**, Natural Resource Scientist, Minnesota Center for Environmental Advocacy, Detroit Lakes, MN

**Joe Courneya**, Extension Educator 4-H, Assistant Professor, American Indian Youth Programs, UofMN Extension, Hawley, MN

**Dan Wilkens**, Red River Watershed Mgmnt Bd and Administrator, Sand Hill Watershed District, Fertile, MN

**Jill Bakken**-Bagley, **Garry Kotts**-Stephen/Argyle, and **Karen Thoreson**-Climax/Shelly. High School Science Instructors and River Watch Advisors

**Andrew Sheppard**, Graduate Student, U of MN Computer Science, Minneapolis MN

**Wayne Goeken**, Director, International Water Institute's Center for Watershed Education, Erskine, MN

**Laura Bell**, Naturalist and Senior Lab Assistant, Ag and Natural Resources Department, U of MN, Crookston

**Chris Waltz**, Energy Conservation Specialist - MN GreenCorps, Center for Sustainability, U of MN, Crookston

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UNIVERSITY OF MINNESOTA CROOKSTON

InternationalWaterInstitute
Flood research and watershed education for the Red River Basin

UNIVERSITY OF MINNESOTA EXTENSION

Red River Watershed Management Board

Appendix I: Focus Group Protocol

**Focus Group Protocol**

1. Discuss your involvement with the River Watch Project.
2. How does the one-day leadership session effect your relationship and involvement with the River Watch Project?
3. Describe your relationship with your community as it related to the River Watch Project.
4. What types of outreach projects were you involved in related to the River Watch Project?
5. Describe the modules and educational resources you have received and used related to the River Watch Project.
6. Describe the challenges of the River Watch Project?
7. What has work well related to the River Watch Project?
8. What could be improved related to the River Watch Project?
9. How could the improvements be made?
10. Why are you involved with the River Watch Project?

Appendix J: Transcript of Focus Group Meeting

**Focus Group Meeting with selected teachers of the River Watch Program**

**June 24, 2010, Univ. of MN – Crookston**

A: OK, we're going to go ahead and get going for sake of time and like I said I am recording, no names, don't care where you're from, that's no part of this, um, so what I want to do is just gather your insights, challenges, the benefits, all the good stuff, about the program and your experiences with it, so first thing, what do you see as the benefits of participating in River Watch? What are some of the benefits?

My kids love it.

A: Your kids love it? OK, why?

They get to do real world science and they get to present it to people who can make a difference.

Well, I think there, you're teaching, this program teaches the kids to be environmentally aware, environmental education, I just don't think we have enough of that in schools, and I don't think it should start when they're River Watch kids, this stuff should start way down in elementary school, so if anything, this program hopefully will grow into that.

What it's done for us is it's just given the kids lots of opportunities that they wouldn't have had if they wouldn't have been in the program. Testing is one of the things, but presenting at forums, you know, doing different types of trips and our kids have been involved with leadership programs, so it's things that they couldn't have done without it.

A: K.

A lot of students don't actually, I haven't started doing it yet with students, but it's just, I am involved in monthly meetings where we work together to plan things and just, the resources that are available and I bring (?) in all these experts in different areas in different areas and getting together with teachers who have all these different issues with it and just the collaboration is really a big (couldn't understand) will be valuable in doing a lot of the stuff.

I think it's good that students get to us real science equipment, because our schools can't always afford to buy the heavy-duty science equipment, and for them to be able to use things that scientists actually use is good.

A: OK. Anybody else?

Well, from a standpoint of a public agency, I see it as a fair exchange we get high quality data they get the opportunity for a lot of what's been talked about here, the educational aspect, hands-on, you know real field science.

I think it's a lot of inquiry that the kids don't often get maybe with classes and, it's not that River Watch is a class for me at all, but they learn to ask questions and they learn how to do sound research based on SOPs and statistics and being able to present it and I just think that's really important because then they have a better, they're more well-rounded in how they present what they know and how they get that information.

A: What about, is there something else? What about the challenges, I know I used to be a classroom teacher with No Child Left Behind, and the emphasis on standards-based instruction, how do you see River Watch aligning to your science standards, does it? Does it not? Is it a good fit? Bad fit? Do you have to make it fit? What's going on there?

It's probably a good fit but for the way we do it, its' not something that we do with a whole class, it's just you know, some kids, so it's not like a lot of standards are being met for a particular class, so I don't really, we're not involved with it for that particular reason, try to meet standards.

A: So you do it as like an extracurricular, as a, I won't say "club" but as a... after school activity?

Yes.

A: OK.

I think it meets many standards very well, but like you said, we're just meeting (?) a small population of students.

I think that's one of the goals of this project for the next year or two is to try and make curriculum that can be integrated into classes when people might not necessarily have the opportunity to teach a class called Watershed Science, but...

A: OK. What are some of the challenges of the program? In your experience, from your perspective, what are some of the challenges that need to be addressed or should be addressed?

The biggest challenge is time, when that, when September 1st comes around, you don't wear the River Watch hat, you have a hundred other hats you have to trade off and if you could devote all your time to River Watch you could stay busy, but there are a hundred other things to do, and you just, there's just not enough days, days in the week, not enough hours in the day.

I mean, this is a project that on a teacher's level does take hundreds of hours per year, and it's something that most of us volunteer to do, and so I agree, I think time is the biggest issue.

I think the geographical isolation of the program is an issue because I don't live close enough to the Red River to take part in this particular program itself, but if it were expanded to include service waters or other rivers or something like that, then I, you know, I'd be there and the kids would be there to, to, you know, do the stuff (couldn't understand) program.

A: So some way to adapt it to other situations?

Yeah, adapt it to other situations and then you'd have to go through the same process of advertising in some way, having groups like this meet in other locations and set up a program, so it's going to be similar to River Watch but adapt it to your particular locale.

And that's one of the goals, you know, is to be able to take this and be able to implement it around the state, but there's going to be a lot of work to get it to there you need to have people like we have here that are in charge and are willing to do a lot to help the teachers, and I think they do, but like has been said, it is an incredibly time consuming thing that for all of us is just an add-on, it's just additional things, it's great opportunities for the kids, but it's a lot of work.

And it's good opportunities for the teachers too.

It's a lot of work and a lot of time.

I think it's um, it's hard for us to be able to talk to each other, not necessarily like communication is difficult or anything, but the time it takes or um, you know, to have just conversations about how does this work in your class, how do you choose your students, what...you know, like all that kind of stuff is, you don't always get enough time to just talk to each other about how it, like logistically works, sometimes.

I think the other thing is you better have good administrators that are going to support it because if you don't, it's not going to, I don't think it will work, you can't be fighting to get out of school to go test or to get vehicles or get subs, I mean, administrators have to be behind you with this at least to a pretty good extent.

Because you're gone a lot.

A: And so how do you broach that subject with them? How do you justify that to the administrators?

Watershed's paid sub-pay, and that's a big deal, you know, money. And you're always willing to pay the $90 a day that you're gone and that's important, but, it's just communication and you know, another thing is when your kids volunteer to say "you know what, when's the next School Board meeting? We'd like to come and we'd like to give our presentation to you" that's, that will get you farther than just about anything, they like to see the kids involved and then they like to see the kids get press, you know, when they go do things, that's good for your school, it's a good program for your school, not just for the kids, so if you can, if they can figure that out, that would be good.

A: What about students, um, it sounds like most of you do this as an after school type of activity, so, what about recruitment selection, who and how, what do you see in your students? How do you get your students?

Mine fill out an application that has a personal information page, a release page, you know, signing "I'm going to be good and I'm going to" you know…"you can use my picture and you can, if I print anything you can use it" and then there's also a teacher evaluation page and that teacher has to say you know can this student miss one time a month, that kind of thing, so for me it's an application process and it's grades 9-12.

I just ask students, the students that seem to have a little more of an inclination towards biology, 10 through 12 and I just ask them if they're interested and generally they say "yes".

I have a I kinda took over River Watch, two, three, four, five years ago at my school and before that it was kind of a, it was billed as a day to get out of school and to be outside and all that good stuff, and so to change that has been difficult for me and so I'm still working on a good plan, some years have been better than others, it just depends on the kids, it depends on my time, and so, I haven't worked out the best solution yet.

We were talking yesterday too about it and we do this process too you know, we have the kids that are the you know, gonna well, for one thing they have to stay off the deficiency list, you know, maybe if you're on that list you can't go, and you have to fill out the forms and but, I wish we were reaching kids that were from all walks, not just the brightest and the best, because, we were talking yesterday, nine times out of ten, those brightest and best (couldn't understand) and the kids that are going to stay in the community, you want them to be good students (couldn't' understand) as well, so it just needs to grow.

And I think one thing that I like about the application that I use is you don't have to have the best and the brightest, that there might be, you know, if the teacher is saying, can this student miss and be responsible for it, if they check "no" I'm like, well, I want to know why. Or do you think, is there something, even if the student isn't academically independent, um, please describe why they would be good for this program, or…and that's really nice to know too.

You mentioned about students being on the deficiency list and a couple of my students were resident for quite some time on our RNI restricted ineligible list and I told them, "well, we're not MHSL but I don't take kids out, if you're not, you should at least be off that list, you should be surviving and you know, if you need some help we can help you out, we can help you study" but there are some kids that I've had that are not, like you said, they're not the brightest and best so to speak as far as academically, but they really want to do the, I mean, if they want a day off they can just skip quite frankly, um, but they want to go out, they want to do these things, they want to handle the equipment you know, and I think it makes them feel important, they're doing something real, and so some of these kids even though it was kinda slow progress, they would keep working at it because they really wanted to go out, you know, it was kind of a nice carrot to have for them, ok, hey, you made it off RNI, alright, we're going out next week, you know, get your stuff, let's get going, and yeah, these are sometimes kids that they don't show a lot of enthusiasm, just in general, for their school work, but "no, I'll do it for something that I really want to participate in" so

A: I heard mentioned earlier about communication amongst yourselves what is the network, what is the mode or is there a mode in which you can communicate, is there a website, is there a discussion board? If you wanted to contact each other, how would you do it during the project time?

Email.

Well, there's a website now.

I think everyone uses email (?), but now we have a website

It's still kind of...hasn't been used much, it's in the implementation stage.

A: What is it a website?

It's a (couldn't understand)

It's kind of being developed to get teachers to be able to collaborate not only on discussions but also sharing resources and lesson plans and eventually when the curriculum is developed that's where that would work too, and it might have a place for students too, we haven't really focused on that yet, for students who are involved in real research, which is I think one of the goals of this workshop is to get you know, not just lesson plans incorporated in classes, but students working with the university or college students or something to do research and some sort of tools for them to communicate, you know, they can't just come here all the time, but that's kind of been the process until we find out what works.

A: Is the website up and live right now?

Yeah.

A: What's the address?

Riverwatchteacher.org

And I think that's going to be really helpful I mean for, particularly for our group we're way off on the edge of the basin and I think, well, everything's relative I guess, but some of your schools may be a little bit at least closer together and you know, but we're, we're way off in the hinterlands and we get to see you guys at forum basically and that's you know, that's about the only time we'll see you, but it would be nice then to have some, be able to have some interaction um, and I don't know if the, I guess that's more for the teachers, the problem with the kids start up that was, well, I guess we could be on there too, but the Facebook, was that again, officially through our school, you can't do that, so then they can go ahead and do it on their own outside or what have you or, I really don't want them accessing it, you know, back door through school because then your, you know your program is circumventing your school policies and that's not really a you know a great model to have working but, so that has been kind of an issue because I've said "oh great, you can sign up for this site" you can't get on to it from school and some of those kids they're saying "oh yeah, everyone's got" not everyone has, I think you were talking about a lot of the kids, their families don't have a lot and so they may not have all this access to all the technology at home and it is at school where they can get on to those things, so that needs to be kind of

See I have no problem asking administration to let them do Facebook at school, for this, I mean, you have to make sure you watch them, but I think it would be, at our school, I think the administration would go for it if it's for an educational purpose. You kinda alter the system for it but...

Yeah, our problem right now is I think they have to, they either have to, the way that they do it it seems like they'd either have to block or unblock sites for the school server and so then once you do that then if somebody's in another lab (?) they can also get onto it.

I think for our purposes the Google site is going to be fine (?)

Yeah

But otherwise (couldn't understand) collaborated was we sent individual emails or if we make a phone call, or have meetings like this.

Yeah, Ray mentioned the kids forum, I think one of you guys mentioned a teacher forum, just have teachers get together without their kids, so you know, tell us what you're doing, what's working and what's not working and...so a teacher's forum would be kind of

A few of us have been meeting every month and that's been really useful, but it would be good to have a discussion like that really often with everyone who's

A: Are you talking live or virtual?

Live

We've tried it both ways.

We could do where you have virtual meetings.

To me it has to be somewhat early too, I mean, not Spring.

(Talking)

Maybe late Fall or something like that after you've done your summer testing and then your fall testing and then

Budget phrases (?)

Yeah, cuz then you're done with that so then you just (couldn't understand) your activities, just not in Spring.

A: So looking at the calendar and kind of revamping it based on the needs of the teacher and the school calendar…is that what I'm hearing?

As far as having the teacher forum, yes.

A: For teacher's forum.

For teacher's forum, yeah, I would say later in Fall.

Kids's forum is always March, middle of March.

It's the same day as all the other events in the state, middle of the week of college Spring Break, cuz that's when the campus is available, unfortunately there's other events that are held, so, that's kind of been a

Individual thing

Activities during that time of year.

But if we can do it before that I think it would be better.

Well, I mean, like literally, yeah, I know there's always stuff going on but I mean, specifically, on that particular day when we do that, that Wednesday of the break week, I don't know what else is going up in the Northwest, but I know there's math in the Fargo Moorhead area, there's competition that day every year, and then I'm not sure what regions you guys are in for Knowledge Bowl if you have that going at your school, but our sub regions are always held that week and we've finally got them to rotate the school size because they do actually a three day sub region, so they'll do small, medium and large school sizes, well at least they rotate now, before it was small schools were always on Wednesday and so if you were a small school you had choices, you could go to Forum or you could go to your sub region, you really didn't have any other you know, any other way to get around that, so to have that many events with again, those kids that are, like you said, a lot of them are involved in you know, everything and um, yeah, it becomes difficult to you know, get them to sacrifice on these other things and say "ok, yes, now I'm committing to this one activity"

A: So what are you taking away personally from this experience this week?

Well, I'm a new teacher, I'm just at one year now and just started River Watch and I didn't really know anything so it was just great to get a start on everything.

A: So you haven't started buy you're going to?

Going to start this year, yeah, I mean I just needed this to know what to do really and get ideas, so it was really good.

A: OK. And if you could improve it somehow, what would you do? What would you want? What would be on your dream list for River Watch right now?

For this week or for the whole program?

A: For the whole program, what would be on your dream list?

More infrastructure, equipment, maybe so that the teachers could work a little more independently, I'm speaking as a resource provider, and, well it's evolving and these other pieces are going to be falling into place from other agencies to where maybe we'll be doing things a little bit differently, especially as we handle our data and things like that.

So do you actually bring that equipment around to, is there like a (couldn't understand) you rotate between different.

Yeah, otherwise I'm (couldn't understand) for data and scheduling and things like that.

So then with our region, with the majority of the schools having been outfitted with literally their own dedicated setups then that's pretty cushy then I'm guessing.

Oh, they've got other things that (couldn't understand)

No, but I mean for us to have it that's pretty cool to have?

Well, that would be great because (couldn't understand) and also, maybe even just a little bit more ownership in the whole process.

A: Ownership from who?

Well, ownership meaning this is my contribution, I don't have to wait for this guy from the district to come and bring me the tools, and the kids do get kind of possessive of, cuz we share now with one other school that we just started up this year, and they're going "if those guys lose this or that" you know, some little article, you know, it's like "that's ours" which is kind of nice, it's they feel this is our equipment, we go do this job, it's like their tool box.

If you can develop that kind of conscientiousness with the gear, that's

Sometimes it's "hey, don't swing that over the fence"

Talking/laughing couldn't understand.

I wanted to take away research opportunities for my kids and I think that there are, there really are very, there's a lot of opportunities and they vary from biological to geological to, I needed research opportunities for my River Watch kids, and I have a lot of ideas, so that was exciting for me.

And I think they planned this really well and they get in schools, if you want to get more involved, here are some things that you can do and I think that's, they're taking just the testing and the monitoring and now they're saying "here's some other things that you can do" that will have you know, a pretty big influence, with flooding and things like that and that's pretty neat if you're a 17, 17, 18 year old kid and you're doing things that not only are potentially helping the rivers of the PCA but if you have an impact on flood prediction, that's real world, and I think they're, they as in River Watch, they're making a good effort at making that stuff available and bringing in the right people to show us how to do it and I think it's heading in the right direction. I know it's heading in the right direction.

I think like all of us, our kids want to make a difference too, you know, I mean this is a very thankless job and we don't get a lot of pat on the backs, but you want your kids to have that and so I think that when they feel like they are making a difference and what they're doing is contributing to somewhere, that that's really important. That we can tell them we go out and do this because of "X" and cuz that makes a difference down the line, that's really important to them.

(Talking couldn't understand.)

I guess what I was looking for when I came here is kind of a recharge, it's like I kind of go through the year and you get bogged down by May and you think about next year you're like, you know, we don't get any extra time, but you sometimes just needed a shot of motivation or inspiration, whatever it is, and that's kind of what I was looking for. Not necessarily, um, well, lesson plans are great and all that kind of stuff, but it's the motivation to keep going sometimes, that's what I need.

And that there are other teachers out there who are trying as hard as you are to make sure that their programs continue and that they get better and you just, it can be kind of like a support network too.

I don't think initially this was, when we first talked about this, I think that this class, this whole idea just kind of had a metamorphosis along the way, it wasn't, this week isn't initially what I thought it was going to be when we very first, it was more like a um, maybe a part of an environmental education class, that I would be able to bring back home and then teach, um, but I think that things change and so I, but I think what we did come away with like they said was great stuff. The people that we got to meet and listen to and share their experiences were I think, I mean, I don't' know where else we would have been able to do that.

Speaking for myself, I'm way behind the curve because I came with the intent of learning a lot more about watershed and water's sustainability issues and hoping to take some of just that information back to the classroom and try to work that into, you know, to weave that into what's required on the standards and it really provided that.

A: Anything else?

(end of transcript)

# Appendix K: Teacher Designed Lesson Plans

## Lesson Plan Title: Groundwater

**Target Learners:**
This lesson is intended to be used in an eighth grade earth science course. This lesson would be completed as part of an overall unit on water.

**Standards:**
8.3.2.3.1 Describe the location, composition and use of major water reservoirs on the Earth, and the transfer of water among them.

**Topic:**
This lesson will give 8th grade students background information on groundwater. It will give students an understanding of the function of aquifers and the ways that groundwater can be negatively impacted.

**Curriculum Links:**
This lesson will link to units on water, geology and watersheds.

**Objectives:**
- Students will be able to define terms pertaining to groundwater such as permeability and porosity
- Students will be able to use a groundwater simulator
- Students will be able to build their own groundwater model
- Students will understand the movement of water through an aquifer
- Students will understand how and why water storage in an aquifer changes over time.

**Materials:**
- Groundwater Simulator
- Large glass beaker (500 ml or larger)
- 250 ml (or larger) glass beaker (fill with water)
- Pea-gravel (can use aquarium stones)
- Sand
- Peat moss or top soil
- Small sections of screen (must measure at least 8 inches in length by 3 inches in width)
- Food coloring
- Ruler
- Containers (to build the maze in)
- Salt
- Aluminum foil
- Waxed paper
- A small glass
- Tennis tube cans
- Milk/water jugs (1 gallon in size)
- Toothpicks
- Meter stick

- Small fan (for exploring Bernoulli's principle)
- Spring scale
- Graduated cylinders

**Time:**
This lesson will take approximately 4 days for 50 minute class periods.

**Scope and Sequence:**

Day 1: Intro to groundwater

This lesson is taken from the following website:
http://www.ngwa.org/programs/educator/lessonplans/groundwater1.aspx
-this lesson can be done in conjunction with a tour of local municipalities water system
-the terms can be introduced as notes

**General definitions and discussion points**
On the first day of the lesson, the instructor will give notes on all the terms associated with groundwater (see terms below). The notes would be followed up with a class discussion on the local aquifer and groundwater supplies.

**What is groundwater**
Groundwater is defined as water that is found beneath the water table under the Earth's surface.

**Why is groundwater important**
Groundwater, makes up about 98 percent of all the usable fresh water on the planet, and it is about 60 times as plentiful as fresh water found in lakes and streams. Because groundwater is not visible (in most cases), it is often overlooked when considering all of the water on Earth, and yet, water beneath the land surface is a valuable resource. Protecting it from contamination and carefully managing its use will ensure its future as an important part of ecosystems and human activity.

**How does groundwater move through rock and/or soil**
Water in the ground travels through pores in soil and rock, in fractures, and through weathered areas of bedrock.

**Other important definitions**
The amount of pore space present in rock and soil is known as **porosity**.

The ability of fluids to travel through the rock or soil is known as **permeability**. The permeability and porosity measurements in rock and/or soil can determine the amount of water that can flow through that particular medium. A "high" permeability and porosity value means that the water can travel very quickly. Groundwater can be found in aquifers. An **aquifer** is a body of water-saturated sediment or rock in which water can move readily.

There are two main types of aquifers: **unconfined and confined.**

An **unconfined aquifer** is an aquifer that is exposed to the surface of the land. Because this aquifer is in contact with land, it is impacted by meteoric water and any kind of surface contamination. There is not an impermeable layer to protect this aquifer.

A **confined aquifer** is an aquifer that has a confining layer that separates it from the land surface. This aquifer is filled with pressurized water (due to the confining layer).

If the water is pressurized at a high enough value, when a well is drilled into the confining aquifer, water rises above the land surface. This is known as a flowing **artesian water well**.

The pressure of the water is called the **hydraulic head**. Groundwater movement or velocity is measured in feet (or meters) per second. **Darcy's law** is one method used to compute this value (because groundwater cannot be viewed completely, like surface water, volume cannot be accurately measured). Darcy's law uses both the hydraulic head value, the hydraulic gradient, and the permeability of the material that the aquifer is traveling. The actual computation is velocity = permeability x hydraulic gradient (hydraulic head/distance).

In some areas, the bedrock has low permeability and porosity levels, yet groundwater can still travel in the aquifers. Groundwater can travel through fractures in the rock or through areas that are weathered. Limestone, for example, weathers in solution, creating underground cavities and cavern systems. At the land surface, these areas are known as **"karst"**.

The voids in the rock, created as limestone goes into solution, can cause collapses at land surface. These collapses are known as **sinkholes**. Sinkholes often are a direct conduit to the groundwater and are areas where contamination can easily infiltrate the aquifers. On topographic maps, sinkholes appear relatively circular with hatched marks (indicating a depression); they may or may not be filled with water (depending on the groundwater levels). These areas also can have land subsidence as mass wasting occurs in areas with a sudden change in slope and contact with water.

Porosity and permeability of the sediment, soil, and bedrock in the area also affects the **recharge** rate of the groundwater. This means that in some areas, the groundwater can be pumped out faster than it can replenish itself. This creates a number of problems.

One of these problems is called **"drawdown."** This is a lowering of the aquifer near a pumping well. This can occur in areas where the well is pumping faster than the groundwater aquifer is recharged. This creates voids in the bedrock and can lead to additional land subsidence or sinkholes (as there is no longer water present and the void cannot hold the weight of the material above and collapses).

<u>Day 2: Groundwater Demonstration</u>
This uses a large Plexiglass groundwater simulator. (see details in supplemental material)

This lesson uses the same resource from above:
http://www.ngwa.org/programs/educator/lessonplans/groundwater1.aspx
-this simulator is available for use from local county resource offices, watershed districts or soil and water conservation districts

**Instructions:**

- Make sure that the groundwater simulator and all other materials were set up prior to class beginning. Simulator should be in the very front of the class for all students to see.

- Stand behind the simulator. Show students each feature of the simulator. Emphasize the new vocabulary words that were just introduced earlier in the lesson. Be sure that students are recording their observations in their lab books, along with the definitions of the new words.
- Students will be evaluated by turning in their observations and definition at the end of the class. Review the standard format for lab observations.
- Ask for at least two to three student volunteers. One will be the groundwater recharge person and the other will be the “polluter”. The third can be the one that empties the buckets and fills bottles as needed.
- Have the recharge student begin to fill the reservoir with plain tap water. As this is slowly saturating the sand, gravel and clay, ask students what they see. Water begins to fill the simulator and enter the wells. Finally, water enters the river and pond.
- Point to the clay layer (it's black). Clay is the confining layer in the simulator. Explain that this could be bedrock. Point to the confining aquifer. Ask students to list the wells (they are numbered) that are drilled into the confined aquifer, and in the unconfined. What are the benefits?
- Ask for another volunteer. This will be the well pump student. Ask the student to pump one of the wells in the confined aquifer. What happens to the water levels in all of the wells when this is done vigorously? Review drawdown and cone of depression and how this can work with contamination.
- Now, ask the "polluter" to fill up the UST (underground storage tank) with red dye. This will represent gasoline (high BTEX and with MTBE!). Ask them to fill the landfill with blue or green dye. This represents the leachate. Both leak!
- Have student record their observations. The chemicals are slowly leaking into the unconfined aquifers and river and pond.
- Now, have the pumper pump the well hard again. Have students pay attention to what happens (the contamination is going towards that well and polluting the other wells in its path). Explain how industries can easily do this.
- Eventually the recharge reservoir also becomes contaminated.
- Students should observe that the confining aquifer was the last to be polluted.

<u>Day 3: Make your own groundwater model</u>

This activity should follow the groundwater introduction lesson plan (that clearly defines groundwater, terms) and demonstration with the groundwater simulator. This lesson uses the same national groundwater association website as above.

**Introduction**

Previously, we saw firsthand the many different features that can be found beneath the Earth. Who can name some of the features (students should name the unconfined aquifer, the confined aquifer, recharge rate, the different layers of sediment, etc.)? Now, today we will build our own profile. We will try using different sediments to see what effect they have on recharge rates, permeability, and porosity. Work in teams of two or three.

**Materials**
- Large glass beaker (500 ml or larger)
- 250 ml (or larger) glass beaker (fill with water)
- Pea-gravel (can use aquarium stones)
- Sand
- Peat moss or top soil
- Small sections of screen (must measure at least 8 inches in length by 3 inches in width)
- Food coloring
- Ruler
- Disposable pipet to draw well water
- food coloring
- tall clear glass
- a long clear straw
- disposable plastic container with tight lid
- hard straws or plastic tubing
- flexible tubing
- small funnel to fit inside tubing
- modeling clay

**Activity**
- Roll the screen into a tube shape, about 2 inches in diameter. This will be your well.
- Place the tube into the beaker vertically. One student must hold the well straight while the other student is adding the layers of remaining material.
- Gently cover the bottom of the beaker with a layer of pea-gravel. It should be about 3 inches deep.
- Pour water over the gravel until it is about 1-inch in depth. This will be your groundwater.
- Add a layer of sand, about 2 inches in depth.
- Then add the soil, about 2 inches deep.
- Now you may release the well (it should be held stable by the layers of rock, sand, and soil).
- Add 5 drops of food coloring (any color is fine) to the 200 ml of water in the second beaker. Swirl to mix. This will be your polluted water.
- Have students draw their model (to scale). Be sure they include the groundwater level. They should use a ruler to get the exact measurements.
- Now, have the students predict what will happen when they add the contaminated water to their models. They should write down their predictions.
- Have one student pour 150 ml of the polluted water onto the surface of the model (not directly into the well, but around the well). The remaining students should be timing the event and recording all observations.
- The remaining 50 ml of polluted water is to be used as a comparison for the well water contamination level. Students should draw the well water out with the disposable pipet.

Have students answer the following questions:
- How many minutes did it take for the contamination to reach the groundwater?

- How long did it take for the contaminated water to reach the well?
- When did you notice the biggest changes in your model?
- When did the changes begin to slow down?
- How could this model be changed to allow the water to travel faster? Slower?
- How could you have better protected the well in your model?
- Compare the color of your well water to the original polluted water. Why were they different?
- Discuss the relationship between water contamination at the surface and water contamination under the ground. Which do you think is easier to remediate and why?

Day 4: Groundwater flow in aquifers

This lesson uses this national groundwater association activity:
http://www.ngwa.org/programs/educator/lessonplans/aquiferflow.aspx
-as a pre-cursor to this lesson, make sure the properties of water have been discussed

**Introduction/questions**
Ask students: How does water move through an aquifer? What ways does water enter and leave the aquifer? How much time does water spend in an aquifer?

**Key terms**
Pascal's principle, Bernoulli's principle, cohesion, adhesion, capillary action, buoyant forces, specific gravity, diffuse recharge, discrete recharge, sinkholes, losing streams, well pumps, artesian wells, residency time. Students should be familiar with all of the above listed terms. Review this information if needed.

**Activity**
This activity explores numerous properties of water. Some of the properties and principles that come into play in the movement of water into and through aquifers are: capillary action, cohesion and adhesion of water molecules, water pressure, Pascal's principle, and Bernoulli's principle. Students will work with materials and water to understand the laws governing the movement of water.

Allow students to brainstorm about how water enters an aquifer. Explain to the students that water enters the aquifer and is called recharge. Recharge occurs when streams and rivers cross the permeable formation and go underground or when precipitation falls directly on the outcrop of the permeable formation. Some recharge of groundwater happens when water seeps and oozes through the subsurface and other recharge of groundwater, occurs through a vast network of localized openings that are able to rapidly transport both water and contaminants. Water that seeps and oozes through the subsurface is called diffuse recharge. That water which flows through localized openings is called discrete recharge. Some recharge features include:

- Sinkholes, which are large openings in the land's surface from dissolution of karst that have underground drainage. Sinkholes provide direct connection between surface water and groundwater. Erosion by groundwater produces karst topography characterized by sinkholes, caves, and disappearing streams.

- Losing streams, which are surface streams that contribute water to the karst groundwater system in localized areas. These streams are typically a dry gravel streambed most of the year, except after major rainfall.

Ask students to brainstorm how water exits an aquifer. Explain to students that water exits aquifers by well pumps or in artesian wells and springs. Well water exits the aquifer by hand or electric pumps. Artesian wells and springs exist where the sheer weight of new water entering the aquifer puts pressure on the water deep inside the aquifer. This hydrostatic pressure forces water up to the surface through faults and wells. Artesian water is water confined under pressure like that in a pipe. It occurs in permeable beds bounded by impermeable formations.

Wells are often the preferred source of drinking water, when compared to surface water. This is because it is closer to much of the population compared to water found in streams, rivers, and lakes, and because the water quality is usually higher because of filtration and natural purification processes.

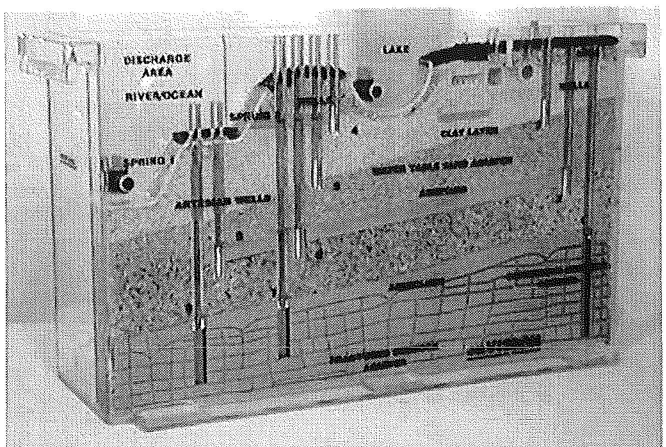
1. Allow students to explore how pumps bring up groundwater with the following experiment. Use these materials: food coloring, tall clear glass, and a long clear straw.
- Fill a tall clear cup with colored water. Lower a clear straw into the water and cover the end with your thumb. Bring up the straw with the water column inside.
- To build the water column higher, which is what happens inside a pump, quickly lower the straw back into the cup with your thumb off the top. Cover the top of the straw and pull up quickly.
- Get a rhythm going, and practice making an airtight seal with your thumb. You may not be able to actually have water come out of the top of the straw because the airtight seal is hard to maintain, but you should be able to see the water column mounting taller inside the straw.

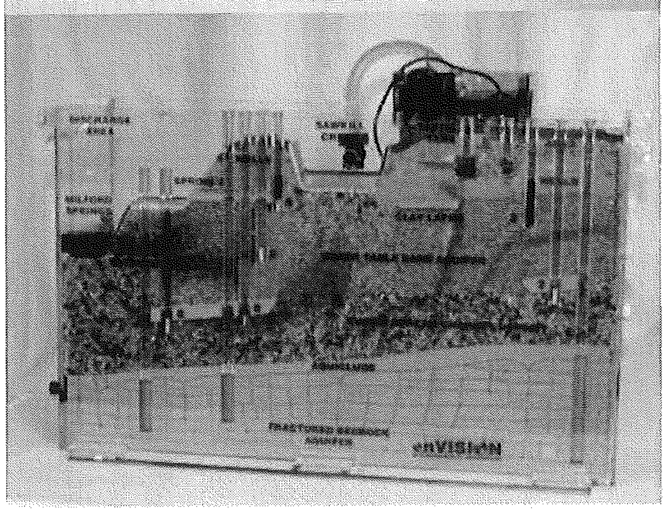
2. Allow students to construct a demonstration of artesian springs to compare to the water movement by a pump with the following experiment.
- Begin by gathering the following materials: disposable plastic container with tight lid, hard straws or plastic tubing, flexible tubing, small funnel to fit inside tubing, modeling clay.
- Cut the hard tubing or straw one-fourth of the length of the straw. Make two small openings in the lid of the container and put in straws.
- Press modeling clay around the base of the straws where it is inserted into the top to make the joints air and watertight.
- Fill the container with water and put on the lid.
- Attach the tubing to the taller straw piece and attach a funnel to the tubing.
- With the container on a waterproof surface, hold the funnel above the container. Pour water into the funnel. The water goes into the container and pushes water out of the lower straw. This water is acting as an artesian spring, with the tall column of water inside the flexible tube pushing the aquifer water in the container by hydrostatic pressure.

Discuss with students how fast water flows in aquifers. Review Darcy's law to instruct students on the actual calculation of groundwater velocity. Water movements in aquifers normally range from 1 meter per day to 1 meter per year. Karst or carbonate aquifer groundwater travel rates are often 1 mile per day, while nonkarst are a few feet per year. Dye tests indicate travel time for water from a single point can be variable and can exit from multiple springs and wells. A complex flow system is guessed at by using information from wells and dye tests.

**Supplemental Materials:**

Groundwater simulator-
The pictures below show an example of a groundwater simulator. They can be purchased as kits from enVISION. Another option is that many counties, soil and water districts or watershed districts have these simulators and they can be borrowed for use by the school.



**Resources**

- Fluid Dynamics
  http://home.earthlink.net/~dmocarski/chapters/chapter7/main.htm
- Highlights in the History of Hydraulics. This site has short biographies of just about all the scientists who have contributed to our understanding of fluids and forces.
  http://www.lib.uiowa.edu/spec-coll/Bai/hydraul.htm
- Water Science for Schools Groundwater: Wells
  http://ga.water.usgs.gov/edu/earthgwwells.html
- *The Hidden Sea: Ground Water, Springs, and Wells, 2nd Edition* by Francis H. Chapell, published by NGWA (2000). *The Hidden Sea* tells the story of human interaction with groundwater throughout history. Available from NGWA; call customer service at 800 551.7379 begin_of_the_skype_highlighting 800 551.7379 end_of_the_skype_highlighting or purchase from the online bookstore.
- *Understanding Groundwater* by W. Jesse Schwalbaum, published by Nova Science Publishers Inc. (1997). Written by a hydrogeologist, *Understanding Groundwater* is designed to introduce the subject of groundwater to those who may rely on groundwater resources or who may be concerned with local groundwater issues but are not necessarily trained in a scientific or technical field. Available from NGWA; call customer service at 800 551.7379 begin_of_the_skype_highlighting 800 551.7379 end_of_the_skype_highlighting or purchase from the online bookstore.

**Student Assessment:**

There are several opportunities for class discussion and writing assignments in this lesson. These activities may be used as formal or informal assessments to gage student knowledge of the topic to determine if any information has to be re-taught. There could be an end-of-unit test or quiz as well.

## Lesson Plan Title: Watersheds

**Intended Learners:**
This lesson is intended to be used in a high school environmental science or earth science course. This unit would be completed before units on water quality, flooding, stream morphology and topographic mapping are completed. It is meant to be a background unit.

**Minnesota State Science Standards addressed in this unit:**

9.1.1.2.1 Formulate a testable hypothesis, design and conduct an experiment to test the hypothesis, analyze the data, consider alternative explanations and draw conclusions supported by evidence from the investigation.

9.1.3.4.4 Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve data collection.

9.3.4.1.1 Analyze the benefits, costs, risks and tradeoffs associated with natural hazards, including the selection of land use and engineering mitigation

9.3.4.1.2 Explain how human activity and natural processes are altering the hydrosphere, biosphere, lithosphere and atmosphere, including pollution, topography and climate.

**Topic:**
This lesson will give high school students an introduction to watersheds. The purpose of this unit is to introduce students to the concepts associated with a watershed and stream flow.

**Curriculum Links:**
This unit can then lead to units on topographic mapping, stream geomorphology, water quality monitoring; land use; and flooding.

**Objectives:**
- Students will be able to define the term watershed and list the characteristics of a watershed.
- Students will be able to locate their home/school in a watershed using a variety of maps
- Students will learn what the water cycle is and how it impacts a watershed
- Students will learn about substances that contaminate water bodies

**Materials:**
- Computers
- Internet access

**Time:**
This lesson would take approximately 4 days for 50 minute class periods.

**Scope and Sequence:**

**Day 1: What is a watershed?**

This lesson was adapted from this website:
http://www.watersheds.org/teacher/WatershedsEverywhere.pdf

*-This lesson was written for middle school learners. It can be modified to meet the needs of older students at the high school level. An excellent PPT presentation on watersheds more suited to high school learners is available at:*
*http://extension.usu.edu/waterquality/files/uploads/PPT/watershed%2010 1%20sss.ppt*

The instructor will begin by writing the definition of a watershed and basin on the board.

- *Watershed: - the land area from which surface runoff drains into a stream channel, lake, reservoir, or other body of water; also called a drainage basin*
- *Basin: the entire geographical area drained by a major river and its intersecting streams.*

Explain that watersheds are named after the main river or creek that drains the water. Everyone has a watershed address. Students will figure out the school's watershed address. Have them think of what creeks or rivers are nearby. Place the Red River Basin map on your overhead. Identify and trace the basin boundary. Now place the rivers and watersheds in Minnesota/North Dakota map on your overhead and identify the sub-watersheds within the basin. Continue this process until you have identified minor watersheds within the local area. Decide which river basin your school is in. Have students find their home on the map so they can determine what minor watershed they live in. Have students locate the headwaters and small tributaries of streams near their home. Have students highlight from the headwaters, the entire length of the stream. Where does the creek end?

Assignment: Each student should complete his or her watershed address on the worksheet: What is your watershed address (in supplemental materials)?

Wrap up: Briefly review the maps used in this session. They are all about watersheds, from the Red River Watershed (Hudson Bay), to their smaller watershed. Everybody has a watershed address. Ask a student to share their complete watershed address out loud. Compare it to mailing addresses. Ask if they could find someone's home by their watershed address?
Ask what kind of map they would need?

**Day 2 & 3: The water cycle.**

This lesson is found at the following website:
http://www.math.montana.edu/~nmp/materials/ess/hydrosphere/novice/water-cycle.html

The hydrosphere surrounds all living things on Earth. Water is essential for all plants and animals to survive. The primary focus of this unit is to create an awareness of water, its uses, and to develop an understanding of its impact on life. The activities in this section explain:

- where water is found,
- the movement of water from one part of the hydrosphere to another,
- water quality, *and*
- conservation.

**Part I**

Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and

falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the ocean.
When students first learn the process of water evaporation and condensation which are inherent to the water cycle, they often form an unrealistic view of the pattern that this process follows. The following activity helps students understand that the water cycle is not a continuous circular motion, but rather a cycle that varies in nature.

Use the diagram of the water cycle in the supplemental materials to complete this activity. Have students try to describe what the picture means. *Water is essential to all life and life activities. Plants and animals need water to survive. Water is found throughout the world. It is in the soil, underground, marshes, swamps, ponds, streams, rivers, lakes, glaciers, oceans, clouds, and precipitation. There is a continual movement of these elements as they travel from one part of the hydrosphere to another. This is called* the Water Cycle.

Next, have students look at a pathway in the water cycle. Precipitation falls from clouds as rain or snow. It falls to the ground and flows into streams. The streams are part of a river system that brings water to the ocean. As rivers move toward the ocean they gain water from the many branches of the system. Once the water reaches the ocean it evaporates, returns to clouds, and condenses. It may return to earth as rain, sleet, hail, or snow. Then, the process can begin again.

After learning about the water cycle, ask students to think of as many places that water might be able to go when it falls to the earth. After they form a list, the teacher should try to group these ideas into the following nine categories.

- Soil
- Plants
- Rivers
- Lakes
- Clouds
- Oceans
- Animals
- Ground Water
- Glaciers

Students are then divided into nine groups. Each group is assigned one of the above categories to illustrate their assigned process on a large piece of butcher paper, newsprint, or poster board. When the illustrations are finished, they are hung on the wall around the classroom and these will serve as the different stations for the next portion of this activity.

***PART 2***
Using the student-made posters, create nine stations to represent the water cycle. Place a small, square box at each station to use as a random number cube. (*The teacher needs to make these nine cubes ahead of time according to directions found in supplemental materials.*)

***SCENARIO***
Rain drops falling to the earth accumulate in different places on the earth's surface and stay in

these places for varying amounts of time. We can model this using the random number cubes to represent where various rain drops go at different times in the water cycle. The goal is to help students understand that the patterns of the water cycle vary according to the location of the falling water droplets.

The students become the rain drops (water droplets) and are **responsible for recording their own paths** in the water cycle. It might be a good idea to have them predict beforehand where they think the water droplets will spend the most time. Each student has a piece of paper with the name of each of the stations (see sample answer sheet in supplemental materials) They are divided into 9 equal groups again and line up at each of the nine stations. They take turns rolling the cube at the station and they record where they go.
The activity continues with the water droplets (students) flowing around the room in the pattern of the water cycle and making tally marks as they go. After about 20 minutes, the teacher stops the flow of the water droplets and has them add up their tally marks for each station.

> *EXAMPLE*
> Student one starts at the glacier station. They make a tally mark by the glacier station on their paper. When the shake the dice, they might get "stay". They make another tally mark by the glacier station on their paper and go to the end of the line at the same station. When they get another turn, they might get "rivers", so they make a tally by the river station on their paper and go to the end of the line at the river station.

*WRAP UP and DATA ANALYSIS*
Students then get together in equal groups and add up their totals for each station. The teacher then calls for group totals and puts them on the board to come up with one large group total for each of the 9 stations. At this point, the students discuss which stations have the largest totals and forecast possible causes for the differences.

A small group of students can then take these totals and enter them in a spreadsheet ( e.g., Microsoft Works, MS Word, Excel, Quatro Pro, or Clarisworks). From the spreadsheet, they can create graphs that will show them the percentage of time that the water droplets were at each station. (*Variation: Students can calculate the averages using calculators and graph them in groups on poster paper.).*

**<u>Day 4: Introduction to water quality</u>**

Student should review the water cycle at the beginning of the class period. In this lesson we will learn about what makes water "clean" or "dirty" and what some of the issues that can affect water quality.

Begin class by having a class discussion to get student's previous knowledge of what they think makes a body of water polluted. Ask the following questions of the class and make lists of responses on the board: How can you tell if a river or lake is clean? By sight alone? What other things are important to look at? Have students get into small groups and hypothesize how they think the pH, DO and temperature of a body of water might be based on geography, time of year, time of day, etc. The groups should ideally select a local lake or river that is close to them and that they have seen or used.

Finally, break the class into 10 groups and ask them to use the internet to answer the following question about these water quality issues. Finish by having a class discussion on their findings.

What are the issues that could be affecting water quality in your water body?

- Stormwater
- Fertilizer/Lawns- watering, grass, buffers
- Wastewater
- Density- Loss of habitat, increase of impervious surfaces
- Invasive species- Eurasian watermilfoil, zebra mussels, purple loosestrife, etc.
- Erosion
- Sedimentation- deltas
- Non-point source pollution
- Construction
- Pesticides

**Supplemental Materials:**

General materials for the entire unit:

- Link to MN DNR watershed page: http://www.dnr.state.mn.us/watersheds/index.html
- EPA Surf Your Watershed page: http://cfpub.epa.gov/surf/locate/index.cfm
- DNR Lakefinder page: http://www.dnr.state.mn.us/lakefind/index.html

Day 1 Materials-

DNR Watershed Assessment Tool Web Address:
http://www.dnr.state.mn.us/watershed_tool/index.html

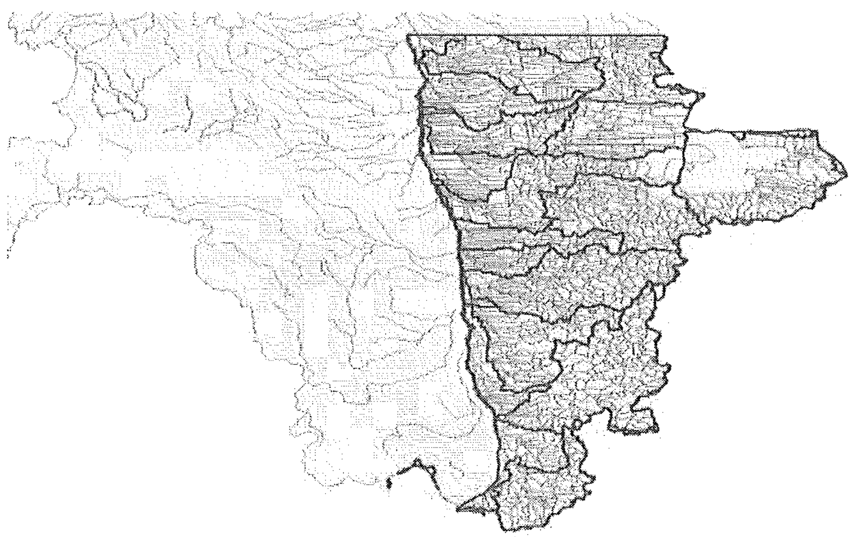
## What is your watershed address?

| STREET ADDRESS | WATERSHED ADDRESS |
|---|---|
| **School** | **Local river/creek** |
| **Town/city** | **Regional river** |
| **County** | **River basin** |
| **State** | **Largest river** |
| **Country** | **Ocean/Gulf** |

Example Watershed Address

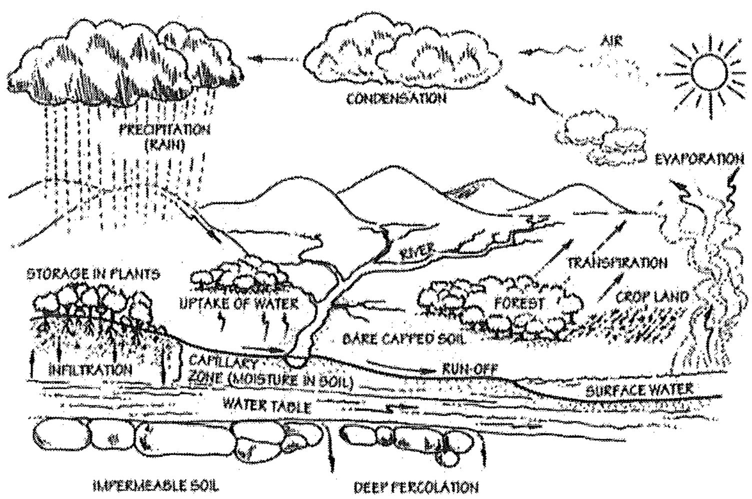
| STREET ADDRESS | WATERSHED ADDRESS |
|---|---|
| School: **Scotland HS** | Local river/creek: **Dawson Creek** |
| Town: **Scotland** | Regional river: **James River** |
| County: **Bon Homme** | River basin: **Missouri River** |
| State: **South Dakota** | Largest river: **Mississippi** |
| Country: **United States** | Ocean/Gulf: **Gulf of Mexico** |

INSERT WATERSHED MAPS HERE



Day 2 Materials-

## The Water Cycle




***DIRECTIONS*** for Creating Cubes
This grid indicates nine places that water can stay momentarily during the water cycle. You need to make a random number cube (*at one time called dice*) for each of the nine stations. Since water droplets falling to the earth accumulate in different places on the earth's surface and stay in these places for varying amounts of time, the dice at each station vary. By using the dice, the students will begin to understand that the patterns of the water cycle vary according to the location of the falling water droplets. Draw illustrations on each face of the boxes that will be used as the random number cube.

**Soil Station Cube**
- 2 sides- clouds
- 1 side - rivers
- 1 side - plants
- 1 side - groundwater
- 1 side - stay *STAY means the water droplet stays at the station*

**Plant Station Cube**
- 4 sides - clouds

- 2 sides - stay

**River Station Cube**

- 1 side - animals
- 1 side - lakes
- 1 side - groundwater
- 1 side - oceans
- 1 side - clouds
- 1 side - stay

**Lake Station Cube**

- 2 sides - stay
- 1 side - clouds
- 1 side - oceans
- 1 side - groundwater
- 1 side - lakes

**Cloud Station Cube**

- 1 side - soil
- 1 side - lakes
- 1 side - glaciers
- 1 side - stay
- 2 sides - oceans

**Ocean Station Cube**

- 2 sides - clouds
- 4 sides - stay

**Animal Station Cube**

- 2 sides - soil
- 3 sides - clouds
- 1 side - stay

**Ground water Station Cube**

- 3 sides - stay
- 2 sides - lakes
- 1 side - rivers

**Glacier Station Cube**

- 1 side - groundwater
- 1 side - clouds
- 1 side - rivers
- 3 sides - stay

### Sample Answer Sheet for Water Cycle Activity

Each time the water droplet (that's you) go to one of these stations. **Mark a " / " in the box.** You will add these up later to determine where water droplets spend most of their time in the water cycle.

| | | |
|---|---|---|
| SOIL<br><br>Total = ________ | PLANTS<br><br>Total = ________ | RIVERS<br><br>Total = ________ |
| LAKES<br><br>Total = ________ | CLOUDS<br><br>Total = ________ | OCEANS<br><br>Total = ________ |
| ANIMALS<br><br>Total = ________ | GROUND WATER<br><br>Total = ________ | GLACIERS<br><br>Total = ________ |

**Student Assessment:**
Science Binder-For an environmental studies or environmental science class, a good assessment is to have students keep a binder of all activities and assignments done in class. It is a good item to refer back to as well as other lessons are completed

Class Discussion-class discussions are a good means to determine how the class is doing with the concepts from the lesson.

**Lesson Evaluation:**
The science binder will be a good evaluation tool as it will determine if the lesson objectives are being met. The binders should be checked throughout the course of a lesson to determine if students are understanding the main components of the lesson. A quiz can also be added during the lesson or even a small test at the end of the lesson. Tests and quizzes can be better gauges of student understanding. A quiz would tell a teacher if they would have to re-teach something that is not being understood by the class.

Lesson Plan Title: Red River Geology

**Target Learners:**
This lesson is intended to be used in an 8th grade earth science course. This unit could be done in conjunction with a broader unit on geology with this unit being specific to the Red River Basin.

**Standards:**
8.1.3.3.1 Explain how scientific laws and engineering principles, as well as economic, political, social and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigations.

8.3.1.2.1 Explain how landforms result from the processes of crust deformation, volcanic eruptions, weathering, erosion and deposition of sediment.

8.3.1.2.2 Explain the role of weathering, erosion and glacial activity in shaping MN current landscape.

**Topic:**
This topic will introduce earth science students to the geology of the Red River at present due to recent geological events.

**Curriculum Links:**
This lesson would tie into a larger lesson on glacial geology that is part of an 8th grade earth science class.

**Objectives:**
- Students will understand the basic geological formations due to glaciation
- Students will understand the formation of the Red River basin as relates to Glacial Lake Agassiz
- Students will gain an understanding of how glaciers move
- Students will understand what types of landforms are created from glacial movement
- Students will understand how flooding relates to the geology of the Red River Basin

**Materials:**
- 9 x 13 baking pan or cookie sheet
- tin roof sundae ice cream -1/2 gallon carton
- chocolate chips
- peanuts
- rubber gloves
- paper plates and plastic spoons
- access to a freezer
- water
- cups
- dirt
- plastic tub or sink
- plaster of Paris
- pictures of glaciers and landforms created by glaciers
- maps of Red River Basin

**Time:**
This lesson would take approximately 3 days for 50 minute class periods.

**Scope and Sequence:**

Day 1-Glaciers (pictures showing landscapes described below can be found in the supplemental materials).

Portions of this lesson came from this web site:
http://blog.lib.umn.edu/rager001/mnatteachers/Glacier%20Process.doc
-similar information can be obtained for ND from the North Dakota State geology department web site.

1. Ask the students about their travels through Minnesota. What did they notice as they drove around? In Southeastern Minnesota, you'll notice rolling hills and trees. Lots of livestock grazing in hilly pastures. Farming looks different with contour farming. Small rivers and streams with very few lakes. This area is called the driftless area because the last glacier didn't move through the area. In Northeastern Minnesota, you'll see trees and lakes with very little farming.

The glacier took away most of the topsoil, so very little grows. Before the last glacier came, there was a mountain range as big as the Rocky Mountains. Today, the Sawtooth Mountain Range is still in NE MN and the highest point in MN, Eagle Mt., is there. In Northwestern Minnesota, you'll find many lakes, but very flat land. There is very rich soil, but when it floods, the water stretches for miles because there is nothing to stop it. (Glacial Lake Agassiz can be talked about here or on the 2nd day). There is very rich soil and crops grow well. The soil that was taken from NE MN was deposited in Southwestern Minnesota. There is evidence of the glacier in many locations around SW MN.

2. How many glaciers came through MN? Most people agree there were three. Glaciers are names for the places they came from. These three glaciers have the names of the states, although at the time the glaciers came through, we didn't have states! The three glaciers are the Nebraskan, Kansan and the Wisconsin. Not the entire glacier moved through MN, in most cases, it was only a finger or lobe that extended into the state. The Wisconsin was the last glacier that came into MN and made most of the changes we see today.

3. Glaciers moved only inches a year (2-4 inches was average). As a glacier moved, it would melt from the bottom, so it really moved as it melted. It would often move rocks and push them along in front of the glacier, as well as dirt that may have been a hill in front of the glacier.

Some of the rocks and dirt, known as till, would refreeze into the glacier. Other times, the rocks and dirt were pushed into hills and ridges in front of the glacier. As the glacier moved and melted, the melted water would fill in holes left by the glacier-creating lakes.

**Activity (appropriate for 8th grade)**
4. Now we are going to create a few features you can see today in Minnesota. You will need a 9 x 13 cake pan, a block of tin roof sundae ice cream, chocolate chips, peanuts and rubber gloves. You will also want enough plates and spoons for each student.

5. You'll want to set the glacier in the 9 x 13 pan and sprinkle till (chocolate chips and peanuts) on the glacier and around MN. The glacier will begin in NE MN. As it sits and begins to melt, explain how the melting water and the movement of the glacier carved out Lake Superior. When it moves, the Sawtooth Mts. Are chopped down to big hills that still remain. There should be till moving with the glacier. As the glacier moves, it will leave steaks behind. A streak of white will be ice cream, which represents water. If there is a streak of chocolate or a chocolate chip or peanut, those represent hills and bigger hills. As the glacier moves, students should notice how the glacier doesn't touch the driftless area in SE MN. When it reaches SW MN, the glacier stops near the Iowa and South Dakota border and all the till out front forms a

ridge. That ridge today is Buffalo Ridge and has more elevation than other places on the prairie. The weather may often be different on either side of it, and it gets a large amount of wind which has made it a prime location for windmill farms. The glacier begins to retreat and sits again near Ortonville and starts to melt quickly. The water forms a lake, with a natural dam being formed from the till of the glacier. But the lake can't hold all the water and the dam bursts. When the dam bursts, the water quickly cuts through the rich topsoil of SW MN and carves a deep path. This river was known as the Glacial River Warren and today is better known as the Minnesota River. As the river formed, it carved out its path as it rushed along. When it reached the Mankato area, the river hit a wall of bedrock, which it could not move. The water bounced back and curved back to the north, creating a unique direction for the river. Today, you can see evidence of the width and depth of the river as you follow the river. This high banks and wide hills on each side are evidence of the size of the Minnesota River over 10,000 years ago. (Now, go ahead and have the class eat the glacier).

**Day 2-Glacial Lake Agassiz**

**Background (pictures in supplemental materials)**
This lesson came from the following source: http://www.wordiq.com/definition/Glacial_Lake_Agassiz
-topographic maps can also be found online: http://www.digital-topo-maps.com/

Lake Agassiz was an immense lake—bigger than all of the present-day Great Lakes combined—in the center of North America, which was fed by glacial runoff at the end of the last ice age. First postulated in 1823 by William Keating, it was named after Louis Agassiz in 1879 after he was the first to realize it was formed by glacial action.

The lake's modern-day remnants, the largest of which is Lake Winnipeg, dominate the geography of Manitoba. Forming around 11,700 years ago, the lake came to cover much of Manitoba, western Ontario, northern Minnesota, northern North Dakota, and Saskatchewan. At its greatest extent it may have covered as much as 440,000 square kilometers, larger than any lake currently in the world (including the Caspian Sea).

The lake drained at various times south into the Minnesota River (part of the Mississippi River system), into the Great Lakes, or west through the Yukon Territory and Alaska. A return of the ice for some time offered a reprieve, and after retreating north of the Canadian border about 9,900 years ago it refilled. These events had significant impact on climate, sea level and possible early human civilizations. Climatologists believe that a major outbreak of Lake Agassiz in about 11000 BC drained through the Great Lakes and Saint Lawrence River into the Atlantic Ocean. The massive outflow of fresh water slowed ocean current circulation, cutting off the Gulf Stream and bringing about a ten-century global cooling known as the Younger Dryas.

The last major shift in drainage occurred about 8,500 years ago, when the lake took up its current watershed, that of Hudson Bay. The lake drained nearly completely over the next 1,000 years or so, leaving behind Lake Winnipeg, Lake Winnipegosis, Lake Manitoba, and Lake of the Woods, among others. These lakes are still shrinking slowly, due to isostatic rebound.

While mostly gone along with the ice sheet that fed it, Lake Agassiz left marks over a wide geographic area. Apparent beaches, miles from any water, can be found in many locations—these mark the former boundaries of the lake. Several modern river valleys, including the Red River, the Assiniboine River and the afore-mentioned Minnesota River, were originally cut by water entering or leaving the lake. The Red River Valley agricultural region also exists because of the silt that sank to the bottom of the lake.

**Activity**

Students should have a set of topographic maps or use those found online. Have students break into groups and use topographic maps to identify the beach ridges of glacial lake Agassiz stressing that there is more than one. Students can then identify key features such as cities and roads. Students can prepare a summary of land features and man-made features that are on and around the beach ridge.

**Day 3-Landforms and flooding in the basin** (pictures of these landforms in the basin or found in supplemental materials)

This lesson came from the following source:
http://geologyonline.museum.state.il.us/tools/lessons/6.1/lesson.html
-a stream table would be very useful for this activity and can show the affects of glaciers on the landscape on a micro scale

**Background:** Glaciers are made up of fallen snow that, over many years, compresses into large, thickened ice masses. Glaciers form when snow remains in one location long enough to transform into ice. What makes glaciers unique is their ability to move. Due to sheer mass, glaciers flow like very slow rivers. Some glaciers are as small as football fields, while others grow to be over a hundred kilometers long. Glaciers made up most of the landforms that we have in Illinois including glacial lakes, kettle lakes, till, and moraines.

Till is material that is deposited as glaciers retreat, leaving behind mounds of gravel, small rocks, sand, and mud. It is made from the rock and soil ground up beneath the glacier as it moves. Glacial till can form excellent soil for farmland. Material a glacier picks up or pushes as it moves forms moraines along the surface and sides of the glacier. As a glacier retreats, the ice literally melts away from underneath the moraines, so they leave long, narrow ridges that show where the glacier used to be. Glaciers don't always leave moraines behind, because sometimes the glacier's own meltwater carries the material away. Streams flowing from glaciers often carry some of the rock and soil debris out with them. These streams deposit the debris as they flow. Consequently, after many years, small steep-sided mounds of soil and gravel begin to form adjacent to the glacier. These mounds are called kames.

Kettle lakes form when a piece of glacier ice breaks off and becomes buried by glacial till or moraine deposits. Over time the ice melts, leaving a small depression in the land, filled with water. Kettle lakes are usually very small and are more like ponds than lakes.

Glaciers leave behind anything they pick up along the way, and sometimes this includes huge rocks. Called erratic boulders, these rocks might seem a little out of place, which is true, because glaciers have literally moved them far away from their source before melting away.

**Procedure:**

1. Have a discussion about what glaciers are, how they are formed, glacial movement within the Red River Basin, and what landforms glaciers create. Introduce and discuss the terms kettle, moraine, lateral moraine, terminal moraine, glacial lake, till, meltwater, kame, cirque, outwash stream, crevasse.

2. Conduct an activity in which students build a glacier and observe the effects of glacial movement. To do this, create a miniature glacier by freezing gravel, sand or small rocks in a cup of water. Have the students place the cup into the freezer over night. The next day they should be able to tear the paper cup away and use the glacier to simulate its movement over dirt, wood or other material. At the same time they should be melting a pile of ice cubes on a mound of dirt so that

they can see the result of the melting glaciers on the land. It is important to show actual photographs of what occurs so that students can make connects to the larger life-size version of what they are seeing.

A suggested alternative is, rather than using individual ice cubes, freeze water in a rectangular gallon container. Set up a stream table with sand and start the "glacier" at one end by pushing it into the sand. Set a lamp at the "south" end to simulate global warming. As the day goes by, check the regress of the melting "glacier." River systems, lateral moraines, terminal moraines, and glacial lakes should all develop. You can show the depression of the Earth's crust by putting a piece of play dough under the stream table and allowing it to flatten. As the "glacier" melts, the bottom of the stream table should rebound creating a gap in the play dough.

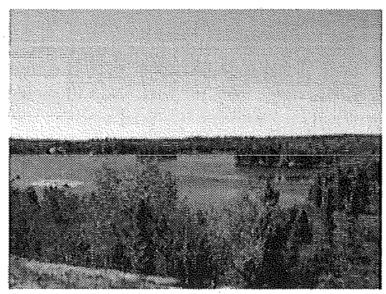
**Questions:**

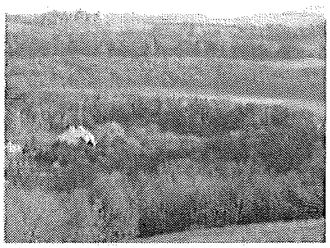
- What types of landforms do glaciers create?
- How do glaciers change the shape of the land?

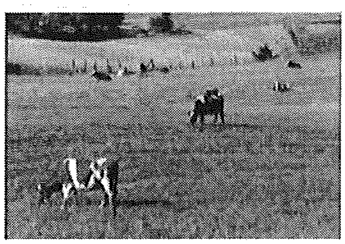
**Extensions:**

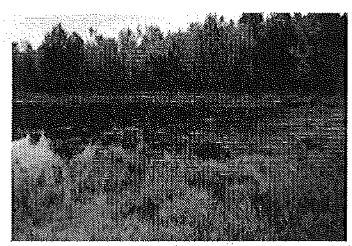
- Students can develop a presentation of the various landforms discussed in this lesson.

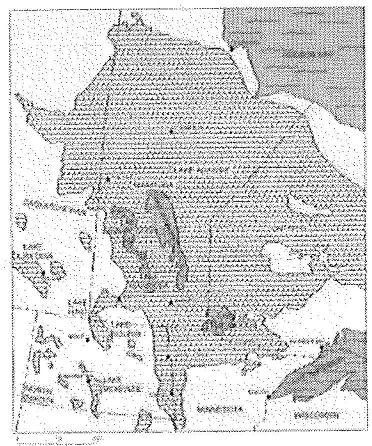
**Supplemental Materials:**

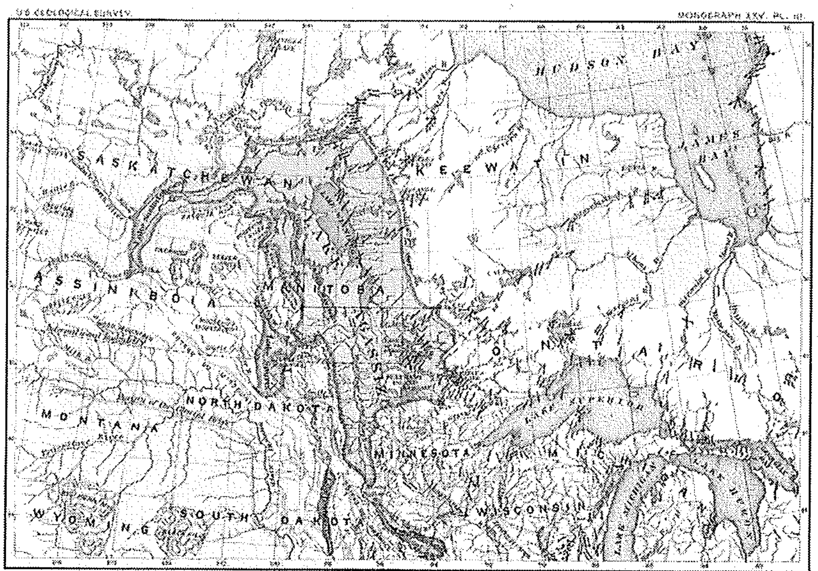













MAP SHOWING THE AREAS OF LAKE AGASSIZ AND OF THE UPPER LAURENTIAN LAKES.

Lake Agassiz and associated Glacial Lakes   Glacial Striae   Terminal Moraines

-NDSU website showing geologic features Red River Basin
http://www.ndsu.nodak.edu/nd_geology/

**Student Assessment:**

Students can be assessed on class discussions and participation in activities. They could also do daily reflections on a set of questions given at the end of the class.

**Final Project**
**Natural Selection by Species Interactions**

**by Karen Thoreson**

**Introduction:**
This is an inquiry-based five-day unit plan addressing the topic of natural selection, with each day covering a distinctly different aspect of natural selection. Each day begins with structured inquiry in the form of teacher-provided questions that are meant to familiarize the students with the days' topics and stimulate further questions from the students. The activities that follow on Days 1-3 (investigations, labs or simulations) will allow the students to make decisions and develop their own questions within the parameters set forth by the activity itself. Finally on Day 4, the students will be expected to develop their own method of investigation to ask important questions, gather, analyze and evaluate information as well as answer questions proposed by the instructor to complete their PowerPoint Presentations which will be presented to the class on Day 5.

1. **Project Title:**
   Natural Selection by Species Interactions

2. **Intended Audience:**
   **Grade Level:** High School Sophomores
   **Population characteristics:** These students have had one year of Physical Science at the High School level. They have also had Life and Earth Science at the junior high level. These students comprise the entire 10th Grade, including a few special educations students, general education students and a few honor students.
   **Groupings:** Whole group, small groups (3-4), pairs or individual

3. **Related Standards:**
   **National Science Education Content Standards**
   **Content Standard A: Science as Inquiry**
   As a result of activities in grades 9-12, all students should develop:
   - Abilities necessary to do scientific inquiry *(SI1)*
   - Understandings about scientific inquiry *(SI2)*

   **Content Standard C: Life Science**
   As a result of their activities in grades 9-12, all students should develop understanding of
   - Biological Evolution *(LS Evol 1-5)*
     - Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.
     - The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.
     - Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms.
     - The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

    - Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.
- The Interdependence of Organisms (*LS Inter 3&4)*
    - Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years.
    - Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms.
- The Behavior of Organisms *(LS Beh 2&3)*
    - Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.
    - Like other aspects of an organism's biology, behaviors have evolved through natural selection. Behaviors often have an adaptive logic when viewed in terms of evolutionary principles.
- The molecular Basis of Heredity *(LS Gene 3)*
    - Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.

**Content Standard F: Science in Personal and Social Perspectives**
As a result of activities in grades 9-12, all students should develop understanding of

- Population Growth *(SPSP 1)*
    - Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution.

**Content Standard G: History and Nature of Science**
As a result of activities in grades 9-12, all students should develop understanding of

- Nature of Scientific Knowledge (*HNS 2&3*)
    - Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.
    - Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.

**Standard: Unifying Concepts and Processes**
As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes.

- Evidence, models and explanation (*UCP 2)*
- Evolution and equilibrium (*UCP 4*)

**Minnesota State Science Standards**
**Grade: 9-12**
**Strand: Life Science**
**Sub-Strand B. Diversity of Organisms**
**Standard:** The student will classify, compare and contrast the diversity of organisms on Earth and their modes of accommodating the requirements for life.
**Benchmarks:**

3. The student will use scientific evidence, including the fossil record, homologous structures, embryological development or biochemical similarities, to classify organisms in order to show probable evolutionary relationships and common ancestry.

**Sub-Strand C. Interdependence of Life**
**Benchmarks:**

2. The student will explain how adaptations of species and co-evolution with other species are related to success in an ecosystem.
3. The student will identify examples of mutualism, commensalism, and parasitism in a stable ecosystem.
4. The student will predict and analyze how a change in an ecosystem, resulting from natural cause, changes in climate, human activity or introduction of invasive species, can affect both the number of organisms in a population and the biodiversity of species in the ecosystem.

**Sub-Strand E. Biological Populations Change Over Time**
**Benchmarks:**

1. The student will understand that species change over time and the term biological evolution is used to describe this process.
2. The student use the principles of natural selection (sexual selection) to explain the differential survival of groups of organisms as a consequence of:
    - The potential for a species to increase its numbers;
    - The genetic variability of offspring due to mutation and recombination of genes;
    - A finite supply of the resources required for life; and
    - The ensuing selection based on environmental factors of those offspring better able to survive and produce reproductively successful offspring.
3. The student will describe how genetic variation between populations is due to different selective pressures acting on each population, which can lead to new species.
4. The student will use biological evolution to explain the diversity of species.

4. **Topics:**

**Day 1** will concentrate on the introduction of natural selection, with the students becoming familiar with directional, stabilizing and disruptive selection and the graphing of such.

Breeding bunnies on **Day 2** will reinforce the concept of natural selection by looking closely at how adaptations can make an organism better suited for its environment. This simulation deals with natural selection in terms of the role the abiotic environment plays on the organism's adaptations.

**Day 3** will introduce sexual selection as a means of natural selection, and the students will understand the role that other organisms play in the process of natural selection.

**Day 4** looks into coevolution and how species interactions in the form of mutualism, parasitism, competition and predation can bring about natural selection and how organisms can coevolve within the parameters of that relationship. Students will be dividing into groups to research one of the species interactions to be presented on **Day 5.**

**5. Curriculum Links:**

This five-day unit plan on natural selection will fit into **Unit 4—Evolution** of the textbook currently in use for 10th Grade Biology, "Modern Biology". Prior to the implementation of this unit, the students will have an understanding of Charles Darwin, descent with modification, natural selection, the fossil record, biodiversity, anatomy and embryology, divergence, radiation, artificial selection and the concept of coevolution. Students will also have prior knowledge of population genetics, the Hardy-Weinberg Principle, mutations and genetic drift. This unit plan serves to incorporate much of this previous material with a more in-depth study of specific interrelationships, which will emphasize the textbook material. In addition, the unit plan relates these topics to species relationships, such as predation, parasitism, competition and mutualism, a subject discussed later in the unit on Ecosystems. After the natural selection unit plan, the students will continue on with the formation of species, then classification.

6. **Learning Objectives: Upon completion of this Unit Plan, the student will be able to/understand that:**
- Relate the concepts of adaptation and fitness to the theory of natural selection.
- Present scientific findings using clear language, accurate data, appropriate graphs, tables, and available technology.
- Draw conclusions from inquiries based on scientific knowledge and principles and from the use of logic and evidence (data) from activities and simulations
- Design and carry out scientific inquiry (investigation), communicate and critique results through peer review
- Identify questions and concepts that guide scientific investigations.
- Explain how biogeography provides evidence that species evolve adaptations to their environments.
- Explain how the various components of the abiotic environment can influence natural selection within a population
- Explain how organisms can undergo coevolution.
- Identify traits that vary in populations and that may be studied.
- Explain the importance of the bell curve to population genetics.
- Contrast the effects of directional selection, disruptive selection and stabilizing selection on populations over time.
- Graph data from population simulations in a way that conveys mastery of the data.
- Natural selection is the process by which evolution works.
- Sexual selection has implications for the males of some species.
- The outcome of sexual selection affects the progeny and how that occurs.
- Predation, parasitism, mutualism, and competition effects on the organisms involved.
- Relationships involving predation, parasitism, mutualism and competition can result in coevolution.
- Put their ideas together in a PowerPoint Presentation and deliver a thoughtful and informative presentation to the class.

**7. Materials:**
- Disruptive Selection Scenario (2)
- Stabilizing Selection Scenario (2)

- Directional Selection Scenario (2)
- Natural Selection Worksheet (Supplementary Materials)
- 1 bag red dried beans
- 1 bag white dried beans
- 6 brown lunch bags
- 18 paper dishes
- Labels
- Pens
- Graph Paper
- Breeding Bunnies Gene Frequency Data Sheet (on-line)
- Breeding Bunnies Discussion Questions (on-line)
- Computers with Internet connections
  - Internet simulations
  - Internet resources for projects
- Flashy Fish Data Form (on-line)
- Flashy Fish Discussion (on-line)
- Flashy Fish Data Table (Supplementary Materials)
- Classroom resource materials / resource books
- Library
- Packets
  - Predator / Prey
  - Parasitism
  - Mutualism
  - Competition
- LCD projector and screen

8. **Time:**
   5 consecutive days, 50 minutes per day

9. **Scope and Sequence:**

## <u>Day 1: How Does Evolution Really Work?</u>

**Motivation:** If organisms have indeed changed over time, what is the mechanism by which this changed occurred?

**Video:** How Does Evolution Really Work? (8 minutes)

**Class Discussion:** Natural Selection (see Background Information below)

**Activity:** After a short discussion which briefly introduces the bell curve as well as the three general patterns of natural selection, the class will divide up in groups of three. Each group will be given a short scenario from a real-life population. (See Natural Selection Scenarios and Worksheet, Supplementary Materials) From the discussion information, each group will be given the task of devising three questions that they feel will help them determine which pattern of selection their scenario represents. The student groups will explain how the population will adapt to the environmental changes presented in their scenario, and how that would affect the original population depicted by the bell curve. Finally, the student groups will sketch a line graph representing their population after selection has taken place. The graph will show both the original population's bell curve and the final curve hypothesized by the students. (Note: time constraints will allow only a sketch of a graph, which in this case is sufficient to determine adequate understanding of the concepts.)

**Background Information:**
***Bell Curve, Stabilizing, Disruptive and Directional Selection***
***Bell Curve*** -- This graph illustrates that most members of a population have similar values for a given, measurable trait. Only a few individuals display extreme variations of the trait.
***Stabilizing Selection*** – Individuals with the average form of the trait have the highest fitness. The average represents the optimum for most traits; extreme forms of most traits confer lower fitness on the individuals that have them.
***Disruptive Selection*** – Individuals with either extreme variation of a trait have greater fitness than individuals with the average form of the trait.
***Directional Selection*** – Individuals that display a more extreme form of a trait have greater fitness than individuals with an average form of the trait.

**Homework: Complete the following:**
Natural Selection Worksheet

**References:**
1. Video
http://www.pbs.org/wgbh/evolution/library/11/2/real/e_s_4.html
2. Background Information
Modern Biology, 2006, Holt, Rinehart and Winston
http://www.brooklyn.cuny.edu/bc/ahp/LAD/C21/C21_Directional.html
http://www.starsandseas.com/SAS%20Evolution/SAS%20natselection/natselec_direction al.htm

## Day 2: Natural Selection Simulation

**Motivation:** Just what is it about an organism that enables it to live in its environment? What are those features called? Name some features of the animals that live in the wild in this area that enable it to do so.

**Activity:** Breeding Bunnies Simulation (Groups of 3 students)
This simulation will reinforce the concept of natural selection by looking closely how an adaptation, in this case fur, makes this organism better suited for its environment. Two goals of this simulation are to show the impact that genetics has on the evolution of a population of organisms and also to make students aware of the influence the environment has on organisms before we proceed on to sexual selection and coevolution on Days

3-5. In the context of this simulation the students are asked to hypothesize how natural selection affects the gene frequency over several generations. Through the decision-making process the students will determine if this is, in fact, an example of natural selection and if it is applicable in a real world setting.

**Homework:** Complete the following:
Gene Frequency Data Sheet, Discussion Questions and Graph

**References:**
1. Breeding Bunnies Activity, Gene Frequency Data Sheet and Discussion Questions
http://www.pbs.org/wgbh/evolution/educators/lessons/lesson4/act1.html

## Day 3: Sexual Selection as Natural Selection

**Motivation:** Show the students a picture of a peacock, and then ask: Do males and females of each species look alike? Can you give some examples? Can you give some reasons for these differences? Are these differences always in the best interest of the male? Why? What effect will the female choice make on the offspring? Do you think flashiness indicates better genes? Why?

**Class Discussion:** Sexual Selection Overview (see Background Information)

**Activity:** Flashy Fish (Pairs of Students)
This simulation will reinforce the concept of natural selection by looking at intraspecific as well as interspecific relationships between male and female guppies and their predators. In addition to the goal of helping the student better understand the concept of natural selection, this simulation also serves to help them understand the concept of sexual selection and explains the interplay between selection factors in a population of guppies. The students are asked to hypothesize what causes guppy color variation and also set up an experiment within the parameters of the simulation that will enable them to collect data, analyze the results and come up with a conclusion.

**Homework:** Complete the following:
Flashy Fish Data Form and Discussion
Flashy Fish Data Table

**Background Information:**
Females tend to choose the males they mate with based on certain traits. Visit various web sites (listed below) to provide examples and photos of flashy males. Reflect on the motivation questions (above) during this discussion.

**References:**
1. Discussion Photos of Sexual Selection and Flashy Males
http://evolution.berkeley.edu/evosite/evo101/IIIE3Sexualselection.shtml
http://news.nationalgeographic.com/news/2003/04/0408_030408_colorfulbirds.html
2. Flashy Fish Activity, Data Form (Questions only) and Discussion Questions

http://www.pbs.org/wgbh/evolution/sex/guppy/index.html
3. Flashy Fish Data Table, (Supplementary Material)

## Day 4: Co-evolution of Interacting Species Presentation
## Mutualism, Parasitism, Competition, and Predation

**Motivation:** Name different ways organisms interrelate with one another. Introduce predator/prey, competition, parasitism, mutualism and commensalism. What effect does one organism have on the other? Who benefits? Who is harmed? Why can't commensalism be considered a form of coevolution?

**Class Discussion:** The questions in the motivation above will serve to present the basics of each of the 5 interactions. The topic of coevolution will be addressed (see background information). From there a connection will be made as to how coevolution occurs through species interactions.

**Background Information:**
Evolution is ongoing and in a given environment, many species may be evolving at once. Each species is part of the forces of natural selection that act upon the other species. When two or more species have evolved adaptations to each others' influence, the situation is called coevolution. For example, a species may have evolved a way to avoid being eaten, while the animals that eats them have evolved strategies to keep eating them. Ask the students to use their knowledge of each of the other interactions to create a coevolution scenario.

**Project**: The class will be divided into 4 groups. Each group will be given a packet of information on one of the four modes of coevolution / species interactions. Students are to research a set of questions as well as the questions they formulate on their own while conducting their research. Through their research they are to gather, organize, analyze and evaluate information related to all of these questions and from there prepare a teachable lesson to share with the rest of the class via PowerPoint. Students must cover all items in the project outline. These will be presented Friday. Additionally, each group will be asked to compose a worksheet to be completed by their classmates as both an assessment of the classes' attentiveness and an evaluation tool for the presenting group. (See Supplementary Material for the actual hand outs).

**1. Mutualism**
- **Internet resources**
- **Video:** *Ancient Farmers of the Amazon*
  http://www.pbs.org/wgbh/evolution/library/01/3/l_013_01.html
- **Case Study:** Co-evolution of Plants and Pollinators
  http://www.pbs.org/americanfieldguide/teachers/insects/insects_sum.html
- **Big Question:** Do these organisms intend to help each other out?

**2. Parasitism**
- **Internet resources**
- **Video:** *A Mutation Story*
  http://www.pbs.org/wgbh/evolution/library/01/2/l_012_02.html

- **Case Study:** *Fighting Malaria*
  http://www.pbs.org/safarchive/4_class/45_pguides/pguide_702/4572_malaria.html
- **Case Study:** Bunnies in the Outback
  http://library.thinkquest.org/03oct/00128/en/rabbits/history.htm
- **Big Question:** What is the Red Queen hypothesis? Did your example have this characteristic?

3. **Competition**
   - **Internet resources**
   - **Case Study**: Intraspecific Coevolution of the Anolis Lizard
     http://books.google.com/books?id=ydCJC26WCNQC&pg=PA91&lpg=PA91&dq=Anolis+lizard+fauna+of+the+Caribbean+coevolution&source=web&ots=cKFwOBdz9J&sig=1kSLHINNwSCEB36s7WXILNqYkEY&hl=en&sa=X&oi=book_result&resnum=4&ct=result
   - Case Study: Coevolution of Weeds and Crops
     http://books.google.com/books?id=uK9R7N-QaJMC&pg=RA1-PA69&lpg=RA1-PA69&dq=weeds+and+crops+coevolution&source=web&ots=546CaxXQU4&sig=LOpfinSfFp_1O4TLrq7ZFH2IHcXg&hl=en&sa=X&oi=book_result&resnum=1&ct=result
   - **Video:** *Biological Invaders*
     http://www.pbs.org/wgbh/evolution/library/10/3/l_103_03.html
   - **Big Question:** In your opinion, what is the most invasive species of all?

4. **Predator / Prey**
   - **Internet Resources**
   - **Case Study:** *The Arms Race*
     http://evolution.berkeley.edu/evosite/evo101/IIIF1Armsrace.shtml
   - **Case Study:** Squirrels, Birds and the Pinecones They Love
   - **Video:** *Toxic Newts*
     http://www.pbs.org/wgbh/evolution/library/01/3/l_013_07.html
   - **Big Question:** Why do pronghorn antelope run so fast? There isn't a predator on the continent that can chase it down.

## Day 5: Interacting Species Presentation

Each student group will present their PowerPoint Presentations to the rest of the class. The information presented will be noted by each student by completing the worksheets made by each group. (See PowerPoint Rubric, Supplementary Materials) Additionally, each group will be asked to turn in a key for their worksheet to assess both the observing students' attentiveness and each presenting group's effectiveness.

**11. Student Assessment Criteria:**

Student success in each of the assignments below depends on their ability to manipulate data in a manner that demonstrates their ability to gather, organize, analyze and evaluate information related to the questions the instructor set forth as well as original student questions.

Each of the assignments listed below will be corrected and graded according to the school-wide grading scale (92%-100% = A, 85%-91% = B, 77%-84% = C, 70%-76% = D, 0-69% = F).

Daily Assignments:

- Day 1: Natural Selection Worksheet
- Day 2: Gene Frequency Data Sheet, Discussion Questions and Graph
- Day 3: Flashy Fish Data Form (Questions only), Discussion Questions and Data Table

PowerPoint:

- Graded on Rubric

PowerPoint Worksheets

- Created by each group for the rest of the class to complete and hand for individual student assessment (how well was the individual student listening?) as well as group evaluation (how effective was the group at getting their point across?)

**12. Evaluation of the Lesson:**

Again, the success of each of the criteria below depends on the ability of the students to manipulate data in a manner demonstrating the students' ability to gather, organize, analyze and evaluate information related to the questions the instructor has set forth as well as original student questions.

Success of this lesson will be determined if 90% of the students are able to:

- correctly identify the specific pattern of selection (selective, directional or disruptive) exemplified in their scenario (Day 1)
- complete and turn in all worksheets from Days 1-3 with a grade of C or above
- effectively carry out the simulations (Days 2 & 3)
- work independently on their inquiry-based projects with guidance but minimal help from the teacher
- complete their PowerPoint Presentation with a grade of C or above. (Days 4 & 5)
- individually complete the three co-evolutionary relationships worksheets authored by each of the other groups with a grade of C or above (Day 5)

**Conclusion:**

This purpose of this unit plan is to allow the students to use their knowledge of evolution and species interactions to determine how these two can work together in the form of coevolution. Through the simulation, investigations, activities and inquiry-based research, the students will gain an understanding of and appreciation for the interrelatedness among all organisms everywhere. The ultimate purpose of this plan is to make the students familiar enough with coevolution so they can see it happening on a personal level, and understand that humans are involved in many cases of coevolution in the terms of antibiotic resistance in the medical world and pesticide resistance in the agricultural world, to name a few. I want the students to understand how coevolution 'works'; to be able to apply the broader theme to decisions they will have to make in their lifetimes. I want them to be part of a better informed public, making intelligent decisions as voters, citizens and leaders of tomorrow.

Supplementary Materials---

Natural Selection Scenarios and Worksheet

## Directional Selection

The following two scenarios are examples of directional selection. Each group will choose one scenario with no indication of which pattern it is. The students will then follow the directions on the Natural Selection worksheet.

### Example 1: Breeding of the Greyhound Dog.

Early breeders were interested in dog with the greatest speed. They carefully selected from a group of hounds those who ran the fastest. From their offspring, the greyhound breeders again selected those dogs that ran the fastest. By continuing this selection for those dogs that ran faster than most of the hound dog population, they gradually produced a dog that could run up to 64km/h (40mph).

The greyhound was originally used to hunt the fastest of game, fox and deer. Their breed dates to Egypt in 3BC.

### Example 2: Peccaries and Cacti

Peccaries are great predators of cacti, which form one of their favorite foods. When peccaries discover an untouched population of cacti, they go to work and quickly exploit the new source of this delicacy.

With lots of choice, and lots of new material to eat, peccaries naturally choose to consume those cactus plants with the fewest spines. Even with their tough mouths, they prefer to eat the cacti with 70 spines first, before going on to tackle the plants with 80 spines.

In this new, peccary-filled, environment, the cacti with more spines are better adapted, more fit, and get eaten less often.

As a result, at flowering time there are more cacti with higher spine numbers; thus, there are more of their alleles going into pollen, eggs, and seeds for the next generation.

Over long periods of time, in the constant presence of hungry peccaries, the population of cacti will gradually shift in the direction of the more heavily-spined cactus varieties. The later (newer) distribution curves will show a virtual absence of low-spine-numbered plants and a much greater preponderance of high-spine-numbered plants.

## Disruptive Selection

The following two scenarios are examples of disruptive selection. Each group will choose one scenario with no indication of which pattern it is. The students will then follow the directions on the Natural Selection worksheet.

### Example 3: The African Butterfly

In a **species** of African butterfly *Pseudacraea eurytus* the colorations range from a reddish yellow to blue. In both cases, these extremes of color, from different ends of the spectrum, look like (mimic) other species of butterflies that are not normally the prey of other the local predator group of birds and other insects. Those butterflies that are moderate in coloration are eaten in far greater numbers that those at the extremes of the color spectrum. As a consequence, those butterflies with extremes of coloration survive as a greater percentage of the population available to pass on those genes for coloration to the next generation.

### Example 4: Spiny Cacti

A population of spiny cacti is in genetic equilibrium, with no forces of selection acting on it, the distribution curve of number of cacti showing a particular number of spines is broad and symmetrical.

A road is built quite close to the study site, which keeps away the peccaries and the parasitic insects, but with the road comes the tourists.

In many desert areas of the United States, passing cactus aficionados like to pick up a souvenir cactus to take home with them after a day-trip out into the desert. This is a serious problem in some areas because the tourists always take the better looking cacti, and these happen to be the ones with the middle-spine-numbers.

Years of collecting have left their toll on the roadside cacti. In this environment, it is maladaptive to be good looking and have a reasonable number of spines. Low-spine-number plants are not picked because they don't "look right", and high-spine-number varieties are left alone because they are too hard to pick.

## Stabilizing Selection

The following two scenarios are examples of stabilizing selection. Each group will choose one scenario with no indication of which pattern it is. The students will then follow the directions on the Natural Selection worksheet.

### Example 5: Siberian Husky

Look at the Siberian Husky, a dog bred for working in the snow. The Siberian Husky is a medium dog, males weighing 16-27kg (35-60lbs). These dogs have strong pectoral and leg muscles, allowing it to move through dense snow. The Siberian Husky is well designed for working in the snow. If the Siberian Husky had heavier muscles, it would sink deeper into the snow, so they would move slower or would sink and get stuck in the snow. Yet if the Siberian Husky had lighter muscles, it would not be strong enough to pull sleds and equipment, so the dog would have little value as a working dog.

### Example 6: Peccaries and Spiny Cacti

The desert populations of spiny cacti are under attack. Peccaries are eating those plants with low-spine-number causing their alleles to vanish from the gene pool and enriching the remaining gene pool in those alleles that create cacti with high-spine-numbers.

Just as the community of cacti and peccaries are adjusting to one another, a second predator, a parasitic insect, arrives in the study area.

This insect lays its eggs at the base of the cacti's spines. When the grubs hatch, they bore into the cacti to eat the soft inner pulp, to grow, to pupate, and to emerge as new adults later in the year.

Preferring densely spined cacti, these egg-laying parasites more often destroy varieties of plants with larger numbers of spines. An infested cactus rarely survives.

In this new situation, with the cactus population under attack from a predator and a parasite, both extremes of spine value are being removed.

Peccaries are consuming the low-spine-number plants, and the insects are killing the high-spine-number plants. As these gene combinations are removed from the cactus gene pool, there is less and less variety possible in subsequent generations.

## Natural Selection Worksheet

**Names**______________________________

*Directions: Obtain a natural selection scenario. Carefully read the scenario and look for environmental pressures, biotic and/or abiotic, exerted on the population. Next, propose three questions which will help you to determine which pattern of selection your scenario illustrates. If you have difficulty, reread the section on natural selection in your text.*

*Once you have determined which pattern of selection your scenario represents, sketch a bell curve illustrating the original population. Then on the same graph, sketch the new curve obtained after the selective pressure has had an effect on the population. This will enable us to see the shift in the organism's distribution of traits from the 'original' population to that of the 'adapted' population.*

1. What is the environmental pressure on your population?

2. List three questions which will help you determine the selection pattern you chose.

    1.

    2.

    3.

3. Which pattern of natural selection did you choose?

4. How do you know?

5. Sketch your graph on the back of this page.

## Flashy Fish Data Table

*Fill in the blanks with the data you obtain after at least 6 generations. Then, below the table, write a brief summary. Do you see any trends? If so, what are they? Can you give any reasons for the trend(s)?*

| Predators ⇨<br>Initial Male Guppy Population ⇩ | 30 Rivulus | 30 Rivulus & 30 Acara | 30 Rivulus, 30 Acara<br>And 30 Pike Cichlids |
|---|---|---|---|
| Mostly Drab | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest |
| Even Mix of Drab and Bright | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest |
| Mostly Bright | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest | ____% brightest<br>____% bright<br>____% drab<br>____% drabbest |

**Brief Summary:**

**Natural Selection by Species Interactions**
**PowerPoint Presentation Rubric**

| | Advanced (4) | Proficient (3) | Developing (2) | Limited (1) |
|---|---|---|---|---|
| **Presentation is at least 8 slides long** | More than 8 slides | 8 slides | 6-7 slides | 5 or less slides |
| **Title slide with topic, group member names** | Topic and group members clearly stated on the first slide; picture added | Topic and group members clearly stated in the first slide | One of the two components is missing | This slide is omitted |
| **Information is put in students' own words** | Students always put content into their own words | With a rare exception, students put content into their own words | Students usually put content into their own words | Students rarely put content into their own words |
| **Presentation is completed on time and rehearsed** | Presentation is complete, students have practiced beforehand and are ready to present when the bell rings | Presentation is complete, but the students have not practiced beforehand; | Presentation is complete, but students need additional time to discuss logistics of presenting | Presentation is not complete |
| **Content slides provide examples and concrete details** | Presentation includes at least 8 examples / concrete details | Presentation includes at least 6 examples / concrete details | Presentation includes at least 4 examples / concrete details | Presentation includes less than 4 examples / concrete details |
| **Presentation follows a logical order** | Presentation flowed in a logical order at all times | Presentation flowed in a logical order most of the time | Presentation flowed in a logical order very little of the time | Presentation did not flow in a logical order; progression was interrupted and varied |
| **Presentation makes good use of pictures** | At least 4 appropriate pictures were used | At least 2 appropriate pictures were used | Pictures were used, but not at an appropriate time during the presentation | The use of pictures was minimal; many pictures were not suitable |
| **Content slides answer all questions posed on handout** | All of the questions were addressed and answered; supplementary information was added | All of the questions were addressed and answered | No more than 2 of the questions remained unanswered | 3 or more questions remained unanswered |
| **The Big Question is answered on the last slide** | The Big Questions was answered in detail | The Big Question was answered | Details concerning the Big Question were left out; student understanding is questionable | The Big Question remained unanswered |
| **Students present material clearly and effectively; confident body posture, consistent eye contact and clear enunciation** | Students are able to present material clearly and effectively close to 100% of the time | Students are able to present material clearly and effectively close to 75% of the time | Students are able to present material clearly and effectively close to 50% of the time | Students are not able to present material clearly and effectively |
| **Worksheet asks well thought our questions; all questions are covered in the presentation** | Worksheet asks applicable questions 100% of the time; all questions were covered in the presentation | Worksheet asks applicable questions 80% of the time; most questions were covered in the presentation | Worksheet asks applicable questions 60% of the time; about half the questions were covered in the presentation | Worksheet asks applicable questions less than half the time; few questions were covered in the presentation |
| **Group clearly shows independent investigative abilities** | Group was able to work independently on investigating topic with minimal teacher guidance | Group was usually able to work independently on investigating topic with minimal teacher guidance | Group was not usually able to work independently on investigating topic; needed teacher guidance | Group needed constant teacher guidance and was not able to work independently on investigation and research |

**PowerPoint Presentations Packets**
**Mutualism Packet**

- **Internet resources**
- **Video:** *Ancient Farmers of the Amazon*
  http://www.pbs.org/wgbh/evolution/library/01/3/l_013_01.html
- **Case Study:** Co-evolution of Plants and Pollinators
  http://www.pbs.org/americanfieldguide/teachers/insects/insects_sum.html
- **Big Question:** Do these organisms intend to help each other out?

This assignment is based upon your power of inquiry. Your task is to present a PowerPoint presentation based upon your research of the questions below. Logically, there will be questions that you formulate while conducting your research as well. Through your research, gather, organize, analyze and evaluate information related to all of these questions and develop an informative presentation concerning the coevolutionary nature of the mutualistic relationship. Additionally, your group must make a worksheet that the rest of the class can use to take notes on your presentation.

1. What is the purpose of mutualism?
2. If mutualism is advantageous for both organisms, what are the benefits to each?
   - Discuss examples you find in your research
3. In terms of biological change, what is the concept of coevolution?
4. How does the video "Ancient Farmers of the Amazon" serve as an example of coevolution within the context of a mutualistic relationship?
   - What is the relationship between the ants and the fungus? How does this relationship influence the way they evolve?
   - What is the relationship between the ants and the mold? What kind of evolution does this initiate?
   - Why was Cameron Currie's discovery of the bacteria on the ants' bodies so amazing?
5. Your case study involves the coevolution of plants and pollinators.
   - Why are the pollinators so important to the flowers?
   - Why are pollinators so willing to do all the work of pollinating flowers? What's in it for them?
   - Why are a variety of pollinators so important to our ecosystem?
6. Answer the Big Question.

**Make sure your presentation includes the following criteria:**

- Presentation is at least 8 slides long
- Title slide includes topic and names of group members
- Content slides providing sufficient information to educate the class
- Information is put in your own words
- Presentation is completed on time
- Content slides provide examples and concrete details
- Presentation follows a logical order
- Presentation is in your own words
- Presentation makes good use of pictures to further make a point
- Content slides answer all of the questions posed above
- The Big Question is answered on the last slide

**Parasitism Packet**

- **Internet resources**
- **Case Study:** *Fighting Malaria* http://www.pbs.org/safarchive/4_class/45_pguides/pguide_702/4572_malaria.html
- **Video:** *A Mutation Story*
- http://www.pbs.org/wgbh/evolution/library/01/2/l_012_02.html
- **Case Study:** Bunnies in the Outback http://library.thinkquest.org/03oct/00128/en/rabbits/history.htm
- **Big Question:** What is the Red Queen hypothesis? Did your example have this characteristic?

This assignment is based upon your power of inquiry. Your task is to present a PowerPoint presentation based upon your research of the questions below. Logically, there will be questions that you formulate while conducting your research as well. Through your research, gather, organize, analyze and evaluate information related to all of these questions and develop an informative presentation concerning the coevolutionary nature of the parasitic relationship. Additionally, your group must make a worksheet that the rest of the class can use to take notes on your presentation.

1. What is the purpose of parasitism?
2. Is parasitism advantageous for both organisms? What are the benefits? The detriments?
   - Discuss examples you find in your research
3. In terms of biological change, what is the concept of coevolution?
4. How does the case study "Fighting Malaria" serve as an example of coevolution within the context of a parasitic relationship?
   - What are the benefits to the Plasmodium parasite?
   - Why are there two hosts needed?
   - Of what advantage is there in being heterozygous for the sickle-cell trait?
   - Do you think the demographics of malaria and sickle-cell anemia are a coincidence? Why or why not?
   - Do you think the parasite and the human immune system are coevolving? Why?
5. Your other case study involves the coevolution of rabbits and a virus, Myxoma
   - How was the Myxoma virus used to control the rabbit population?
   - Of what importance would a 'specie-specific' virus be in this case?
   - What caused the rabbit population to recover after the initial population crash?
6. Answer the Big Question.

Make sure your presentation includes the following criteria:

- Presentation is at least 8 slides long
- Title slide includes topic and names of group members
- Content slides providing sufficient information to educate the class
- Information is put in your own words
- Presentation is completed on time
- Content slides provide examples and concrete details
- Presentation follows a logical order
- Presentation is in your own words
- Presentation makes good use of pictures to further make a point
- Content slides answer all of the questions posed above
- The Big Question is answered on the last slide

**Competition Packet**

- **Internet resources**
- **Case Study:** Intraspecific Coevolution of the Anolis Lizard
  http://books.google.com/books?id=ydCJC26WCNQC&pg=PA91&lpg=PA91&dq=Anolis+lizard+fauna+of+the+Caribbean+coevolution&source=web&ots=cKFwOBdz9J&sig=1kSLHINNwSCEB36s7WXILNqYkEY&hl=en&sa=X&oi=book_result&resnum=4&ct=result
- Case Study: Coevolution of Weeds and Crops
  http://books.google.com/books?id=uK9R7N-QaJMC&pg=RA1-PA69&lpg=RA1-PA69&dq=weeds+and+crops+coevolution&source=web&ots=546CaxXQU4&sig=LOptmSfFp_1Q4TLrq7ZFH2IHcXg&hl=en&sa=X&oi=book_result&resnum=1&ct=result
- **Video:** *Biological Invaders*
  http://www.pbs.org/wgbh/evolution/library/10/3/l_103_03.html
- **Big Question:** In your opinion, what is the most invasive species of all?

This assignment is based upon your power of inquiry. Your task is to present a PowerPoint presentation based upon your research of the questions below. Logically, there will be questions that you formulate while conducting your research as well. Through your research, gather, organize, analyze and evaluate information related to all of these questions and develop an informative presentation concerning the coevolutionary nature of the competitive relationship. Additionally, your group must make a worksheet that the rest of the class can use to take notes on your presentation.

1. What is the purpose of the competitive relationship?
2. Is competition advantageous for both organisms? What are the benefits? The detriments?
   - Discuss examples you find in your research
3. In terms of biological change, what is the concept of coevolution?
4. How does the video "Biological Invaders" serve as an example of coevolution within the context of a competitive relationship?
   - Why is the brown tree snake considered an invasive species?
   - Why are invasive species so successful?
   - What does the brown tree snake compete with?
5. Your case studies involve the coevolution of weeds and agricultural crops and the coevolution of the anolis lizard..
   - How do weeds and crops compete? What do they compete for?
   - Does a native species have an advantage over an exotic species? If so, what are they?
   - What is the human role in this relationship?
   - How do the two sizes of lizard point to coevolution through a competitive relationship?
6. Answer the Big Question.

Make sure your presentation includes the following criteria:

- Presentation is at least 8 slides long
- Title slide includes topic and names of group members
- Content slides providing sufficient information to educate the class
- Information is put in your own words
- Presentation is completed on time
- Content slides provide examples and concrete details
- Presentation follows a logical order
- Presentation is in your own words
- Presentation makes good use of pictures to further make a point
- Content slides answer all of the questions posed above
- The Big Question is answered on the last slide

**Predator / Prey Packet**

- **Internet Resources**
- **Case Study:** *The Arms Race* http://evolution.berkeley.edu/evosite/evo101/IIIF1Armsrace.shtml
- **Case Study:** *Squirrels, Birds and the Pinecones They Love* (further example)
- **Video:** *Toxic Newts* http://www.pbs.org/wgbh/evolution/library/01/3/l_013_07.html
- **Big Question:** Why do pronghorn antelope run so fast? There isn't a predator on the continent that can chase it down.

This assignment is based upon your power of inquiry. Your task is to present a PowerPoint presentation based upon your research of the questions below. Logically, there will be questions that you formulate while conducting your research as well. Through your research, gather, organize, analyze and evaluate information related to all of these questions and develop an informative presentation concerning the coevolutionary nature of the predator/prey relationship. Additionally, your group must make a worksheet that the rest of the class can use to take notes on your presentation.

1. What is the purpose of the predator/prey relationship?
2. Is the predator/prey relationship advantageous for both organisms? Who benefits?
   - Discuss examples you find in your research
3. In terms of biological change, what is the concept of coevolution?
4. How does the video "Toxic Newts" serve as an example of coevolution within the context of the predator/prey relationship?
   - Why is the newt becoming more and more toxic?
   - How does the garter snake respond to this?
   - Are there other effects on the snake? Is this effect beneficial? Why or why not?
   - Do you think this coevolution can go on forever? Why or why not?
5. Your case study involves the coevolution of the Murex snail and the crab.
   - How do the snails protect themselves?
   - How does the crab respond?
   - Why these examples are called 'The Great Arms Race'?
6. Answer the Big Question.

**Make sure your presentation includes the following criteria:**

- Presentation is at least 8 slides long
- Title slide includes topic and names of group members
- Content slides providing sufficient information to educate the class
- Information is put in your own words
- Presentation is completed on time
- Content slides provide examples and concrete details
- Presentation follows a logical order
- Presentation is in your own words
- Presentation makes good use of pictures to further make a point
- Content slides answer all of the questions posed above
- The Big Question is answered on the last slide

**Final Unit Plan**
**Earth Systems: Inside and Out**
**Jessica Hanson**

## Geologic Time Scale and Crookston Geologic History

As I was thinking of how to take some of the knowledge I learned during this class to my students, I felt that they would benefit most from lessons created to enhance their knowledge of geologic time and Crookston geologic history. During weeks 2-3 of this class, we focused on relative and absolute dating of rocks as well as local geologic features and I find both topics to be difficult to teach to my students.

Geologic time, dating of rocks, and geologic events are difficult for students to grasp since they deal with such long time periods and large numbers which tend to make them shy away. It is important for students to understand how our earth has changed over the immense time since earth began. By completing the activity dealing with relative dating of rocks, the students will be able to understand the principles of superposition and that index fossils can give you an idea of how old a rock layer is compared to another rock layer.

After the second activity, The Half-Life of Twizzlers and M&Mium, the students will be better able to understand the absolute dating that scientists use. They will be able to describe what a half-life is and how it relates to absolute dating of rocks.

Finally, they will complete an activity that will enable them to reconstruct the geologic events that have formed Crookston's land features the way they are today. They will be able to be creative in telling their version of Crookston's geologic story by designing a graphic representation of the events and presenting them to class. This final presentation will serve as the summative assessment for the unit.

## Unit Plan

***Intended Learners*:**

My 8th grade earth science class (with possible extensions added to an environmental science class in the future)

- My 8th grade class is generally composed of 13-14 year old students of varying motivation, ability, and interest in earth science. They are familiar with classroom procedures and inquiry-based learning before this lesson will be taught.
- This unit will encompass small group to large group learning and sharing of information.

***Minnesota State Science Standards Addressed in this unit:***

8.I.B.1 – The student will know that scientific investigations involve the common elements of systematic observations, the careful collection of relevant evidence, logical reasoning, and innovation in developing hypotheses and explanations.

8.I.B.2 – The student will describe how scientists can conduct investigations in a simple system and make generalizations to more complex systems.

8.III.A.2 - The student will describe how features on the Earth's surface are created and constantly changing through a combination of slow and rapid processes of weathering, erosion, sediment deposition, landslides, volcanic eruptions, and earthquakes.

8.III.A.4 – The student will interpret successive layers of sedimentary rocks and their fossils to document the age and history of the Earth.

8.III.A.5 – The student will recognize that constructive and destructive Earth processes can affect the evidence of Earth's history.

***Topics*:**

Since the concept of geologic time is a difficult one for students to grasp, I focused this unit plan around three of the questions posed during our class. They are:

1) How, where and why would you look for evidence of a rock's age?
2) Why do you think time is important in the study of Earth?
3) How do geologists use the idea of "the present is the key to the past" in studying geology?

This unit plan will address geologic time, both relative and absolute dating, and how it connects to Crookston's geologic history. To start, the students will become familiar with relative dating using rock columns with fossils and determining the relative ages of the fossils and rock layers. This lesson will be followed by an activity designed for the students to find out about absolute dating using Twizzlers and M&Ms. Finally, the students will create geologic timelines including major events in the geologic history of Crookston. They will finish by presenting their "geologic story" to the class for their summative assessment.

***Curriculum Links*:**

This unit will follow units involving the rock cycle, weathering, erosion and deposition, plate tectonics, earthquakes, and volcanoes and will be followed by a unit featuring oceanography. This unit will serve as a culmination in the study of earth processes that begin the year. This unit will allow the students to use all the knowledge during the earth processes section of the year to put together the story of why Crookston looks the way it does now. They will be able to put a time on the major events happening in Crookston's history and will allow the students to demonstrate their knowledge. Since this unit will serve as the ending of a larger unit, we will move onto a unit containing oceanography. This oceanography unit will make use of the eras in Crookston's history when the area was covered by oceans to demonstrate why knowing about the oceans is essential even though we live thousands of miles away from the nearest one.

***Objectives*:**

- Students will be able to distinguish relative dating from absolute dating and the importance of each.

- Students will be able to organize Crookston's geologic events in the order in which they occurred.
- Students will be able to explain half-lives of elements and how it is used in absolute dating of rocks.
- Students will be able to work harmoniously in small groups.
- Students will be able to organize their data and complete all questions in each activity.
- Students will be able to relay Crookston's geologic history in a story format to the class.

***Materials***

Activity 1 Materials list (Who's on First? A relative dating activity)

Each student group will need:

- Set of nonsense syllables
- Set of fossils
- Paper
- Pencil/pen

Activity 2 Materials List (Half-Life)

Each student group will need:

- 2 Twizzlers
- 50 M&Ms
- plastic cup
- white paper
- graph paper

Activity 3 Materials List (Geologic Time Scale I)

Each student group will need:

- 5 meters of copy paper taped together
- glue
- scissors
- meter stick
- tape
- Geologic Time Scale Pre-Questionaire
- "Making a Time-Line" direction sheet
- Crookston geologic events

***Time*:**

This unit will take at least one week to complete and could possibly be extended to encourage completeness and creativity on the geologic story.

***Scope and Sequence (Day to Day procedures--adapted from lessons found in the resources):***

Day One

*This activity adapted from Who's on First? A relative dating activity, http://www.ucmp.berkeley.edu/fosrec/BarBar.html)*

1) Bellringer activity: Pre-assess students understanding of relative and absolute dating by asking thumb up or thumbs down questions.
   A) Do you think there is a way to tell which rock layers are oldest? How?
   B) Is there a way to tell the exact birthdate of rocks?
   C) Do rocks have "birthdates"? (Hint: Think back to the rock cycle… is there a beginning?"
2) Next split the students into small groups and hand out materials for the relative dating activity.
3) The students will try to put the nonsense syllables in the correct order, stacked on top of each other. Allow the students to struggle with this for a time.
4) After each group has finished, the groups should share with the others how they put their cards in order. Establish the correct order by comparing groups.
5) The students should write their syllables in the correct order on their paper.
6) Discuss the relative ages of the syllables, such as how you know that "x" layer is older than the "m" layer.

Next, use the same procedure with the sketches of fossil cards.

In conclusion, use these discussion questions:

A) Which fossil organisms could possibly be used as index fossils
B) Name three organisms represented that probably could not be used as index fossils and why.
C) In what kinds of rocks might you find the fossils from this activity?
D) What is the Law of Superposition and explain how this activity illustrates this law.
E) How would this relative dating help you to determine the exact age of the rocks or fossils?

Day Two

*This activity is adapted from Calculating Half-Lives of Twizzlers and M&Mium accessed at The Science Behind our Food website, http://apps.caes.uga.edu/sbof/main/index.cfm?page=resources*

1) Bellringer activity: Review relative dating from yesterday
2) Introduce absolute dating and the difference between relative and absolute dating, why each are used, and split the students into groups
3) Hand out materials needed, 2 twizzlers, 2 sheets of graph paper
4) Procedures for students in small groups

A) Measure the length of the twizzler and record on the y axis of the graph paper
B) Give students the direction to eat ½ of the twizzlers length.
C) Measure the new length of the twizzler. Record the length of the twizzler at the next point of the x axis.
D) Repeat, 2-4 times depending on the length of the twizzlers you started with. (the longer the twizzlers, the more steps you can take before using the whole thing)
E) Draw a line to connect the lengths using a smooth line. (Do not connec the dots with straight lines!)
F) Review how to make a graph, and add title, labeling the axis, and add color.

5) Repeat this procedure except tell students to bite ½ of the twizzler every 45 seconds and record on the graph paper. Again, draw a smooth fit line.

6. On the back of the graph paper, the students will answer the following questions. After all groups are finished, we have a large group discussion.

A) Did the Twizzler ever totally disappear? Why not?
B) If you continued eating half the twizzler, will it ever disappear?
C) What was the half-life of the Twizzer on the second graph paper?
D) How do you know?
E) If you had started with a twizzler twice the size, what would your graph look like?
F) How about ½ the size?

Determining the Half-Life of M& Mium

1) Deliver the materials to the students while still in their small groups.
2) Count the number of radioactive M&Mium atoms you receive. Record the total number you start with on your data table.
3) Shake the cup.
4) Pour your M&Mium atoms on the desk. The atom has decayed if you can no longer see the M on the atoms. (They are upside down). Since they are no longer radioactive, they are safe to eat! Make sure all group members get to eat the safe atoms! As you eat them, make sure to count how many atoms have decayed on your data table.
5) Continue this procedure until you have no radioactive atoms remaining. Make sure to record how many decay each time you pour out the atoms.
6) Construct a graph to show how many atoms decayed each half-life. Make to label the axises and to give the graph a title.
7) From your data table or graph, What is the half-life of M&Mium? (How many shakes does it take to decay the numbef of M&Mium to half?)

Day 3-5

*This lesson plan is based on Tamara McDaniel's Geologic Time Scale I from www.geology.wisc.edu/~museum/hughes/GeoTimeScale1.html

1) Bellringer activity: Review relative and absolute dating. Discussion about geologic time to just introduce the lesson. This lesson will be designed to be inquiry-based, so introduction should only introduce without giving a lot of information.
2) Split the students into groups of four. Groups should be two girls, two boys.
3) Start with Geologic Time Scale Questionaire
   A) The students will probably know some of the questions and definitely not others. They should answer questions to the best of their abilities.
   B) Collect Questionaires. They will get these back at the end of the lesson so that they can correct their answers before they finish.
4) The students will follow the Making a Geologic Time Line directions to construct their time lines.
   A) Take a few minutes to review how to figure out million years into cm.
   B) Use the Crookston Geologic Events to plug into the timeline.
5) Include pictures of what Crookston would look like during each time period. Draw these right on the time line.
6) Follow the rubric and directions to write Crookston's geologic time story. Decide who will read the story and illustrate it.
7) This activity will take 1 day to make the timeline and pictures. 1 day to write the story and to illustrate. At least 1 day to do presentations of the stories.

**Supplementary Materials:**

These worksheets, directions, and rubric can be found at the end of the unit plan.

**Assessment of Students:**

Activity One: Participation in group work, correct timeline of nonsense syllables and fossil sketches (completion points)

Activity Two: Correctly graphed data and answered questions (graphs will be checked to make sure they have each required part, and the questions will be graded)

Activity Three: Correctly constructed time line, completed questionnaire, rubric for presentation of Crookston's geologic story (their timelines and questionnaires will be graded using completion points, and their stories will be graded using the rubrics in the supplementary materials)

**Evaluation of Unit:**

I will look at the number of students/groups who do the activities successfully and try to make improvements in directions for the next year. The rubric will provide a more objective way to grade the Geologic Story and a way for students to know what their grades will be when they are finished. Over all, I think that if the students are able to accomplish the objects set out at the beginning of the unit plan, I will consider it a success while keeping in mind that there are always improvements that can be made.

**Conclusion:**

I am looking forward to trying out this unit this coming school year. I have struggled to teach geologic time and Crookston's geologic history in a meaningful way, and I think that the inquiry-based lessons contained here will help. For students to really appreciate our earth, they need to know how it works. It is important for them to connect with the way natural processes happen, and by being able to understand a bit about our local geologic history they will be able to identify reasons to become stewards of our planet.

**Resources (broken down by activity, and includes supplementary materials and websites):**

**1. Minnesota State Science Standards.**
http://education.state.mn.us/MDE/Academic_Excellence/Academic_Standards/Science/index.html. Accessed July 22, 2009.

- These are the 2003 academic standards that are located 2/3 of the way down this page. Our standards are in the process of changing, but these standards should show up again in the new 2009 versions.

**Activity One:**

This activity is located at: http://www.ucmp.berkeley.edu/fosrec/BarBar.html

Who's on First: A Relative Dating Activity by Marsha Barber and Diana Scheidle Bartos

- The set of nonsense syllables and fossil sketches are also available on this page
- I would probably enlarge the syllables and sketches when I used these in my classroom, but since they are set up very nicely, I would use them as is.

**Activity Two:**

This activity is located at:
http://apps.caes.uga.edu/sbof/main/lessonPlan/Calculating%20Halflife%20Twizzlers%20MMs.pdf

Calculating the Half-Life of Twizzlers and M&Mium (I couldn't find authors of this activity)

- This website provides the data tables and graph paper that the students will need to do this activity, and I would use them as is

**Activity Three:**

This activity is located at: http://www.geology.wisc.edu/~museum/hughes/GeoTimeScale1.html and was written by Tamara McDaniel

- This activity has great directions to building a time line for the students, and I would use them. I would create a list of the geologic events from Crookston's history and use them instead of the more general geologic events.
- I would modify the questionnaire to include questions about Crookston's geologic history.
- Below is the rubric I would use to grade the presentation of the geologic stories.

**Oral Presentation Rubric : Crookston's Geologic Story**

Teacher Name: **Mrs. Hanson**

Student Name: ______________________________

| CATEGORY | 10 | 7 | 5 | 3 |
|---|---|---|---|---|
| Content | Students incorporate at least 5 geologic events in Crookston's history in the correct order into their stories. | Students incorporate 4 geologic events in Crookston's history mostly in the correct order. | Students incorporate 3 geologic events in Crookston's history and they may be out of order. | Student incorporates 2 or less geologic events or they are out of order. |
| Collaboration with Peers | Almost always listens to, shares with, and supports the efforts of others in the group. Tries to keep people working well together. | Usually listens to, shares with, and supports the efforts of others in the group. Does not cause "waves" in the group. | Often listens to, shares with, and supports the efforts of others in the group but sometimes is not a good team member. | Rarely listens to, shares with, and supports the efforts of others in the group. Often is not a good team member. |
| Preparedness | Student is completely prepared and has obviously rehearsed. | Student seems pretty prepared but might have needed a couple more rehearsals. | The student is somewhat prepared, but it is clear that rehearsal was lacking. | Student does not seem at all prepared to present. |
| Presentation | Student participates in presentation, speaks clearly, and uses visual aids. | | | Student does not participate in group presentation. |

Date Created: **Jul 22, 2009 12:40 pm (CDT)**