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Evaluation of a Combination Approach to Pedagogy in a Soil Science Laboratory Classroom and an Environmental Site Assessment Sample

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Evaluation of a Combination Approach to Pedagogy

in a Soil Science Laboratory Classroom and an

Environmental Site Assessment Sample

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A thesis submitted to the faculty of
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ABSTRACT

Evaluation of a Combination Approach to Pedagogy
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Chapter 1 of this study explores research that has shown that the use of technology in the classroom can be beneficial to student learning. Additionally, a need for Environmental Site Assessment (ESA) instruction in university level core environmental science classrooms has been demonstrated. This study includes an investigation of the potential benefits of using a combination of pedagogies: web-based teaching tools and ESA instruction in a laboratory classroom. The research design included two class formats, one that employed web-based tools (PowerPoint and video) and ESA instruction, and one that did not, with four class sections. All classes were taught by the same instructor and teaching assistant. Weekly quizzes, labs, a final exam, informal interviews and a student survey were used to measure effectiveness of the teaching tools. Significant improvement was exhibited on application questions featured on the final exam with the experimental group scoring higher on 6 of the 15 questions. Additionally, students' preparation and enthusiasm was improved among the experimental groups. Student ratings and performance for the two different formats were similar. Success in the class may depend on the students' preparation and personal desire to succeed. In conclusion, these results suggest that a combination of pedagogies that employs web-based tools and ESA instruction in the laboratory classroom may improve student's preparation for class activities and acquisition of career skills, as well as their enjoyment and enthusiasm to participate in class activities.

Chapter 2 represents a sample of the required application activity from the soil science class. It includes the background, test results, procedures, conclusions and recommendations for an Environmental Site Assessment (ESA). ESA instruction is arguably an important addition to soil science curriculum and as such is demonstrated here as an example of the skills displayed and information applied by students who are instructed in writing ESAs.

Keywords: science education, soil science, PowerPoint, technology, laboratory classroom, ESA, Wallsburg, UT

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Abstract

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Research has shown that the use of technology in the classroom can be beneficial to student learning. Additionally, a need for Environmental Site Assessment (ESA) instruction in university level core environmental science classrooms has been demonstrated. This study includes an investigation of the potential benefits of using a combination of pedagogies: web-based teaching tools and ESA instruction in a laboratory classroom. The research design included two class formats, one that employed web-based tools (PowerPoint and video) and ESA instruction, and one that did not, with four class sections. All classes were taught by the same instructor and teaching assistant. Weekly quizzes, labs, a final exam, informal interviews and a student survey were used to measure effectiveness of the teaching tools. Significant improvement was exhibited on application questions featured on the final exam with the experimental group scoring higher on 6 of the 15 questions. Additionally, students' preparation and enthusiasm was improved among the experimental groups. Student ratings and performance for the two different formats were similar. Success in the class may depend on the students' preparation and personal desire to succeed. In conclusion, these results suggest that a combination of pedagogies that employs web-based tools and ESA instruction in the laboratory classroom may improve student's preparation for class activities and acquisition of career skills, as well as their enjoyment and enthusiasm to participate in class activities.

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Introduction

Advances in and an increasing dependence on technology in everyday life necessitates the use of technology to fuel and supplement learning in the laboratory classroom. While there is an ever growing and evolving pool of data related to the use of innovative technology in the classroom, there are many approaches and tools that are never formally evaluated (Shephard, 2003). Additionally, the methods that are evaluated and reported on often focus on success, while failures are less likely to be published (2003). Further, there are even less studies reported on involving an approach that introduces technology in the science laboratory. Therefore, there is a need for research on the use of technology in the laboratory classroom.

While instructors may be hesitant to make large-scale changes to utilize technology in their teaching, it is evident that an ever-evolving academic and professional world is a different place than when many started teaching. Some have suggested that higher education must adapt to the changing environment and that more efficient knowledge creation and distribution methods can fuel successful changes (Kim, 2010). Others advocate the use of webcasts and podcasts as a means of utilizing technology in order to more efficiently distribute learning materials in the science classroom, though this approach comes with limitations (Traphagan Kucsera, & Kishi, 2010). Despite the potential benefits of using technology to enhance learning, researchers claim that "instructors often hesitate to integrate new products or technology into their courses without evidence that it will benefit student learning" (2010).

Within the discipline of environmental science, a need for instruction on Environmental Site Assessment (ESA) writing has been demonstrated to prepare students for careers. Similarly, advantages of inquiry-based and project-based instruction have been highlighted (St. John & Callahan, 2003; Juhl, Yearsley, & Silva, 1997; Wee & Shepardson, 2004).

In the current study we seek to evaluate the effectiveness of using a combination of selected pedagogical methods on student performance and attitude. Specifically, web-based tools (PowerPoint and video clips accessed via the web) and ESA instruction were used to explore the potential benefits of a combination approach in a soil science laboratory class.

Literature Review

Technology as a pedagogical tool

Video has been used widely in a variety of classroom settings with a range of outcomes. One study reports that webcasts used in a university level geology class may have a positive effect on student learning and performance, but found that webcasts also had a negative effect on class attendance (Traphagan et al., 2010). However, while the availability of PowerPoint slides had a greater negative impact on attendance, the ability to watch webcasts nullified the effects of missing class (2010). Additionally, researchers found that viewing webcasts was associated with higher class performance (2010). These findings suggest that the advantages of both PowerPoint slides and video may be maximized if there was a way to overcome the negative impact they had on attendance.

The merits of video over textbook learning in the laboratory classroom have been documented widely. A study evaluating the use of streaming video to support learning in a life sciences course concluded that “abstracting real-life scenarios into text often results in over-simplification, while video may lead to a better description by the teacher and enhanced visualization, recognition and identification by students” (Green Voegeli, & Harrison, 2003). In one case study, Larkin (2002) compared the use of a video made to help learners acquire procedural skills to a written handout and an illustrated PowerPoint® presentation. In terms of students’ perceptions of ease and quality of learning, the written handout was the best and the video the worst, but the tests show that average scores for all three tools used were high. Interestingly, overall success was dependent primarily on the enthusiasm and persistence of the instructor, not on the learning tool (Shephard, 2003). This finding implies a combination approach may work well and that enthusiasm of the instructor is vital.

Disciplines outside of the science realm have also utilized video segments (created to replace lecture material) to enhance learning. In a study conducted at the University of Arkansas at Little Rock, an instructor videotaped all learning activities and converted them to movies that highlighted best practices for students in a foreign language/English as a second language methods course (Dhonau & McAlpine, 2002). Students could view the videos over the internet and watch videos made by peers and professors on the course web page at any time. The instructors utilized this resource because there was too much material to cover in the classroom and it allowed them to free up some classroom time for discussion and active learning. Responses from students about the usefulness and effectiveness of the videos were positive (2002). This finding highlights a potential benefit to instructors; increasing the resources made available to students outside of class results in more class time for discussion.

Another study on the use of video technology used web lectures (videos of lectures about 20 minutes long) to allow for more in-class time for hands-on learning activities (Day & Foley, 2006). This study was a quasi-experiment that took place over a 15-week course. Two sections of 46 students were taught and tested, one section with web lectures and one with traditional lectures. The results indicate that the experimental group (the web lecture section) had significantly higher grades and did better on all assignments and tests (2006).

A further study was conducted in a dental school where video recordings of dental school lectures were *requested* by the students (Brittain Glowacki, Ittersum, & Johnson, 2006). The school chose to use podcasts (audio recordings available on the web) instead of video in an effort to meet the students' needs. In a self-report survey approximately 87% of the of students who reported using the media sources (about a third of the class failed to complete the survey) said that they felt the podcasts had a positive effect on their grades (2006).

In a study on science education and pedagogical tools, McLaughlin (2010) stated that "technology can enable experiential teaching and learning in the 21st century classroom, making science education more rigorous, relevant, and based on relationships that extend beyond academic walls." In her study, attitude surveys were used and responses from students indicate that this generation considers technology a part of their daily life, suggesting a level of comfort and familiarity with technology that may make technology easier to introduce than in the past (2010).

At present, students entering college often expect technology to be integrated into their learning environment, just as it is outside of the classroom (Solheim Longo, Cohen, & Dikkers, 2010). "PowerPoint, although one of the most frequently used presentation programs, is rarely used to its full advantage by faculty," as a means of integrating technology into the classroom (Ruffini, 2009). Slide show presentation software (SSPS), including PowerPoint, helps organize and enhance the delivery of curriculum content while accommodating students of various ages, backgrounds and learning styles (2009). Additionally, Selimoglu and Arsoy (2009) indicate that "teaching with PowerPoint presentations enforces learning effectiveness by stimulating student's imagery systems."

Research suggests that when preparing PowerPoint presentations it is best to use high-quality photographs or line-art rather than amateurish clip-art, and use a variety of presentation methods (i.e. slides, questions, discussion, video clips); while avoiding distracting backgrounds, gratuitous dissolves, spins and other transformations (Delwiche & Ananthanarayanan, 2004). Additionally, it is recommended that no more than seven bullet points be used on a slide, that only essential information be included, that the font and font size should be appropriate and legible and that a dark text should be used on a light background (Ruffini, 2009).

Further support of the use of video to enhance learning can be found in a study on instructional videos. Hibbert (2014) claims that "video has the ability to convey material through auditory and visual channels, [thus] creating a multisensory learning environment." He found that when a video displayed how an assignment needed to be completed it got more views, about three times as many views as there were students in the class. The researchers also indicated that a video is not useful if the students could read the same information and not gain anything less, meaning videos should show more than what text can describe.

Overall, these studies show the potential benefits of using technology, specifically PowerPoint and video resources to aid in instruction. Benefits highlighted include: helping students visualize things that a textbook could never adequately describe; teaching procedural skills; creating more time for in-class activities, discussion and hands-on learning; and utilizing a resource that students feel is an integral part of their every day lives. The literature on this subject is void of studies that incorporate video and SSPS in the *laboratory* classroom as a means of enhancing student performance and experience.

Career skills acquisition pedagogy through ESA instruction

Most universities that offer a BS program in Environmental Sciences are designed to provide broad training in the fundamentals of the subject in order to allow students to compete for a wide variety of jobs. While this is a valuable framework, Neil Hansen, Ph.D. faculty of Brigham Young University, has that there is also great value in including training in specific applicable skills that will make students more competitive for careers (personal communication, April 1, 2014). Hansen conducted a study of jobs related to the Environmental Sciences and reported on a variety of factors including relevant job duties and technical skills. He found that among the most common duties were: the ability to write professional reports and permits, supervision of a project, teamwork, and the analysis and interpretation of test results. In addition to this finding, he discovered that a coveted skill in a new employee is the ability to perform and prepare an ESA.

The study conducted by Hansen offers a unique perspective into the importance of technical writing and knowledge of ESAs and how to prepare them. Though this study is currently unique, the data are relevant and useful as they surveyed *current* job listings and the requirements for hire. Students need to be equipped with skills that will help them to be hired. This suggests a need for increased writing experiences in core classes, as well as specific instruction on ESAs. Currently, the Brigham Young University program for a BS in Environmental Science requires a technical writing class and core classes in biology, chemistry, environmental science, and soil science, with many electives in various branches of the field. However, few of these core classes offer instruction on ESAs. Additionally, St. John and Callahan (2003) found that an ESA project as a tool to incorporate directed-inquiry learning was an effective means of improving student learning and experience. They studied a college-level introductory geology course that required students to participate in a semester-long project on the geology of their home property. The students were given general guidelines and requirements and were directed to resources to collect information. End-of-the semester surveys revealed positive reactions from 36 participating students and only three negative reactions which were related to workload. Final grades of students in the ESA project classes were compared to those who were not required to do the ESA project and mean GPAs showed evidence of improved learning among participants in the ESA project group (GPA=2.69 for ESA group and 2.17 for non-ESA group). Researchers were successful in accomplishing their goal to make geology more relevant to non-science majors.

Another study was conducted in a capstone class at a technical college in which an interdisciplinary approach to project-based learning was implemented (Juhl, Yearsley, & Silva, 1997). Students were required to complete a project that was designed to enhance training and employability for students chemical and environmental technician associate degree programs. The project required sampling and analysis of a local river. Lectures were not given during the duration of the project. Rather, time was devoted to allowing students to run tests on their samples. This course was one of the final courses in the associate program and was a demonstration of knowledge acquired as well as a means to allow students to develop employability skills through experience. Skills utilized that would improve students' resumes for employment included "computer graphing, word processing, oral and written communication, organization and conflict resolution" (1997). These findings suggest that an extensive, interdisciplinary project offers a meaningful alternative to teaching via traditional science lecture.

Others report on the merit of field-trips as an effective supplement to classroom and laboratory instruction in college-level ecology courses (Lei, 2010). They found that students often prefer field trips and corresponding activities over indoor class and laboratory exercises "because they were more realistic, interesting, and interactive" (2010). For these reasons field-trips may be not only necessary, but also a meaningful part of a project-based experience.

According to the National Research Council (NRC, 2000), science teaching should be inquiry based, meaning it moves learners beyond merely hands-on experiences to experiences that allow them to be actively engaged in discovering phenomena, exploring interesting possibilities, and making sense of scientific ideas (2000). In addition, the NRC has developed a list of five essential features of inquiry-based teaching including: learners generating investigate-able questions, planning and conducting investigations, gathering and analyzing data, explaining their findings, and sharing and justifying their findings with others (2000). Wee and Shepardson (2004) investigated student perceptions of inquiry-based pedagogy related to environmental concepts and issues. They concluded that students perceived the environmental inquiry-based experiences to be nontraditional in the approach to teaching and assessment. Researchers also suggest that there may be implications to students' interest in and attitude toward science in using inquiry-based pedagogy (2004). They cite Shymansky, Kyle and Alport (1983) whose meta-analysis of curricula revealed that inquiry-based science teaching can lead to more positive attitudes toward science. Wee and Shepardson (2004) call for additional research in this area.

Using a combination of pedagogies that employs technology, including PowerPoint and video, and Environmental Site Assessment instruction has not been examined. Though similar studies incorporating individual pedagogies have proven successful, none claim the benefit of improving student learning, preparation, career skills, *and* perceptions. We hope to provide evidence that all of these benefits are attainable through a combination of pedagogies.

Research Hypothesis

Soil science students who experience an enhanced learning setting through a combination of pedagogical tools including web accessed PowerPoint slides and videos and Environmental Site Assessment instruction, will have higher performance, preparation and an overall better experience. The mean scores on graded quizzes, lab reports, and a final exam will be greater in the experimental group. Additionally, instructor and teaching assistant perception of students' preparation for lab activities will be greater in the experimental groups and students' self-report end-of-semester surveys will reveal a better perception among students in the experimental group of their overall experience and learning by the end of the semester.

Sample

The study was conducted in Fall semester 2013 and Winter semester 2014 using four sections of the soil science laboratory class (PWS 283) in the Department of Plant and Wildlife Sciences in the College of Life Sciences at Brigham Young University. Students were not randomly assigned to the sections; they were self-assigned as students enrolled in whichever class best fit their schedule. However, students choosing a lab were unaware of the differences between sections. The class sections met at the same time but on different days (Tuesday or Wednesday from 1 to 4 p.m.). The control classes met on Tuesday for the first semester and Wednesday the second semester and vice versa for the experimental classes in an effort to eliminate any weekday bias. A total of 40 students enrolled in the control classes and 44 students enrolled in the experimental classes.

Demographics of the classes were assessed to determine equivalence of the samples (Table 1.1). Demographic information was provided in a self-report format, with three students failing to complete the survey and, thus, not included in the comparison. The control classes had 5% less males than the experimental group. Ages of students ranged from 18 to 41 with 86.4% of students falling into the 18-24 range, with the average age of the control and experimental classes being 22.1 and 22.4 respectively. The experimental classes had 9.1% more married individuals than the control classes. The Department of Plant and Wildlife Sciences has four possible majors for students to declare, with three of those requiring the PWS 283 course (Environmental Science, Wildlife and Wildlands Conservation, and Landscape Management). All but 10 students participating in this study had one of these as their declared major, with five students per group with an undeclared major or major in a different college. Therefore, most students in the study would have taken other science courses to meet department requirements for these majors. Most all of the students, regardless of major, were enrolled concurrently in a companion Soil Science lecture class (PWS 282), which is also required by students in these majors. A possible confounding factor in this study is GPA. When students were asked to report their average GPA, 43.2% of students in the control classes that responded rated themselves as having either an A or A- GPA, while 23.8% of students in the experimental classes that responded reported a GPA of an A or A- . Bearing in mind that this is educational research, the similarities among the groups were greater than typically seen in such studies.

Methods

A comparison study between two soil science laboratory classes was used to evaluate the effects of a combination of pedagogical approaches on student performance, preparation and attitudes.

The Control Group

Both classes in the control group met from 1-4 p.m. on either Tuesday (Fall 2013) or Wednesday (Winter 2014) in the same laboratory classroom. Measures were taken to ensure that other elements of these classes were consistent. Several components of Plant and Wildlife Science 283 were included in both the control and the experimental classes in this study:

Instructor. All control and experimental group classes were instructed by Bryan Hopkins, a Ph.D. faculty member at Brigham Young University specializing in Environmental

Soil Science. Hopkins teaches both undergraduate and graduate level courses in the Department of Plant and Wildlife Sciences. Hopkins presented lecture material in class and was available via e-mail or office visits outside of class throughout each semester.

Teaching assistant (TA). All control and experimental group classes were supported by the same teaching assistant who attended each class and graded all assignments under the direction of the professor. The TA conducted office hours weekly in which any student could come for additional direction. The TA was also accessible to students via e-mail throughout each semester.

Pretest. All students from control and experimental groups took a pretest that included ten questions on soil science concepts that were later taught during the semester. This test was used to measure students' knowledge of subject matter prior to beginning the course. The pretest also included a demographic section asking students their gender, age, marital status, major and average GPA. Students were also given the opportunity to opt out of inclusion in the study, though no students did.

Reading Material. All classes were provided with identical reading material in the form of introductory reading for each lab. The control classes were instructed to read the material carefully in preparation for class activities. Students were required to report on their completion of the reading and were awarded completion points towards their final grade for doing so. The experimental classes were provided the reading material but were instructed to prepare for class activities by viewing a weekly PowerPoint presentation on the internet, and that the reading material was optional for their section.

Lecture. Each of the control group classes were presented with a lecture from Dr. Hopkins each week. Both classes in the control group were instructed on content related to the preparatory reading material.

Lab activities. All classes in both the control and experimental groups participated in identical lab activities. These activities included analysis of soil pH, electrical conductivity, texture by hydrometer method, phosphorus, and nitrogen, among others. All groups did the same soil analysis though classes in the control group focused on learning to do the procedures, while classes in the experimental group focused on application of the results of the procedures.

Lab Reports. Each class was required to attend class, participate in lab activities and submit a lab report to be graded. Lab reports included data from group lab activities as well as questions connecting lab activities to the reading material/content.

Quizzes. Each class began with a quiz. The quiz was designed to measure mastery of concepts from the previous lab, as well as understanding of preparation materials. About half of the questions related to concepts from the prior lab, and about half of the questions related to the preparation materials for that week's lab. Questions featured on quizzes were objective.

Field-trips. All classes went on two field-trips during the semester. One field trip was early in the semester and one was near the end of the semester. Lab 12 corresponded to the second field-trip and no quiz or preparation material was provided that week in any of the classes.

Writing assignment. All classes were required to complete a writing assignment. Specific guidelines for these assignments differed between the control and experimental classes. The control group classes wrote on a topic related to soil science approved by the instructor. The experimental group wrote the soils component of an ESA.

Final Exam. Each class took a final exam at a time scheduled by the university. The final exam was administered in the same classroom as weekly labs and students were allowed an hour and a half to complete it.

The Experimental Group

Both classes in the experimental group met from 1-4pm on either Wednesday (Fall 2013) or Tuesday (Winter 2014) in the same laboratory classroom. Measures were taken to ensure that other elements of these classes were kept consistent. Classes in the experimental group participated in the following pedagogical activities:

PowerPoint instruction. Both classes in the experimental group were provided with a PowerPoint presentation available through the school's online learning system, LearningSuite (LearningSuite, Brigham Young University, Provo, UT, USA). Students had access to the PowerPoint presentations at any time and from any computer with an internet connection through LearningSuite. Students in the experimental group were to view the PowerPoint and all associated content prior to class each week. PowerPoints included slides on the content that was presented in the reading material, as well as instructional video clips, instructional images and objective practice questions (Table 1.2). Additionally, PowerPoint slides included content that the control group only received via their weekly class lecture. The professor did his best to ensure that identical information was presented to the control group during their in-class lecture. However, the PowerPoint presentations were more visually engaging as video and illustration were utilized and examples and practice questions were used to reinforce the information presented. Students were required to report on their completion of the PowerPoint (and associated content) via a self-report tool on LearningSuite and were awarded completion points towards their final grade for doing so. Over the course of the semester, 12 PowerPoint presentations were used to support the 14 labs (the first lab activity and one field-trip did not have PowerPoint presentations).

Video clips. All students in the experimental classes were required to view the videos that were included in the preparatory PowerPoint slides. A total of 36 instructional videos were included in the PowerPoint slides (due to instructional needs of the various labs, some presentations contained as many as 12 videos while others contained zero). Videos were short segments of instruction related to the content of the slides. Some videos included teaching from the instructor with demonstrations, photographs and voiceovers. Other videos included demonstrations of lab procedures with voiceovers indicating instructions relating to lab set-up and procedural steps.

Environmental Site Assessment (ESA) instruction. All students in the experimental classes were instructed on the basics of writing an ESA. Their class time spent on lecturing was focused on applying the information presented in PowerPoints to preparing an ESA. Students in the experimental classes were assigned groups and required to take their own soil samples. Lab activities in which soils were tested for various properties often allowed students the opportunity to test their *own* samples in order to gather data for their ESA report. Variation in lecture content between the control and experimental groups necessitated a difference in class format (Table 1.3).

Writing Assignment: ESA. Both classes in the experimental group were required to write an abbreviated ESA including an introduction, history of the area, presentation of soil characterization data obtained during the lab, at least two tables, an interpretation of data, and a conclusion.

Measures

Quizzes, lab reports, and final exam. A weekly quiz was used in each class for both control and experimental groups to minimize the potential for decreased class attendance for the experimental group. Traphagan et al., (2010) observed that when students were provided with online access to learning materials, class attendance decreased. This quiz allowed for evaluation of the preparation tools utilized on a weekly basis, and encouraged attendance as quizzes were included in the final grade for each student. Students who failed to use the preparation materials were not included when comparisons of grades on specific assignments were compared. This was done to keep the non-participants from skewing the data. Mean scores on weekly quizzes, lab reports, and the final exam were compared and evaluated for statistical differences using a standard t-test. The quizzes, lab reports and final exam were the primary means of assessing the effectiveness of the PowerPoint pedagogical tool as a means of improving student performance.

Interviews Informal interviews with the instructor and the TA were used to assess students' preparation for lab activities. No numeric data were collected reflecting interview responses. However, these interviews are informative for understanding aspects not quantified in the quizzes, lab reports, and final exam and represent the primary means of assessing the effectiveness of the video clips as a pedagogical tool for preparing students for laboratory activities.

Application questions. Ten questions which bridged concepts taught in lecture to practical application of the information were included at the end of the final exam (Appendix A). These evaluated each student's ability to apply knowledge learned to assessing soils at a site. Some of the questions were applicable to writing of an ESA, but most were generic application questions. This was the primary data collected to assess whether or not the ESA pedagogical tool was effective in helping students apply the principles and methods that they learned in class. The responses were graded blindly based on a predetermined rubric. Scores on these questions were not included in students' final exam scores.

End-of-semester survey. A self-report survey administered by the university was used to measure students' feelings about the class and the instructor. Items included in the survey relied on a combination of Likert scale and fill-in-the blank questions (Table 1.4). Results from these surveys were compared to analyze potential differences in attitudes and experiences between the control and experimental groups.

Results

Quizzes, lab reports, and final exam

A comparison of the mean scores on weekly quizzes of the control and the experimental group with significance measures (*P*-values) is shown in Table 1.5. The experimental group scored statistically higher than the control group on only one of the twelve quizzes. However, the control group had statistically higher scores than the experimental group on three of the twelve quizzes. Mean scores on lab reports were also compared, revealing statistical differences in only two instances (Table 1.6). The control group scored statistically higher on two of the twelve lab reports. Over 90% of all students came to class having completed the preparation material. Those students who came prepared scored significantly higher than those who did not on six of the twelve quizzes.

Other data comparisons included mean scores on the final exam, pre-test, and writing assignment of the control and experimental groups. There was no statistical difference in the average scores for the main portion of the final exam across groups. However, these mean comparisons reveal that the experimental group had statistically higher mean values for the writing assignment (Table 1.7). Additionally, the average final grade in the experimental group was not statistically higher that the control group (86.3% for the experimental group and 86.0% for the control group).

Interviews

The instructor reported that the experimental classes seemed more interested and more excited about the lab work. He reported that students in the experimental classes came to class ‘enthused’ and were generally more excited to participate in lab activities. Also, the instructor said their excitement increased his own excitement and therefore created a more positive learning environment. The TA confirmed the general feeling of excitement in the experimental classes. Both the instructor and the TA remarked that students in the experimental classes were more prepared to participate in lab activities and needed less direction to complete the assigned activities.

Application questions

A comparison of the mean scores on the application questions of the final exam revealed significantly higher scores in the experimental group (Table 1.8). The experimental group scored significantly higher on six of the 15 questions, as well as higher overall on this section of the final exam.

End-of-semester survey

Ratings from the end-of-semester student survey were statistically similar between the classes (the scores from the control and experimental groups lie within a one standard deviation range) (Table 1.9). However, the experimental classes reported spending more time outside of class, though they rated less of this time valuable to their learning than the control classes.

Discussion

We discovered that a combination approach incorporating technology and ESA instruction greatly helped students apply what they learned in the class. The greatest success of this study was observed in the scores on the application questions given at the end of the graded portion of the final exam. The magnitude of the differences was very large, with an overall increase of 121% in all of the final exam questions for the experimental groups. The differences were statistically significant on six of the 15 questions, with an average increase of 448% for the experimental groups. The experimental group did significantly better than the control group overall on these questions most likely because of their ESA instruction, including lectures focused on applying class concepts and the process of writing their own ESAs over the course of the semester. In addition, they used soils that they had collected themselves for many of the lab procedures and for which they were writing about. The instructor's original primary goal was to enable students to bridge basic soil science concepts to apply that knowledge in actual scenarios. This new pedagogy approach has proven to be effective in this aspect of the class without diminishing other aspects of the learning process (as evidence by no decreases in overall grades, individual lab grades, final exam grades, and mostly equivalent grades on weekly quizzes). This evidence suggests that the inclusion of ESA instruction in the soil science class would be a beneficial addition in terms of better preparing students for careers in the field.

Another outcome that was more difficult to measure was the success of the video clips. One factor to consider is the content of the videos presented in the PowerPoints. Most of the 39 videos were demonstrations of procedures for the lab activities the students would duplicate during the class. While these videos improved student performance according to the TA and the instructor (they reported that students completed the lab an average of about 30 minutes earlier for experimental over the control group), we did not quantify these differences. This is regrettable because this was likely the greatest advantage of using the video technology.

Preparation and enthusiasm of the students in the experimental treatment was increased through the combination of pedagogical approaches, including the ESA instruction. Additionally, though student ratings of the course were similar among groups, positive experiences shared by the instructor and the TA suggest that students enjoyed being in the experimental classes more than the control classes. Despite these positive findings, this study does not support the hypothesis that the use of web accessed tools, including PowerPoint and video clips, would lead to higher grades for the currently graded activities under the conditions of this study. The data reveals mixed results with some lab report and quiz grades higher in the experimental group, and some higher in the control group, and others equivalent. However, grades would be expected to improve in the future with the addition of applied questions similar to those assessed in this study.

One of the most direct measures of the effect of the PowerPoint and video clips versus the reading material are the grades for the quizzes given at the start of each class. As compared to lab, final exam, and class grades, quizzes were conducted closest to the time when students viewed the preparation materials (PowerPoint or reading material). And, the quizzes represent the independent work of each student, as compared to lab scores, which represent the work of a lab group of two to four students.

The general trends of the data showed better performance on quizzes for the experimental group on earlier quizzes, but with greater performance in the control group on later quizzes. The experimental group scored numerically higher on four of the first five quizzes, although only one of these was statistically significant. In contrast, the control group scored numerically higher on five of the final seven quizzes, with three of these statistically significant. Assuming this trend is real, we speculate several reasons why this may have occurred, including: 1) time between preparation and quiz, 2) earlier PowerPoint presentations were relatively better designed, 3) length of PowerPoint presentations, and 4) increasing difficulty of content later in semester.

Time between student preparation and taking the quiz was possibly a reason for differences because material would be the most fresh in students' minds if viewed closest to taking the quiz. Many students report that they read the materials immediately prior to class. This would likely help the students using the reading material on the quizzes. We were not able to measure the amount of time between when students in the experimental group viewed the PowerPoint and when they took the quiz, but the very nature of the PowerPoint (including the need to sit at a computer to view it) suggests that more time would pass between viewing the PowerPoint and taking the quiz.

There is also the possibility that earlier PowerPoint presentations were better designed than those presented later in the semester. Reports from the instructor suggest that more time and attention may have been put into earlier PowerPoints, while later PowerPoints were put together during a busy and demanding semester. This could explain any improved scores among the control group on quizzes in the later part of the semester.

Additionally, the PowerPoints were often considerably longer than the reading material. This was necessary and intentionally designed to allow more class time for application discussion. However, this necessitated including information that was not on quizzes. This may have made it more difficult for students in the experimental group to prepare for quizzes as the materials they were preparing with were lengthy.

Finally, the content likely grew more difficult over the course of the semester. Though this would be true for both the control and experimental groups, coupled with the length of the preparation materials this factor could have affected the experimental group more heavily as the materials would be both long and difficult. The control group would have been reading materials of similar length and despite increased difficulty the length of the materials would necessitate simplicity in the presentation of information that may have made it easier to understand and remember for the quizzes. Also, a slightly higher overall GPA was observed in the control group which could explain an improved score on more difficult material.

In response to these hypothesized reasons for the quiz results, the instructor revised later presentations in subsequent semesters and adopted a hybrid approach of having students view the PowerPoint and videos but also reviewing principles before taking the quiz. Interestingly, preparation in general appeared more important than the type of preparation used. Students who prepared by either reading the material or viewing the PowerPoint out performed those who did not prepare on all of the quizzes. This suggests that if students do some sort of reading or PowerPoint viewing they will perform better in class.

In contrast to quizzes, lab report grades are relatively weaker evidence of the benefit of the PowerPoint because students work together on the labs so even if only one student understood the concept well, the entire group of 3 or 4 could end up with a high score as that student mentors their peers. The students are also given a week to complete their lab allowing for additional time to seek direction from the professor, the TA, or other reference materials including the internet. Lab scores may be more reflective of students' willingness and abilities to complete an assignment and less upon preparation activities provided for them.

The end-of-semester survey administered by the university revealed that students' in the control group rated their experience similar to those in the experimental group on all questions. Most of the mean response ratings fell between a score of 6 and 7, which can be represented by the options 'Agree' and 'Strongly Agree.' All groups rated all items generally positively. Also, the difference between 'Agree' and 'Strongly Agree' is quite subjective. Thus, slight differences between groups (numerically favoring the control group, although not statistically significant) could be due to perceived increased workload of having to view a lengthy PowerPoint each week in the experimental group, compared to the experimental group who only had to read a few pages of content.

Furthermore, while demographic data suggests that the groups were close to equal in terms of gender, age, and major, the data show a slight difference in average GPA of the students that may have impacted these results. A higher percentage of the control group reported being "A" students (43.2% for control and 23.8% for experimental), while a higher percentage of the experimental group reported being "B" students (15.3% for control and 22.2% for experimental) (Table 1.3). This suggests that the control group may have had more students who had a greater record of classroom success than the experimental group. Despite this possible difference with slight favor for the control group, the experimental group had statistically similar grades for this course—providing further evidence that the pedagogy approach taken for this study is effective, especially with minor modifications discussed herein.

A possible improvement for future studies of this nature is to include the Student Assessment of their Learning Gains (SALG) instrument to measure five basic student gains (Seymour et al., 2000). Those gains include (1) the aspects of the course that helped the student in their learning, (2) understanding, (3) skills, (4) attitude, and (5) integration of knowledge.

Limitations

While discussing the results of this comparison study it is also important to analyze the various limitations that may have affected the results. Overall, the mixed results of the various pedagogies can also be attributed to small sample sizes and a lack of true experimental conditions (the groups were self-assigned through the process of registering for classes by the individual students so true randomization did not take place).

On top of these external factors, some inherent limitations were likely introduced by adding a new TA to the class. Also, the professor had the difficult task of presenting the information included in the PowerPoint to the control group in lecture format without slides; this was in an attempt to follow traditional lecture techniques for this lab. Occasionally, it would be impossible to present identical information due to time constraints and the inability to show graphics used in the PowerPoint to the lecture (control) sections.

All things considered however, limitations were minimized as much as possible and, although are acknowledged, were likely minimal in terms of these findings. Some limitations could be overcome in future application of this experiment by more detailed record keeping and by cutting some of the content in the PowerPoints to allow for more directed focus and clarity of the most important information.

Anticipated Costs for Application

In order to duplicate the experimental portion of this study a few additional costs outside of the usual costs for a laboratory class of this scope are required. In addition to the typical lab equipment, this teaching tool will require the use of a digital camcorder. Also, software with the capability of editing digital video as well as Microsoft Office PowerPoint is required. Instructors can expect to spend several additional hours per PowerPoint preparing material for the slides, as well as several hours per PowerPoint for whoever is preparing the video resources. However, implementing the SALG program would be free and could be of immense value to improving overall investigations.

Conclusion

Our research shows that general attitude and preparation to participate in lab activities were improved by the use of web-based tools including PowerPoint and video. Additionally, completion of preparation materials in general (by either reading materials or viewing a PowerPoint) was important to performance. Following this study the instructor chose to continue with PowerPoint and video preparation materials. The instructor opted for a combination approach that incorporated an introduction lecture to refresh what was covered in the preparation materials. This was chosen because the absence of a negative effect on student performance and the presence of improved preparation suggest that our approach is beneficial, though it needs some adjustments. Reports from the professor and teaching assistant suggest that the use of web-based learning tools is still effective in preparing students for lab activities as well as making more time available for in-class discussion on application of content (i.e. ESA instruction). ESA instruction revealed improved career skills (i.e. application of concepts), though students' perception of the class experience was similar among treatments. A more positive learning atmosphere and enthusiasm among the students participating in the ESA instruction was observed.

Future instructors of science-based laboratories might consider using a hybrid technology-lecture approach rather than placing too much emphasis on technology and/or lecture formats. Additionally, improvements should be made to study students' attitude about the experience, using the NSF-Sponsored student assessment of learning gains (SALG) could provide new insight as to whether web-based technology improves student learning, understanding, skills, attitudes and integration of knowledge. This type of focused and specific information would allow instructors to make specific alterations to improve students' overall learning experience. Overall, our findings suggest that incorporating a variety of pedagogical tools, especially ESA instruction, can improve the learning and experience of students.

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Table 1.1 Student demographics for the control and experimental groups

	Control Group	Experimental Group
Gender		
Female	22 (55.0%)	22 (50.0%)
Male	18 (45.0%)	22 (50.0%)
Age		
18	2 (5.3%)	3 (7.0%)
19	9 (23.7%)	4 (9.3%)
20	6 (15.8%)	8 (18.6%)
21	5 (13.2%)	4 (9.3%)
22	5 (13.2%)	9 (20.9%)
23	4 (10.5%)	5 (11.6%)
24	1 (2.6%)	5 (11.6%)
25+	6 (15.8%)	5 (11.6%)
Marital Status		
Single	30 (78.9%)	30 (69.8%)
Married	8 (21.1%)	13 (30.2%)
Major	-	-
Environmental Science	7 (18.4%)	10 (23.3%)
Wildlife/Wildlands	15 (39.5%)	14 (32.6%)
Landscape Management	11 (29.0%)	14 (32.6%)
Other	5 (13.2%)	5 (11.6%)
GPA		
A	1 (2.7%)	1 (2.4%)
A-	15 (40.5%)	9 (21.4%)
B+	8 (21.6%)	14 (33.3%)
B	5 (13.5%)	8 (19.0%)
B-	4 (10.8%)	6 (14.3%)
C+	3 (8.1%)	3 (7.1%)
C	1 (2.7%)	0 (0.0%)
C-	0 (0.0%)	1 (2.4%)

Note: Variations in percentages reflect missing responses from self-report offered by students

Table 1.2 Outline of PowerPoint slides, videos, images and questions used in each lab

	Lecture and PowerPoint Topic	# of Slides	# of Videos	# of Images	# of Questions
Lab 2	Soil Classification	56	12	29	9
Lab 3	Physical Properties	70	4	21	13
Lab 4	Structure and Bulk Density	37	3	16	7
Lab 5	Soil Colloids	46	2	7	8
Lab 6	Soil Moisture	51	0	18	9
Lab 7	Water Movement through Soil	14	0	0	2
Lab 8	Measuring Soil Measure and Temperature	58	4	30	8
Lab 9	Soil pH	53	2	17	10
Lab 10	Soil Cations and Saline-Sodic Soils	38	6	9	4
Lab 11	Soil Biology and Organic Matter	64	0	14	4
Lab 13	Nitrogen	50	3	7	6
Lab 14	Estimating Nutrient Bioavailability	51	0	12	6

Table 1.3 Experimental design for control and experimental groups

	Control Group			
	Before Class	First Class Activity	Second Class Activity	Final Class Activity
Week 2	Reading: Lab 2	Lab 1 & 2 quiz	Lecture: Lab 2 Reading	Lab 2
Week 3	Reading: Lab 3	Lab 2 & 3 quiz	Lecture: Lab 3 Reading	Lab 3
Week 4	Reading: Lab 4	Lab 3 & 4 quiz	Lecture: Lab 4 Reading	Lab 4

	Experimental Group			
	Before Class	First Class Activity	Second Class Activity	Final Class Activity
Week 2	PowerPoint: Lab 2	Lab 1 & 2 quiz	Lab 2	Lecture: Lab 2 Application
Week 3	PowerPoint: Lab 3	Lab 2 & 3 quiz	Lab 3	Lecture: Lab 3 Application
Week 4	PowerPoint: Lab 4	Lab 3 & 4 quiz	Lab 4	Lecture: Lab 4 Application

Note: This represents only a portion of the 14 week course, the remainder of the course followed this general class format up until the Final Exam

Table 1.4 End-of-semester survey questions

	Comparing this course with other university courses you have taken, please indicate an OVERALL rating for the following:
1	Course: PWS 283
2	Instructor: Dr. Bryan Hopkins
	Please respond to each of the following items regarding this course: PWS 283
	Likert scale options for questions: (Very Strongly Disagree-1), (Strongly Disagree-2), (Disagree-3), (Somewhat Disagree-4), (Somewhat Agree-5), (Agree-6), (Strongly Agree-7), (Very Strongly Agree-8)
3	I learned a great deal in this course.
4	Course materials and learning activities were effective in helping students learn.
5	This course was well organized.
6	Evaluations of students' work were good measures of what students learned in the course.
7	Course grading procedures were fair.
8	This course helped me develop intellectual skills (such as critical thinking, analytical reasoning, integration of knowledge).
9	For this course, about how many hours per week did you spend in class?
10	What percentage of the time you spent in class was valuable to your learning?
11	For this course, about how many hours per week did you spend out of class (doing assignments, readings, etc.)?
12	What percentage of the time you spent out of class was valuable to your learning (as opposed to just busy work)?
	Please respond to the following statements regarding the instructor:
13	Showed genuine interest in students and their learning.
14	Provided adequate opportunities for students to get help when they needed it.
15	Provided opportunities for students to become actively involved in the learning process.
16	Gave students prompt feedback on their work.
17	Provided students useful feedback on their work.
18	Responded respectfully to students' questions and viewpoints.
19	Was effective in explaining difficult concepts and ideas.
20	This instructor and course contributed to the Mission and Aims of a BYU Education.

Notes:
Likert scale options for questions 1 and 2: (Exceptionally Poor-1), (Very Poor-2), (Poor-3), (Somewhat Poor-4), (Somewhat Good-5), (Good-6), (Very Good-7), (Exceptionally Good-8)

Likert scale options for questions 3-8 and 13-19: (Very Strongly Disagree-1), (Strongly Disagree-2), (Disagree-3), (Somewhat Disagree-4), (Somewhat Agree-5), (Agree-6), (Strongly Agree-7), (Very Strongly Agree-8)

Table 1.5 Summary of the mean scores and *P*-values for weekly quizzes for the control and experimental groups

	Control Mean	Experimental Mean	*P*-value
Lab 2 Quiz	7.8	8.2	0.449
Lab 3 Quiz	6.9	8.1	0.0007*
Lab 4 Quiz	7.5	7.7	0.48
Lab 5 Quiz	8.8	8.3	0.086
Lab 6 Quiz	8.9	9.1	0.538
Lab 7 Quiz	9.7	9.2	0.0181*
Lab 8 Quiz	8.2	7.8	0.352
Lab 9 Quiz	9.1	8.4	0.0462*
Lab 10 Quiz	8.5	7.7	0.077
Lab 11 Quiz	8.4	8.8	0.152
Lab 13 Quiz	9.1	8.5	0.0128*
Lab 14 Quiz	7.9	7.9	0.895

Note: * significant at the 0.05 level

Lab 1 and 12 excluded due to lack of a quiz on that day

Score out of 10 points

Table 1.6 Summary of the mean scores and *P*-values for weekly lab reports for the control and experimental groups

	Control Mean	Experimental Mean	*P*-value
Lab 2	17.8	18.3	0.3135
Lab 3	18.8	18.8	0.9718
Lab 4	18.4	19.0	0.1092
Lab 5	18.8	18.8	0.936
Lab 6	18.4	18.0	0.285
Lab 7	18.1	17.8	0.571
Lab 8	17.7	18.3	0.216
Lab 9	18.7	18.5	0.6502
Lab 10	19.0	18.4	0.197
Lab 11	18.4	17.1	0.0006*
Lab 13	18.4	17.4	0.0329*
Lab 14	19.1	19.4	0.199

Note: * significant at the 0.05 level

Lab 1 and 12 excluded due to lack of a PowerPoint/reading

Score out of 20 points

Table 1.7 Summary of the mean scores and *P*-values for final exam, pre-test and writing assignment for the control and experimental groups

	Control Mean	Experimental Mean	*P*-value
Final Exam (/200)	171.5	168.1	0.4235
Pre-test (/10)	3.5	5.2	0.0021*
Writing assignment (/100)	88.4	91.4	0.0218*

Note: * significant at the 0.05 level

Table 1.8 Summary of the mean scores and *P*-values for the application final questions for the control and experimental groups

	Control Mean	Experimental Mean	*P*-value
Question 1 (/1)	0.23	0.25	0.7912
Question 2 (/1)	0.33	0.50	0.1067
Question 3 (/1)	0.13	0.55	<0.0001*
Question 4 (/1)	0.68	0.91	0.0072*
Question 5 (/1)	0.04	0.73	<0.0001*
Question 6 (/1)	0.05	0.39	0.0002*
Question 7 (/1)	0.13	0.73	<0.0001*
Question 8 (/2)	1.65	1.68	0.7912
Question 9 (/1)	0.58	0.41	0.1318
Question 10 (/1)	0.45	0.73	0.0093*
Question 11 (/1)	0.80	0.77	0.7644
Question 12 (/1)	0.88	0.95	0.1921
Question 13 (/1)	0.83	0.75	0.4089
Question 14 (/1)	0.60	0.50	0.3638
Question 15 (1/)	0.38	0.45	0.4662
Total (/16 points)	7.71	10.3	<0.0001*

Note: * significant at the 0.05 level

Table 1.9 Summary of the mean ratings and standard deviations (SD) for the end-of-semester student survey for the control and experimental groups

	Fall 2013				Winter 2014				Combined Means	
	Control	SD	Experimental	SD	Control	SD	Experimental	SD	Control	Experimental
Question 1	6.7	1.03	6.1	1.34	7.1	0.83	6.6	0.93	6.9	6.3
Question 2	7.3	0.75	6.6	1.29	7.5	0.65	6.9	0.83	7.4	6.7
Question 3	6.8	1.02	6.3	1.39	7.4	0.84	7.0	0.87	7.0	6.6
Question 4	6.8	1.23	6.3	1.29	7.1	0.86	6.9	0.83	6.9	6.6
Question 5	6.5	1.32	6.3	1.24	7.1	0.62	6.6	0.93	6.7	6.4
Question 6	6.6	1.00	6.3	1.24	6.8	1.19	6.2	1.29	6.7	6.3
Question 7	6.6	0.88	6.4	1.10	6.8	1.31	6.5	1.18	6.7	6.4
Question 8	6.6	1.00	6.2	1.45	6.9	1.00	6.8	1.07	6.7	6.5
Question 9	3.0	0.00	3.1	0.70	2.9	0.23	2.9	0.23	3.0	3.0
Question 10	82.0	19.63	80.5	21.71	90.7	9.17	83.5	9.96	85.6	81.8
Question 11	1.2	0.73	1.7	1.20	1.2	0.73	1.9	0.79	1.2	1.8
Question 12	85.0	16.06	76.4	24.79	87.5	12.15	81.8	16.29	86.0	78.8
Question 13	7.2	0.85	6.8	1.34	7.2	0.89	6.9	1.05	7.2	6.8
Question 14	6.8	1.37	6.5	1.30	6.8	1.12	6.9	1.17	6.8	6.7
Question 15	7.2	0.77	6.8	1.34	7.6	0.63	7.4	0.71	7.4	7.1
Question 16	6.7	1.46	6.2	1.27	7.2	0.80	6.7	1.26	6.9	6.4
Question 17	6.5	1.47	6.3	1.25	6.6	0.94	6.6	1.28	6.5	6.4
Question 18	7.2	0.75	6.7	1.13	7.4	0.63	7.4	0.62	7.3	7.0
Question 19	6.9	1.00	6.5	1.14	7.0	1.04	6.9	0.93	6.9	6.7
Question 20	6.9	0.85	6.4	1.22	7.2	0.80	6.7	1.10	7.0	6.5
Response rate	77%		85%		100%		89%		85%	87%

Chapter 2: Environmental Site Assessment

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Abstract

Environmental Site Assessment

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Master of Science

The environment and the careers that investigate and support it are fundamental to the world we live in. With research and development of the land, air, and water; people are able to discover problems and implement solutions in order to best use, preserve, and beautify the earth. Soil is one of the most basic and immensely important resources. Obvious uses of soil include its supporting role in providing nutrients for the growth of plants and its structural role in the foundation for plants, buildings, roads, etc. In addition to these commonly known uses of soil, it provides a uniquely long list of benefits and uses that make it one of the earth's most valuable, and yet often, ignored resources. One common investigation, which includes soil as a component, is an Environmental Site Assessment (ESA). An ESA is an important tool that is used often with the transfer of property and in preparation to utilize an area of land in a new way.

There are two general types of ESAs, Phase I and Phase II. A Phase I ESA seeks to identify the presence or likely presence or threat of release of any hazardous substances on a property or into the ground, ground water or surface water of the property. A Phase I ESA can only officially be prepared by a Qualified Environmental Professional. A Phase I ESA includes a property description, building/structure descriptions, historical and current land use, interviews, historic aerial photos and map summaries, governmental database reviews, historic document summaries, site reconnaissance, and conclusions. This chapter serves as a sample ESA prepared for instructional purposes to support the addition of ESA instruction in the soil science laboratory classroom at Brigham Young University. Findings of note included in this ESA include high levels of phosphorus on the testing site, with otherwise generally pristine conditions for grazing. Considerations should be taken in order to use the site for development or farming.

Keywords: Environmental Site Assessment, Soil Science, ESA Instruction, Wallsburg

Environmental Site Assessment Sample

Location: Agricultural Field, Wallsburg, UT

Approx. 40.39671^{o}, -111.44242

Chapter 2 Table of Contents

1. Executive Summary

The site located at approximately 40.39671°, -111.44242 was surveyed and sampled in the spring and fall of 2014 to assess current conditions and isolate any potentially harmful environmental conditions. We had reason to believe there were higher than normal levels of phosphorus due to previous reports. The site is located northwest of the town of Wallsburg, UT and comprises a field of roughly 3 hectares (7.6 acres). The site is undeveloped and currently used primarily for pasture and hay. Formerly, the site was native range with no known significant anthropogenic uses other than livestock grazing. The rockiness of the soil prevents the soil from being more useful, however with proper irrigation measures, a few crops could be grown with limited success.

Overall the area is mostly pristine, though some potential water quality issues related to phosphorus have been of concern by local citizens and government agencies. Streams that run through and near this land are in part responsible for the runoff that feeds Deer Creek Reservoir, which then drains to Utah Lake. Utah Lake is nutrient polluted with resultant algae blooms each summer. These blooms are a recreational problem and, more importantly, can result in the death of aquatic life due to hypoxia. The algae can also be directly toxic, as evidenced by the death of a dog as a result of drinking the water during a particularly heavy algae bloom in the previous year. Many water bodies and other sources are potentially responsible for the nutrient pollution—including the Wallsburg watershed where levels of phosphorus in the soil are high. However, our findings are that these levels do not rise to a serious concern currently. Addition of phosphorus to this soil from fertilizer and other sources is not advisable for many years in the future until, if and when, soil tests show a reduction to more low to moderate levels. As such, we see no known concerns for this or other reasons with regard to transfer of land. If future landowners wish to build, farm, or raise livestock on the land serious consideration should be taken in terms of disposal of waste and application of fertilizers. A high water table suggests that leaching will take place more easily and readily. Also, higher than average levels of phosphorus and a water quality concern in the area suggest that raising livestock on the property is not advisable unless plans are in place to deposit the animal waste somewhere else. We also found no other environmental limitations for the many parameters investigated, including salts, sodium, pH, and so forth. Our conclusion is that, based on the parameters analyzed for this assessment, this property is likely free from current environmental hazard.

2. Background

2.1 Site Description and Features

The site has an elevation of approximately 1,730 meters (5,676 feet) and comprises a field of roughly 3 hectares (7.6 acres). The area receives annual rainfall of about 61 centimeters (24 inches) and remains frost free for approximately 111 days per year. The climate of this site is characterized by cold snowy winters and relatively cool dry summers. The average annual high temperature is 15^{o}C (58.9^{o}F), while the average low temperature is -1.7^{o}C (29^{o}F). The average temperature of the area is 6.7^{o}C (44^{o}F). The site receives an average annual snowfall of 190 centimeters (75 inches). The site is undeveloped and currently used primarily for pasture and hay. Formerly, the site was native range with no known significant anthropogenic uses other than livestock grazing. The area is located in Wasatch County adjacent to fields of comparable development. Native rangeland is found within 1.6-4.8 kilometers (1-3 miles) on all sides, with the Uinta National Forest to the south and the Bureau of Land Management areas on the other three sides. Native vegetation includes a predominance of water sedge (*Carex aquatilis*) and Nebraska sedge (*Carex nebrascensis*) with many varieties of grasses, shrubs, and forbs (Table

2.59). The town is located in a mountain valley of Utah County. There is a slight gradual northward slope. The soil is predominantly Kovich Loam with many stones present, though no appearance of significant erosion. No septic tanks, pits, ponds or lagoons are onsite. Streams run adjacent to the site and empty into Utah Lake.

The site is located near the town of Wallsburg, UT with a current population of about 250-300. Historically the town had a maximum population of 528 in 1900, indicating minimal possibilities for anthropogenic influences to the area. The site is located approximately 2,750 meters (1.7 miles) northwest from Wallsburg. Other communities in close proximity are Heber City (13 miles, population 12,911) to the north and Orem (20 miles, population 91,648)/Provo (23 miles, population 116,288) to the west (United States Census Bureau).

The site has an ecological classification of Intezonal Wet Fresh Meadow (Sedge) and is dominated by sedges, grasses and rushes. The potential plant community is approximately 90 percent grasses and grass-like plants, 5 percent forbs and 5 percent shrubs (Table 2.59). Predominate wildlife include mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), moose (*Alces alces*), sage grouse (*Centrocercus urophasianus*), upland game birds, song birds, water fowl and shorebirds, and a variety of rabbits and rodents. There are no known threatened or endangered species on site.

A small stream runs parallel to the property, cutting a meandering line to the southwest. The water is shallow and the banks of the stream are eroded and covered in grasses. There are no significant sources of air pollution in this valley, although the Provo/Orem area has significant air quality problems, predominately in the winter months, with possibility of movement up into this valley. The only significant industry in the area is agricultural hay production and livestock grazing.

2.2 Site History and Land Use

The town of Wallsburg was established in 1862. This site was developed for hay production and pasture at about that time and has been used for this purpose since that time. Prior to that the site was native rangeland with no known significant anthropogenic uses. The site is currently owned by the Alan Ashton family and managed by Jeff Dunn. Land owners use the land for pasture and hay.

2.3 Adjacent Property Land Use

Adjacent properties include fields of comparable use. The town includes many houses and buildings but they are located far enough from this site to have minimal impact. The valley outlet is to the north with mountain ridges on the other three sides, although adjacent agricultural properties separate this site from the native range and mountains. Most local properties are used as lots for farms and residential housing.

3. Work Performed and Rationale

3.1 Scope of Assessment

The site was assessed visually as well as through quantitative and qualitative measures. In-field characterization of the site included measures of visual erosion risk, slope steepness, a survey of vegetative cover and type, a land use observation, infiltration rate measure and a survey of irrigation practices. Additionally, soil samples were collected and tests were used to assess: pH, salinity, nitrate-nitrogen, organic matter, phosphorus, calcium, magnesium, sodium, potassium, and SAR. Tests of adjacent water sources include total phosphorus, dissolved phosphorus, total solids and a test for *Escherichia coli*. Plant samples were also collected and tested for nutrients.

3.2 Exploration, Sampling and Test Screening Methods

Standard sampling procedures were followed to collect samples using a soil probe (9.3).

3.3 Chemical Analytical Methods

1. **pH, Soluble Salts, sodium Adsorption Ratio determined on a saturated paste.** Rhodes, J.D. Soluble Salts, pp. 167-179. In: A.L. Page (ed), Methods of Soil Analysis Part 2. 1982. American Society of Agronomy, Inc. Madison, WI.

2. **Exchangeable Calcium, Magnesium, Potassium, Sodium. Ammonium acetate method. pH 8.5.**
   Normandin, V., J. Kotuby-Amacher, and R.O. Miller. 1998. Modification of the ammonium acetate extractant for the determination of exchangeable cations in calcareous soils. Commun. Soil Sci. Plant Anal. 29(11-14), 1785-1791.

3. **Total Nitrogen. Dumas Method. See #14.**

4. **Minerals by Microwave Assisted Acid Digestion with Milestone Ethos EZ. Followed by ICP Analysis.**
   EPA 3051A.

4. Presentation and Evaluation of Results

The soil is classified as Kovich Loam (62% Sand, 16% Clay, 22% Silt). The pH of the soil is nearly neutral, though slightly acidic and the soil has a very low salinity measure and therefore poses no salinity problem. Levels of nitrate-N are considered low, while levels of phosphorus are high and levels of potassium are considered very high. Bulk density readings indicate a bulk density of 1.68 g/cc, showing some compaction compared to native conditions.

This site has a visual erosion risk of 0 (on a scale of 0-5, 0=none, 5=severe). The slope steepness is 0.45% and the area has 100% vegetative cover of perennial grass. The land use is classified as grass, hay, and pasture. Management practices include artificial, subsurface drainage systems and the field is surface irrigated by flooding, though this finding differs from the soil survey it represents the most current data. Tissue sampling of on-site vegetation reveal "normal" levels of nutrients in the plants.

Water quality tests of the surrounding area reveal high levels of phosphorous. Phosphorous loading into the surface water creates water quality issues downstream, although the source for this loading is only a small part from this property with an exposure surface area of less than 1% compared to all stream banks.

5. Interpretations and Conclusions

Overall this site is a generally pristine location. The site is used for pasture and hay and is adequate for such purposes. If future land owners wish to use the site for agriculture they may have difficulties with the rockiness of the soil and short growing season. Additionally, the soil is high in phosphorus (Table 2.2), which could suggest a risk to the nearby water sources. However, the level of phosphorus does not rise to the level of being considered an environmental hazard (over 50 mg/kg of bicarbonate extractable P), the soil is high in phosphorus in terms of plant nutrition, meaning no fertilizer is needed. The soil also has high levels of potassium, but this nutrient does not represent a water quality risk. The soil is most likely natively high in phosphorus from the minerals in the parent material. Other studies upstream have shown high soil phosphorus in places where it was not expected. This strongly suggests that the majority of the phosphorus in the water is likely coming from natural sources and not from anthropogenic activities. Therefore, phosphorus is not an environmental problem at this site. This site is not in need of remedial practices and is acceptable for property transfer in its current condition.

6. Recommendations

No immediate remedy is recommended. Though no remedial practices are required, it is recommended that future land owners use the best land and water management practices, including soil testing and careful application of fertilizers only as needed. Phosphorus fertilizers should only be applied if future soil testing reveals that such fertilizer is necessary. Currently, the soil has ample phosphorus to support agricultural production for many years to come.

7. References

NRCS (2015). United States Department of Agriculture, Natural Resources Conservation Service Ecological Site Description. Retrieved from https://esis.sc.egov.usda.gov/ESDReport/fsReport.aspx?id=R047XA008UT&rptLevel=general&approved=yes&repType=regular&scrns=&comm=

US Climate Data (2015). *Climate Wallsburg-UT.* Retrieved from http://www.usclimatedata.com/climate/wallsburg/utah/united-states/usut0432

"Web Soil Survey." *Web Soil Survey*. United States Department of Agriculture, n.d. Web. 17 Feb. 2015. http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.

8. Tables

List of Explorations, Samples Collected

-Soil samples taken on field site (Figure 1)
-Water samples from Main Creek at Roundy Lane (approximately .5 miles southeast of field site)

8.1 Soil Analytical Data

Table 2.1 Soil characteristics of Wallsburg agricultural field

Characteristic	Value
pH	6.6
EC dS m^{-1}	1.3
Ca mg kg^{-1}	105
Mg mg kg^{-1}	25.8
K mg kg^{-1}	7.3
Na mg kg^{-1}	41.2
SAR	0.9
NO_3-N mg kg^{-1}	7.1

Table 2.2 Soil total elemental composition

Element	mg kg^{-1}
P	23.5
As	1.87
B	30.2
Ba	185
Ca	15868
Cd	9073
Co	8.81
Cr	58.3
Cu	13.1
Fe	17386
K	5216
Mg	5876
Na	280
Ni	21.7
P	1231
Pb	4.66
S	1121
Sr	81.8
Ti	831
Zn	63.5

8.2 Groundwater Analytical Data

Table 2.3 Summary of Groundwater Data in Wallsburg Watershed

Location	Dissolved P mg L^{-1}	E. Coli MPN	Total P mg L^{-1}
Main Creek: Roundy Lane (approx. .5 miles from field site)	0.057	5.3	0.678

Table 2.4 Phosphorus measures from Main Creek (SE of field site .5 miles) in March and May

	March 2015	May 2015
Distance from head waters (m)	19617	19617
Flow Rate (L/s)	85.6	7.6
Dissolved Reactive P (ppm)	0.012	0.023
Load (mg/s)	1.07	0.18
Total Reactive P (ppm)	0.032	0.042
Load (mg/s)	2.71	0.32
Dissolved Total P (ppm)	0.012	
Load (mg/s)	1.027	
Total P	0.058	
Load (mg/s)	4.96	

9. Appendices

9.1 Site Map and Photographs

Figure 1. Site Map Area of Interest (source: USDA, NRCS)
Field sampled indicated by blue striped region.

Figure 2. Soil Map (source: USDA, NRCS)
Map Unit Key designations displayed

Figure 3. Site Proximity to Wallsburg Township (source: Yahoo Maps)
Approximately 2,750 meters (1.7 miles) from test site to Wallsburg, UT

Figure 4. Southwest view from site

Figure 5. Northeast view from site

Figure 6. Southeast view from site

Figure 7. Northwest view from site

9.2 Soil Survey Reference Tables

Table 2.5 Soil Map Key (source: USDA, NRCS)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent
K_c	Kovich loam	0	0.10%
K_d	Kovich loam, channeled	7.2	95.7%
K_h	Kovich loam, moderately deep water table	0.3	4.2%
Totals for Area of Interest		7.6	100.0%

Table 2.6 Shallow Excavations (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00) Dusty (0.28) Unstable excavation walls (0.01)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00) Dusty (0.28) Unstable excavation walls (0.01)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Depth to saturated zone (1.00) Dusty (0.28) Unstable excavation walls (0.01)

Table 2.7 Small Commercial Buildings (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Flooding (1.00) Depth to saturated zone (0.98)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Flooding (1.00) Depth to saturated zone (0.98)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Flooding (1.00)

Table 2.8 Unpaved Local Roads and Streets (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Frost action (1.00) Depth to saturated zone (0.75) Flooding (0.40) Dusty (0.28)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Frost action (1.00) Depth to saturated zone (0.75) Flooding (0.40) Dusty (0.28)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Frost action (1.00) Flooding (0.40) Dusty (0.28)

Table 2.9 Farmland Classification (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	Farmland of statewide importance
K_d	Kovich loam, channeled	Farmland of statewide importance
K_h	Kovich loam, moderately deep water table	Farmland of statewide importance

Table 2.10 Hydric Rating by Map Unit (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	95
K_d	Kovich loam, channeled	95
K_h	Kovich loam, moderately deep water table	5

Table 2.11 Irrigated Capability Class (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	3
K_d	Kovich loam, channeled	3
K_h	Kovich loam, moderately deep water table	3

Table 2.12 Irrigated Capability Subclass (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	w
K_d	Kovich loam, channeled	w
K_h	Kovich loam, moderately deep water table	w

Table 2.13 Non-irrigated Capability Class (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	7
K_d	Kovich loam, channeled	7
K_h	Kovich loam, moderately deep water table	7

Table 2.14 Non-irrigated Capability Subclass (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	w
K_d	Kovich loam, channeled	w
K_h	Kovich loam, moderately deep water table	w

Table 2.15 Soil Taxonomy Classification (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	Fine-loamy, mixed, frigid Cumulic Endoaquolls
K_d	Kovich loam, channeled	Fine-loamy, mixed, frigid Cumulic Endoaquolls
K_h	Kovich loam, moderately deep water table	Fine-loamy, mixed, frigid Cumulic Endoaquolls

Table 2.16 Soil Compaction Resistance (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Low resistance	Kovich (90%)	Content of sand (0.55)
				Soil structure (0.80)
				Moderate resistance for surface structure size (0.80)
				Content of clay (0.86)
				Soil structure (0.90)
K_d	Kovich loam, channeled	Low resistance	Kovich (90%)	Content of sand (0.55)
				Soil structure (0.80)
				Moderate resistance for surface structure size (0.80)
				Content of clay (0.86)
				Soil structure (0.90)
K_h	Kovich loam, moderately deep water table	Low resistance	Kovich (95%)	Content of sand (0.55)
				Soil structure (0.80)
				Soil structure (0.80)
				Content of clay (0.86)

Table 2.17 Soil Rutting Hazard (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Severe	Kovich (90%)	Low strength (1.00)
			Peaty surface soils (5%)	Low strength (1.00) Wetness (0.50)
K_d	Kovich loam, channeled	Severe	Kovich (90%)	Low strength (1.00)
K_h	Kovich loam, moderately deep water table	Severe	Kovich (95%)	Low strength (1.00)

Table 2.18 Yields of Irrigated Crops - Barley (USDA, NRCS)

Map unit symbol	Map unit name	Rating (bu)
K_c	Kovich loam	63
K_d	Kovich loam, channeled	63
K_h	Kovich loam, moderately deep water table	66.5

Table 2.19 Yields of Irrigated Crops - Grass-Legume-Hay (USDA, NRCS)

Map unit symbol	Map unit name	Rating (tons)
K_c	Kovich loam	3.6
K_d	Kovich loam, channeled	3.6
K_h	Kovich loam, moderately deep water table	3.8

Table 2.20 Yields of Irrigated Crops – Pasture (USDA, NRCS)

Map unit symbol	Map unit name	Rating (AUM)
K_c	Kovich loam	6.75
K_d	Kovich loam, channeled	6.75
K_h	Kovich loam, moderately deep water table	7.13

Table 2.21 Disposal of Wastewater by Irrigation (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Too acid (0.03)
				Droughty (0.02)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Too acid (0.03)
				Droughty (0.02)
K_h	Kovich loam, moderately deep water	Very limited	Kovich (95%)	Filtering capacity (1.00)
				Depth to saturated zone (0.86)
				Too acid (0.03)
				Droughty (0.02)

Table 2.22 Disposal of Wastewater by Rapid Infiltration (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
				Slow water movement (1.00)
				Stone content (0.14)
				Cobble content (0.02)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
				Slow water movement (1.00)
				Stone content (0.14)
				Cobble content (0.02)
K_h	Kovich loam, moderately deep water	Very limited	Kovich (95%)	Depth to saturated zone (1.00)
				Slow water movement (1.00)
				Stone content (0.14)
				Cobble content (0.02)

Table 2.23 Land Application of Municipal Sewage Sludge (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Flooding (0.40)
				Too acid (0.03)
				Droughty (0.02)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Flooding (0.40)
				Too acid (0.03)
				Droughty (0.02)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Filtering capacity (1.00)
				Depth to saturated zone (0.86)
				Flooding (0.40)
				Too acid (0.03)
				Droughty (0.02)

Table 2.24 Manure and Food Processing Waste (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Leaching (0.70)
				Droughty (0.02)
				Too acid (0.01)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Leaching (0.70)
				Droughty (0.02)
				Too acid (0.01)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Filtering capacity (1.00)
				Depth to saturated zone (0.86)
				Droughty (0.02)
				Too acid (0.01)

Table 2.25 Overland Flow Treatment of Wastewater (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Seepage (1.00)
				Depth to saturated zone (1.00)
				Flooding (0.40)
				Too acid (0.03)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Seepage (1.00)
				Depth to saturated zone (1.00)
				Flooding (0.40)
				Too acid (0.03)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Seepage (1.00)
				Depth to saturated zone (0.86)
				Flooding (0.40)
				Too acid (0.03)

Table 2.26 Slow Rate Treatment of Wastewater (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Too acid (0.03)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Filtering capacity (1.00)
				Depth to saturated zone (1.00)
				Too acid (0.03)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Filtering capacity (1.00)
				Depth to saturated zone (0.86)
				Too acid (0.03)

Table 2.27 Embankments, Dikes and Levees (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00) Piping (1.00) Dusty (0.28)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00) Piping (1.00) Dusty (0.28)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Piping (1.00) Depth to saturated zone (0.86) Dusty (0.28)

Table 2.28 Irrigation, General (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Seepage (1.00) Depth to saturated zone (1.00) Rapid water movement (0.71) Low water holding capacity (0.25) Slope (0.01)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Seepage (1.00) Depth to saturated zone (1.00) Rapid water movement (0.71) Low water holding capacity (0.25) Slope (0.01)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Seepage (1.00) Rapid water movement (0.71) Depth to saturated zone (0.44) Low water holding capacity (0.25) Slope (0.01)

Table 2.29 Irrigation, Micro - Above Ground (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
			Peaty surface soils (5%)	Depth to saturated zone (1.00) Seepage (1.00)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
K_h	Kovich loam, moderately deep water table	Somewhat limited	Kovich (95%)	Depth to saturated zone (0.44)

Table 2.30 Irrigation, Micro - Subsurface Drip (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
K_h	Kovich loam, moderately deep water table	Somewhat limited	Kovich (95%)	Depth to saturated zone (0.44)

Table 2.31 Irrigation, Sprinkler - Closed Spaced Drops (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00) Slope (0.12)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00) Slope (0.12)
K_h	Kovich loam, moderately deep water table	Somewhat limited	Kovich (95%)	Depth to saturated zone (0.44) Slope (0.12)

Table 2.32 Irrigation, Sprinkler - General (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Depth to saturated zone (1.00)
K_h	Kovich loam, moderately deep water table	Somewhat limited	Kovich (95%)	Depth to saturated zone (0.44)

Table 2.33 Irrigation, Sprinkler -Graded (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Seepage (1.00) Depth to saturated zone (1.00) Rapid water movement (0.71) Slope (0.50) Low water holding capacity (0.25)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Seepage (1.00) Depth to saturated zone (1.00) Rapid water movement (0.71) Slope (0.50) Low water holding capacity (0.25)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Seepage (1.00) Rapid water movement (0.71) Slope (0.50) Depth to saturated zone (0.44) Low water holding capacity (0.25)

Table 2.34 Irrigation, Surface – Level (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Seepage (1.00)
				Depth to saturated zone (1.00)
				Rapid water movement (0.71)
				Low water holding capacity (0.25)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Seepage (1.00)
				Depth to saturated zone (1.00)
				Rapid water movement (0.71)
				Low water holding capacity (0.25)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Seepage (1.00)
				Rapid water movement (0.71)
				Depth to saturated zone (0.44)
				Low water holding capacity (0.25)

Table 2.35 Pond Reservoir Areas (USDA, NRCS)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)
K_c	Kovich loam	Very limited	Kovich (90%)	Seepage (1.00)
K_d	Kovich loam, channeled	Very limited	Kovich (90%)	Seepage (1.00)
K_h	Kovich loam, moderately deep water table	Very limited	Kovich (95%)	Seepage (1.00)

Table 2.36 Soil Erosion, K Factor (USDA, NRCS)

Map unit symbol	Map unit name	Rating
Kc	Kovich loam	0.32
Kd	Kovich loam, channeled	0.32
Kh	Kovich loam, moderately deep water table	0.32

Table 2.37 Soil Erosion, T Factor (USDA, NRCS)

Map unit symbol	Map unit name	Rating (tons/acre/year)
Kc	Kovich loam	3
Kd	Kovich loam, channeled	3
Kh	Kovich loam, moderately deep water table	3

Table 2.38 Wind Erodibility Group (USDA, NRCS)

Map unit symbol	Map unit name	Rating
Kc	Kovich loam	6
Kd	Kovich loam, channeled	6
Kh	Kovich loam, moderately deep water table	6

Table 2.39 Wind Erodibility Index (USDA, NRCS)

Map unit symbol	Map unit name	Rating (tons/acre/year)
Kc	Kovich loam	48
Kd	Kovich loam, channeled	48
Kh	Kovich loam, moderately deep water table	48

Table 2.40 Available Water Capacity (USDA, NRCS)

Map unit symbol	Map unit name	Rating (cm/cm^2)
K_c	Kovich loam	0.09
K_d	Kovich loam, channeled	0.09
K_h	Kovich loam, moderately deep water table	0.09

Table 2.41 Available Water Storage (USDA, NRCS)

Map unit symbol	Map unit name	Rating (cm/cm^2)
K_c	Kovich loam	14.51
K_d	Kovich loam, channeled	14.3
K_h	Kovich loam, moderately deep water table	14.3

Table 2.42 Bulk Density, One-Third Bar (USDA, NRCS)

Map unit symbol	Map unit name	Rating ($grams/cm^3$)
K_c	Kovich loam	1.37
K_d	Kovich loam, channeled	1.37
K_h	Kovich loam, moderately deep water table	1.37

Table 2.43 Organic Matter (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	2.44
K_d	Kovich loam, channeled	2.44
K_h	Kovich loam, moderately deep water table	2.44

Table 2.44 Percent Clay (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	15.8
K_d	Kovich loam, channeled	15.8
K_h	Kovich loam, moderately deep water table	15.8

Table 2.45 Percent Sand (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	62
K_d	Kovich loam, channeled	62
K_h	Kovich loam, moderately deep water table	62

Table 2.46 Percent Silt (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	22.2
K_d	Kovich loam, channeled	22.2
K_h	Kovich loam, moderately deep water table	22.2

Table 2.47 Surface Texture (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	Loam
K_d	Kovich loam, channeled	Loam
K_h	Kovich loam, moderately deep water table	Loam

Table 2.48 Water Content, 15 Bar (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	7.8
K_d	Kovich loam, channeled	7.8
K_h	Kovich loam, moderately deep water table	7.8

Table 2.49 Water Content, 1/3 Bar (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	15.3
K_d	Kovich loam, channeled	15.3
K_h	Kovich loam, moderately deep water table	15.3

Table 2.50 AASHTO Group Classification-Surface (USDA, NRCS)AASHTO Group Classification-Surface (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	A-4
K_d	Kovich loam, channeled	A-4
K_h	Kovich loam, moderately deep water table	A-4

Table 2.51 Drainage Class (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	Poorly drained
K_d	Kovich loam, channeled	Poorly drained
K_h	Kovich loam, moderately deep water table	Poorly drained

Table 2.52 Frost Action (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	High
K_d	Kovich loam, channeled	High
K_h	Kovich loam, moderately deep water table	High

Table 2.53 Hydrologic Soil Group (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	B/D
K_d	Kovich loam, channeled	B/D
K_h	Kovich loam, moderately deep water table	C

Table 2.54 Representative Slope (USDA, NRCS)

Map unit symbol	Map unit name	Rating (percent)
K_c	Kovich loam	2
K_d	Kovich loam, channeled	2
K_h	Kovich loam, moderately deep water table	2

Table 2.55 Unified Soil Classification-Surface (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	CL-ML
K_d	Kovich loam, channeled	CL-ML
K_h	Kovich loam, moderately deep water table	CL-ML

Table 2.56 Depth to Water Table (USDA, NRCS)

Map unit symbol	Map unit name	Rating (cm)
K_c	Kovich loam	46
K_d	Kovich loam, channeled	46
K_h	Kovich loam, moderately deep water table	76

Table 2.57 Flooding Frequency Class (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	Rare
K_d	Kovich loam, channeled	Rare
K_h	Kovich loam, moderately deep water table	Rare

Table 2.58 Ponding Frequency Class (USDA, NRCS)

Map unit symbol	Map unit name	Rating
K_c	Kovich loam	None
K_d	Kovich loam, channeled	None
K_h	Kovich loam, moderately deep water table	None

Table 2.59 Plant species composition on-site (USDA, NRCS)

Plant Species Composition (lbs acre^{-1})				
Grass/Grasslike				
Group	Plant Common Name	Plant Scientific Name	Annual Production (lbs acre^{-1}) Low	High
0: Dominant Grasses			3500	4500
	water sedge	*Carex aquatilis*	1000	1250
	smallwing sedge	*Carex microptera*	250	500
	Nebraska sedge	*Carex nebrascensis*	1000	1250
	tufted hairgrass	*Deschampsia cespitosa*	750	1000
	mountain rush	*Juncus arcticus ssp. littoralis*	250	500
1: Sub-Dominant Grasses			2650	4000
	creeping bentgrass	*Agrostis stolonifera*	150	250
	meadow foxtail	*Alopecurus pratensis*	150	250
	fewflower spikerush	*Eleocharis quinqueflora*	150	250

	alpine timothy	*Phleum alpinum*	250	500
	marsh bluegrass	*Poa leptocoma*	150	250
	hardstem bulrush	*Schoenoplectus acutus var. acutus*	150	250
2: Sub-Dominant Forbs			850	1600
	Parry's aster	*Symphyotrichum foliaceum var. parryi*	50	100
	heartleaf bittercress	*Cardamine cordifolia*	50	100
	white marsh marigold	*Caltha leptosepala*	50	100
	wild mint	*Mentha arvensis*	50	100
	elephanthead lousewort	*Pedicularis groenlandica*	50	100
	Tweedy's plantain	*Plantago tweedyi*	50	100
	graceful buttercup	*Ranunculus inamoenus*	50	100
	water ragwort	*Senecio hydrophilus*	50	100
	longstalk clover	*Trifolium longipes*	50	100
	seaside arrowgrass	*Triglochin maritima*	50	100
	hookedspur violet	*Viola adunca*	50	100

Shrub/Vine

Group	Plant Common Name	*Plant Scientific Name*	Annual Production (lbs acre^{-1}) Low	High

3: Sub-Dominant Shrubs			300	700
	shrubby cinquefoil	*Dasiphora fruticosa ssp. floribunda*	50	150
	Woods' rose	*Rosa woodsii*	50	150
	Geyer willow	*Salix geyeriana*	50	150

9.3 Soil Sampling Procedure (by Dr. Bryan Hopkins)

1. Choose Unique Sampling Areas

Combining soil from different areas of your property can invalidate your soil analysis. In other words, when submitting soil for analysis, DO NOT combine soil from your garden with soil from your lawn. Common areas to sample include your: front lawn, back lawn, vegetable garden, orchard, and flower beds. Any areas that have received the same fertilizer application over the past two years, have the same vegetation, and have the same type of soil may be combined into one sample. However, be sure to keep problem areas separated from the rest of your soil for diagnostic purposes.

2. Determine Budget Constraints

Each unique area that is sampled will typically cost $15- $30 plus shipping to analyze. Prioritize areas that are most problematic in order to fit within your unique budget constraints.

3. Obtain Proper Sampling Equipment

Visit your local garden center to obtain sample bags and a soil probe. Clean cloth bags are best for soil because they allow the soil to "breathe", but paper bags will work if the soil is not wet. DO NOT use plastic bags unless the soil will arrive to the lab within 24 hours and will be kept cool. We have cloth bags available for you to use. Contact us if you need a bag for your sample.

5. Collect Soil Cores

For each unique sampling area, collect 8 to 20 soil cores by moving in a zig-zag through the area and retrieving soil cores at random. Depending on the type of soil in the area you are sampling, you should insert the soil probe at a depth of 4 inches. Generally, it is easier to sample soil when the soil is moist, and has been compacted. We recommend stepping on each spot where you will be inserting the soil probe before sampling. Additionally, you may disregard living or dead vegetation when sampling.

6. Mix the Soil

Using clean hands or clean gloves, mix the soil in your sample bucket. DO NOT use objects with fertilizer dust on them (gloves, spades, etc.), nor objects made of rubber or non-stainless steel metal to mix the soil.

7. Mark the Soil Sample Bag

Write your name, address, unique sample ID, and average sample depth for the area the soil came from on each sample bag. The unique sample ID should be some way for you to identify where each distinct bag of soil came from.

8. Transfer Soil

Transfer about 2 cups of soil from your bucket into the sample bag, and seal the bag shut using strings, zip ties, or tape.

9. Deliver Soil

Send your soil samples to the Analytical Lab as soon as possible. If you need to store the soil before submission to the lab, keep it cool (preferably frozen), and avoid allowing the soil to be exposed to long periods of heat. Additionally, DO NOT allow your soil samples to come into contact with anything that could contaminate the soil (fertilizer dust, solid contaminants, liquid contaminants) while in storage.

9.4 Records Review: USDA, NRCS Soil Survey Summary

SUITABILITIES AND LIMITATIONS FOR USE

1) Building Site Development
   a) Shallow Excavations (Table 2.6)

      This site has a shallow excavation rating of 'very limited,' meaning it is not favorable for shallow excavations. This is due to the relatively shallow depth to the saturation zone as well as dusty conditions and unstable excavation walls. These limitations would be difficult to overcome.

      > "Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing.
      >
      > Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected" (USDA, NRCS).

   b) Small Commercial Buildings (Table 2.7)

      This site has a small commercial buildings rating of 'very limited,' meaning it is not a favorable location for a small commercial building. Features that explain this rating include the sites' propensity for flooding and the depth to the saturated zone.

      > "Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread

footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected" (USDA, NRCS).

c) Unpaved Local Roads and Streets (Table 2.8)

This site has an unpaved local roads and streets rating of 'very limited,' indicating that it is not suitable for such uses.

"Unpaved local roads and streets are those roads and streets that carry traffic year round but have a graded surface of local soil material or aggregate. They are graded to shed water, and conventional drainage measures are provided. These roads and streets are built mainly from the soil at the site. Soil interpretations for local roads and streets are used as a tool in evaluating soil suitability and identifying soil limitations for the practice. The rating is for soils in their present condition and does not consider present land use. Soil properties and qualities that affect local roads and streets are those that influence the ease of excavation and grading and the traffic-supporting capacity" (USDA, NRCS).

2) Land Classifications

a) Farmland Classification (Table 2.9)

This site has been identified as a farmland of statewide importance. This suggests that the land is suitable for food, feed, fiber, forage and oilseed crops, although a short growing season would be a major limitation for most species.

> "Farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland. It identifies the location and extent of the soils that are best suited to food, feed, fiber, forage, and oilseed crops. NRCS policy and procedures on prime and unique farmlands are published in the "Federal Register," Vol. 43, No. 21, January 31, 1978" (USDA, NRCS).

b) Hydric Rating by Map Unit (Table 2.10)

This site has a Hydric Rating of 95 (except for a small portion (4.2%) that has a rating of 5). This means that 95% of the site rated 95 is comprised of hydric components. This means that the soils were formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil. Onsite testing would be required to determine more specific components.

> "This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric

components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation" (USDA, NRCS).

c) Irrigated Capability Class (Table 2.11)

This site has an irrigated capability class rating of 3. This suggests the soil has severe limitations that reduce the choice of plants, require special conservation practices, or both.

"Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations that show suitability and limitations of groups of soils for rangeland, for woodland, or for engineering purposes. In the capability system, soils are generally grouped at three levels-capability class, subclass, and unit. Only class and subclass are included in this data set. Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use. Class 3 soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both" (USDA, NRCS).

d) Irrigated Capability Subclass (Table 2.12)

This site has an irrigated capability subclass rating of 'w.' This rating indicates that water in the soil may interfere with plant growth or cultivation, though the wetness may be partially corrected with artificial drainage.

"Capability subclasses are soil groups within one capability class. They are designated by adding a small letter, "e," "w," "s," or "c," to the class numeral, for example, 2e. The letter "e" shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; "w" shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage)" (USDA, NRCS).

e) Non-irrigated Capability Class (Table 2.13)

This site has a non-irrigated capability class of 7. This indicates that the soil has severe limitations that make it unsuitable for cultivation and that restricts its use mainly to grazing, forestland and/or wildlife habitat.

"Capability classes, the broadest groups, are designated by the numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use.

Class 7 soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat" (USDA, NRCS).

f) Non-irrigated Capability Subclass (Table 2.14)

This site has a non-irrigated capability subclass rating of 'w.' This indicates that water in the soil would interfere with plant growth or cultivation, though it could be overcome with artificial drainage.

"Capability subclasses are soil groups within one capability class. They are designated by adding a small letter, "e," "w," "s," or "c," to the class numeral, for example, 2e. The letter "e" shows that the main hazard is the risk of erosion unless close-growing plant cover is maintained; "w" shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage" (USDA, NRCS).

g) Soil Taxonomy Classification (Table 2.15)

This site has a soil taxonomy classification of 'fine-loamy, mixed, frigid Cumulic Endoaquolls.'

The soil is a very rich soil with a mollic epipedon of 60 centimeters.

"The system of soil classification used by the National Cooperative Soil Survey has six categories (Soil Survey Staff, 1999 and 2003). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements" (USDA, NRCS).

3) Land Management

a) Soil Compaction Resistance (Table 2.16)

This site has a soil compaction resistance rating of ‘low resistance’ due to the soil texture and structure. This indicates that the soil is not very resistant to compaction and the soil has certain features that favor the formation of a compacted layer.

> “This interpretation rates each soil for its resistance to compaction. Compaction tends to reduce water infiltration which affects plant production and composition, increases runoff which generally increased erosion rates, and affects organisms living within the soil. Compaction is predominantly influenced by moisture content, depth to saturation, percent of sand, silt, and clay, soil structure, organic matter content, and content of coarse fragments. Rating class terms indicate the extent to which the soils are made suitable by all of the soil features that affect the suitability of soil material for chaining. "Low resistance" indicates that the soil has one or more features that favor the formation of a compacted layer. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site” (USDA, NRCS).

b) Soil Rutting Hazard (Table 2.17)

This site has a soil rutting hazard rating of ‘severe.’ This indicates that ruts form readily, suggesting a high risk of soil displacement, deformation and compaction.

> “The ratings in this interpretation indicate the hazard of surface rut formation through the operation of forestland equipment. Soil displacement and puddling (soil deformation and compaction) may occur simultaneously with rutting. Ratings are based on depth to a water table, rock fragments on or below the

surface, the Unified classification of the soil, depth to a restrictive layer, and slope. The hazard is described as slight, moderate, or severe. "Severe" indicates that ruts form readily. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

4) Vegetative Productivity

a) Yields of Irrigated Crops (Component) (Table 2.18, 2.19, 2.20)

This site has estimated yields of the following crops and quantities: barley: 63 (bu), grass/legume/hay: 3.6 (tons), pasture: 6.57 (AUM).

"These are the estimated average yields per acre that can be expected of selected irrigated crops under a high level of management. In any given year, yields may be higher or lower than those indicated because of variations in rainfall and other climatic factors. It is assumed that the irrigation system is adapted to the soils and to the crops grown, that good-quality irrigation water is uniformly applied as needed, and that tillage is kept to a minimum. In the database, some states maintain crop yield data by individual map unit component and others maintain the data at the map unit level. Attributes are included in this application for both, although only one or the other is likely to have data for any given geographic area. This attribute uses data maintained at the map unit component level. The yields are actually recorded as three separate values in the database. A low value and a high value indicate the range for the soil component. A "representative" value indicates the expected value for the component. For these yields, only the representative value is used. The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby areas and results of field trials and demonstrations also are considered. The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that ensures the smallest possible loss. The estimated yields reflect the productive capacity of each soil for the selected crop. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change" (USDA, NRCS).

5) Waste Management

a) Disposal of Wastewater by Irrigation (Table 2.21)

This site has a disposal of wastewater by irrigation rating of 'very limited.' This suggests that the site is not suited for the disposal of wastewater by irrigation. Reasons include the filtering capacity, depth to the saturation zone, the acidity of the soil and droughty conditions.

"Wastewater includes municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Disposal of wastewater by irrigation not only disposes of municipal wastewater and wastewater from food-processing plants, lagoons, and storage ponds but also can improve crop production by increasing the amount of water available to crops. The ratings are based on the soil properties that affect the design, construction, management, and performance of the irrigation system. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

b) Disposal of Wastewater by Rapid Infiltration (Table 2.22)

This site has a disposal of wastewater by rapid infiltration rating of 'very limited.' Shallow depth to saturated zone, slow water movement, stone content and cobble content make this site unfavorable for disposal of wastewater by rapid infiltration.

"Rapid infiltration of wastewater is a process in which wastewater applied in a level basin at a rate of 4 to 120 inches per week percolates through the soil. The wastewater may eventually reach the ground water. The application rate commonly exceeds the rate needed for irrigation of cropland. Vegetation is not a necessary part of the treatment; thus, the basins may or may not be vegetated. The thickness of the soil material needed for proper treatment of the wastewater is more than 72 inches. As a result, geologic and hydrologic investigation is needed to ensure proper design and performance and to determine the risk of ground-water pollution. Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage. The ratings are based on the soil properties that affect the risk of pollution and the design, construction, and performance of the system. Depth to a water table, ponding, flooding, and depth to bedrock or a cemented pan affect the risk of pollution and the design and construction of the system. Slope, stones, and cobbles also affect design and construction. Saturated hydraulic conductivity (Ksat) and reaction affect performance. Permanently frozen soils are unsuitable for waste treatment. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

c) Land Application of Municipal Sewage Sludge (Table 2.23)

This site has a land application of municipal sewage sludge rating of 'very limited.' This is due to the filtering capacity of the soil, the depth to the saturation zone, flooding and acidity of the soil. These factors make the site unfavorable for land application of municipal sewage sludge.

> “Application of sewage sludge not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Sewage sludge is the residual product of the treatment of municipal sewage. The solid component consists mainly of cell mass, primarily bacteria cells that developed during secondary treatment and have incorporated soluble organics into their own bodies. The sludge has small amounts of sand, silt, and other solid debris. The content of nitrogen varies. Some sludge has constituents that are toxic to plants or hazardous to the food chain, such as heavy metals and exotic organic compounds, and should be analyzed chemically prior to use. The content of water in the sludge ranges from about 98 percent to less than 40 percent. The sludge is considered liquid if it is more than about 90 percent water, slurry if it is about 50 to 90 percent water, and solid if it is less than about 50 percent water. The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the sludge is applied, and the method by which the sludge is applied. The properties that affect absorption, plant growth, and microbial activity include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, available water capacity, reaction, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones,

cobbles, a water table, ponding, and flooding can hinder the application of sludge. Permanently frozen soils are unsuitable for waste treatment. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

d) Manure and Food-Processing Waste (Table 2.24)

This site has a manure and food-processing waste rating of 'very limited.' This means the site is not suitable for applications of high rates of manure due to filtering capacity of the soil, the depth to the saturation zone, leaching, and acidity of the soil.

"The application of manure and food-processing waste not only disposes of waste material but also can improve crop production by increasing the supply of nutrients in the soils where the material is applied. Manure is the excrement of livestock and poultry, and food-processing waste is damaged fruit and vegetables and the peelings, stems, leaves, pits, and soil particles removed in food preparation. The manure and food-processing waste are solid, slurry, or liquid. Their nitrogen content varies. A high content of nitrogen limits the application rate. Toxic or otherwise dangerous wastes, such as those mixed with the lye used in food processing, are not considered in the ratings. The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, the rate at which the waste is applied, and the method by which the waste is applied. The properties that affect absorption include saturated hydraulic conductivity (Ksat), depth to a water table, ponding, the sodium adsorption ratio, depth to bedrock or a cemented pan, and available water capacity. The properties that affect plant growth and microbial activity include reaction, the sodium adsorption ratio, salinity, and bulk density. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood that wind erosion or water erosion will transport the waste material from the application site. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

e) Overland Flow Treatment of Wastewater (Table 2.25)

This site has an overland flow treatment of wastewater rating of 'very limited.' This makes the site unsuitable for such treatment due to seepage, the depth to saturation zone, flooding and acidity of the soil.

“In this process wastewater is applied to the upper reaches of sloped land and allowed to flow across vegetated surfaces, sometimes called terraces, to runoff-collection ditches. The length of the run generally is 150 to 300 feet. The application rate ranges from 2.5 to 16.0 inches per week. It commonly exceeds the rate needed for irrigation of cropland. The wastewater leaves solids and nutrients on the vegetated surfaces as it flows downslope in a thin film. Most of the water reaches the collection ditch, some is lost through evapotranspiration, and a small amount may percolate to the ground water.

Wastewater includes municipal and food-processing wastewater and effluent from lagoons or storage ponds. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. Food-processing wastewater results from the preparation of fruits, vegetables, milk, cheese, and meats for public consumption. In places it is high in content of sodium and chloride. The effluent in lagoons and storage ponds is from facilities used to treat or store food-processing wastewater or domestic or animal waste. Domestic and food-processing wastewater is very dilute, and the effluent from the facilities that treat or store it commonly is very low in content of carbonaceous and nitrogenous material; the content of nitrogen commonly ranges from 10 to 30 milligrams per liter. The wastewater from animal waste treatment lagoons or storage ponds, however, has much higher concentrations of these materials, mainly because the manure has not been diluted as much as the domestic waste. The content of nitrogen in this wastewater generally ranges from 50 to 2,000 milligrams per liter. When wastewater is applied, checks should be made to ensure that nitrogen, heavy metals, and salts are not added in excessive amounts. The ratings are for waste management systems that not only dispose of and treat wastewater but also are beneficial to crops. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

f) Slow Rate Treatment of Wastewater (Table 2.26)

This site has a slow rate treatment of wastewater rating of 'very limited.' This suggests that the site is not suitable for such treatment due to the filtering capacity of the soil, the depth to saturation zone, and the acidity of the soil.

"Slow rate treatment of wastewater is a process in which wastewater is applied to land at a rate normally between 0.5 inch and 4.0 inches per week. The application rate commonly exceeds the rate needed for irrigation of cropland. The applied wastewater is treated as it moves through the soil. Much of the treated water may percolate to the ground water, and some enters the atmosphere through evapotranspiration. The applied water generally is not allowed to run off the surface. Waterlogging is prevented either through control of the application rate or through the use of tile drains, or both. Soil properties are important considerations in areas where soils are used as sites for the treatment and disposal of organic waste and wastewater. Selection of soils with properties that favor waste management can help to prevent environmental damage. Municipal wastewater is the waste stream from a municipality. It contains domestic waste and may contain industrial waste. It may have received primary or secondary treatment. It is rarely untreated sewage. The ratings are based on the soil properties that affect absorption, plant growth, microbial activity, erodibility, and the application of waste. The properties that affect absorption include the sodium adsorption ratio, depth to a water table, ponding, available water capacity, saturated hydraulic conductivity (Ksat), depth to bedrock or a cemented pan, reaction, the cation-exchange capacity, and slope. Reaction, the sodium adsorption ratio, salinity, and bulk density affect plant growth and microbial activity. The wind erodibility group, soil erosion factor K, and slope are considered in estimating the likelihood of wind erosion or water erosion. Stones, cobbles, a water table, ponding, and flooding can hinder the application of waste. Permanently frozen soils are unsuitable for waste treatment. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect agricultural waste management. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

6) Water Management

a) Embankments, Dikes, and Levees (Table 2.27)

This site has an embankments, dikes and levees rating of 'very limited.' This suggests the site is not suitable for raised structures of soil material constructed to impound water or protect against overflow. This is due to the shallow depth to saturation zone, piping and dusty conditions on the site.

> "Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. Embankments that have zoned construction (core and shell) are not considered. The soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction. The ratings do not indicate the suitability of the undisturbed soil for supporting the embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties. Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability. Rating class terms indicate the extent to

which the soils are limited by all of the soil features that affect the specified use. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

b) Irrigation, General (Table 2.28)

This site has a general irrigation rating of 'very limited.' Seepage, depth to saturation zone, rapid water movement, low water holding capacity and slope make this location unfavorable for the use of irrigation general irrigation systems. However, careful management of overhead sprinkler irrigation could be used effectively to enhance yields.

"This interpretation evaluates a soil's limitation(s) for installation and use of irrigation systems. This interpretation is for non-specific irrigation methods and is intended to provide initial planning information. If the type of irrigation system has been determined, additional interpretations provide more specific information. The ratings are for soils in their natural condition and do not consider present land use. Irrigation systems are used to provide supplemental water to crops, orchards, vineyards, and vegetables in areas where natural precipitation will not support desired production of crops being grown. The soil properties and qualities important in design and management of irrigation systems are sodium adsorption ratio, depth to high water table, available water holding capacity, saturated hydraulic conductivity (Ksat), slope, calcium carbonate content, ponding, and flooding. Soil properties and qualities that influence installation are stones, depth to bedrock or cemented pan, and depth to a high water table. The properties and qualities that affect performance of the irrigation system are depth to bedrock or to a cemented pan, the sodium adsorption ratio, salinity, and soil reaction. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

c) Irrigation, Micro (Above Ground) (Table 2.29)

This site has a micro (above ground) irrigation rating of 'very limited.' Depth to saturation zone and seepage make this location unfavorable for micro irrigation methods used above ground.

"This interpretation evaluates a soil's limitation(s) for irrigation systems that apply frequent applications of small quantities of water on the soil surface as drops, tiny streams or miniature spray through emitters or applicators placed along a water delivery line. Generally, these irrigation systems are very efficient in terms of both water and energy use and are suitable for use in vineyards, orchards, windbreaks, nurseries, and on truck crops and some row crops. The ratings are for soils in their natural condition and do not consider present land use. The soil properties and qualities important in the design and management of drip micro-irrigation systems are depth, wetness or ponding, percolation, and flooding. The soil properties and qualities that influence installation are depth, flooding, and ponding. The features that affect performance of the system and plant growth are the content of salts, calcium carbonate, or sodium. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

d) Irrigation, Micro (Subsurface Drip) (Table 2.30)

This site has a micro (subsurface drip) irrigation rating of 'very limited.' Depth to saturation zone make this location unfavorable for micro (subsurface drip) irrigation methods.

"This interpretation evaluates a soil's limitation(s) for irrigation systems that apply low volumes of water below the soil surface as drops, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line. Subsurface micro-irrigation systems are buried and apply water directly and very slowly to the root zone. Generally, these systems are very efficient in terms of both water and energy use and are suitable for use in windbreaks, vegetables, berries, landscape plantings, vineyards, orchards, and some row crops. The ratings are for soils in their natural condition and do not consider present land use. The soil properties and qualities important in the design and management of subsurface micro-irrigation systems are soil depth, available water capacity, wetness or ponding, saturated hydraulic conductivity, pH (soil reaction), erosion potential, and flooding. The soil properties and qualities that influence installation are soil depth, stoniness, flooding, and ponding. The features that affect performance of the system and plant growth are available water capacity, shrink-swell potential, pH (soil reaction), and the content (or amount) of salts, calcium carbonate, and sodium. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

e) Irrigation, Sprinkler (Closed Spaced Drops) (Table 2.31)

This site has a sprinkler (closed space drops) irrigation rating of 'very limited.' Depth to saturation zone and slope make this location unfavorable for sprinkler (closed spaced drops) irrigation methods. A small portion of the site (4%) has a 'somewhat limited' rating meaning a small portion of the area has fewer limitations for use of sprinkler irrigation making that portion moderately favorable for such irrigation practices.

> “This interpretation evaluates a soil's limitation(s) for installation and use of sprinkler irrigation systems equipped with low pressure spray nozzles mounted on closely spaced drops that apply water close to the ground surface. The ratings are for soils in their natural condition and do not consider present land use. These systems are generally found on linear move or center pivot systems, and they have separate slope criteria from other sprinkler systems because of their higher application rates, which increase risk of runoff and irrigation-induced erosion on steeper slopes. Examples of these types of systems include Low Pressure in Canopy (LPIC), Low Energy Precision Application (LEPA), Low Elevation Spray Application (LESA), and Mid-Elevation Spray Application (MESA) systems. These types of irrigation systems are generally suitable for small grains, row crops, and vegetables. The soil properties and qualities important in the design and management of sprinkler irrigation systems utilizing close spaced spray nozzles on drops are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, saturated hydraulic conductivity, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface texture, surface rocks, salinity, sodium adsorption ratio, wetness, erosion potential, and available water holding capacity. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The

limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

f) Irrigation, Sprinkler (General) (Table 2.32)

This site has a general sprinkler irrigation rating of 'very limited.' Depth to saturation zone makes this location unfavorable for general sprinkler irrigation methods. A small portion of the site (4%) has a 'somewhat limited' rating meaning a small portion of the area has fewer limitations for use of sprinkler irrigation making that portion moderately favorable for such irrigation practices.

"This interpretation evaluates a soil's limitation(s) for installation and use of sprinkler irrigation systems, excluding those equipped with closely spaced outlets on drops, which are covered by a different interpretation. The ratings are for soils in their natural condition and do not consider present land use. Sprinkler irrigation systems apply irrigation water to a field through a series of pipes and nozzles and can be either solid set or mobile. Generally, this type of irrigation system is suitable for small grains, row crops, vegetables, and orchards. The soil properties and qualities important in the design and management of sprinkler irrigation systems are depth, available water holding capacity, sodium adsorption ratio, surface coarse fragments, saturated hydraulic conductivity, salinity, slope, wetness, and flooding. The features that affect performance of the system and plant growth are surface rocks, salinity, sodium adsorption ratio, wetness, and available water holding capacity. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

g) Irrigation, Surface (Graded) (Table 2.33)

This site has a surface (graded) irrigation rating of 'very limited.' Depth to saturation zone and slope make this location unfavorable for surface (graded) irrigation methods.

"This interpretation evaluates a soil's limitation(s) for graded border and graded furrow surface irrigation systems. Graded border irrigation systems allow irrigation water to flow across the soil surface while being confined by borders.

Graded furrow irrigation systems are systems that allow irrigation water to flow down furrow valleys while the crop being irrigated is planted on the furrow ridge. Generally, graded border systems are suitable for small grains while graded furrow systems are suitable for row crops. The ratings are for soils in their natural condition and do not consider present land use. The soil properties and qualities important in the design and management of graded surface irrigation systems are depth, available water holding capacity, sodium adsorption ratio, surface rocks, saturated hydraulic conductivity, salinity, slope, wetness, and flooding. Features that affect system performance and plant growth are salinity, sodium adsorption ratio, wetness, calcium carbonate content, and available water holding capacity. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

h) Irrigation, Surface (Level) (Table 2.34)

This site has a surface (level) irrigation rating of 'very limited.' This site is therefore unfavorable for surface (level) irrigation due to seepage, depth to saturation zone, rapid water movement, and low water holding capacity.

“This interpretation evaluates a soil's limitation(s) for basin, paddy, level furrow, or level border irrigation systems. The ratings are for soils in their natural condition and do not consider present land use. Level surface irrigation systems use flood irrigation techniques to spread irrigation water at a specified depth across the application area. Basin, paddy, and borders generally use external ridges or borders to confine the water, while level furrow systems use furrow valleys and end blocks or border ridges to confine the water during irrigation. With furrow irrigation the crop is usually planted on the furrow ridge. Generally, basin, paddy and level border irrigation systems are suitable for rice, small grain, pasture, and forage production. Level furrow systems are generally suited for row crops. The soil properties and qualities important in the design and management of level surface irrigation systems are depth, available water holding capacity, sodium adsorption ratio, saturated hydraulic conductivity, salinity, slope, and flooding. The soil properties and qualities that influence installation are depth, flooding, and ponding. The features that affect performance of the system and plant growth are salinity, sodium adsorption ratio, and available water holding capacity. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the interpretation. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. The results of this interpretation are not designed or intended to be used in a regulatory manner. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

i) Pond Reservoir Areas (Table 2.35)

This site has a pond reservoir areas rating of 'very limited.' This rating is due to seepage and suggests that the site is unfavorable for a dam or an embankment.

"Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (Ksat) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site" (USDA, NRCS).

SOIL PROPERTIES AND QUALITIES

1) Soil Erosion Factors

a) K Factor, Whole Soil (Table 2.36)

This site has a soil erosion K factor of 0.32. Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. "Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments" (USDA, NRCS).

b) T Factor (Table 2.37)

This site has a soil erosion T factor of 3 tons per acre per year.

"The T factor is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year" (USDA, NRCS).

c) Wind Erodibility Group (Table 2.38)

This site has a wind erodibility group rating of 6. This suggests it is not very susceptible to wind erosion, especially when vegetated.

"A wind erodibility group (WEG) consists of soils that have similar properties affecting their susceptibility to wind erosion in cultivated areas. The soils assigned to group 1 are the most susceptible to wind erosion, and those assigned to group 8 are the least susceptible" (USDA, NRCS).

d) Wind Erodibility Index (Table 2.39)

This site has a wind erodibility index of 48 tons per acre per year. This means 48 tons per acre per year can be expected to be lost to wind erosion if not covered by vegetation.

> "The wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion" (USDA, NRCS).

2) Soil Physical Properties

a) Available Water Capacity (Table 2.40)

This site has an AWC of .09 cm of water per centimeter of soil.

> "Available water capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in centimeters of water per centimeter of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure, with corrections for salinity and rock fragments. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. It is not an estimate of the quantity of water actually available to plants at any given time" (USDA, NRCS).

b) Available Water Storage (Table 2.41)

This site has an AWS of 14.3 cm water per cm depth of soil.

> "Accumulates the AWC for a specified depth range. Used to produce data for the muaggatt table." (USDA, NRCS)

c) Bulk Density, One-Third Bar (Table 2.42)

This site has an un-compacted bulk density at 1/3 bar of 1.37 g/cm^3.

> "Bulk density, one-third bar, is the oven dry weight of the soil material less than 2 millimeters in size per unit volume of soil at water tension of 1/3 bar, expressed in grams per cubic centimeter. Bulk density data are used to compute linear extensibility, shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. Depending on soil texture, a bulk density of more than 1.4 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure. For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

d) Organic Matter (Table 2.43)

This site has an average native organic matter reading of 2.44%.

"Organic matter is the plant and animal residue in the soil at various stages of decomposition. The estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained by returning crop residue to the soil. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth. It is a source of nitrogen and other nutrients for crops and soil organisms. An irregular distribution of organic carbon with depth may indicate different episodes of soil deposition or soil formation. Soils that are very high in organic matter have poor engineering properties and subside upon drying. For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

e) Percent Clay (Table 2.44)

This soil at this site has an average of 15.8% clay.

"Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. The estimated clay content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The amount and kind of clay affect the fertility and physical condition of the soil and the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, saturated hydraulic conductivity (Ksat), plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations. Most of the material is in one of three groups of clay minerals or a mixture of these clay minerals. The groups are kaolinite, smectite, and hydrous mica, the best known member of which is illite. For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

f) Percent Sand (Table 2.45)

This soil at this site has an average of 62% sand.

"Sand as a soil separate consists of mineral soil particles that are 0.05 millimeter to 2 millimeters in diameter. In the database, the estimated sand content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification. For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

g) Percent Silt (Table 2.46)

This soil at this site has an average of 22.2% silt.

"Silt as a soil separate consists of mineral soil particles that are 0.002 to 0.05 millimeter in diameter. In the database, the estimated silt content of each soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of sand, silt, and clay affects the physical behavior of a soil. Particle size is important for engineering and agronomic interpretations, for determination of soil hydrologic qualities, and for soil classification. For each soil layer, this attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

h) Surface Texture (Table 2.47)

The predominate soil texture at this site is Loam.

"This displays the representative texture class and modifier of the surface horizon. Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand" (USDA, NRCS).

i) Water Content, 15 Bar (Table 2.48)

The water content at 15 bar of this site is 7.8% volumetric water holding capacity.

“Water content, 15 bar, is the amount of soil water retained at a tension of 15 bars, expressed as a volumetric percentage of the whole soil material. Water retained at 15 bars is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils. Water retained at 15 bars is an estimation of the wilting point. Water content varies between soil types, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. For each soil layer, water content is recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used” (USDA, NRCS).

j) Water Content, One-Third Bar (Table 2.49)

The water content at 1/3 bar of this site is 15.3% volumetric water holding capacity.

“Water content, one-third bar, is the amount of soil water retained at a tension of 1/3 bar, expressed as a volumetric percentage of the whole soil. Water retained at 1/3 bar is significant in the determination of soil water-retention difference, which is used as the initial estimation of available water capacity for some soils. Water retained at 1/3 bar is the value commonly used to estimate the content of water at field capacity for most soils.

Water content varies between soil types, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. For each soil layer, water content is recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

3) Soil Qualities and Features

a) AASHTO Group Classification (Surface) (Table 2.50)

The soil has an AASHTO Group Classification of A-4.

"AASHTO group classification is a system that classifies soils specifically for geotechnical engineering purposes that are related to highway and airfield construction. It is based on particle-size distribution and Atterberg limits, such as liquid limit and plasticity index. This classification system is covered in AASHTO Standard No. M 145-82. The classification is based on that portion of the soil that is smaller than 3 inches in diameter. The AASHTO classification system has two general classifications: (i) granular materials having 35 percent or less, by weight, particles smaller than 0.074 mm in diameter and (ii) silt-clay materials having more than 35 percent, by weight, particles smaller than 0.074 mm in diameter. These two divisions are further subdivided into seven main group classifications, plus eight subgroups, for a total of fifteen for mineral soils. Another class for organic soils is used. For each soil horizon in the database one or more AASHTO Group Classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil" (USDA, NRCS).

b) Drainage Class (Table 2.51)

The site has a drainage class of 'poorly drained.'

"'Drainage class (natural)' refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized-excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained" (USDA, NRCS).

c) Frost Action (Table 2.52)

The site has a frost action rating of 'High.'

"Potential for frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, saturated hydraulic conductivity (Ksat), content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured, clayey soils that have a high water table in winter are the most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible.

Frost heave and low soil strength during thawing cause damage to pavements and other rigid structures” (USDA, NRCS).

d) Hydrologic Soil Group (Table 2.53)

The site has two soil groups. Kc and Kd are in the B/D group while Kh is in the C group. This means the soil has a slow infiltration rate when the soil is thoroughly wet and a slow rate of water transmission.

“Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes" (USDA, NRCS).

e) Representative Slope (Table 2.54)

The area has a representative slope of 2% and a north facing slope (aspect).

"Slope gradient is the difference in elevation between two points, expressed as a percentage of the distance between those points. The slope gradient is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

f) Unified Soil Classification (Surface) (Table 2.55)

This site has a unified soil classification of CL-ML.

"The Unified soil classification system classifies mineral and organic mineral soils for engineering purposes on the basis of particle-size characteristics, liquid limit, and plasticity index. It identifies three major soil divisions: (i) coarse-grained soils having less than 50 percent, by weight, particles smaller than 0.074

mm in diameter; (ii) fine-grained soils having 50 percent or more, by weight, particles smaller than 0.074 mm in diameter; and (iii) highly organic soils that demonstrate certain organic characteristics. These divisions are further subdivided into a total of 15 basic soil groups. The major soil divisions and basic soil groups are determined on the basis of estimated or measured values for grain-size distribution and Atterberg limits. ASTM D 2487 shows the criteria chart used for classifying soil in the Unified system and the 15 basic soil groups of the system and the plasticity chart for the Unified system. The various groupings of this classification correlate in a general way with the engineering behavior of soils. This correlation provides a useful first step in any field or laboratory investigation for engineering purposes. It can serve to make some general interpretations relating to probable performance of the soil for engineering uses. For each soil horizon in the database one or more Unified soil classifications may be listed. One is marked as the representative or most commonly occurring. The representative classification is shown here for the surface layer of the soil" (USDA, NRCS).

4) Water Features

a) Depth to Water Table (Table 2.56)

The depth to the water table for Kc and Kd sections is 46 cm, while the depth for the Kh section is 76cm to the water table.

"'Water table' refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table. This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used" (USDA, NRCS).

b) Flooding Frequency Class (Table 2.57)

The site has a flooding frequency class rating of 'rare,' meaning flooding is unlikely but possible under certain conditions.

"Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly." Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. "Rare" means that flooding is unlikely but possible under unusual weather conditions. The chance of flooding is 1 to 5 percent in any year" (USDA, NRCS).

c) Ponding Frequency Class (Table 2.58)

This site has a ponding frequency class rating of 'none,' meaning that ponding is not probable.

> "Ponding is standing water in a closed depression. The water is removed only by deep percolation, transpiration, or evaporation or by a combination of these processes. Ponding frequency classes are based on the number of times that ponding occurs over a given period. Frequency is expressed as none, rare, occasional, and frequent. "None" means that ponding is not probable. The chance of ponding is nearly 0 percent in any year" (USDA, NRCS).

Appendix A

Application Final Exam Questions

1) You observe plants with new leaves that are completely chlorotic. You talk with Dr. Hopkins and he suggests that it is likely S deficiency because this nutrient is not mobile in plants (tends to show up on new leaves instead of old ones) and has symptoms which include general chlorosis. What is the BEST way to be 100% certain that this is the correct diagnosis?
    a. apply S fertilizer in replicated areas and observe the response
    b. soil test for S
    c. tissue test for S
    d. water test for pH
    e. all of the above would work equally well
    f. no way to confirm this

2) When taking a soil sample to help diagnose a visual plant symptom, it is best to ________.
    a. take samples in both the problem area and adjacent to it
    b. do a complete analysis of all tests we have performed in this class
    c. always transport the samples to the lab within the same day
    d. all of the above are generally needed
    e. none of the above

3) Tests are done on soils of the identical soil series located in close proximity to a popular resort. Compared to steeper sloped areas, the soils that are on slopes of less than 5% have average bulk density of 1.68 g/cm^3 and 10% greater water content and are significantly higher in nitrogen, potassium, and many other elements, as well as many organic chemicals. What is the likely source of the differences? _________________________

4) A professional football coach is complaining that pesticides are killing the grass on his team's practice field and he is worried that it is also impacting the health of the team since they spend so many hours in close contact with the turf. The grass is brown and very thin, except around the perimeter of the field where trees and shrubs line the edge to provide privacy. The field where the team plays games looks great. Both fields are sandy with similar chemistry and they are managed identically. The main differences are in the physical properties with 1.63 and 1.79 g/cm^3 for the game and practice fields, respectively. Also, the game field has a narrow particle size distribution of mostly medium sized sand and the practice field has a wide particle size distribution with an even mix of fine, medium, and coarse sized sand. How are (or are not) pesticides impacting the turf negatively? Are there any other concerns?

5) An ___________________ is a report prepared that identifies potential or existing environmental contamination liabilities.
    a. soil survey
    b. NRCS site survey
    c. ESA

d. ECL report
e. RFLP
f. EEA
g. soil series environmental contamination query
h. none of the above

6) You are working for a consulting firm doing a report to identify environmental contamination liabilities, which of the following is required to be part of the documentation submitted as part of the assessment?
    a. conceptual model validation
    b. adjacent property land use
    c. absence, presence, degree of target analytes
    d. all of the above are required
    e. none of the above are required

7) T/F When writing a report to identify environmental contamination liabilities, it is essential to avoid speculating with regard to the analytical data. This data should be presented alone and without bias.

8) You take penetrometer readings at three sites near to each other with identical soil series with the following results: 1) north of fence = 540 psi, 2) under fence that has been in place for decades = 280 psi, and 3) south of fence = 400 psi. Which side of the fence likely has the least plant growth and has had the largest stocking rate? (Assume same size of animals and same time of exposure when the soil was grazed while wet.) Why did you take the readings at the fence?

9) Complete the following using the Utah County soil survey book—choosing between a Benjamin silty clay (soil 1) or an Bramwell silty clay loam (soil 2) with slopes near 0%.
Which soil is more productive for plant growth? _____
Shallower water table? _____
Shrink-swell potential? _____
What page is the general description for the Benjamin Series found on?_____
What page is the specific description for the Benjamin silty clay found on? _____

10) Answer the following questions with regard to assessing the site shown in the picture below. How many soil types do you initially observe under the pivot (circular area being irrigated)? _____ If assessing both soil type and management history, what is the minimum number of samples that would need to be taken based on this picture? ________ Besides soil analysis, what other information would you want to collect?