Stormwater Education:
Evaluating learning when siting stormwater facilities at the landscape scale

Daniel Cronan, 2017
University of Oregon, Department of Landscape Architecture

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Evaluating learning when siting
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Submitted in Partial Fulfillment
For the Master of Landscape Architecture

Department of Landscape Architecture,
University of Oregon

Master's Project Committee:

Project Chair: Professor David Hulse
Project Committee Member: Chris Enright, Ph.D.

Acknowledgements:

I'd like to take this opportunity to express my gratitude for my project chair, Professor David Hulse. Your encouragement, advice, and patience has helped me throughout this project and will continue to do so throughout my career. It is my hope to echo similar guidance to future students.

I would like to thank my committee member, Chris Enright. You constantly go the extra mile to ensure that students are learning, and I feel privileged to have learned this and many other things from you.

I would like to thank my fellow master's students for their feedback, cooperation, and of course friendship. Thank you for all of your help along the way, and I wish the best for you in your future endeavors.

Last but not least, I'd like to thank my wife, Sara, for supporting me throughout this project and for being in my life.

ABSTRACT:

PURPOSE: Evaluating a student's development is key to understanding whether and how they are learning. This project focuses on landscape architecture and planning education, using a set curriculum, courses, and workshops as vehicles for experimentation. It systematically evaluates student learning within a studio course and a workshop by analyzing self-reported and spatially explicit evidence of learning about stormwater infiltration system design.

METHOD: The method gathers, assesses, and evaluates evidence of student learning. It uses measurement and mapping combined with student surveys to evaluate two forms of evidence: self-reported and spatially explicit. Self-reported evidence are responses to a questionnaire administered both before and after course instruction to determine which key factors of students' stormwater designs improved. The spatially explicit evidence is student designs for stormwater related interventions in landscape form and pattern, again both early in the sequence and after instruction. The spatially explicit evidence for both the studio and workshop were evaluated using a spatial analysis tool, "SUSTAIN" (an ArcGIS plugin), which uses siting criteria specified by the U.S. Environmental Protection Agency (EPA) that distinguish places suitable for stormwater infiltration facilities.

RESULTS: The results of this study present and interpret the evaluation of self-reported and spatially explicit evidence of learning. The results indicate that students from the workshop showed evidence of learning from a spatially explicit evidence evaluation, however comparisons of the self-reported evidence from initial to final were mixed. These results are intended to provide recommendations for future courses regarding siting stormwater facilities at the landscape scale.

CONCLUSION: I conclude that both spatially explicit and self-reported evidence together best indicate learning for design and planning students, with the evidence in this project most compelling regarding short-course workshop format classes.

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1.6 KEY TERMS and ACRONYMS

BMP. *Best Management Practice*

Design Charrette. *An intensive planning session where citizens, designers and others collaborate on a vision for development. It provides a forum for ideas and offers the unique advantage of giving immediate feedback to the designers (Jason, 2008).*

EPA. *Environmental Protection Agency*

GI. *Green Infrastructure: Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. It is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits (EPA, 2004a).*

NPDES. *National Pollutant Discharge Elimination System*

Studio. *LA 4/594 Landscape Planning and Design Studio, Fall 2016, University of Oregon*
Instructors: Professor David Hulse & Professor Rob Ribe

SUSTAIN. ***S**ystem for **U**rban **S**tormwater **T**reatment and **A**nalysis **IN**tegration*

Workshop. *Stormwater Management Workshop, Winter 2017*
Instructor: Daniel Cronan

1.7 LIST of FIGURES and TABLES

Chapter 1. Introduction

1.1 MOTIVATIONS

"Assessment of student learning demonstrates that the institution's students have knowledge, skills, and competencies consistent with institutional and program goals and that graduates meet appropriate higher education goals."
-Douglas J. Eder, Ph.D

Evaluating student learning reflects the program goals of a higher education institution. Our current education system asks educators to maintain standards for skills learned or conveyed throughout a curriculum, and students are required to exit academic programs with a specific set of competencies pertinent to their field. These competencies have the potential to be viewed as indicators of student strengths and weaknesses. They can be measured to understand if, and if so, how knowledge is acquired.

The aim of this project is to develop and apply an evaluation framework, relevant to the field of Landscape Architecture, to determine learning within design instructional courses by measuring, evaluating, and comparing student skills and competencies using two forms of evidence. As a personal development interest, this project is intended to enhance my professional skills as an efficient and effective educator within the field of Landscape Architecture.

1.1.1 Landscape Planning and Design Education

The field of Landscape Planning and Design can be defined as "a particular form of planning at a regional scale which integrates land use, physical planning, and environmental issues" *(Frank, 2006)*. Within the past three decades, Landscape Planning and Design education has undergone significant advances to develop student learning within formal course instruction. Studios and workshop course types focus on current and relevant issues, and they are effective in initiating student interest and preparing students for practice with the field *(Lusk & Kantrowitz, 1990)*.

1.1.2 Significance of focus on Landscape Planning and Design Education

Landscape Planning and Design studios and workshops ask students to provide solutions to current problems for a specific geographical location using tools and guidance. Studios typically last for an entire academic term, and focus on a wide range of topics, theories, and specific circumstances relevant to a given study area. Workshops are often briefer, and are generally designed to "foster learning how to learn" *(Frank, 2006)*. This project evaluated evidence of student learning in a 10-week Studio and a half-day Workshop. This evaluation led to guidance for revising particular components of a Landscape Planning and Design Stormwater Workshop.

1.2 PROJECT PURPOSE

1.2.1 Purpose

The purpose of this project is to provide and demonstrate a systematic approach for evaluating student learning within a Landscape Planning and Design Studio and a Workshop using two forms of evidence: self-reported and spatially explicit. This approach will provide educators with guidance for developing instructional courses to aid student learning. The project evaluates student knowledge, skills, and competencies throughout courses related to current stormwater issues for a particular geography. The results indicate students' self-understanding of key concepts from self-assessment and provide a faculty-produced spatial evaluation of student designs.

1.2.2 Relevance of Project

The framework in this project intends to contribute to Landscape Architecture and Planning education. It is also my intention to contribute to Green Infrastructure (GI) and stormwater education by creating, delivering, and revising a Landscape Planning and Design Workshop to site suitable locations for stormwater infiltration. This project aims to address the need for initial and final self-reported and spatially explicit student evaluations as guides of how to improve instruction to revise learning about this topic. Reporting the relationship of learning to this evidence will indicate what revisions need to be made to course materials and instruction.

1.3 RESEARCH QUESTION

By proposing the use of a combination of mixed evidence, this project seeks to answer the following research question:

What types of evidence best indicate student learning in term-long and short course instruction in stormwater planning and design?

1.4 GOALS and OBJECTIVES

1.4.1. GOALS

The goals of the project are:

a) Guide and assess student learning in a 10-week design studio and a half-day workshop when siting appropriate areas for stormwater infiltration facilities;

b) Use questionnaires and spatial design proposals to evaluate student learning;

c) Develop a self-assessment for course instructors to indicate instructor development within the project.

This project employs a five part framework *(Figure 1.1)*, each part of which occupies a specific step in a chronologic sequence. This five-step process is the heart of the project and is further described in Chapter 2: Methods. Each of the five steps also serves as a measurable objective that can be used to gauge progress towards the goals listed above.

1.4.2 OBJECTIVES

a) INSTRUCT:
-Present relevant material concerning stormwater facilities and their design
-Present a method for siting suitable locations for stormwater infiltration facilities;

b) ASSESS:
-Assess student initial and final understanding of stormwater infiltration
-Gather evidence of initial and final student team designs in the studio and individual student designs in the workshop;

c) EVALUATE:
-Evaluate a combination of self-reported and spatially explicit evidence to determine student learning:
i) Compare statements from initial and final questionnaires;
ii) Evaluate improvement from initial to final designs using 'SUSTAIN';

d) DIAGNOSE
-Diagnose issues in stormwater instruction material and results;

e) PRESCRIBE
-Prescribe recommendations for improving an instructional course regarding siting of stormwater facilities at the landscape scale.

The following section briefly summarizes some central information from key relevant literature.

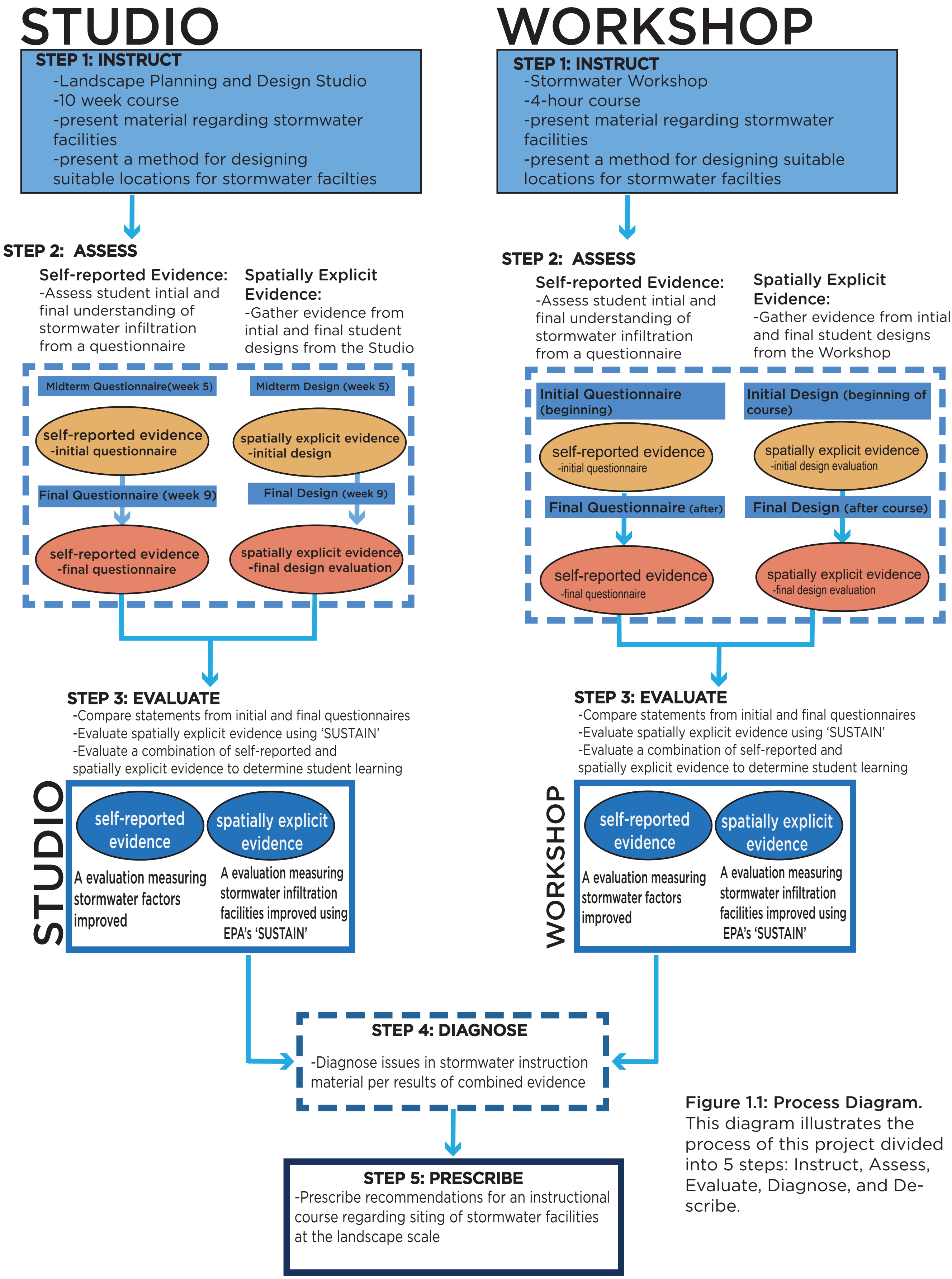


Figure 1.1: Process Diagram. This diagram illustrates the process of this project divided into 5 steps: Instruct, Assess, Evaluate, Diagnose, and Describe.

1.5 LITERATURE BACKGROUND

1.5.1 The Cagliari Workshop

In 2015, an educational Landscape Planning and Design workshop was conducted in Cagliari, Italy which addressed particular key competencies in sustainability acquired through scenario exercises *(Albert et al, 2015)*. During the workshop, an evaluation method was implemented to report findings from the study. Responses to surveys, statements in interviews, and observed changes in behavior provided the method of inquiry to gauge skills acquired during the sessions. The study reported significant positive change in individual and overall development contributing to planning skills. However, researchers indicated the study was unable to comprehensively assess educational development from an initial to final survey assessment due to time limitations. Likewise, the study did not address evidence of change indicated by geospatial design outputs during the workshop.

The Cagliari Workshop played a central role in the development of this project as it laid out a framework for evaluating student self-reported data from a Landscape Planning and Design workshop. Because the researchers noted the lack of an initial and a final questionnaire and a spatially explicit evaluation, I was drawn to use these components within my master's project. This master's project addresses the knowledge gap identified in *Albert et al. 2015* by presenting a systematic approach for evaluating self-reported and spatially explicit evidence of student learning.

1.5.2 Stormwater Education

The *U.S. Environmental Protection Agency (EPA)* has developed a framework to site and evaluate *Green Infrastructure (GI)* in our urban environments. At the federal level, all stormwater management decisions are required to follow reguations implemented through the *National Pollutant Discharge Elimination System* (*NPDES*). Many cities around the US are beginning to require municipal stormwater permits for new stormwater facilities and retrofits. These facilities are commonly referred to as *Best Management Practices (BMPs)*. Siting and selecting the type of particular facilities can be done through a series of suitability mapping analyses with tools such as ArcGIS and the EPA's own tool, *SUSTAIN (Shoemaker et al., 2012)*.

The EPA's stormwater facility suitability criteria and municipal stormwater managment regulations for the City of Eugene, Oregon were used to develop course content and instructional guides explained within STEP 1. INSTRUCT *(Figure 1.1)*.

1.5.2 Cognitive Load Theory

Cognitive load theory is based on the premise that: "if cognitive working memory requires too much capacity, learning will be hampered (Jong, 2009)." The theory asserts that cognitive working memory must be activated by various forms of learning exercises which have varying levels of intensity corresponding to the difficulty of the presented information. According to the theory, there are three contributing types of cognitive load which require various methods of teaching: intrinsic, extraneous, and germane. First, *intrinsic cognitive load* describes the burden on learning posed by "material that contains a large number of interactive elements and is regarded as more difficult than material with a smaller number of elements and/or with a low interactivity (Jong, 2009)." Large amounts of material require more student processing. A second load type is *extraneous cognitive load*. This type refers to the presentation of instructional material which may require a separation of tasks (Jong, 2009). This separation of attention requires additional processing for the learner. For example, synthesizing theoretical information within a workshop might call for a discussion exercise, whereas technical and site specific design practices might require a design charrette exercise. Simultaneously mixing of these two types of processing contributes to cognitive load in student learning. Third, *germane cognitive load* refers to imposed processing and organizing of a schema or a plan to solve a given problem. The theory explains that student performance and learning increase when a variety of information processing techniques are employed *(Sweller et al., 1988)*. When students are given more options for organizing ideas, concepts, and skills, they are able to respond to problems with high variability.

Timing within a course for measuring cognitive load through self-reported evidence varies from study to study (Jong, 2009). Initial and final questionnaires, which occur at various stages during or outside of a course, can indicate specifically what information was retained by the student.

This project seeks to understand what skills and knowledge can be obtained during a Studio and a Workshop related to siting suitable locations for stormwater infiltration. I used an initial and final assessment of self-reported and spatially explicit evidence to measure specific factors and skills in student learning. In the Chapter 4: Conclusion, Cognitive load theory provided guidance for improvement of the processing of self-reported and spatially explicit evidence of learning. By understanding and using this theory, it is my hope to improve the Workshop by using responsive activities and evaluations to increase learning.

Three Types of Cognitive Loads

1) Intrinsic- A function of number of interactive elements;

2) Extraneous- Requires separation of tasks;

3) Germane- Requires organized schema or problem solving plan.

Chapter 1 Summary

The Introduction Chapter provided an overview of the project and a summary of key issues, goals, and objectives. In addition, it also identified a research gap in current literature regarding evaluating student learning about Landscape Planning and Design education in regards to stormwater, and finally, introduced the five-step framework employed in the project.

This study seeks to evaluate student learning within courses about siting stormwater facilities with special consideration to improving teaching. The Methods Chapter that follows explains the process by which evidence of student learning was gathered and used to evaluate whether or not learning occurred. It offers an approach for evaluating two forms of evidence of student learning: self-reported and spatially explicit. The self-reported evidence takes the form of responses to a questionnaire administered both before and after a formal course of instruction. The spatially explicit evidence takes the form of student design proposals for stormwater related interventions in the form and pattern of a landscape, again both early in the sequence and after instruction. The evaluations of this evidence consist of a comparison of the first questionnaire responses with the second, and a comparison of the first spatially explicit designs of stormwater facilities with the second. Both stages of evaluation seek to identify specific evidence of learning, as well as the type of learning that occurred. The evaluation leads to Results, reported in Chapter 3: Results, then it informs recommendations for how to improve the course of instruction to lead to better student learning.

Chapter 2. Methods

2.1 METHODS SUMMARY

This study seeks to evaluate student learning within courses regarding stormwater, with a focus on improving teaching. The Methods Chapter explains the process by which evidence of student learning was gathered and the methods used to evaluate whether or not learning occurred. It offers an approach for evaluating two forms of evidence: self-reported and spatially explicit. Within this project, the term ‘STEPS’ is used to describe the process *(Figure 2.1)*.

STEP 1: INSTRUCT; In both the Studio and the Workshop, material concerning the siting of stormwater facilities was conveyed to students. A method for designing such facilities was also given to students in the form of an instructional guide.
STEP 2: ASSESS; The self-reported evidence on which assessment of learning is partly based, takes the form of responses to a questionnaire administered both before and after a formal course of instruction. Student team designs from the Studio and Workshop student designs were also collected for evaluation.
STEP 3: EVALUATE; The evaluations of this evidence consist of a comparison of the initial questionnaire responses with the second, and a comparison of the first spatially explicit designs of stormwater facilities with the second. Both stages of evaluation seek to identify specific evidence of learning, as well as the type of cognitive load that occurred. The spatially explicit evidence takes the form of student designs for stormwater related interventions in the form and pattern of a landscape. One such design was produced mid-way through the course of instruction, and the other at its conclusion.
STEP 4: DIAGNOSE; The evidence of student learning was used to determine instructional context or means of delivery in need of revision for subsequent courses of instruction concerning planning and design using suitability criteria.
STEP 5: PRESCRIBE; Revisions based on the overall process were made to the Workshop.

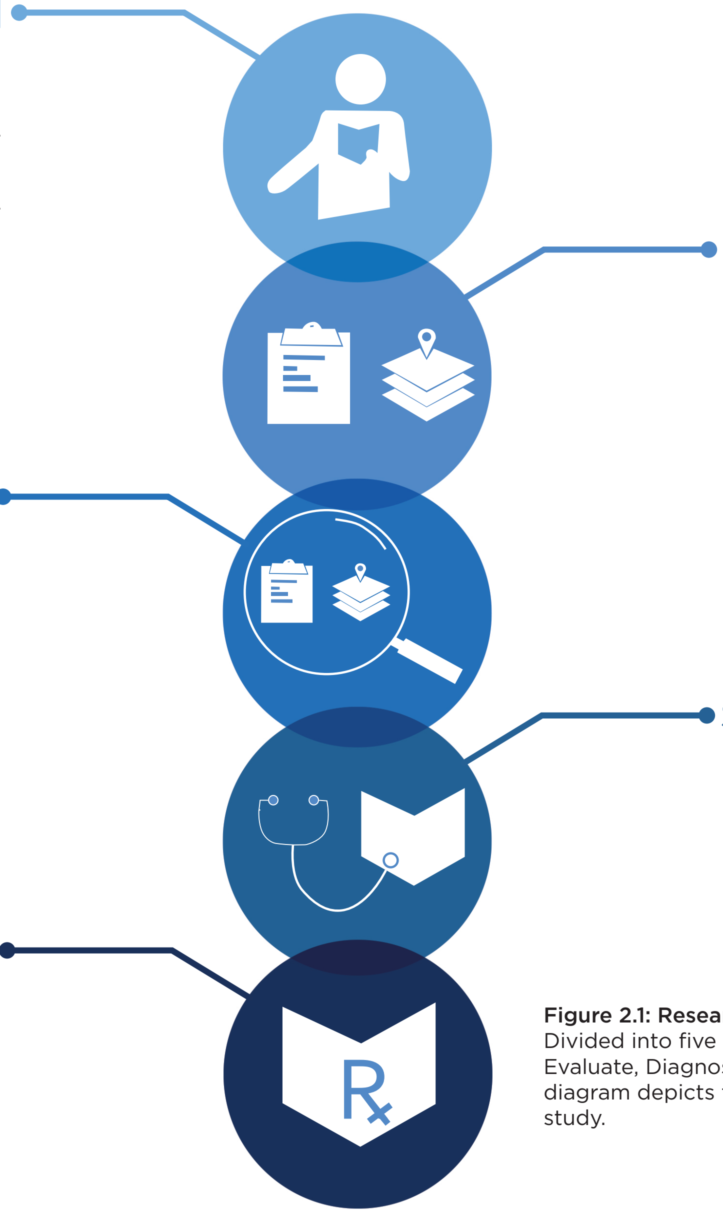


Figure 2.1: Research Process Summary: Divided into five Steps (Instruct, Assess, Evaluate, Diagnose, and Prescribe), this diagram depicts the overall process of this study.

2.2 RESEARCH STRATEGY

Landscape Architecture research is rapidly evolving and expanding as a way to provide knowledge-based decisions for practice and education. Deming and Swaffield's 2011 book, 'Landscape Architecture Research,' provides a systematic typology and vocabulary for describing distinct research approaches in the field. Using Deming and Swaffield's vocabulary, the research strategy for this project can be classified in multiple rows and columns within *Figure 2.2*. For example, the research fits the strategy of 'interpretation,' since the results are an 'interpretation' of student learning. However, the core objective of this project fits the constructionist strategy, as the aim of the research is to link investigator presumptions with reality *(Deming and Swaffield, 2011)*. 'Reality,' within the project context, is student learning, whereas 'presumptions' can be defined as the perceptions about what is/ is not being learned.

The objective of the 'Evaluation and Diagnosis' strategy is to merge these two forms of evidence to show student learning quantitatively (spatially explicit evidence) and qualitatively (self-reported evidence). This project also uses deductive strategies to evaluate learning and diagnose needed changes in course content and delivery to improve learning. Evaluation and diagnosis is a strategy to develop explanations and interpretations through specific processes *(Deming and Swaffield, 2011)*. Detecting learning by applying specific indicators and tools to both self-reported and spatially-explicity evidence, this method may become a more generally transferable approach for educators within planning and design.

	Inductive (theory building)	**Reflexive (theory/practice interactions)**	**Deductive (theory testing)**
Objectivist strategies	Description	Modeling and correlation	Experimentation
Constructionist strategies	Classification	Interpretation	Evaluation and diagnosis
Subjectivist strategies	Engaged action	Projective design	Logical systems

Figure 2.2: Strategies of Inquiry: This graphic positions the core strategies of this project using Deming and Swaffield's typology presented in Landscape Architecture Research.

2.3 FOUNDATIONS OF KNOWLEDGE CLAIMS

George Santayana defined knowledge as 'the cognizance one existence takes of another' *(Santayana, 1937)*. This research project seeks to support teaching-based learning claims by demonstrating an approach through which the cognizance of learning can be found in two forms of evidence: self-reported and spatially explicit. Within the field of Landscape Architecture, project evaluations are increasingly conducted to determine the efficacy of a project. Within Landscape Architecture education, evaluations of student proposals for landscape change are regularly used to indicate individual student learning, but often in less than systematic ways. As students transition to practice from education, institutional fact-based approaches to research can be supported by practice-based knowledge claims. "Practice-based knowledge is recognized to be personal, contested, contingent and reliant upon individual meaning making while university traditions have built on the assumption that knowledge exists as discrete facts developed, distributed, and institutionalized in good research by expert authorities" *(Kennedy, 2015)*. This study seeks to relax the dichotomy between the two by using a method applicable in both practice and teaching.

The project uses evaluation and diagnosis as a research strategy to determine the nature of learning within the context of material conveyed in both a workshop and a studio. The evidence gathered addresses notions of learning from the student's perspective and a spatial evaluation conducted using SUSTAIN, a tool developed by a Federal Agency, the Environmental Protection Agency *(EPA)*.

The role of this project methodology within Landscape Architecture research operationalizes the "Evaluation and Diagnosis" research strategy by using the following research methods *(Figure 2.3)*:

a) *Questionnaire surveys*
b) *Measurement and mapping, modeling*

2.3.1 Self-Reported Evidence: Initial to Final Assessment

Students' self-reported responses to a questionnaire survey provide evidence to gauge learning within this study. An initial and final assessment of student knowledge provides evidence of specific factors and processes learned during both the studio and the workshop.

2.3.1 Spatially Explicit Evidence: Initial to Final Assessment

The spatially explicit evidence gathered and assessed during this project can be categorized by Deming and Swaffield (2011) under the research method of measurement and mapping under the research strategy of 'Modeling." This portion of *STEP 2: ASSESS (Figure 2.4)* was conducted using SUSTAIN, a spatial evaluation and analysis tool to develop a comparison of initial and final design evaluations for each team and participant in the workshop and the studio.

Assumptions about Knowledge & the World	The Purpose of Knowing	Examples of Theoretical Perspective	Examples within Landscape Architecture	Typical Research Strategies	Typical Research Methods	Predominant Modes of Representation
Objectivism	**Instrumental/ Predictive** *What, where & how?*	[Post]positivist natural sciences	Landscape perception studies Landscape ecology.	Descriptive survey Modeling Experimentation & Quasi-experiments	Measurement and mapping Questionnaire surveys Statistical analysis Alternative futures	Mathematical symbols, with written interpretation
[Social] Construction	**Interpretive** *Who, when and why?*	Pragmatism Hermeneutics Symbolic Interaction Phenomenology	Design process Place studies Community studies Historical studies Project evaluations	Classification Ethnography Discourse Analysis Iconography Historiography Evaluation and Diagnosis	Close observation Interviews and focus groups Documentary analysis Life histories Post Occupancy Evaluation	Written narrative, with illustrative diagrams and photographs
Subjectivism	**Critical** *What are the consequences?* *How might things be done differently?*	Critical Inquiry Post-structuralism Feminist	'Expressivist' Theory 'Critical Visual Studies' Design scenarios	Action Research Projective Design Logical systems & argumentation	Deconstruction Reflection Creative Intervention	Diverse media -written -graphic -aural -performance

Figure 2.3: Foundations of Knowledge Claims: This diagram (from Deming and Swaffield, 2011) illustrates the research strategy applied to particular methods of inquiry for this study.

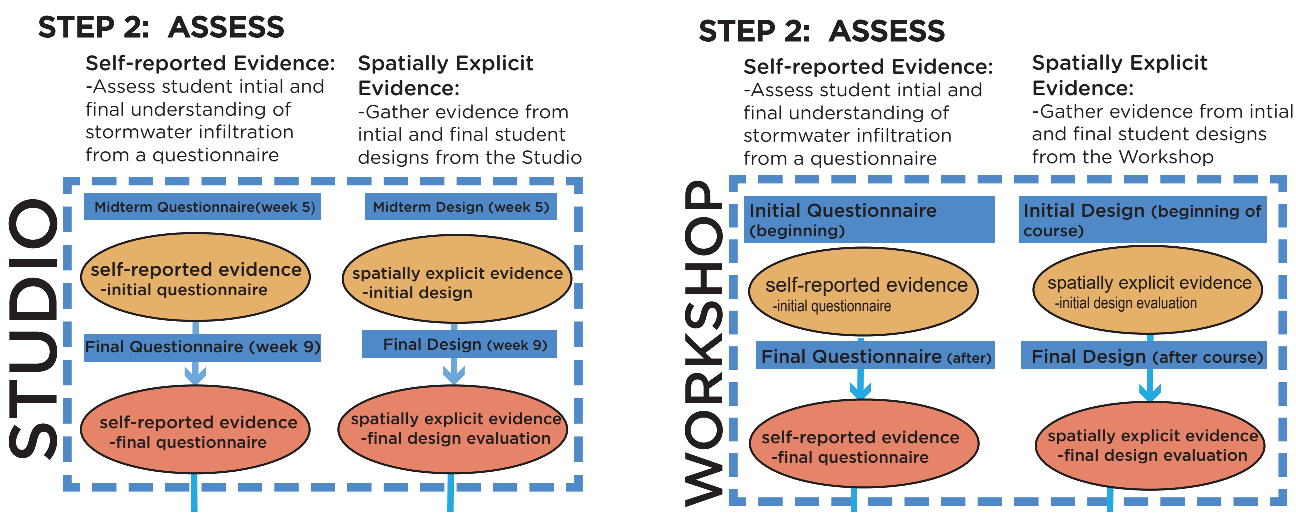


Figure 2.4: Detail of STEP 2: ASSESS: This diagram shows STEP 2 within the process and with details about what is happening within each part of the step.

2.4 PROCESS OVERVIEW

2.4.1 Overview

As described previously, this project compares and contrasts self-reported and spatially explicit evidence. In the next section, detailed descriptions of both forms of evidence are presented *(Figure 2.4).*

2.4.2 Overview of Landscape Planning and Design Studio

Students teams were asked to propose changes to a range of land use and land cover conditions for a study area at the confluence of the McKenzie and the Willamette River for a 30-year time horizon. These changes were driven by the need to accommodate 16,000 additional residents during this 30-year period. As with any major change in development, proper planning for infrastructure has to be taken into account. With the aim of reducing impact on wildlife habitat and biodiversity, concepts of green infrastructure were presented.

Among the program elements, 50 acres of land designated for stormwater infiltration facilities were asked to be apportioned at the landscape scale as one component of a larger Green Infrastructure system.

A stormwater suitability mapping exercise was then demonstrated to convey a method for siting suitable stormwater infiltration facilities. Stormwater infiltration suitability criteria established by the EPA were presented to the students *(Figure 2.5)* during a formal instructional exercise. During the exercise, students were asked to apply the criteria using suitability mapping with ESRI's ArcGIS. Students were then given the option to use the criteria within their team designs. After a midterm review of first draft student proposals, student teams were encouraged to revise their designs in response *(Figure 2.6)*. Anonymous evidence was gathered from student teams in the forms of questionnaire and design proposals at week 5 (initial) and week 10 (final) for purposes of this study and sequestered for the author of this report until the term had ended and student's grades were recorded with the University Registrar.

Stormwater Infiltration Design Criteria

slope ≤ 15%
depth to bedrock ≥ 60 inches
hydrologic soil groups = A, B,or C
depth to water table ≥ 6 feet
distance from roadway ≥ 50 ft
distance from streams/waterbody ≥ 100 ft
distance from water supply (well field) ≥ 100 ft

Source: United States Environmental Protection Agency (EPA) (2005) Storm Water Management Model (SWMM) Version 5.0.005b.
https://www.epa.gov/water-research/storm-water-management-model-swmm

https://www.epa.gov/water-research/system-urban-stormwater-treatment-and-analysis-integration-sustain

Figure 2.5: Stormwater Infiltration Design Criteria: Criteria defined by the EPA for suitable locations for stormwater infiltration used within course instruction for the Studio and the Workshop.

2.4.3 Overview of Workshop

In contrast to the instructional setting of the 10-week Fall 2016 design studio, a half-day stormwater workshop was conducted in Winter 2017, also with a focus on siting stormwater infiltration facilities at the landscape scale. The four-hour workshop used the same study area, GIS based representation, and suitability criteria as a means to produce self-reported and spatially-explicit evidence of learning *(STEPS 1 & 2, Figure 2.1 & Figure 2.4)*. Content and material specific to siting stormwater facilties was taken from the Studio and revised for the Workshop. Initial questionnaires were administered to participants at the start of the workshop to gauge preliminary understanding of stormwater systems and urban hydrology. Following a basic explanation of stormwater infiltration facilities, terms, and relevant case studies, a design exercise was administered to assess initial spatially-explicit understanding of stormwater infiltration suitability criteria and their application in proposing future stormwater facilities. As noted in *Figure 2.4*, students were presented with a series of maps illustrating potential areas for stormwater infiltration using the EPA's Criteria *(Figure 2.5)*. In addition to the criteria, a dataset of Eugene's existing Stormwater Green Infrastructure network was provided to the participants. Participants were then asked to locate additional locations for stormwater infiltration. A final stormwater questionnaire was administered 2 weeks after the workshop.

Figure 2.6: Studio work: Students working in studio prior to Final Review. To protect individual's privacy, a filter was applied to the images to disguise the identity of the students.

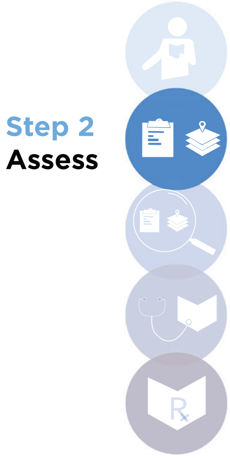
Figure 2.7: Workshop exercise: Students participating in an exercise during the Stormwater Workshop. To protect individual's privacy, a filter was applied to the images to disguise the identity of the students.

2.5 PROCESS SUMMARY

Course instruction, evaluation of student learning, and the determination of instructional materials for subsequent courses is an iterative process in education. Prior to presenting the results, I offer below a brief summary of the method used within this project.

2.5.1 STEP 1: INSTRUCT

Students were presented with course material regarding concepts, key terms, and essential background for siting stormwater facilities at the landscape scale in two different instructional settings: a ten week landscape design studio (Studio) and a half-day stormwater workshop (Workshop). Stormwater infiltration suitability criteria established by the Environmental Protection Agency *(EPA)* under the National Pollutant Discharge Elimination System *(NPDES)* were presented to students using ArcGIS. A method using this tool was presented to students as a way to identify suitable locations for stormwater infiltration facilities within a given study area in Eugene and Springfield, Oregon.



2.5.2 STEP 2: ASSESS

Gathering Self-Reported Evidence of Learning by relevant factor

Questionnaires were given to students at two intervals during both the studio and the workshop to assess learning. Based on the criteria used by the EPA for siting successful stormwater facilities (*Muthukrishnana, EPA, 2004*), an interpretation of relevant stormwater factors was developed for the questionnaire. By conducting an investigation of suitable criteria for stormwater infiltration BMP design, the following factors were addressed in pre- and post-instruction questionnaires (See Appendix A1 & A2 for questionnaires).

The Five Relevant Factors

A) System factors-
- 1) Terrain
- 2) Impervious cover
- 3) Land Use

B) Runoff factors-
- 4) Reduction and mitigation of runoff

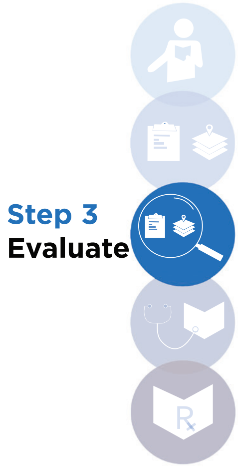
C) Flooding factors-
- 5) Flooding and Design Storms

Gathering Spatially Explicit Evidence of Learning

As a method of inquiry, spatial analysis was used to indicate evidence for both the Landscape Planning and Design Studio and the Stormwater Workshop. After completion of both the studio and the workshop, student designs were digitized for evaluation using EPA's 'SUSTAIN' to evaluate initial and final designs.

Relevance of SUSTAIN

SUSTAIN or the **S**ystem for **U**rban **S**tormwater **T**reatment and **A**nalysis **IN**tegration *(Shoemaker, 2012)*, processes information built on science-based parameters shown to effect stormwater quality and creates a scaled ranking of suitable locations for various stormwater facilities *(Appendix C)*. These parameters can then be used to evaluate locations for potential BMPs *(Appendix. C)*. Material presented within both the studio exercise and the stormwater workshop used EPA defined criteria for siting stormwater infiltration facilities, therefore the adequacy to measure and evaluate these factors in student team and individual designs can be explained as a relevant objective approach for spatial analysis. The tool uses criteria established by the EPA under compliance of the National Pollutant Discharge Elimination System *(NPDES)*, therefore this metric has the potential to encourage students to comply with federal and state standards for stormwater management *(USEPA, 2004a, 2004b).*



2.5.3 STEP 3: EVALUATE

Evaluating Self-Reported Evidence of Learning

The initial and final questionnaires were completed voluntarily and anonymously by Studio and Workshop students. The results from the questionnaires were sequestered until the courses were completed and then delivered to the researcher. Initial and final results from the questionnaire were compared by factor to determine self-reported learning.

The self-reported evidence evaluation depicts change in student responses from initial to final questionnaire. It indicates students' perceptions of what they have learned about stormwater facility design for the Studio and the Stormwater Workshop. If learning occured, the degree of learning was depicted as 'LOW, MEDIUM, or HIGH' *(Figure 2.8)*. My primary objective is to report indications of student learning within the course. Using this process allows for combination of qualitative and quantitative evidence of learning. An example of a Workshop student's self-reported evaluation is described as an example in the Results Chapter.

Evaluating Spatially Explicit Evidence of Learning

The spatially explicit evidence evaluation consists of using EPA's SUSTAIN to contrast changes in student team and workshop students' initial and final designs, looking specifically for improvement in complying with EPA suitability criteria. SUSTAIN was used to compare the suitability of the initial design to the final design of each student. SUSTAIN's output delimits the total acreage suitable for each specific infiltration facility or BMP. Digital maps of student designs were contrasted by using a function in a Map Algebra Expression of ESRI's ArcGIS known as 'Raster Calculator'. A change map was then created, showing all locations where cover conditions had changed from initial to final spatially explicit designs. The scale of learning from initial to final design was shown as *"LOW, MEDIUM, or HIGH (Figure 2.8)."* An example of a Workshop student's spatially explicit evaluation is described as an example within the Results Chapter.

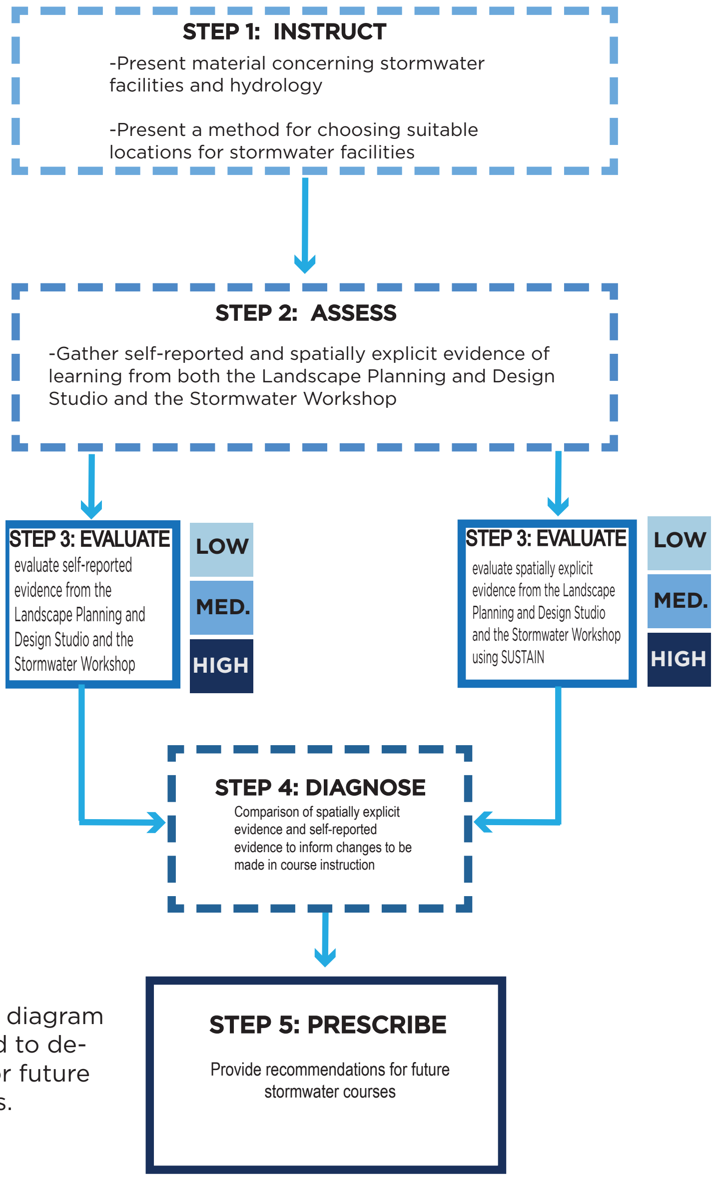
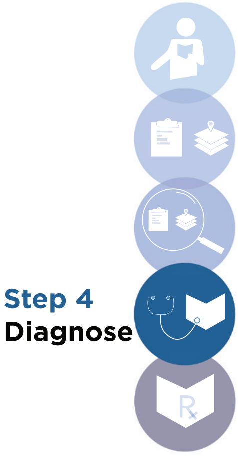


Figure 2.8: Processing Diagram: This diagram shows how the evidence is processed to develop a diagnosis and prescription for future stormwater course recommendations.



2.5.4 STEP 4: DIAGNOSE

Here, the instructional material, topics, skills, (Syllabus, Problem Statements, Assignments/Exercises) for the course is analyzed to pinpoint ways to improve student learning within the Workshop. A comparison of students' self-reported and spatially explicit evidence evaluation shows the student's grasp of knowledge relevant to siting stormwater infiltration facilities at the landscape scale within a range from low to high. Contrasts across the entire group of students in evidence evaluation indicate possible topics, skills, and exercises to be improved for the Workshop course materials delivery and content. An example of how these improvements can be made is demonstrated in the Results Chapter.

2.5.5 STEP 5: PRESCRIBE

The prescribe step proposes revisions to Workshop course material, structure, and exercises to improve student learning. Within the Results Chapter, recommendations are made to improve the Workshop based on a specific student's self-reported and spatially explicit evidence. Overall recommendations for the Workshop are also given based on the overall outcome of student learning from the Workshop.

Chapter 2 Summary

The previous Methods chapter outlined the methods used in this study. I used a five-step process *(Figure 2.1)* to gauge student learning within a Studio and a Workshop. The gathers, assesses, and evaluates evidence of student learning. It uses measurement and mapping combined with student surveys to evaluate two forms of evidence: self-reported and spatially explicit. Self-reported evidence are responses to a questionnaire administered both before and after course instruction to determine which key factors of students' stormwater designs improved. The spatially explicit evidence is student designs for stormwater related interventions in landscape form and pattern, again both early in the sequence and after instruction. In the next chapter, RESULTS, I first explain the overall results from the Workshop. I then use evidence of learning from an anonymous student example from the Workshop to describe details of the approach in each STEP.

3.1 OVERVIEW OF RESULTS

The Results Chapter presents and interprets results regarding learning in the Workshop. It provides overall results for the entirety of the Workshop and a Workshop student example: *student 7*. The student example is used to demonstrate the details of the approach. This chapter summarizes the connection between the evidence of learning and the prescription of recommended changes for the Workshop. The Studio played a key role in the development of the Workshop, however the focus in this chapter is on the Workshop as a detailed example.

Chapter 3. Results

3.2 STUDENT PROCESS EXAMPLE

A student example from the Workshop was chosen because the Stormwater Workshop was organized solely around siting stormwater infiltration facilities at the landscape scale for the study area. As mentioned in the methods chapter, the Stormwater Workshop grew from and was based on studio course instruction regarding siting stormwater infiltration areas.

3.2.1 INSTRUCT

The Stormwater Workshop aimed to inform students about stormwater management at the landscape scale. A stormwater facility siting exercise was the central instructional activity. The four-hour Workshop was divided into two blocks: *(Full workshop syllabus in Appendix B1)*

BLOCK 1:
Conceiving Stormwater Systems *(2 Hours)*

Prior to instruction the students in the workshop were given a questionnaire to gauge their stormwater knowledge before the workshop. Within this section of the course, I presented: principles of basic hydrology, impact of development on natural systems effected by stormwater, sustainable stormwater management pracitices, common definitions, and selected stormwater system design case studies from around the world. At the end of the BLOCK 1 (Appendix B1), students were divided into teams and asked to site locations for stormwater infiltration areas within the study area. Student teams then chose a representative to report findings to the class.

BLOCK 2:
How to site stormwater facilities *(2 hours)*

After a 30-minute break, students were presented with the EPA's framework for stormwater management networks under the NPDES permit: Point (infiltration), Line (conveyance), and Area (collection). Examples and locational suitability criteria for each facility were then presented. Students were then given a spatial data set using an Adobe Illustrator file format with mapped layers of the locations meeting suitability criteria for point, line, and area facilities. Students were then asked to use the data set to design a stormwater network for point (infiltration) facilities within the study area.

Step 2
Assess

3.2.2 ASSESS

Students were given initial questionnaires *(Appendix A)* concerning factors of stormwater knowledge before the workshop, and final questionnaires *(Appendix A)* 2 weeks after the workshop. Self-reported evidence of learning for the project is comprised of results from both questionnaires for each student. Initial spatially explicit student designs created within BLOCK 1 and Final student designs from BLOCK 2 of the workshop were also gathered and compared for formulation of the spatially explicit evidence of learning.

Step 3
Evaluate

3.2.3 EVALUATE

An evaluation of teaching takes a measure of its effectiveness (*Shephardprofessor, 2016*). Within STEP 3: EVALUATE, two types of evidence, a specific workshop student's spatial designs and their questionnaire responses were evaluated to determine overall evidence of learning for Student 7.

Self-Reported Evidence:
Student 7, Workshop

Student 7's initial questionnaire results were compared with their final questionnaire results to determine if learning occurred. The student was asked to report knowledge of the Five Relevant Factors at the beginning and two weeks after the workshop:

The Five Relevant Factors

A) System factors-
1) Terrain
2) Impervious cover
3) Land Use

B) Runoff factors-
4) Reduction and mitigation of runoff

C) Flooding factors-
5) Flooding

The initial and final questionnaire results were analyzed to understand if specific information and concepts presented within the workshop were learned by the student. Also, when offered by the student, relevant and specific responses were marked as learning for each of the five relevant factors related to siting stormwater facilities at the landscape scale. For example, in the Initial Questionnaire, Student 7 used general and non-specific language to describe system factors, whereas in the Final Questionnaire Student 7 indicated knowledge of the EPA's federal regulatory siting criteria which were covered in the instructional presentation and used in the final design exercise *(Figure 3.1).*

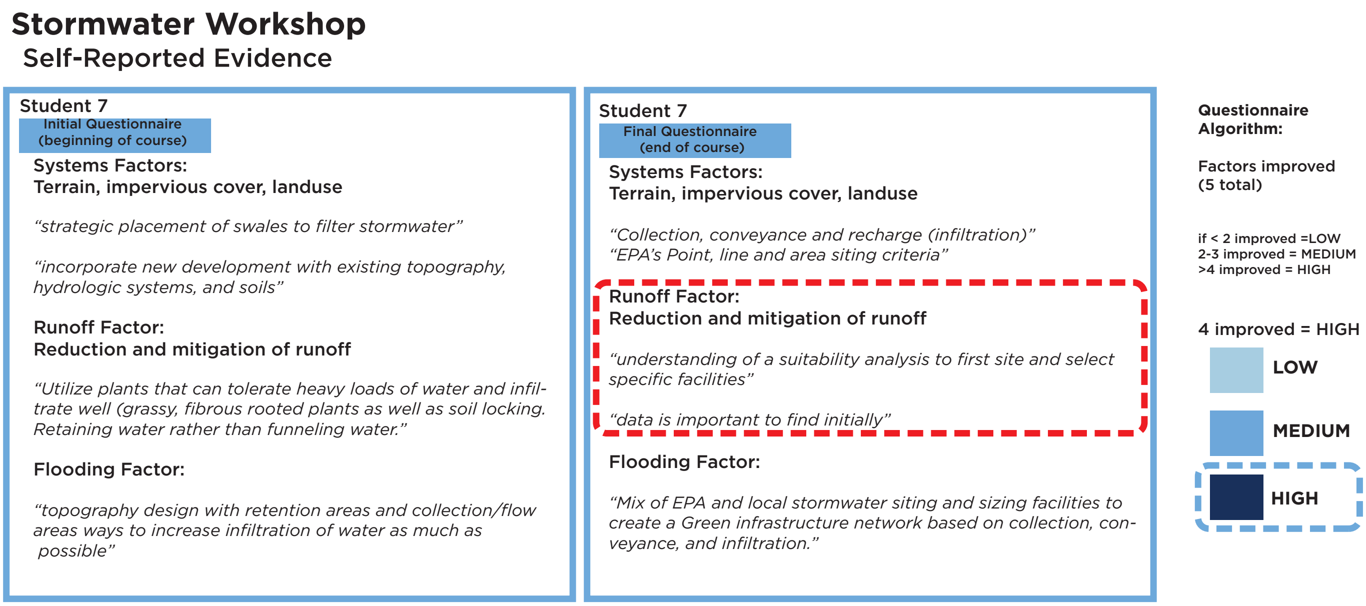


Figure 3.1: Student 7 Self-Reported Evidence Evaluation Diagram: This diagram shows Student 7's responses to the Initial and Final Questionnaire as well as how the evidence will be processed for student 7 in the Workshop. An algorithm was used to gauge student responses from low to high.

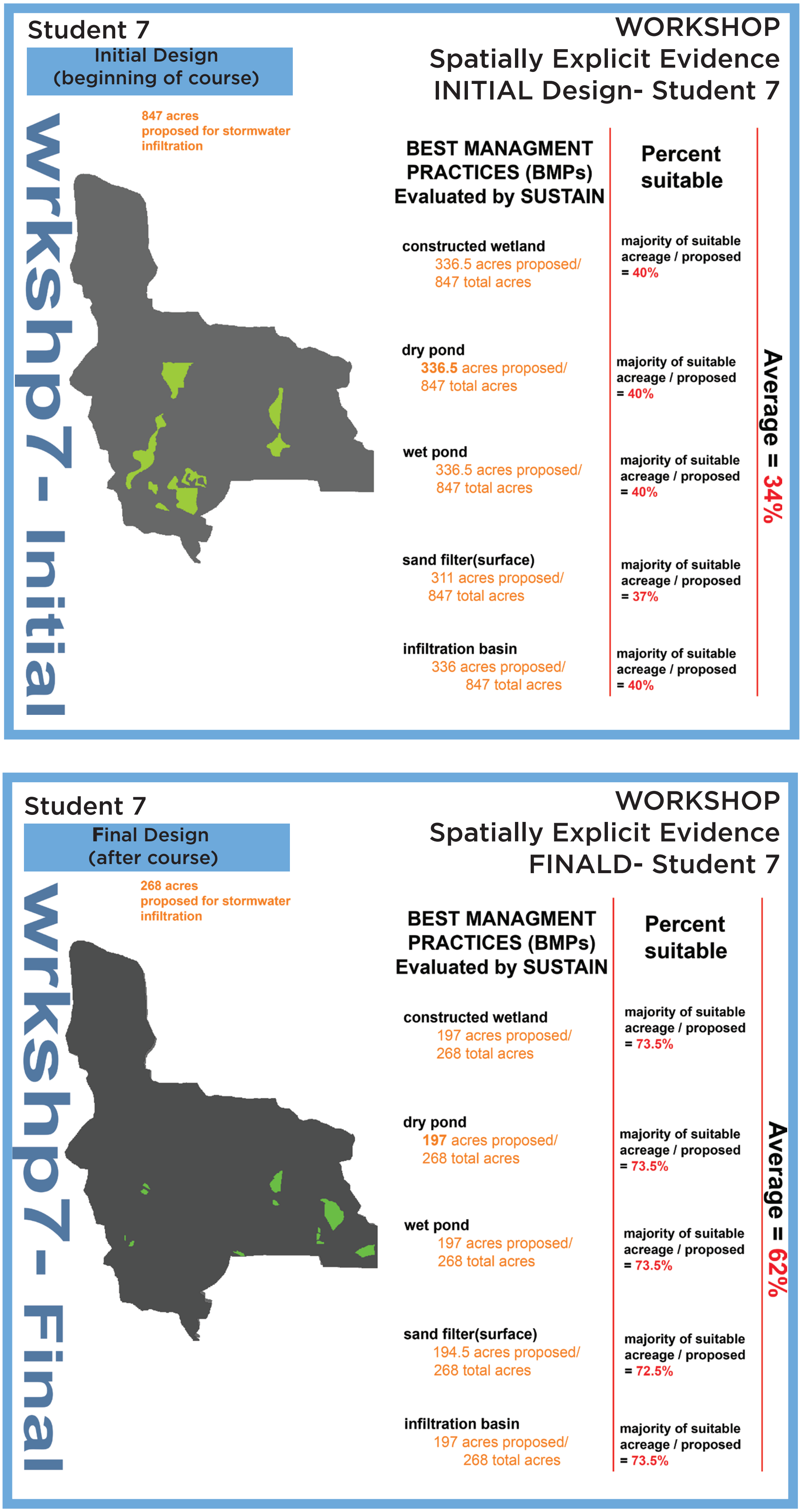
An algorithm was used to gauge student responses from low to high. A student was given a score of 'LOW' if less than two relevant factors improved from initial to final questionnaire. If two to three factors improved, then the student was given a score of 'MEDIUM.' Greater than four improved relevant factors was assigned the score of 'HIGH.'

Spatially Explicit Evidence:
Student 7, Workshop

Within the workshop, the student's initial and final designs from the exercises in BLOCK 1 and BLOCK 2 formed the spatially explicit evidence. The spatially explicit evidence was evaluated by comparing the initial and final designs with an EPA's 'SUSTAIN.' As mentioned before, this digital tool can be used for both siting and evaluating potential areas for stormwater facilities. I used SUSTAIN to evaluate improvement from initial to final designs in each student's siting of stormwater infiltration facilities or 'point BMPs' (Best Management Practices as defined by the EPA): constructed wetlands, dry ponds, wet ponds, surface sand filters, and infiltration basins.

Within STEP 3: EVALUATE, SUSTAIN was used to compare the suitability of the initial to final designs of the student. SUSTAIN's output delimits the total acreage suitable for each specific infiltration facility or BMP. The acreage of each infiltration BMP deemed suitable by SUSTAIN was then used as the numerator whereas the total proposed changed acreage was used as the denominator. The result is the percent suitable land area for both the students' initial and final designs. An increase in percent suitable from Initial to Final Design for a BMP was evidence that learning occurred. The Design Algorithm in Figure 3.2, depicts learning from initial to final design shown as "LOW, MEDIUM, or HIGH." With the example below, Student 7 improved on all five of the BMPs thus receiving a "HIGH" evaluation for spatially explicit evidence of learning.

$$\frac{\textit{acres suitable according to SUSTAIN}}{\textit{total changed acres}} = \textit{Percent Suitable}$$



Design Algorithm:

BMPs improved

if < 2 improved =LOW
2-3 improved = MEDIUM
>4 improved = HIGH

5 improved = HIGH

LOW

MEDIUM

HIGH

Figure 3.2: Student 7 Spatially Explicit Evaluation Diagram. *This diagram shows how spatially explicit evidence was evaluated for student 7. Results were ranked from low to high.*

STEP 3: EVALUATE	STEP 4: DIAGNOSE	STEP 5: PRESCRIBE
Self-reported evidence of learning	*Concept not fully understood by student 7*	*Change Workshop* *-Changes in Course Material* *-Changes in delivery of content*
Spatially explicit evidence of learning	*All BMPs improved*	*Create an Instructional Guide for the Workshop*

Table 3.3 Connection of Evidence to Prescription. This table depicts how evidence was processed from evaluation to prescription for student 7.

Step 4
Diagnose

3.2.4 DIAGNOSE

Here, the instructional material for the course is analyzed to pinpoint ways to improve Student 7's learning within a workshop. The DIAGNOSIS and PRESCRIPTION is organized by cognitive load type from cognitve load theory *(Jong, 2009) briefly described in Chapter 1*. The student's learning based on spatially explicit evidence was high, implying that the student's grasp of siting stormwater infiltration facilities at the landscape scale increased during the workshop. However, the student's self-reported evidence showed less learning than the spatially explicit evidence. From this difference, I conclude the following about the Student 7's performance:

a) **INTRINSIC LOAD:** Student 7 did not understand concepts of runoff reduction. Student 7 reported "understanding of suitability analysis" and "finding data initially" as learned concepts; however, these two statements did not address reducing impervious surfaces or using facilities to allow for infiltration. Using solely the self-reported evidence, I conclude that the course material presented too large a number of topics requiring too large an amount of cognitive processing in too little time. As a contributor to cognitive load, intrinsic load *(Jong, 2009)* presents the idea that a large amount of new information requires a large amount of processing. Retaining the material presented requires an even greater amount of processing through exercises that 'activate' learning.

b) **EXTRANEOUS LOAD:** I also conclude that Student 7 did not report about runoff reduction because the material was not activated adequately with a separate task. Extraneous load *(Jong, 2009)* contributes to a lack of learning if information is not activated with an appropriate exercise or example that compliments the information presented.

c) **GERMANE LOAD:** Workshops are developed and conducted to provide students with a method for learning *(Frank, 2006)*. Germaine load *(Jong, 2009)* contributes to a student's failure to retain knowledge by lack of organization. I conclude that Student 7 did not learn the concept of runoff reduction because an organizational schema was not presented adequately during the workshop nor was Student 7 required to use a schema, thus making it their own.

Step 5
Prescribe

3.2.5 PRESCRIBE

The following section proposes revisions to Workshop course material and structure to improve student learning based on the example evidence from Student 7. The previous section showed that Student 7 seemed to understand the design skills for siting stormwater infiltration facilities well, however specific changes to the Workshop and exercises may aid in developing a deeper more persistent understanding of stormwater planning and design.

For Student 7 to become more fully cognizant of runoff reduction concepts of stormwater management for siting and selecting stormwater infiltration facilities at the landscape scale, the following changes are proposed to the format of the workshop:

a) INTRINSIC LOAD: "A large amount of topics requires a large amount of processing *(Jong, 2009).*" Student 7's learning could have been improved by presenting selected case studies which address runoff reduction. I propose to select a particular case study which demonstrates specific design and planning interventions to reduce runoff by increased infiltration or reduced impervious surfaces. Similarly, I propose to address three topics of discussion (Systems, Runoff, and Flooding) rather than the five presented (Terrain, Impervious cover, Land Use, Runoff, and Flooding) in the Workshop.

b) EXTRANEOUS LOAD: Student 7 did not retain knowledge about reduction of runoff due to me, as Instructor, not activating the information. I presented the material and concepts about runoff reduction, however an exercise would provide a way for Student 7 to retain the knowledge. I propose to add an exercise using the EPA's Stormwater Calculator would provide Student 7 with a hands-on tool showing the benefits of reducing runoff with BMPs.

c) GERMANE LOAD: Student 7 was unable to retain the concept of runoff reduction due to lack of instruction of an organizational schema. A suitability analysis was given to Student 7, however an exercise to explain a method to address the problem of runoff reduction would have helped Student 7's processing of the presented information.

Revisions to the Syllabus (*Appendix B2*) were based on Student 7's results and the Overall Workshop Results (*Appendix D*). These revisions are prescribed to increase student learning during the Workshop. In the final chapter, I use my approach for a self-assessment to address what I have learned during the development of the project.

Chapter 3 Summary

This project aims to answer the researchable question: "What types of evidence best indicate student learning in studio and workshop instruction in stormwater planning and design?" Results from this study imply that a combination of both self-reported and spatially explicit evidence provide broad guidance for indicating the quality of student learning in a workshop focused primarily on siting stormwater infiltration facilities. The course material and exercises can be helpful to aid in production and use of tools, guidelines, and explanations which can be offered within a course regarding siting stormwater facilities with suitability criteria and existing conditions.

The results were used to illustrate changes made to the Workshop to increase student learning. The following chapter is a self-evaluation of my own instruction during the Workshop using the systematic approach of the project to gauge what I learned from the process.

Chapter 4. Conclusion

4.1 SELF-EVALUATION

The following section presents a self-evaluation, and reflects on decisions I made during the process and the reasons to modify future courses of instruction.

Step 1
Instruct

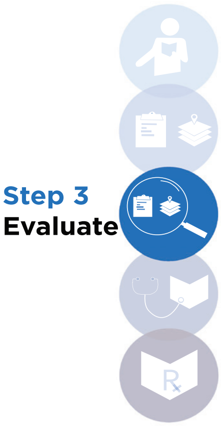
4.1.1 INSTRUCT, Self-Evaluation

My experience as a Teaching Assistant in the Fall 2016 Landscape Planning and Design Studio led to many decisions about how similar material could be portrayed to students within the shorter Workshop. The Workshop was centered on stormwater. This directed student's focus on landscape scale stormwater interventions. By contrast, the Studio asked students to appropriately site a much larger set of land use and land cover types. These two differences in instructional setting and scope complicated comparisons of evidence from the Studio and Workshop students.

Step 2
Assess

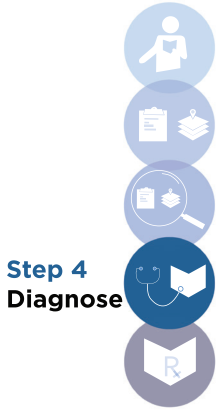
4.1.2 ASSESS, Self-Evaluation

Assessment of self-reported and spatially explicit evidence during the process was useful in understanding what students learned from the Studio and the Workshop. The five relevant factors (Terrain, Impervious cover, Land Use, Runoff, and Flooding) provided helpful indicators with which to organize instruction and gauge student learning from self-reported evidence. The questionnaire development played a crucial role in determining these factors. Similarly, using SUSTAIN as a spatially explicit evaluation tool meant that student designs had to have outputs which could be evaluated spatially. For example, students' designs from the Studio were easily evaluated as a georeferenced shapefile in ArcGIS but hand-drawn designs from the Workshop required more time to convert to a format suitable for SUSTAIN's evaluation.



4.1.3 EVALUATE, Self-Evaluation

The evaluation of self-reported and spatially explicit evidence went through many iterations. Combining and comparing qualitative and quantitative evidence to determine learning is complex in part because the two types of evidence indicate various means of learning. Because the evaluation process was iterative, the project refined a systematic approach for comparing and representing multiple forms of evidence to determine student learning.



4.1.4 DIAGNOSE, Self-Evaluation

Connecting evidence of learning to the prescription for proposed changes in workshop instruction forced me to think about how people learn and what causes them to not retain information. I was able to connect cognitive load theory (Jong, 2006) and Landscape Planning Education literature to prescribe changes to the Workshop.

4.1.5 PRESCRIBE, Self-Evaluation

By making the connection of diagnosis and prescription using cognitive load theory (Jong, 2009), I determined that understanding how students learn is critical in teaching. The types of cognitive load can be detrimental to student learning in any learning setting, therefore adequate methods of course instruction should be researched and exercised.

4.2 LIMITATIONS

Of the many limitations of this project, five stand out as particularly noteworthy:

a) Difference of the Studio and the Workshop: The Landscape Planning and Design Studio was focused on siting and planning for a wide range of land use and cover types rather than siting only stormwater facilities. The overall results from the self-reported and spatially explicit evidence from the Studio did not lend themselves to being evaluating based solely on stormwater.

b) Data: Data presented within the studio did not include a map of existing green infrastructure facilities for the study area. Data for percent impervious cover were also not presented in the Studio.

c) Sample Size: Larger sample size of participants and/or more workshops would have provided a larger set of results for comparison.

d) Cognitive Load: Many qualities from the three types of cognitive load (intrinsic, extraneous, and germane) were not intentionally addressed in the questionnaires and spatial design evaluations. Using each type of cognitive load in development and delivery of the initial and final questionnaires and spatial design evaluations would have provided specific spatially explicit and self-reported evidence of learning or lack thereof.

e) The Revised Workshop Syllabus takes cognitive load theory into account, however a more thorough investigation of cognitive load and application in course instruction must be done to develop an effective way of delivering the material.

4.3 FUTURE RESEARCH IN EDUCATION

Course and Curriculum Development:

After conducting this research project, I understand that I am interested in developing methods and strategies for students to acquire the knowledge, skills and competencies needed for the profession of Landscape Architecture and Landscape Planning and Design.

Evaluative Approaches in Education:

Evaluation metrics have become a crucial component for Landscape Architecture and Landscape Architecture Education. This research project has provided me with a systematic evaluation framework which acts as a foundation for future research. A continuation of this framework will be needed in other courses of instruction in various settings, course materials, and content.

Include Cognitive Load into Questionnaires and Spatial Evaluations:

Using cognitive load in development of a formal course of instruction, course materials, and evaluative approaches (questionnaires and spatial design evaluation tools) would provide educators with a way to improve learning in Workshops and courses. As a potential future research project, I would like to use the theory to develop a syllabus, course exercises and material, and an evaluative component to gauge learning.

APPENDIX A1. Initial Stormwater Questionnaire

This questionnaire is voluntary and your response will remain anonymous. Whether you choose to participate in this study or not, your LA 4/594 grade will not be affected. Results from this questionnaire will be sequestered and then released to the researcher after final grades are submitted for the course.

PLEASE DO NOT PUT YOUR NAME ON THIS SURVEY. You will be provided with a randomly generated code to print in the given space. The questionnaire will take *approximately 15- 20 minutes.*

GENERATED CODE: ___________ (Team number- Code) 10/27/16

STORMWATER QUESTIONNAIRE

1) Which role would you most identify with for solving the stormwater component of the program? (select more than one, if applicable)

- ❑ Primary Designer
- ❑ Creative Consultant
- ❑ Quality Assurance
- ❑ Graphic Representer
- ❑ Observer and Commenter

2A) How reasonably professional of a job do you think you have done so far in integrating terrain-related patterns of land use types, expected impervious surfaces and available potential spaces in siting your proposed stormwater facilities?

	Factors related to terrain	impervious surfaces	potential spaces
	Please fill one	Please fill one	Please fill one
Extremely professional	❑	❍	❍
Moderately professional	❑	❍	❍
Slightly professional	❑	❍	❍
Neither professional nor unprofessional	❑	❍	❍
Slightly unprofessional	❑	❍	❍
Moderately unprofessional	❑	❍	❍
Extremely unprofessional	❑	❍	❍

2B) Please describe in the space available how well you now think you understand how to integrate these factors to synthesize an understanding of hydrologic systems.

3) How much of a professional job do you think you've done so far at locating stormwater facilities to mitigate future pollution from runoff and to anticipate positive effects for biodiversity and habitat conservation?

	Runoff reduction	Biodiversity and Habitat Conservation
	Please fill one	Please fill one
Extremely professional	❍	❍
Moderately professional	❍	❍
Slightly professional	❍	❍
Neither professional nor unprofessional	❍	❍
Slightly unprofessional	❍	❍
Moderately unprofessional	❍	❍
Extremely unprofessional	❍	❍

3B) Please describe in the given space the process that you designate suitable space to ensure runoff reduction and to provide spaces for habitat and biodiversity.

4) How confident are you that your proposed stormwater facility network will address flooding and sizing of facilities for various storm events?

	Flooding	10 yr storm event	25 yr storm event	50 yr storm event
	Please fill one	Please fill one	Please fill one	Please fill one
Extremely professional	❍	❍	❍	❍
Moderately professional	❍	❍	❍	❍
Slightly professional	❍	❍	❍	❍
Neither professional nor unprofessional	❍	❍	❍	❍
Slightly unprofessional	❍	❍	❍	❍
Moderately unprofessional	❍	❍	❍	❍
Extremely unprofessional	❍	❍	❍	❍

4B) Please describe the process or method that you used to address flooding in the given space below.

5) How much has your proposal for your stormwater facility network so far been affected by other teams' proposals? Desk Crits? Precedents or Case Study research?

	other teams' proposals	desk crits	case studies/ precedents
	Please fill one	Please fill one	Please fill one
A great deal	❍	❍	❍
A lot	❍	❍	❍
A moderate amount	❍	❍	❍
A little	❍	❍	❍
None at all	❍	❍	❍

6) In terms of sizing collection, conveyance and recharge stormwater facilities (point, line, area), which method most adequately describes your approach in solving the stormwater program element? (check all that apply)

❑ The Rational Method
❑ The Stormwater Calculator
❑ Methods used in Precedent Research
❑ The Simplified Approach
❑ The Presumptive Approach
❑ The Performance Approach
❑ bifurcation ratio
❑ none of the above
❑ one we invented (please list): ___________

STORMWATER MANAGEMENT POST-WORKSHOP QUESTIONNAIRE

This questionnaire is voluntary and your responses will remain anonymous.

PLEASE DO NOT PUT YOUR NAME ON THIS SURVEY. You will be provided with a randomly generated code to print in the given space. The questionnaire will take *approximately 15- 20 minutes.*

CODE: ___________ (Assigned Code from Workshop) 01/23/17

FINAL STORMWATER QUESTIONNAIRE

1) Which role would you most identify with for solving the stormwater component of the workshop? (select more than one, if applicable)

- ❑ Primary Designer
- ❑ Creative Consultant
- ❑ Quality Assurance
- ❑ Graphic Representer
- ❑ Observer and Commenter
- ❑ Other:______________

2A) How reasonably professional of an understanding do you have concerning various systems that are involved in stormwater networks?

	Factors related to terrain	impervious surfaces	potential spaces
	Please fill one	Please fill one	Please fill one
Extremely professional	☐	☐	☐
Moderately professional	☐	☐	☐
Slightly professional	☐	☐	☐
Neither professional nor unprofessional	☐	☐	☐
Slightly unprofessional	☐	☐	☐
Moderately unprofessional	☐	☐	☐
Extremely unprofessional	☐	☐	☐

2B) Please describe in the space available how well you now think you understand how to integrate these factors (terrain, impervious surfaces, potential spaces) to understand and synthesize hydrologic systems in regards to stormwater management. Also, please list other related systems which you feel are highly important to consider in stormwater management.

3) How professionally do you understand locating stormwater facilities **to mitigate future pollution from runoff** and to anticipate positive effects for **biodiversity and habitat** conservation?

	Runoff reduction	Biodiversity and Habitat Conservation
	Please fill one	Please fill one
Extremely professional	☐	☐
Moderately professional	☐	☐
Slightly professional	☐	☐
Neither professional nor unprofessional	☐	☐
Slightly unprofessional	☐	☐
Moderately unprofessional	☐	☐
Extremely unprofessional	☐	☐

3B) Please describe in the given space **the process** that you used (or would use) to designate suitable space to ensure runoff reduction and to provide spaces for habitat and biodiversity.

4) How confident are you that your proposed stormwater facility network will address flooding and sizing of facilities for various storm events?

	Flooding	10 yr storm event	25 yr storm event	50 yr storm event
	Please fill one	Please fill one	Please fill one	Please fill one
Extremely professional	☐	☐	☐	☐
Moderately professional	☐	☐	☐	☐
Slightly professional	☐	☐	☐	☐
Neither professional nor unprofessional	☐	☐	☐	☐
Slightly unprofessional	☐	☐	☐	☐
Moderately unprofessional	☐	☐	☐	☐
Extremely unprofessional	☐	☐	☐	☐

4B) Please describe the process or method that you used or would use to address flooding in the given space below.

5) How much has your proposal for your stormwater facility network so far been affected by **other teams' proposals**? **the lecture**? **Precedents or Case Study research**?

	other teams' proposals	lecture	case studies/ precedents
	Please fill one	Please fill one	Please fill one
A great deal	☐	☐	☐
A lot	☐	☐	☐
A moderate amount	☐	☐	☐
A little	☐	☐	☐
None at all	☐	☐	☐

6) In terms of sizing collection, conveyance and recharge stormwater facilities (point, line, area), which method or tool most adequately describes your approach in solving the stormwater program element? (check all that apply)

For Landscape Scale:

- ❑ The Rational Method
- ❑ The Stormwater Calculator (water budget)
- ❑ Methods used in Precedent Research
- ❑ The Simplified Approach
- ❑ The Presumptive Approach
- ❑ The Performance Approach
- ❑ bifurcation ratio
- ❑ none of the above
- ❑ one we invented (please list): ___________

For Site Scale:

- ❑ The Rational Method
- ❑ The Stormwater Calculator
- ❑ Methods used in Precedent Research
- ❑ The Simplified Approach
- ❑ The Presumptive Approach
- ❑ The Performance Approach
- ❑ bifurcation ratio
- ❑ none of the above

one we invented (please list): __________

7) What information did you learn **throughout the course** that helped guide decisions about how you were able to site stormwater facilities at the landscape scale and site scale extent?

8) Additional Comments or Questions:

APPENDIX B1. Workshop Outline

STORMWATER MANAGEMENT WORKSHOP
Instructor: Daniel Cronan
January 21st 2017- Half-Day workshop: 10 am – 2 pm

-ASSESS: INITIAL QUESTIONNAIRE-
Assign each student a number, remind them to remember their number (10-15 min)

-INSTRUCT-
BLOCK 1: Conceiving stormwater systems (10: 15- 11:00)
a) Introduction to Stormwater
b) Basic Hydrology
c) Stormwater and Development: High and Low density, impervious cover increase, runoff increase, water contamination
d) Stormwater Management Solutions: Green Infrastructure (collection, conveyance, re charge)
e) Case Study: High Point Development, Seattle, Washington
f) Take Aways- Runoff Reduction, Impervious Surface Reduction

-ASSESS: INITIAL DESIGN-
EXERCISE 1: Each student will design a stormwater network with a given study area. (15-20 min)
Upon completion each student will report results to entire class

-INSTRUCT-
BLOCK 2: How to potentially site Stormwater systems (11:20 – 12:30)
a) Definitions and Glossary
b) Urban Stormwater Management in the U.S.
Policy and Regulations: CLEAN WATER ACT, NPDES
c) Municipal and State Regulations
d) EPA Criteria-Point, Line, Area BMPs
e) Suitability Mapping and locating suitable areas for BMPs with a GIS
f) Sizing: Design Storms, Flooding, and BMP ratios

BREAK (12:30 – 1:00)

-ASSESS: FINAL DESIGN-
EXERCISE 2: Using a given dataset in an Adobe Illustrator file, each student will select a loca tion for one or more of the following for each lettered category (1:00 – 2:00):
A) POINT: constructed wetland, wet pond, dry pond
B) LINE: grassed swale, infiltration trench, vegetated filter strip
C) AREA: porous paving, rooftop garden

RECAP OF THE WORKSHOP: -TAKE-AWAYS (RELEVANT FACTORS): terrain analysis, land use analysis, reduction of impervious surfaces, reduction of runoff, Design storms and flooding

END OF WORKSHOP

-ASSESS: FINAL QUESTIONNAIRE
2 WEEKS LATER: The workshop students are asked to complete the Final Questionnaire (15-20 min)

APPENDIX B2. Workshop Outline (revised)

STORMWATER MANAGEMENT WORKSHOP (REVISED)
Instructor: Daniel Cronan
2 Consecutive half- day Workshop Sessions

DAY 1:

-ASSESS: INITIAL QUESTIONNAIRE-
Assign each student a number, remind them to remember their number (15-20 min)
*INTRINSIC LOAD REDUCTION: Reduced to Address 3 Relevant Factors: SYSTEMS, RUNOFF REDUCTION, FLOODING

-INSTRUCT-
BLOCK 1: Conceiving stormwater systems (10: 20- 11:10)
a) Introduction to Stormwater
b) Basic Hydrology
c) Key stormwater terms and definitions: EPA Green Infrastructure definitions
d) Stormwater and Development: High and Low density, impervious cover increase, runoff increase, water contamination
e) Stormwater Management Solutions: Green Infrastructure Case Studies
i) High Point, Seattle (SYSTEMS Approach)
ii) Lloyd Ecodistrict (RUNOFF REDUCTION Approach)
iii) King County Management Plan (Headwaters at Tyron Creek)
***EXTRANEOUS LOAD REDUCTION: Addition of case studies relevant to reduced 3 relevant factors**

BREAK (10 minutes)

- INSTRUCT-DISCUSSION 1: (11:20 – 12:10)
a) Report Take-Aways, Recap
b) Facilitate conversation regarding the question: “What makes a successful stormwater network?” Record values as students call them out.
c) Ask students to organize values into groups
***EXTRANEOUS LOAD REDUCTION: Adding a task relevant to the topic**
***INTRINSIC LOAD REDUCTION: Reduce intrinsic load by facilitating an activity recalling information covered earlier**
***GERMANE LOAD REDUCTION: Ask Students to organize relevant ideas into categories and create a plan or schema for the following exercise**

LUNCH BREAK (30 minutes)

- ASSESS-EXERCISE 1: (12:40 – 2:00)
Each student will design a stormwater network with a given study area based on assumptions defined from student values in DISCUSSION 1. Upon completion, each student will report results to entire class.
-STUDENTS are encouraged to work on assignment at home but not required.
***INTRINSIC LOAD REDUCTION: Reduce intrinsic load by facilitating an activity to activate values from another task**
***EXTRANEOUS LOAD REDUCTION: Adding a task/exercise relevant to the topic**

DAY 2:

RECAP: Present Project from Exercise 1 and discuss revisions (20 minutes)

-INSTRUCT-
BLOCK 2: How to potentially site stormwater systems (10: 20- 11:10)
a) Definitions and Glossary
b) Urban Stormwater Management in the U.S.
Policy and Regulations: CLEAN WATER ACT, NPDES
c) Municipal and State Regulations
d) EPA Criteria-Point, Line, Area BMPs
e) Suitability Mapping and locating suitable areas for BMPs with a GIS

BREAK (10 min)

- ASSESS-EXERCISE 2: (11:20 – 12:10)
Stormwater Calculator tutorial to understand reduction of runoff and the role of Green Infrastructure.
Students will evaluate their designs from EXERCISE 1 on the previous day
***INTRINSIC LOAD REDUCTION: Reduce intrinsic load by facilitating an evaluation activity relevant to their own work**
***EXTRANEOUS LOAD REDUCTION: Adding a task/exercise relevant to the topic using a visual tool**

BREAK (30 min)

-INSTRUCT-
BLOCK 3: Recap of Lloyd Ecodistrict Case Study for Runoff Reduction/ Impervious Surface Reduction
(12:40 – 1:00)
***GERMANE LOAD REDUCTION: Sequence material by reviewing how the tool can be used in a case study**

- ASSESS-EXERCISE 3: (1:10 – 2:00)
Use EPA's suitability criteria to redesign proposal from EXERCISE 1 to address the 3 relevant factors (systems, runoff reduction, and flooding)
Using a given dataset in an Adobe Illustrator file, each student will select a location for one or more of the following for each lettered category:

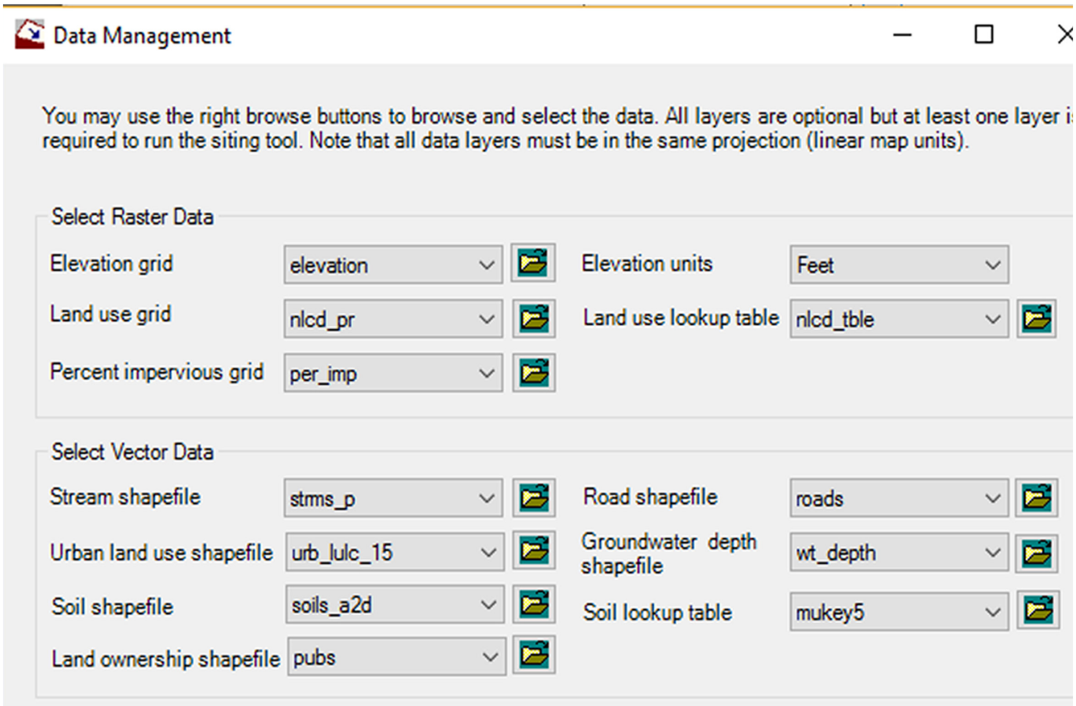
A) POINT: constructed wetland, wet pond, dry pond
B) LINE: grassed swale, infiltration trench, vegetated filter strip
C) AREA: porous paving, rooftop garden
***GERMANE LOAD REDUCTION: Reduce germane load by facilitating an exercise using the three relevant factors, EPA's suitability criteria, and EPA's Green Infrastructure Classification. Students will develop a schema to organize these ideas into a design.**

END OF WORKSHOP

-ASSESS: FINAL QUESTIONNAIRE- (1 week after Workshop)
Assign each student a number, remind them to remember their number (15-20 min)
***INTRINSIC LOAD REDUCTION: Reduced intrinsic load by addressing 3 Relevant Factors: systems, runoff reduction, flooding**

APPENDIX C. SUSTAIN Diagrams

‘SUSTAIN” INPUT DATA. This graphic illustrates the inputs for SUSTAIN to explain the tool’s connection to the Workshop presentation content.



‘SUSTAIN’ Criterion for siting BMPs. This table depicts siting suitability criterion used by ‘SUSTAIN’ to site, evaluate, and rank areas for stormwater facilities.

Table 2-4. Default criteria for BMP suitable locations used in BMP Siting Tool

BMP type	Drainage area (acre)	Drainage slope (%)	Impervious (%)	Hydrologic soil group	Water table depth (ft)	Road buffer (ft)	Stream buffer (ft)	Building buffer (ft)
Bioretention	< 2	< 5%	> 0%	A–D	> 2	< 100	> 100	--
Cistern	--	--	--	--	--	--	--	< 30
Constructed Wetland	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--
Dry Pond	> 10	< 15%	> 0%	A–D	> 4	--	> 100	--
Grassed Swale	< 5	< 4%	> 0%	A–D	> 2	< 100	--	--
Green Roof	--	--	--	--	--	--	--	--
Infiltration Basin	< 10	< 15%	> 0%	A–B	> 4	--	> 100	--
Infiltration Trench	< 5	< 15%	> 0%	A–B	> 4	--	> 100	--
Porous Pavement	< 3	< 1%	> 0%	A–B	> 2	--	--	--
Rain Barrel	--	--	--	--	--	--	--	< 30
Sand Filter (non-surface)	< 2	< 10%	> 0%	A–D	> 2	--	> 100	--
Sand Filter (surface)	< 10	< 10%	> 0%	A–D	> 2	--	> 100	--
Vegetated Filterstrip	--	< 10%	> 0%	A–D	> 2	< 100	--	--
Wet Pond	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--

APPENDIX D. Overall Workshop Results

OVERALL Workshop Results:

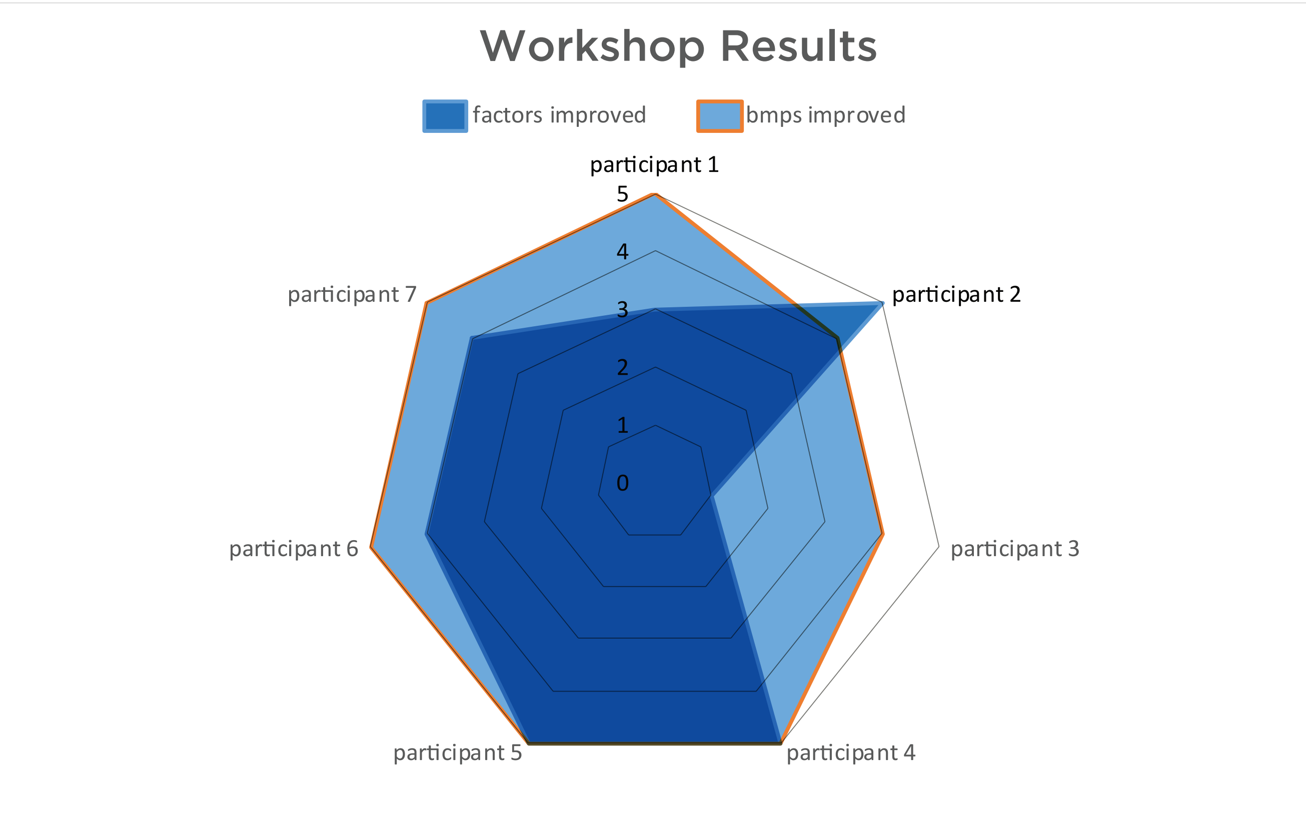
Evidence of learning within the overall Workshop results illustrates a correlation of what students reported as being learned versus how they were able to utilize topics covered within design exercises. Many of the students were able to demonstrate skills acquired through instruction, however the overall results indicate that key concepts regarding the factors presented were not evident in the self-reported evidence of learning.

WORKSHOP							
	Self-Reported			Spatially Explicit			Learning
	positive change	no change	negative	pos.	no change	negative	
student 1	3 factors improved			5 BMPs improved			Medium to High
student 2	5 factors improved			4 BMPs improved			Medium to High
student 3	1 factor improved			4 BMPs improved			Low to Medium
student 4	5 factors improved			5 BMPs improved			High
student 5	5 factors improved			5 BMPs improved			High
student 6	4 factors improved			5 BMPs improved			Medium to High
student 7	4 factors improved			5 BMPs improved			Medium to High

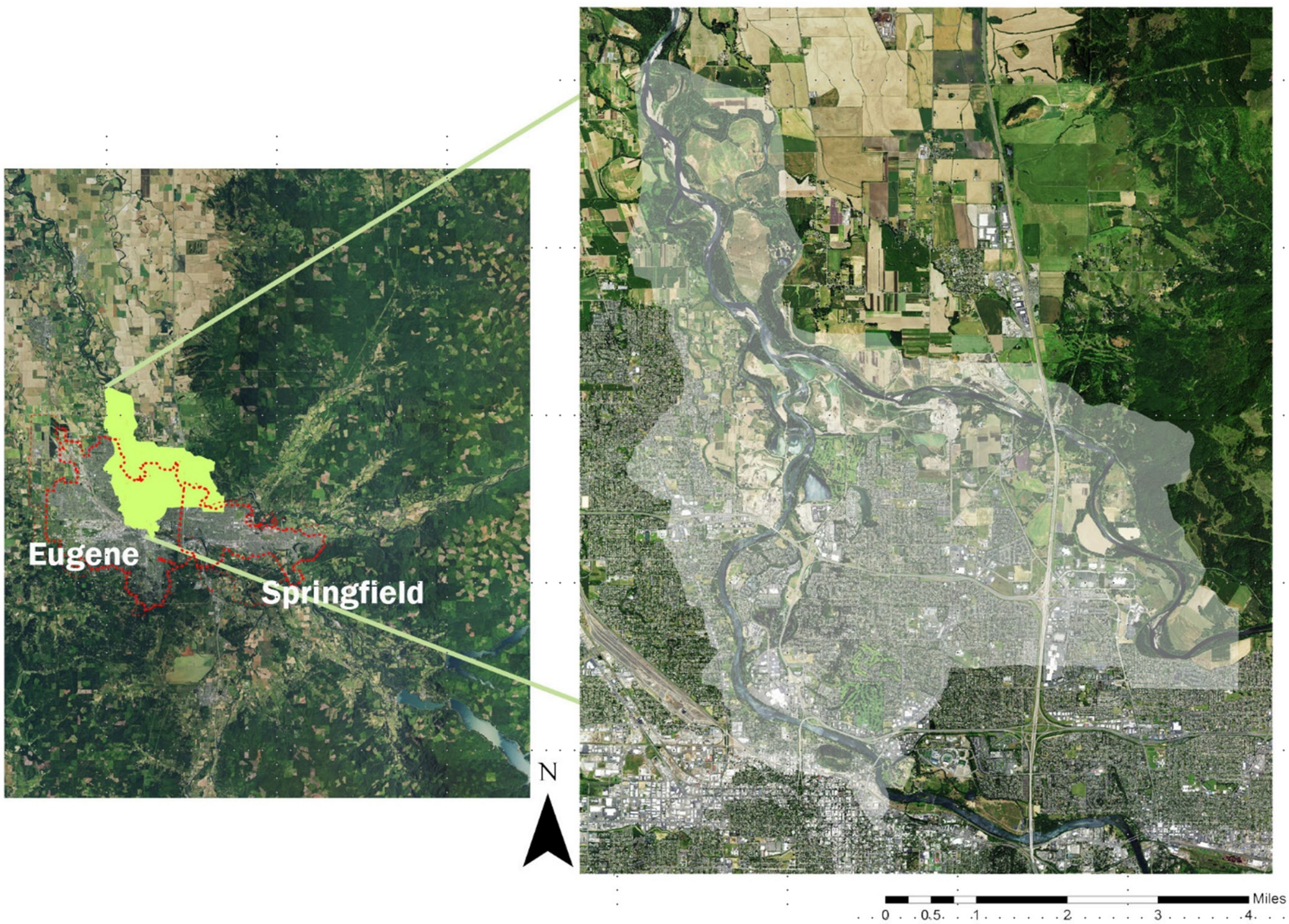
High
Medium to High
Medium
Low to Medium
Low

Workshop Results Diagram:

The following diagram shows the correlation of each workshop student's self-reported and spatially explicit evidence of learning.

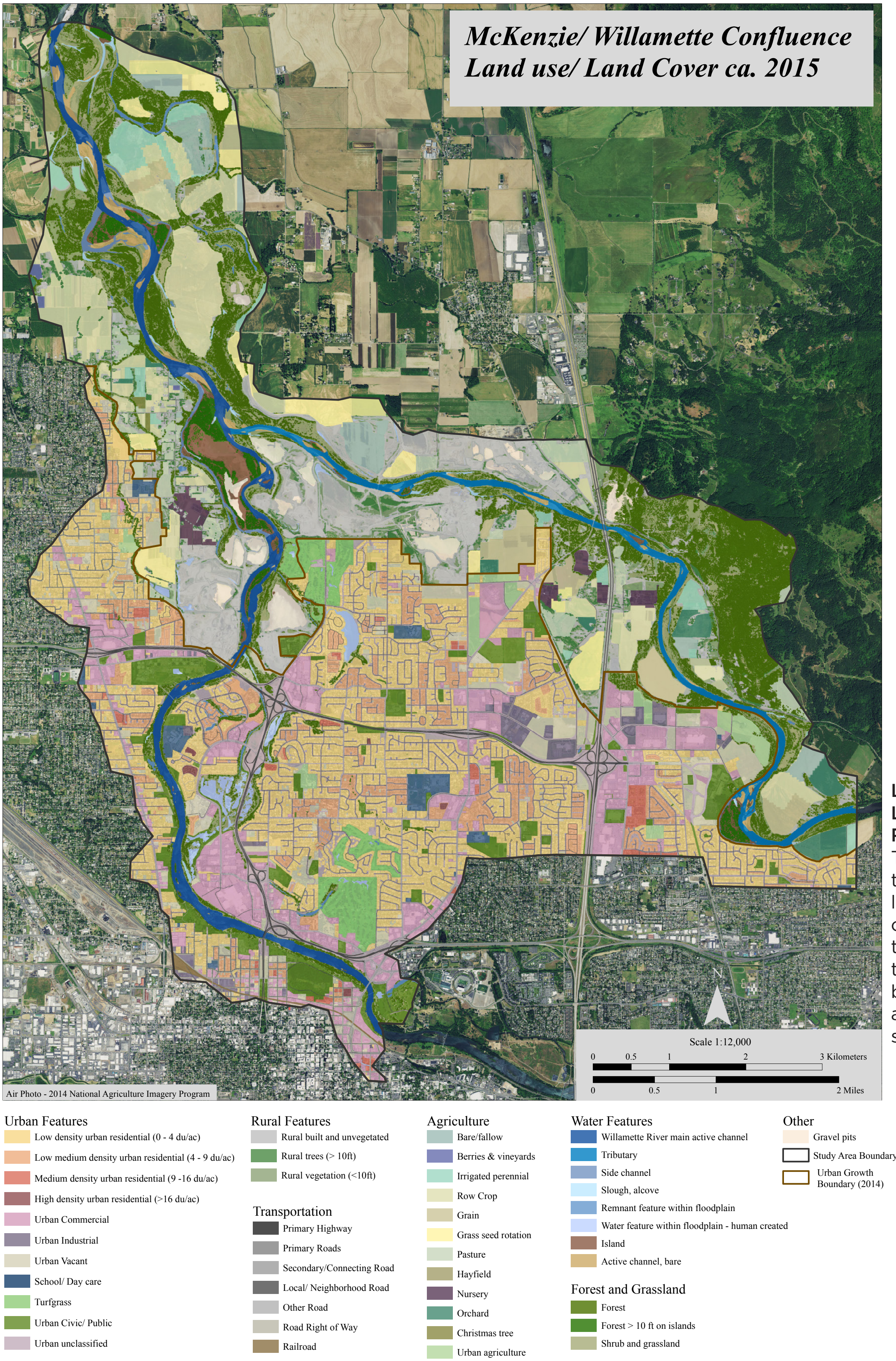


APPENDIX E1. Site Context



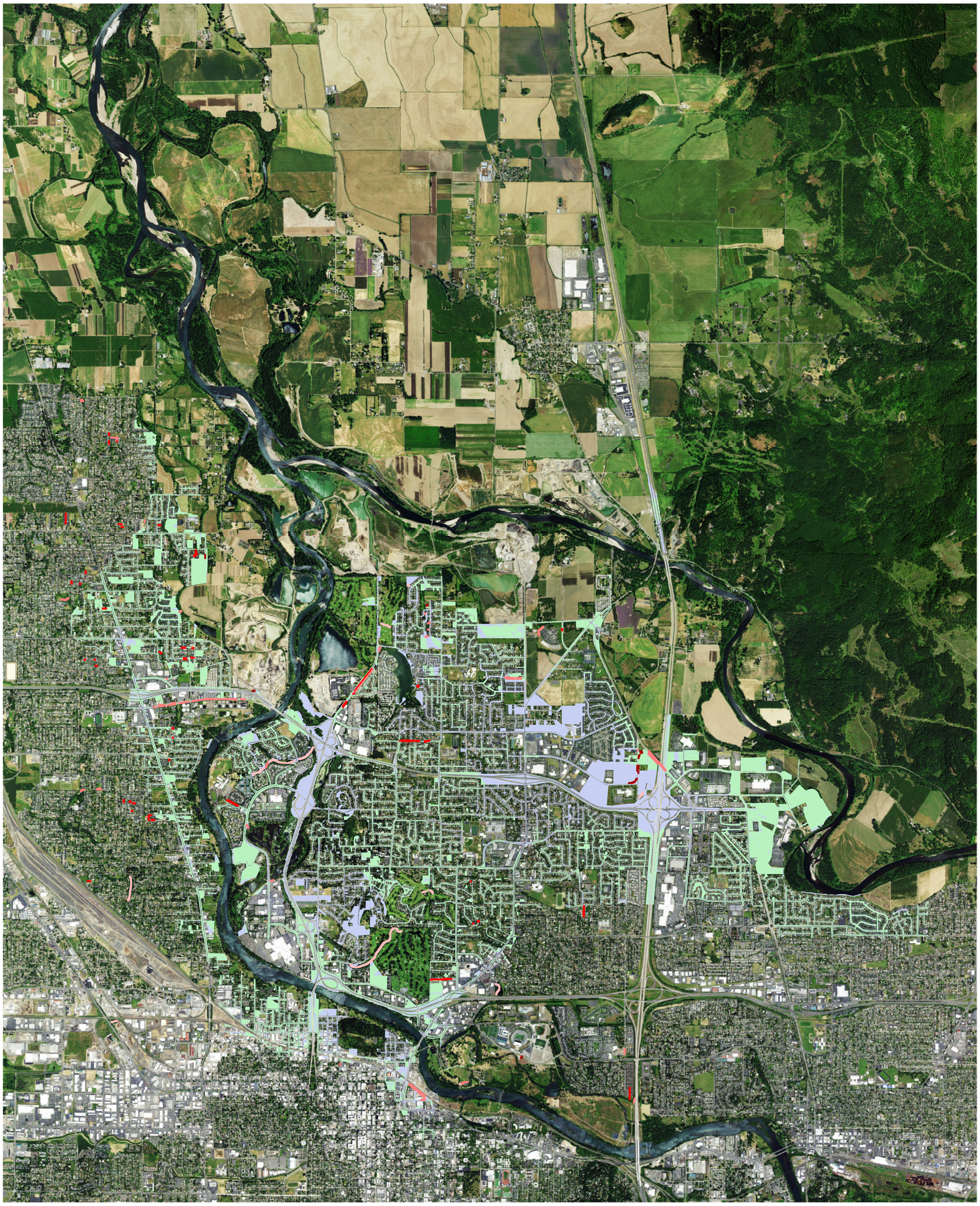
Site Context.
The maps depict the study area used for the Workshop and the Studio. The Study Area is located at the confluence of the McKenzie and Willamette rivers in Eugene and Springfield, Oregon.

APPENDIX E2. Land Use/Land Cover Representation



Land Use/ Land Cover Representation. The representation depicts the land use and land cover representation model that was used for both the Studio and the Workshop.

APPENDIX E3. Workshop ‘Point’ BMP Suitability Representation



Workshop ‘Point’ BMP Suitability Representation. This graphic depicts the dataset that students were given during the workshop to use for designing their stormwater network. The format is a layered adobe illustrator file. The legend column on the left is depicted as the right column attributes were used for the raster analysis legend class.

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