Title

Toward Ecological Literacy: Landscape Design for Public Appreciation of and Education about Sustainable Stormwater Management in San Francisco Bay Area

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Publication Date
2017

Peer reviewed|Thesis/dissertation

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By

Wilasinee Suksawang

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Landscape Architecture and Environmental Planning

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Louise Mozingo, Chair
Professor Michael Southworth
Professor Galen Cranz

Fall 2017

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Abstract

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Stormwater management has long existed as a daunting task for many cities. Within recent decades, a novel landscape design approach to effectively and sustainably manage urban stormwater known as Low Impact Development (LID) was initiated in the United States. Unfortunately, the LID projects, although holding ecological benefits, have often fallen short of achieving public recognition and satisfaction because of their illegible and unkempt looks.

Concerning this onerous problem, the tenet that stormwater knowledge can play a role in stimulating aesthetic appreciation of LID landscapes has been reiterated. This study, accordingly, intends to provide information and insight regarding public appreciation of and education about the LID design. San Francisco Bay Area was chosen as a study area due to its unique and critical stormwater management situations. Eight projects, which demonstrate a range of LID designs, were selected as the test sites. In addition, other eight places representing a range of conventional landscape designs, the non-LID sites, were also selected as the control sites. The questionnaires were developed and distributed to visitors of these 16 selected study sites using the street intercept method. Results from the analysis of 502 responses demonstrate that, in most of the cases, the LID facilities were well recognized and appreciated by the respondents, compared to the conventional-designed landscapes, thereby suggesting that these LID cases can serve as good models for the ensuing projects and, besides, the implementation of LID design in San Francisco Bay Area can be continued without serious concern about public resistance. Nonetheless, because some LID facilities were unlikely to receive positive public responses, making better designs and advancing stormwater literacy are both considered key strategies. The analysis results also reveal that respondents thought they were not quite knowledgeable about sustainable stormwater management, yet they were open to information and knowledge, especially through reading

the interpretive signs at the facilities, leading to the recommendation that LID projects in the Bay Area be developed in a manner that they can facilitate stormwater education.

This dissertation concludes by highlighting the role that landscape design can play in making successful and meaningful LID facilities and, ultimately, establishing desirable relationships between aesthetics and ecology. Based on the review of design strategies proposed in relevant literatures and used in existing projects along with the insights derived from the survey results, an innovative set of design criteria for creating the LID facilities which can enrich aesthetic experience and enhance stormwater knowledge of their visitors is developed. These design criteria include 1) visibility and legibility, 2) accessibility, 3) functionality, 4) attractiveness and interest, 5) cultural aesthetics, 6) ecological revelation, 7) interactive activities, 8) interpretive signage, 9) water features, and 10) application and replication. In addition, this dissertation also develops the guidelines for designing the prominent stormwater management features, which include 1) water tank/ cistern, 2) street gutter/ storm drain/ runnel, 3) pavers/ permeable pavement, 4) lawn/ grass/ turf, 5) rain garden/ bioretention planter/ bioswale, 6) stormwater pond/ constructed wetland, 7) green street/ green parking lot, 8) green roof, 9) green wall, and 10) scupper/ downspout. Even though these criteria and guidelines are developed based on the situations of San Francisco Bay Area, they are considered applicable to other geographical areas.

Dedication

To

my parents, Withoon Suksawang and Srisakul Suksawang,
who have been my first and greatest teachers

and

my husband, Spavit Darnthamrongkul,
who has encouraged and supported me to keep flying toward my dreams.

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Acknowledgements

The completion of this dissertation could not be possible without highly benign supports from a great many people so that I owe endless thanks to all of them with my best regards.

I would like to express my highest respect to His Majesty the late King Bhumibol Adulyadej of Thailand. His inventive ideas and persistent efforts toward conservation and management of water resources in Thailand had inspired my interest in learning about sustainable stormwater management.

I owe a great deal of gratitude to my kindest advisor, Professor Louise Mozingo. Her articles and works had sparked off my enthusiasm to pursue a doctoral study. Her smart advice, considerate support, and warm encouragement had certainly made my Ph.D. life full of happiness. She is my role model and I am very proud to be one of her students.

I am truly grateful to my committee members, Professor Michael Southworth and Professor Galen Cranz, for all insightful comments and useful suggestions. I am very grateful to Professor Kristina Hill, a member of my qualifying examination committee, for all creative ideas. I am also grateful to Professor John Radke, Professor Joe McBride, and Professor Matt Kondolf as my research ideas had been developed when I was taking their classes.

Special gratitude is owed to Kimberlee Stryker for numerous valuable inspirations and experiences. She and her classes were very inspiring and my research ideas became clear when I visited Mint Plaza on a field trip of her class. I am fortunate to have chance to meet, study, and work with her.

I am very thankful to Tony Tieu, Susan Retta, and Mary Ann Clark for all kind and friendly helps. I am also thankful to Amna Alruheili, my colleague in the Ph.D. program, for the wonderful friendship.

I gratefully thank Chai Milin and Pamela Milin for their love, care, and support. Since I had moved into their home, they had taken care of me with kindness. Living with both of them had made me certainly feel at home. I was very lucky to meet them and to live in their lovely home.

I specially thank Mahat Papartassee, Sireerat Sethanant, and Charnwisut Khachondechakul for their helps with site surveying. I would also like to thank all my Thai friends in San Francisco Bay Area, especially Atikom Juntakool, the Milin family, the Papartassee family, the Khachondechakul family, the Sooknetr family, and the Khamrung family, for their friendship and support.

I am thankful to the staffs of El Cerrito City Hall, Brisbane City Hall, and Daly City Civic Center for their helps with distributing the questionnaires. I am also thankful to all respondents who completed and returns the surveys. This research could not be completed without their voluntary participation.

I also would like to express my gratitude to Thailand's Office of Higher Education for the financial support and to staffs of the Office of Educational Affairs, Royal Thai Embassy for their helps throughout my study. I am also grateful for the financial support from the Bay Area Water Quality Fellowship, the Doctoral Completion Fellowship of the University of California, Berkeley, and the Farrand Fund of the Department of Landscape Architecture and Environmental Planning.

A particular debt of gratitude is owed to Professor Angsana Boonyobhas, Professor Danai Thaitakoo, Professor Chaiyasit Dankittikul, and Professor Rujiroj Anambutr, who have educated and assisted me in numerous ways with their very aim to see my success.

Finally, I deeply thank my parents, Withoon Suksawang and Srisakul Suksawang, and my brother, Withitkul Suksawang. I would not have gotten this far without their love and support. I also deeply thank my parents-in-law, Suvit Darnthamrongkul and Supavadee Darnthamrongkul, for their kind encouragement. The deepest thank is owed to my husband, Spavit Darnthamrongkul, who had encouraged and supported me throughout the process of completing this dissertation.

Chapter 1
Introduction

1.1 Research inspiration and impetus

Intrinsically, I am particularly interested in the interrelations between people and their surroundings, both of natural and built environments. I have long been keen to understand how people perceive, assess, and appreciate their world, especially in visual dimension, since I realized that such comprehension is vital for landscape design and planning so as to heighten aesthetic qualities of the environment. During the initial period of my research practice, I focused mainly on the study of visual quality and attitudes toward the aesthetics of landscapes, with an objective to advance basic understanding of visual perception and landscape preference in Thai culture.

Apart from my focus on visual analysis and assessment, working in collaboration with several local and national institutions in Thailand to examine and solve a variety of environmental problems that have contributed to multiple adverse impacts on our living landscapes has also inspired my passion in the concept of sustainability and sustainable design. Specifically, the issue regarding conflicts between ecological and aesthetic values of urban landscapes has led me to realize that landscape aesthetics is beyond the visual dimension and sparked off my interest in scrutinizing the complex relationships between people and their ecosystems, especially the appreciation of ecological aesthetics. Above all, as I am a landscape architect, this particular kind of controversy has certainly triggered my curiosity about how to design a landscape that can band together the ecological and aesthetic functions.

In 2011, I took an over-twenty-hour flight across the Pacific Ocean from Bangkok to Berkeley in order to harness my eagerness regarding public attitudes toward the aesthetic dimensions of sustainable landscapes as well as design criteria for boosting public appreciation of urban ecological facilities. In particular, my interest focuses on the issues intertwined with sustainable stormwater management or low impact development (LID)—an innovative design approach to control both quantity and quality of runoff in which the replication of the pre-development hydrologic regime is the core principle. This is because I noticed that although this kind of landscape design holds ecological benefits, it is unlikely to be recognized and appreciated by the general public. Furthermore, it is also apparently unattractive to many people because of its messy or unkempt looks, which defy picturesque-pastoral ideal of landscape beauty in which tidy and orderly appearance is recognized as one of its fundamentals.

In view of that fact, I aspire to make sustainable stormwater management facilities meaningful to urban dwellers. The main focus of my idea is the roles that these ecologically, yet messily, designed landscapes can play in order to foster communities' joy and beauty, and, ultimately, to enhance people's understanding and awareness regarding sustainable stormwater management as well as global water sustainability. In addition, my concentration is also on the roles that design can play in creating such landscapes.

1.2 Research background and contribution

As urban ecosystems have become seriously degraded, a large number of ecological design projects have been implemented in many cities. Nonetheless, although these efforts hold ecological benefits, they have often fallen short of achieving public recognition and satisfaction. This circumstance has impeded public acceptance and support of various environmental policies and practices. As a result, conflicts and controversies, especially in ecological restoration projects, have occurred again and again. In view of those controversies, the idea that the public should be a key actor to solve and alleviate the ecological crisis had emerged. According to this tenet, city dwellers are encouraged to engage in and also to serve as advocates for sustainable initiatives and projects of the cities. However, in order to be able to effectively do that, people need to be knowledgeable enough regarding the problems and the ways to solve them (Stapp et al. 1969: 33).

Theories of ecological design reiterate the idea that knowledge can evoke an ecological awareness as well as an aesthetic appreciation of the environment. As the research revels, knowledge significantly helps people understand and appreciate what they view (Carlson 1995: 393; Rolston 1995: 376). Based on this principle, interpretation and appreciation of landscapes could be enriched by knowledge—similar to those of arts such as drawings, paintings, music, and poetry (Rolston 1995: 377; Matthews 2002: 37). Accordingly, the idea that knowledge can plays a role in enhancing public appreciation of ecological landscapes has been highlighted, making education, among other things, pivotal to the achievement of ecological design.

Realizing the necessity and opportunity to incorporate both aesthetic and pedagogical principles into ecological landscape design, this dissertation explores innovations to create urban landscapes that provide desirable aspects to enhance user satisfaction together with legible clues to raise public ecological literacy.

The focus of this research, however, is specifically on public satisfaction and education regarding sustainable stormwater management or low impact development (LID)—a landscape design strategy to minimize the impacts on hydrologic regimes. LID design is subtle compared to other urban ecological design practices, perhaps because the LID features—including vegetated swales, bioretention planters, rain gardens, green roofs, constructed wetlands, and permeable pavements, for example—have been found to be illegible or unappealing due to their unkempt looks (Nassauer 1995; Echols 2007). In addition, a large number of research studies have also revealed that lay people are likely to have limited knowledge and understanding of sustainable stormwater management (e.g. Kaplan 1977; Debo and Ruby 1982; Bartlett 2005; Trechter et al. 2008; Central New York Regional Planning and Development Board 2010; Royal Bank of Canada 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015). This results in a low level of public awareness of urban hydrologic functions along with deleterious practices regarding stormwater management.

Given that, the importance of education or provision of scientific knowledge about sustainable stormwater management for the lay public has become widely emphasized. Consequently, the design of many stormwater management systems include the goal of achieving public education about urban stormwater management and satisfaction with both appearance and performance of the projects.

Whereas the effort to enhance ecological knowledge and understanding of sustainably designed landscapes has not yet been broadly put into practice, it has been intentionally implemented in the field of stormwater management for decades driven by a key legislative mandate. In 1999, the US Environmental Protection Agency (US EPA) issued the Phase II Stormwater Rules. According to this mandate, public education and outreach—which refers to the effort to educate citizens about the impacts of polluted stormwater runoff in order to increase their awareness of water quality—is required to be implemented by certain municipalities (US EPA 2005a). This requirement has mostly been fulfilled by providing educational materials (especially brochures, fact sheets, posters, bumper stickers, or websites) for citizens, both kids and adults (US EPA 2005b). Moreover, educational programs, learning activities, and volunteer opportunities have also been widely recommended as additional strategies (US EPA 2005b).

Despite the fact that supplying educational materials and activities is a common means for generating knowledge of sustainable stormwater management, many landscape scholars also support the idea of utilizing stormwater management facilities as on-site demonstrations for advancing citizens' stormwater education. In agreement with this idea, during recent years many places in which stormwater facilities are integrated—such as Canal Park in Washington D.C., Thornton Creek Water Quality Channel in Seattle, Cedar River Watershed Education Center in North Bend, Abbotsford Wetland Park in British Columbia, San Pablo Rain Gardens in El Cerrito, Brisbane City Hall in Brisbane, and several Green Street projects in Portland—have intentionally provided educational opportunities for people with the aim of enhancing public knowledge of stormwater management.

However, while these design practices are ongoing, until today few empirical studies have been done to provide more insight that allows designers to understand public attitudes toward learning about sustainable stormwater management along with design strategies intended to encourage serendipitous education through everyday activities in urban LID facilities. Rather, previous research has been concentrated on examining issues regarding aesthetic perception and preference (e.g. Kaplan 1977, Hemmitt 1983; Lee 1983; Nasar 1987; Nassauer 1988a, 1988b, 1992, 1993, 2004; Sullivan 1994; Ryan 1998, 2000; Gobster 2001; Asakawa, Yoshida, and Yabe 2004; Chiesura 2004; Junker and Buchecker 2008; Brzuszek and Clark 2009; Nassauer, Wang and Dayrell 2009; Kenwick, Shammin and Sullivan 2009; Kaplowitz and Lupi 2012; Dobbie 2013; Dobbie and Green 2013). As a result, knowledge pertinent to the development of innovative design principles for promoting both public satisfaction and education regarding sustainable stormwater management is currently limited. In view of that current knowledge gap, this research aims to investigate the roles that urban landscape design can play in making LID facilities enrich aesthetic experience as well as facilitating stormwater knowledge. This dissertation is a pioneering effort to examine how people perceive and appreciate the LID features and learn about sustainable stormwater management through their direct encounter with the physical settings. Above all, the main goal of this research is to develop a set of design recommendations for designers and related professions to create successful LID facilities which will generate increased public satisfaction and education regarding sustainable stormwater management practices. This insight is considered crucial not only for the landscape design profession but also for our society as a whole in terms of enhancing people's stormwater knowledge and understanding, encouraging individuals to change their attitude and behavior toward sustainable stormwater management, and, ultimately, solving both local and national water quality problems.

1.3 Research questions and hypotheses

Principally, the central interest of this dissertation is to explore how the general public likes and learns about sustainable stormwater management practices in urban landscape design. For that matter, the focus of this dissertation is ***twofold***, the appreciation and the education of sustainable stormwater management or low impact development (LID).

1) Appreciation of sustainable stormwater management

This dissertation poses ***three research questions*** and investigates their specific hypotheses, as discussed below.

1.1) *How do people appreciate the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?*

This dissertation aims to test if the aesthetic attractiveness of the urban landscapes with LID design is significantly lower than that of the typical urban landscapes, those without LID design. Realizing that aesthetic attractiveness is not the only reason people appreciate a particular urban place, this research also intends to investigate the factors confounding the rating of landscape appreciation. It queries two major factors, functional efficiency and ecological performance based on the supposition that these factors potentially play a part in how people value the urban landscapes. More specifically, while how well a certain place serves the purpose and expectation of people is undeniably intertwined with its users' appreciation, how well a place serves as an urban ecological service is increasingly valued in this environmentally sensitive age. As some preliminary field surveys brought up, the LID design could impede the functional performance of an urban landscape. This dissertation, therefore, investigates if the LID design fails to achieve its users' appreciation of its functional efficiency, compared to the non-LID design. Obversely, considering increased global and local environmental concern, this dissertation tests if the LID design enhances its users' appreciation of its ecological performance, compared to the non-LID design. Additionally, for each study site, this research also studies the differences and correlations between the aesthetic attractiveness rating and the other two ratings.

1.2) *How do people evaluate the sustainable stormwater management function of the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?*

Because the LID facilities typically blend with their surroundings, they often look invisible or illegible to the public. This research investigates the ratings for the sustainable stormwater management function of the LID sites, compared to those of the non-LID design. In particular, the hypothesis of this question is that the LID and non-LID design receive the same rating, based on people's perception, for their sustainable stormwater management function. In addition, this research also includes the investigation of the landscape features perceived to help manage urban stormwater in a sustainable way. Furthermore, the study examines the differences and correlations between the rating for sustainable stormwater management function and the appreciation ratings for aesthetic attractiveness, functional efficiency, and ecological performance.

1.3) *How do people evaluate the landscape elements with regard to their attractiveness as well as their effectiveness, sustainability, and recognizability in terms of stormwater management?*

The aim of this part is to investigate four performances—attractiveness, effectiveness, sustainability, and recognizability—of the twelve prominent landscape elements as perceived by the public. The elements to be tested are those LID elements—water tank or cistern, pavers, bioretention planter or rain garden, bioswale or vegetated swale, green street, green roof, green wall, pool or pond, and constructed wetland—and also those that typically exist in urban landscapes—lawn or turf, paving surface, and trench, gutter or storm drain. The hypothesis of this question is that the LID elements are, to some extent, unattractive, ineffective, unsustainable, and unrecognizable in the eyes of the public. In addition to examining the four performance ratings of each landscape elements, this dissertation also investigates the correlations and differences among these four ratings.

2) Education of sustainable stormwater management

For the educational of stormwater management, the study investigates ***two research questions*** along with their specific hypotheses, as discussed below.

2.1) *Do people hold misconceptions and limited knowledge about urban stormwater problems and management efforts?*

As stormwater issues are subtle compared to other ecological concerns, this dissertation intends to investigate some basic conceptions people hold regarding urban stormwater problems and management efforts. The first hypothesis is that the water crisis is of less concern to the public, compared to the other environmental problems such as global warming, sea level rise, air pollution, energy shortage, waste management, soil contamination, and wildlife habitat degradation. The second one deals with the idea about significant sources of water pollution and degradation—if the public perceives runoff is having less impact on the water pollution and degradation problem than discharges from industrial plants. For the third hypothesis, this dissertation tests if people hold misconceptions about the sustainable ways to manage urban stormwater; in particular, as stormwater has long been regarded as excess, dirty water which creates several adverse effects to human health and properties, people tend to think that draining stormwater to sewer treatment plants is the most appropriate measure. In addition to the exploration of people's basic conceptions described above, this research seeks to understand people's ideas of places possessing ecological benefits—more specifically, which places people think they hold ecological benefits. The specific hypothesis for this is that people tend to not mention LID facilities as places holding ecological benefits. In addition, another hypothesis is that people tend to not able to identify places with sustainable stormwater management benefits.

This dissertation, most importantly, also explores the extent to which people think they are knowledgeable about the concepts and measures of sustainable stormwater management. Twenty-five related topics—including 1) sustainable stormwater management, 2) low impact development (LID), 3) best management practices (BMPs), 4) nonpoint source (NPS) pollution, 5) combined sewer overflows (CSOs), 6) stormwater runoff, 7) stormwater interception, 8) stormwater infiltration, 9) stormwater filtration, 10) stormwater detention and retention, 11) storm drain, 12) green infrastructure, 13) green roof, 14) green wall, 15) green street, 16) green parking lots, 17) rainwater harvesting, 19) rain barrel or cistern, 29) rain garden, 20) bioretention planter, 21) bioswale or vegetation strip, 22) permeable pavement and pavers, 23) detention and retention basin, 24) constructed wetland, and 25) riparian and coastal buffer—are listed to be tested. The hypothesis is that, as a number of previous studies revealed, people hold limited knowledge and understanding about sustainable stormwater management.

2.2) *Do people hold limited learning experiences and lack of interest in learning more about sustainable stormwater management?*

Realizing the importance of education in enhancing people's comprehension and appreciation of stormwater management efforts, this research investigates people's learning experiences about sustainable stormwater management. The hypothesis is that people have limited experiences, whether in terms of education or participation. In addition, this dissertation also explores the extent to which people are interested in learning more about sustainable stormwater management as well as their preferred learning options. The hypothesis for this part is that people tend to lack interest in learning more about this issue. For the learning options, the hypothesis is that learning from the interpretive signs at the LID sites is quite preferable, compared to other options including attending classes or workshops, reading publication (books, newspapers, etc.), watching TV programs or listening to radio programs, searching websites or online resources, attending exhibitions in museums or learning centers, and participating in volunteer programs.

Expectedly, the derived knowledge from the above questions is crucial to the exploration of an ultimate research question—how to design the sustainable stormwater management or LID facilities which can satisfy people with attractive landscapes as well as to educate people about sustainable stormwater ecosystems. In particular, this certain kind of knowledge would result in the formulation of design guidelines for making LID facilities beautiful, meaningful, and also useful for enhancing people's ecological literacy regarding sustainable stormwater management.

1.4 Structure of the dissertation

This dissertation comprises fourteen chapters. The brief description of the main ideas and the key contents in each chapter is provided as follows.

The first chapter introduces research inspiration and impetus, research background and contribution, and research questions and hypotheses. Furthermore, this chapter also describes the structure of the dissertation.

The next three chapters review relevant literature regarding history, theories, principles, ideas, and some specific case studies pertinent to the dissertation. Chapter two discusses principles and ideas regarding ecological design, aesthetics, and literacy with the focus on the relationship between scientific knowledge and aesthetic appreciation of landscapes as well as the function of urban landscapes on as learning settings for ecological science and conscience. Chapter three reviews the principles and practices of sustainable stormwater management design, together with the key stormwater regulations and efforts relative to stormwater education in the United States. Chapter four presents the fundamentals pertinent to the study of attitudes toward landscape design and stormwater education. The chapter focuses on the concept of attitude measurement, particularly the use of two types of attitude scale—Likert scale and semantic differential scale. Chapter four also discusses the key research methods for attitude studies along with related research precedents—particularly research in environmental psychology and landscape design, and survey of stormwater knowledge, attitude, and behavior—in order to form the apt methodological framework for this dissertation.

Chapter five, six, and seven are dedicated to the discussion of research procedure. Chapter five describes issues about stormwater management in the study area, the San Francisco Bay Area, and the criteria for site selection as well as the information about the selected research test sites. Chapter six explains the survey procedure of this dissertation—including the survey framework, pilot studies, survey instrument and questionnaire pretests, sampling method and sample size, survey distribution, and also the returned response. Furthermore, the chapter presents the summary of respondents' demographic characteristics along with their relationships with the study sites. Chapter seven reviews the basic principles of statistical tools using for data analysis and hypothesis testing. These tools include both descriptive statistics—frequency distribution, central tendency, and measures of variability—and inferential statistics—independent-samples *t* test, paired-samples *t* test, one-way between-groups ANOVA, one-way within-groups ANOVA, Pearson correlation, and partial correlation. The end of this chapter provides a summary of the survey data and appropriate statistical tools for testing each hypothesis.

Chapters eight to twelve reports the statistical analysis of data from the surveys, in both text and graphic forms, with the aim of examining the five research questions along with testing the research hypotheses. Chapter eight explores the respondents' appreciation of sustainable stormwater management design while chapter nine examines their perception of sustainable stormwater management function of the study sites. Chapter ten analyzed the ratings for attractiveness, effectiveness, sustainability, and recognizability of each of the twelve urban landscape elements. Chapter eleven reports the respondents' conceptions, or misconceptions, along with knowledgeability about sustainable stormwater management, and chapter twelve reports the respondents' learning experience and interest in learning more about sustainable stormwater management issues.

Based on information and insight from the survey data as well as the precedent literature, chapter thirteen discusses the comprehensive role of LID design along with a set of design guidelines for making LID facilities achieve public appreciation and advance education about sustainable stormwater management in San Francisco Bay Area. The last chapter, chapter fourteen, provides the conclusion of this dissertation, which includes the key implications and contributions of the research.

In addition to the fourteen chapters, the dissertation ends with the references along with the appendices. The appendices include the notice of approval for human subjects research of this dissertation, the survey instrument of this research, and the survey instruments used for collecting data for the pilot studies.

Chapter 2

Ecological Design, Aesthetics, and Literacy

2.1 Ecological concern in American landscape design

Fundamentally, ecological concern exists as the basis of landscape design and planning. Particularly in North America, the unique natural characteristics—especially geographical and climatic patterns—of the continent have long marked a great effect on its land development (Newton 1976: 246-247; Pregill and Volkman 1999: 383; Warner and Whittemore 2012: 9). Indeed, since before the European settlers reached this continent, indigenous populations had developed several strategies to modify their land, particularly for agricultural purposes. Prominent among them are gravel-mulch gardens of the Puebloan peoples, Chinampa-style agricultural lands or floating gardens of the Mesoamericans, and the "three sisters" farming of squash, beans, and corn of the Iroquois nations, for example (Pregill and Volkman 1999: 411).

Even though the natives had modified their land for various uses, the Europeans recognized very little or even no trace of land management when they first came to North America (Newton 1976: 246; Grover 2011). Thus, these newcomers, according to Grover (2011), "assumed they were looking at 'untouched' nature." Importantly, Europeans also, as Grover (2011) described, "didn't value the skills or knowledge of the existing civilizations too highly. The fertile landscapes they were beholding must have been ordained direct from God. In making this assumption, they overlooked one of the most sophisticated, wide-spread and sustainable forms of land management ever practiced." As a matter of fact, Europeans had adjusted their previous practices in order to fit with the harshness of natural conditions in the Americas (Newton 1976: 246; Pregill and Volkman 1999: 394-395). Interesting to note, since Europeans considered survival in the perceived wilderness of the new continent a priority, the land practices of the different nationalities in early colonial societies were simple and identical, and initially did not alter the landscape significantly (Reps 1965: 1; Newton 1976: 247). As Europeans expanded and settled into the new environment, their landscape practices reflected prevailing European philosophy of land management as the taming and control of nature.

In the nineteenth century, apart from the picturesque-pastoral aesthetics[1], Frederick Law Olmsted and Calvert Vaux underscored ecological criteria emphasizing concern for urban public health, coping with the problems of epidemic diseases, and promoting the quality of urban life. Olmsted and Vaux inventively proposed the idea that parks could play a significant

[1] Literally, 'picturesque' means 'picture-like'; however, it refers to the eighteenth-century aesthetic appreciation of nature which is considered as art-like scenes. In the United States, this landscape ideal had significantly evolved and shifted during the nineteenth century. As urban dwellers had been stressed by the rapid growth of cities, they had begun to reminisce about the delightfulness of their countryside hometowns. Nostalgia of rural life and scene, thus, was engaged to the aesthetics of the landscape design. This emerged paradigm has been so-called 'pastoral' which refers to the aesthetics of picturesque rural landscape.

role in sanitary services to alleviate urban pollution. Particularly, they explained that parks could clean the air and act as a "lung" of the city (Schuyler 1986: 126-128; Pregill and Volkman 1999: 479). In addition, they also advocated for the "abandonment of the old-fashioned compact way of building towns, and the gradual adoption of a custom of laying them out with much larger spaces open to sun-light and fresh air" (Schuyler 1986: 127). These ideas were eventually developed into the creation of parkways extending from public parks in Buffalo, Brooklyn, and Chicago, and in suburban plans such as Riverside, Illinois. Moreover, Olmsted—along with H.W.S. Cleveland, Robert Morris Copeland, Uriel H. Crocker, and Charles Eliot—also developed the idea of urban park systems which could act as urban infrastructure incorporating systems for urban hydrology, transportation, public health, and biodiversity exemplified by Boston's Emerald Necklace (Schuyler 1986: 143-144; Hill 2009: 143; Laurie 1989: 49).

As a result of the advancement of science and technology that revealed conditions of environmental degradation, in the twentieth century, ecological concerns have dramatically risen the foremost topic of interest in land management and. Subsequently, ecological criteria became fundamental to the priorities for landscape design (Jackson 1975:4-9; Eckbo 1975: 31-37). In addition, ecological science has also significantly been integrated into the field of landscape design in order to reduce adverse environmental impacts or to restore ecological functions of the landscapes. This been promoted as ecological or sustainable design and implemented throughout the country.

2.2 Ecological landscape design in the United States

Beginning since the mid-twentieth century, several ecological problems and their negative effects on both human and environmental health have become more and more distinguishable, resulting in increasing awareness of appropriate and sustainable urban development policies and practices. Aldo Leopold's *A Sand County Almanac: and, Sketches Here and There* (1949) and Rachel Carson's *Silent Spring* (1962) were, among the others, publications that had exceptionally great influence on environmental movement since they depicted the degradation of ecosystems and set off the global concern about environmental crisis. This concern had later fueled by NASA's report on the greenhouse effect and climate change during 1980s which resulted in the establishment of the Intergovernmental Panel on Climate Change (IPCC)[2] in 1988. The reaction in terms of human responsibility to cope with this crisis had embarked on as the emergence of sustainability concept. On March 20, 1987, the World Commission on Environment and Development (WCED) defined sustainable development as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" in the report "Our Common Future," also known as the "Brundtland Report" (World Commission on Environment and

[2] IPCC was established by the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) with the aim of providing the scientific information on the current state of knowledge regarding climate change.

Development 1987). Five years later, the Agenda 21[3] was launched by United Nations Environment Program (UNEP) as the basis for actions regarding sustainable development of the United Nations (UNEP 1992).

Ever since the Brundtland Report, concerns regarding environmental sustainability have emerged in every part of the world. In consequence, the advanced, modern ecological science has been intensively engaged in landscape planning and design. As Karvonen (2011: 21) succinctly noted, "At the beginning of the contemporary environmental era, landscape architects broke the mold of aesthetic practice and reembraced the integrated design approach developed by Olmsted. After World War II, landscape architect Garrett Eckbo promoted landscape design and planning as a science for social engineering, and in the 1960s, ecological planner Ian McHarg crystallized the idea of merging landscape design with ecological science in his groundbreaking book *Design with Nature*." This book, first published in 1969, is regarded as the classic text, pioneering the concept of ecological planning and the scientific method of land suitability analysis. Also known as the "overlay method," it forms the basic concept of Geographic Information Science (GIS) widely used today.

In fact, Native Americans or Indians had long developed effective and sustainable strategies for land development. Nonetheless, as Pregill and Volkman (1999: 411) described, this "environmentally based knowledge was not only put aside by Euroamericans, but actually disparaged as 'superstitious' or 'nonscientific.' In our now more environmentally sensitive era the positive benefits of simple practices are again being recognized, and some of the practices survived. Gravel mulches of the Pueblopeoples of the Southwest have resurfaced in modern 'xeriscape' gardens, Chinampa-style agricultural lands are being reconstructed where the economy and environment do not favor agribusiness techniques. We can only regret how much landscape knowledge and practice of great value was lost in the rush to transform the Amerindian subsistence landscape into the Euroamerican pastoral paradise."

For decades, scientists and designers have put their best efforts into integrating deep ecological knowledge with urban design in order to minimize negative environmental impacts as well as to sustain urban ecological processes. As a result, a number of modern principles and processes of ecological design have been developed and promoted. These principles and practices are widely known as sustainable or ecological design[4]. According to Van der Ryn

[3] Agenda 21 is a publication from the Earth Summit, UN Conference on Environment and Development (UNCED), which was held in 1992 in Rio de Janeiro, Brazil. The number "21" in its name refers to the twenty-first century.

[4] Although the term "ecological design" and "sustainable design" are often used interchangeably, they are not identical. More specifically, while ecological design mainly emphasizes the sustainability of ecosystems, sustainable design, based on the concept of sustainability, encompasses social, economic, and ecological sustainability. Important to note, several thinkers have recently mentioned that social and economic dimensions are also crucial to the achievement of ecological design (e.g. Hough 1995; Gobster and Hull 2000; Hill 2007; Hester 2010). Accordingly, ecological design eventually includes social and economic concerns as bases of its principles and processes.

and Cowan (2007: 33), ecological design is defined as "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes."

By the end of the twentieth century, sustainable or ecological design became the central concept and concern of contemporary urban landscape design driven by regulatory requirements, incentive programs, social movements, and marketing strategies. Regulatory contexts are the most influential force as designs must meet the requirements of the regulations, such as energy efficiency codes and stormwater management rules. Incentive programs such as LEED certificates or awards provided by the United States Green Building Council, supported by the United States Environmental Protection Agency (US EPA) and the American Society of Landscape Architect (ASLA), are also key incentives for moving beyond business as usual. Social movements, particularly the green or sustainable movements, are also crucial motivations for change. Since these movements have gradually altered social trends regarding environmental concern, ecological landscapes, thus, have become more appreciated in public's minds.

Obviously, sustainable design has an enormous influence on urban park design in the United States. According to Cranz and Boland (2004a and 2004b), urban park design has evolved from the models[5] which handled social problems as a result of industrialization and urbanization in their early history to the current model—the ecological or sustainable park (1990-present)—which deals with environmental problems. The "Forum on Urban Parks," held at the Fourth International Outdoor Recreation and Tourism Trends Symposium in 1995, formally introduced ecological approaches to urban park design (Gobster 2001: 36).

Apart from these efforts regarding urban parks, a number of urban plazas, squares, and streetscapes, whether public or private projects, implemented the sustainable design concepts with the aim of providing the ecological infrastructure of cities. This kind of infrastructure is widely known as "green infrastructure," which generally refers to "an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife" (Benedict and McMahon 2006: 1). Furthermore, many scholars also support the idea that urban ecological facilities and services should mimic natural regimes and be integrated into urban fabric (Hough 1995; Johnson and Hill 2002; Hill 2007; Spirn 2012). In view of that fact, advocates coined the idea of "ecological urbanism." As Spirn (2012: 1) noted, "Ecological urbanism is critical to the future: it provides a framework for addressing challenges that threaten humanity, such as global warming, rising sea level, declining oil reserves, rising energy demands, and environmental justice, while fulfilling human needs for health, safety, and welfare, meaning and delight."

Moreover, due to the recognition that people have become more sensitive to environmental issues, sustainable design has also been utilized as marketing and advertising strategies of commercial projects. Seeing that ecological landscapes can play a part in

[5] These models include, according to Cranz (1982), the pleasure ground (1850-1900), the reform park (1900-1930), the recreational facility (1930-1965), and the open space system (1965-1990).

increasing value of the properties, owners and investors have been more interested in implementing sustainable design.

Today, good examples of ecological design projects are abundant and available to be accessed by the general public. Landscape Performance Series[6] organized by Landscape Architecture Foundation (LAF) and Stormwater Case Studies by State provided by American Society of Landscape Architect (ASLA) are, among the others, good sources of collections of exemplary case studies.

2.3 Conflicts between aesthetic and ecological values in landscape design

Although landscape architecture involves both aesthetic and ecological values as the underlying principles of its discipline so as to make landscape design both desirable and sustainable, these two values may not always come together. As Mozingo (1997: 46) described, "Landscape architecture has ecological thinking at the core of its legacy, yet ecology's meaning and significance in design attenuates, if not divides, the profession. On one end of a continuum are those who see the primacy of landscape design in ordering ecological process, on the other, in aesthetic explication."

Additionally, Matthews (2002: 37) states that the assessment of aesthetic values of nature associates two views. As he concisely explains, "From the point of view of contemporary aestheticians, there is the question of whether, aesthetically speaking, nature offers anything like the depth, complexity, and meaningfulness of art. From the point of view of environmental philosophers, aesthetic value may be seen as a source of value that contributes to the overall value of nature, and as a further reason for its preservation. But aesthetic value can also be the enemy of the environmentalist: often decisions made on aesthetic grounds conflict with decisions made on preservationist grounds" (Matthews 2002: 37).

Generally, aesthetic appreciation of contemporary designed landscapes, particularly ecological design projects, appears controversial as various, or even contradictory, approaches—such as philosophies of arts, principles of scenic beauty and picturesque, and also concepts of environmentalism and ecological aesthetics—shape the way they are viewed and judged aesthetically. The key aesthetic controversy is the tension between the environmental model, which focuses on the protection of natural and ecological processes, and the conventional model of scenic beauty, grounded in the philosophy of art and picturesque. More precisely, the visual appearance of landscapes in preservation and restoration practices, which very often looks unkempt, has often come into conflict with the ideal of scenic landscape beauty which glorifies a neat appearance. Although many ecological design projects have been implemented, they have often been unable to achieve shared understanding and

[6] Landscape Architecture Foundation (LAF) developed the collection of cases studies in its Landscape Performance Series which is an interactive set of resources to show values and provide tools for designers, agencies and advocates regarding sustainable landscape solutions. The data is available online at http://landscapeperformance.org/.

satisfaction. In particular, the designed landscapes which hold ecological benefits are not often recognized or appreciated by the public (Nassauer 1995; Mozingo 1997; Gobster 2001; Spirn 2005). This controversy has long impinged upon widespread acceptance and support of the environmental policies and practices and also sparked several conflicts and controversies related to them.

One example, a remarkable case, is the Chicago restoration controversy that occurred in the spring of 1996 (Gobster and Hull 2000: 1-10). This specific controversy emerged when the Forest Preserve District of DuPage County in Chicago was developing the project to cut the forest with an aim of restoring savanna prairie, which existed in the region before European settlement. This project raised a large outcry from local residents and resulted in a temporary suspension in the project. For local residents, seeing trees to be cut down was equivalent to nature destroyed, not restored. This project exemplified the conflict in between interpretation of the ecological values of the landscape practices from different perspectives (Gobster and Hull 2000: 2-7).

Front yard lawn controversies in North America also exemplify these conflicting values. Due to the recognition of their responsibilities to the environment, many homeowners have realized the negative environmental impacts of the pervasive use of lawns and transformed their house lots into vegetable gardens or agricultural plots, which are considered more ecologically, and also economically, beneficial. However, the conflicts have emerged since local communities do not always accept these changes to standard suburban landscape practices. As one example, a Michigan woman, Julie Bass, could spend up to 93 days in jail for planting edible plants in her front yard. The local officials stated that her practice of growing a vegetable garden violated the rule of governing suitable front yard plant materials (Yglesias 2011; Kirpalani 2011). Josée Landry and Michel Beauchamp were forced to remove their front yard kitchen garden, various kinds of vegetables. The town stated that the couple violated the code allowing vegetable garden to take up no more than 30 percent of the front yard (Huffingtonpost.com 2012). Accordingly, they could expect fines of $100-$300 each day until their kitchen garden was removed.

Aesthetic appeal is critical to ecological landscapes because it has a great effect on public acceptance and support which is crucial to the success and sustainability of such landscape designs. For that reason, in David Orr's (2002: 180) words, "The standard for ecological designers is to cause no ugliness, human or ecological, somewhere else and at some later time."

The balance, or tradeoff, between ecological restoration and urban activities is also an important issue. Despite the fact that ecological landscapes are interesting and can promote healthy relationship between people and nature, the limitation of public access to ecologically significant landscapes is sometimes the cause of distancing, rather than connecting people to nature. This circumstance can result in the phenomenon called "museumification" which, according to Gobster (2007: 100), refers to "a process in which places or subjects of the everyday world are transformed in ways that can lead people to think and act toward them as if they had been placed in a museum."

A considerable number of case studies reveal that ecological landscapes are unappealing and unaccepted in some people's eyes. Therefore, public perception and attitude toward the visual appearance or aesthetic dimension of such landscapes warrants inquiry and assessment as an essential component in ecological landscape design and restoration projects.

2.4 Environmental ethics and ecological aesthetics

For centuries, aesthetic philosophy has been deeply implicated in the experience of landscape, particularly as a measure of what should be considered beautiful, appealing, or meritorious. Yet the aesthetic principles grounding landscape design have never been static; instead, they have evolved over time as a result of cultural, social, political, and economic contexts surrounding each period of time. Throughout American history, aesthetic preferences related to urban landscapes have shifted (Pregill and Volkman 1999: xv). Americans reiterated European aesthetics of Renaissance geometries and the English Picturesque as their ideal of landscape beauty during early period of the nation. The evolution of the plan for Washington D.C. from L'Enfant's European Renaissance plan to Downing's romantic scheme and then the McMillan's City Beautiful plan (Tobey 1973: 181; Jellicoe and Jellicoe 1995:308-309) serves as a good example of this point.

Americans also transformed European landscape aesthetics into a distinctive prevailing ideal, most notably through the idea of the "pastoral" promoted by Frederick Law Olmsted, and his collaborators and followers, in designs for urban landscapes. Inspired by the well-tended rural landscape, the pastoral emphasized a tranquil and naturalistic landscape composed of large trees, rolling lawn expanses, clusters of trees, serpentine water features, and sinuous pathways. And eventually, Americans have manifestly demonstrated, as Pregill and Volkman (1999: xiii) noted, a "perennial fascination with the pastoral landscape." Importantly, this aesthetic model later became influential not only nationally but also globally.

In the wake of the environmental crises of the 1960s and 1970s, the concept of sustainability has become widely accepted across the globe and resulted in the increase of public concern regarding the health of our surrounding environment. Rachel Carson's *Silent Spring* (1962) is the key work that drew wide public attention to the decline of the environment. Carson's descriptions of various impacts of DDT, an agricultural pesticide, altered the public's perception of the dangers of human activity on the environment, and, in turn, affect our own health (Brennan and Lo 2011; Johnson and Hill 2002: 273). Significantly, this influenced the development of ideas regarding the protection of the natural and ecological environment. Furthermore, philosophies concerning the moral responsibility to sustain environmental health, known as environmental ethics, also emerged during the 1970s (Brennan and Lo 2011). By definition, environmental ethics center on the study of the relationship between human morality and the intrinsic values of the environment (Brennan and Lo 2011).

Larger ideas about the interrelationship between ethics and aesthetics extend back centuries (Collinson 1985: 266-272; Leatherbarrow 2014, 9-23). More recently, landscape architectural research has included this discussion. Blanchon-Caillot et al. (2012: 4) note that “if ‘ecology’ is added to ‘aesthetics’ and ‘ethics’, the classic tripartite definition of the discipline is formulated.” Stated summarily, since human possesses instinct regarding the power of nature, aesthetic appreciation of ecological landscape design involves a moral decision. Given that, both ethics and aesthetics became integral to the field of environmental conservation and protection.

Over the past decades, the idea of “ecological aesthetics” has led to a reconsideration of the aesthetics of the landscape and a reinterpretation of the aesthetics of the environment. This idea was grounded by Aldo Leopold, who proposed a “Land Ethic’ that brought together the beauty of nature and the ecological integrity. “A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise” is the famous quote from Leopold’s *A Sand County Almanac* (1949). In this book, Leopold argues that the “land” as a whole deserves our moral concern, especially in term of its ecological values. This distinctly marks the alignment of aesthetic preference and the responsibility to protect ecological health (Carlson 2012). Ecological aesthetics, thus, emerged as the new form of landscape beauty which refers to the aesthetic appreciation of the environment in terms of its ecological processes and values. Accordingly, the relationship between ecological and aesthetics values of landscapes, whether natural or human environments, receives greater attention, especially in the field of landscape conservation and restoration.

2.5 Landscape design for ecological aesthetics

Even though the benefits of ecological landscapes are proven, they have often fallen short of achieving public appreciation. As Lyle (1994: 284-485) notes, ecological landscapes typically blend with their surroundings, and thus can be invisible and illegible, drawing little interest from urban dwellers. Another crucial problem is their unappealing appearance, especially unkempt or messy looks, often viewed as undesirable (Gobster 1994; Nassauer 1995). As a result, clash still exists between the visual aesthetics conventions, especially the long-lasting pastoral ideal, and just-emerging ecological models regarding aesthetic appreciation. As Nassauer (1995: 161) precisely observes, “Ecological quality tends to look messy, and this poses problems for those who imagine and construct new landscapes to enhance ecological quality.” Realizing the fact that aesthetics holds a strong appeal for the public, numerous efforts have put into finding ways to make ecological design aesthetically beautiful and delightful in order to achieve public satisfaction.

Indeed, the aesthetic quality of landscapes is important not only to the general public, but also to the landscape designers themselves. According to the statement made by a jury member in one awards issue of *Landscape Architecture* magazine, “We award the projects that are really beautiful and a little irresponsible, but never those that are environmentally responsible but a little ugly” (Griswold 1994: 52 cited in Mozingo 1997: 46). As a matter of fact, as Mozingo (1997: 58) underlines, “Ecological designs do need to appeal to the joyous, the freely given, the heroic. They deserve to be beautiful—to have an aesthetic.”

Without a doubt, designing the landscape that can unite ecological and aesthetic functions is considered an onerous task because ecological benefits in landscape are not easily recognizable and readily desirable (Nassauer 1995; Spirn 2005). Several scholars, whether in design or other fields, have developed principles as well as proposed recommendations for conciliating ecological and aesthetic values in order to promote ecological aesthetics in sustainable landscape design.

Early period in this effort, theorists promoted cultural cues as a principle to advance aesthetic appreciation of ecological landscapes. According to Spirn (1988: 124), "the current understanding of nature and culture as comprising interwoven processes that exhibit a complex, underlying order which holds across vast scales of space and time, not only demands a new aesthetic, new forms, and new modes of design, construction, and cultivation, but also prompts a fresh appreciation for the forms of the past and the processes by which they were created." Seeing that, according to Mozingo (1997: 57), "successfully promulgating ecological design requires the recognition and application of culturally based aesthetics." This idea refers to an attempt to promote ecological functions by utilizing cultural conventions and expectations of landscape beauty (Nassauer 1992: 246, 1997: 67). Initially, vernacular values were seen as especially effective in promoting aesthetics of ecological landscapes (e.g. Hough 1995: 10-12; Nassauer 2012: 221-222).

Apart from taking advantage of vernacular landscapes, understanding that people are deeply attached to the pastoral model of ideal beauty, creating landscapes that appear congruent with conventional expectation is the way to encourage acceptance of and avoid conflict with the public perception. Joan Nassauer (1995: 161-170) proposed "cues to care" based on the knowledge that people prefer the neat, rather than messy, appearance of the landscape. Principally, this idea suggests the designers to provide cues that can indicate human care for the landscape. The cues include 1) mowing, 2) flowering plants and trees, 3) wildlife feeders and houses, 4) bold patterns, 5) trimmed shrubs, plants in rows, linear planting designs, 6) fences, architectural details, lawn ornaments, painting, and 7) foundation planting (Nassauer 1995, 161).

Another significant idea in this regard emphasizes the creation of "impelling forms," according to Hester (1995: 14), or "iconic designs," according to Mozingo (1997: 46), that can engage the public in ecological benefits designed landscapes. According to Brzuszek and Clark (2009: 92-94), although many landscape design scholars have developed and initiated several culture-based design guidelines (e.g. Thayer 1989; Eaton 1990; Nassauer 1995; Treib 1995), the principles by Mozingo (1997) provide a complete set as they critically summarize and deliberately combine each of those prior concepts into a comprehensive set of five principles—which includes 1) visibility, 2) temporality, 3) reiterated forms, 4) expression, and 5) metaphor (Mozingo 1997, 46-59).

Perspectives from social and behavioral science have also been introduced into the process of landscape design in order to enhance public acceptance and support of the ecological projects, particularly restoration landscapes. As Thayer (1989: 101-109) argues, visual aesthetics should not be overemphasized because it "seems inadequate to describe the ways in which sustainable landscapes might serve human well-being." Thayer goes on to state "feelings of community belonging, pride, health, safety, security, sense of self, oneness with nature, and emotional stability over time" should also be included. As Ryan (2000: 225) concludes, "place attachment" based on the idea that "people's interest in protecting urban natural areas often comes from their attachment to these place" is crucial in garnering public appreciation and acceptance of restored landscapes. Furthermore, to provide positive scenes and alleviate negative scenes for those meaningful places is also essential for avoiding conflict and expanding public appreciation (Ryan 2000: 225).

In addition to cultural and social lenses, theorists propose that design can reveal ecological meaning of the landscape (Hagg 1998; Thayer 1998; Mayer 2008). This idea is widely known as "ecorevelatory design," which refers to the design that reveals inherent ecological processes and provides empirical experiences with these processes for people. This approach contrasts with conventional landscape design in which ecological process is mostly hidden or invisible, people are unable to recognize its presence (Helphand and Melnick 1998: xi-xii). In addition to ecorevelatory design, hypernature, referring to the exaggerated revelation of natural processes and structures in the designed landscape, amplifies people's experience and enhance their understanding towards that landscape (Mayer 2008: 17-18). Because this idea is also based on the tenet that designed landscape should be able to catch people's attention, which is always distracted by so many concerns and interests in their urban live, art is also employed as the fundamental principle of hypernature (Mayer 2008: 17-18).

Since landscape design is also viewed and appreciated as a work of art, art is considered another approach for making ecological processes visible and enhancing ecological aesthetics (Hess 1992; Matilskky 1992; Thompson 1994; Calabria 1995; Strelow 2004; Reimer 2010). One example of art-based concept is "eco-scape," which refers to the designed landscape that relates to art practice and promotes ecological conditions through a performative and unsettled space in constant transformation and change (Reimer 2010: 24-37). "Artful rainwater design" also exemplifies this art-based approach. This idea underlines "an intriguing opportunity to transform stormwater management into an on-site design feature" (Echols and Pennypacker 2006: 24). In addition, the artful rainwater design can also be used to create "recognized amenities in the urban landscape—designs that invite visitors to explore, learn, and enjoy aesthetically pleasing landscapes that are publicly recognized as clear value added urban amenities" (Echols 2007: 6).

Designers have proposed a myriad of ideas and principles for enhancing the aesthetic qualities of ecologically designed landscapes and the ones presented here are the most prominently and widely discussed in the literature. Nevertheless, little research has been done with the aim of examining the validity of these design principles as perceived by the public. The pioneering research by Brzuszek and Clark (2009) is the exception. Inspired by the five principles proposed by Mozingo (1997)—visibility, temporality, reiterated form expression, and metaphor, the main purpose of their study was to test the validity of them. More specifically, the central question of this research is how the five principles are important to and perceived by the general public. The researchers selected the Crosby Arboretum in Picayune, Mississippi, to be the study site because it claims the "first fully-realized ecological arboretum in the country" (Brzuszek and Clark 2009: 91). Moreover, before testing the validity of these principles with visitors, the researchers had carefully analyzed the study site and argued that each of these five premises was addressed in the design of Crosby Arboretum. Accordingly, the researchers considered the arboretum qualified to serve as the case study for this research. Interestingly, although the research revealed that the five design criteria are important and can be perceived by the general public, it also suggested two other intriguing points. First, respondents believed that the landscape should be designed in a way that blends into its surrounding, manifests care, and appears to have meaning. The second point is that respondents believed that the landscape needs not be neat and orderly. These two results imply that the proposed design criteria for enhancing public recognition and appreciation of ecological landscapes are not entirely valid. Accordingly, although many ecological projects have been implemented by following these design criteria, they still fall short of achieving public recognition and satisfaction. Recent studies have revealed both ignorance and controversy regarding the aesthetic values of urban ecological facilities (e.g. Kaplan 1977; Debo and Ruby 1982; Hough 1995; Nassauer 1997).

2.6 Ecological literacy and environmental education

At the time of increasingly challenging environmental problems, scholars have promoted the idea that people are the real advocates for sustainable future whether in terms of influencing and supporting sound policies, participating and volunteering in environmental activities and programs, or adjusting and changing their habits toward pro-environment behaviors. Critically, as Stapp and his colleagues state, "To perform these tasks effectively, it is vital that the citizenry be knowledgeable concerning their biophysical environment and associated problems, aware of how they can help solve these problems, and motivated to work toward effective solutions" (Stapp et al. 1969: 31). In other words, as Coyle (2005: xvii) note, "if we are ever to get real control of environmental problems in the U.S. and abroad, we will need a public with a sound base of education, able to understand these problems and address them at their source." Realizing that fact, the National Science Foundation's Advisory Committee for Environmental Research and Education noted in its 2003 report that "In the coming decades, the public will be called upon more frequently to understand complex environmental issues, assess risk, evaluate proposed environmental plans, and understand how individual decisions affect the environment at local to global scales" (National Science Foundation 2003: 41).

Unfortunately, a large number of recent research studies have demonstrated that lay people have limited knowledge and understanding about their surrounding environment and ecosystems. *Environmental Literacy in America* (2005) reported some key findings based on research done over almost a decade by the National Environmental Education & Training Foundation (NEETF) in collaboration with Roper. In this publication, Kevin Coyle—author and former President of NEETF—strongly emphasized that Americans are "by and large both uninformed and misinformed" (Coyle 2005: ii); moreover, they also "believe they know more about the environment than they actually do" (Coyle 2005: v). As he also succinctly noted, "While the simplest forms of environmental knowledge are widespread, public comprehension of more complex environmental subjects is very limited. The average American adult, regardless of age, income, or level of education, mostly fails to grasp essential aspects of environmental science, important cause/effect relationships, or even basic concepts such as runoff pollution, power generation and fuel use, or water flow patterns" (Coyle 2005: xi). Certainly, the public's low level of environmental ethics, along with their thoughtless behavior, contributes to adverse effects on urban ecosystems and continuing degradation of environmental quality. As Randy Hester (2010: 327) points out, "Our most serious community problems today are consistently left unsolved by uninformed public." Furthermore, as David Orr also describes, "The disorder of ecosystems reflects a prior disorder of mind, making it a central concern to those institutions that purport to improve minds. In other words, the ecological crisis is in every way a crisis of education" (Stone and Barlow 2005: x). Accordingly, Antunes and Gadotti (2005: 135) succinctly note that, "the preservation of the environment depends on an ecological conscience and shaping this conscience depends on education."

More than haft a century ago, a noted environmentalist Aldo Leopold remarked upon the importance of education in environmental conservation. As he wrote in his 1944 essay, *Conservation: In Whole or in Part?*, "Acts of conservation without the requisite desires and skill are futile. To create these desires and skills, and the community motive, is the task of education" (Leopold 1944: 319).

With the extensive recognition that education is the most fundamental and essential part for promoting sustainable attitudes and behaviors, many environmental studies and reports end with discussions of the significance of education regards to raising people's awareness of their responsibilities to take care of the environment. Education, thus, has often been recommended as the ultimate means of moving toward our sustainable future. Undeniably, the concern that environmental science is difficult to learn and understand is longstanding and widespread. Recent research reveals, however, a lessening difference in environmental knowledge levels among the lay Americans and those working in environmental agencies and councils, a positive sign that the public can also learn about the complex ecological and environmental concepts. (Coyle 2005: xi)

Generally, the effort to teach or provide scientific knowledge about the environment and its ecosystems for people is known as "environmental education" (EE). Although this kind of effort has often implied education within formal systems or school settings, it has also expanded to include informal education in settings outside school classrooms. As Coyle (2005: x) described, "a number of newer studies have shown that environment-based learning programs with suitable depth, duration, and rigor can boost standardized test scores. This argues for more EE infusion, not less. Despite the average educator's temptation to stay safely within the syllabus and to 'teach to the test,' other trends in American education are opening a number of promising new doors to environmental education. Examples include a growing emphasis on community service, after school programming, the school-community resource connection, comprehensive school reform, and schoolyard habitat and garden programs."

Furthermore, within recent decades, communities have a varied range of opportunities for education beyond, and outside of, formal education systems. These include libraries, museums, science centers, zoos, aquariums, botanical gardens, parks, and environmental centers, institutions, and organizations. School visits to such places have been recognized beneficial in supporting and extending the formal teaching (Rennie and McClafferty 1995). Furthermore, research has shown that these informal education facilities have the potential to reach a wide cross-section of the general public (Ballantyne and Packer 2005).

The effort toward environmental education aims not only to increase "environmental knowledge," but also, and ultimately, to raise "ecological literacy," also known as "environmental literacy," which refers to the ability to understand ecological processes and values of the environment along with the ability to use this understanding to build a sustainable future. The term "ecological literacy" was coined by David Orr and Fritjof Capra in the last decade of the twentieth century. In particular, Orr's *Ecological Literacy: Education and the Transition to a Postmodern World* (1992) and Capra's *The Web of Life: A New Scientific Understanding of Living Systems* (1996) are principal publications that address the idea regarding environmental education and ecological literacy. In recent years, public and non-profit organizations, as well as academic institutions, both in the United States and other countries, have widely promoted and implemented ecological literacy. An influential organization that continues to promote ecological literacy and support studies in this area is the *Center for Ecoliteracy*, founded in 1995, located in Berkeley, California (Stone and Barlow 2005: 1).

Even though efforts to provide environmental education and boost environmental literacy has been widespread in the United States over the last decades. Coyle (2005: x) cautions that environmental education "has not yet reached the critical mass needed to adequately support nationwide environmental literacy." Key to this is to understand the distinction between the provision of information versus knowledge. As Coyle (2005: 54) succinctly explains, "The first is the simple provision of facts and easy concepts that most often generates 'awareness;' the second involves a sequenced series of learning steps that results in a thorough understanding of the subject and its dynamics, including developing skills and learning how to apply them in a real world setting." Undeniably, the media is a very powerful source of environmental information and knowledge. Nevertheless, as Coyle (2005: x) notes, "The media is well positioned to provide widespread but superficial information on environmental subjects; it is poorly positioned to offer in-depth education. This means it provides a steady, even ubiquitous, flow of awareness-building information but it seldom educates on complex matters or builds skills. Sometimes the misapprehensions it fosters can grow into persistent and incorrect myths."

Apart from understanding the distinction between the provision of information and versus knowledge, understanding the distinction between the effect of environmental knowledge on pro-environmental behavior and the effect of environmental literacy on pro-environmental behavior is essential. Again, Coyle (2005: xi) explains that although the NEETF/Roper series of research studies revealed a positive correlation between environmental knowledge and pro-environment behavior—which means those who have a higher level of environmental knowledge tend to have a higher degree of pro-environment behavior, this knowledge, by itself, has limitations because it works best for simple, easy information and behaviors such as buying green products or saving water and electricity. In particular, Coyle (2005: xi) specifically notes, “This knowledge/behavior correlation, though significant, is not fully compelling and probably does not offer lasting environmental stewardship.” Considering this, if environmental stewardship is what we expect as the “pay off” of environmental education, increasing environmental knowledge is not really enough. Instead, environmental education needs to advance learners’ ecological literacy in order to let them develop their sense of involvement and ownership along with their environmental stewardship.

Given that, environmental education and awareness can be seen as engaging three levels of learning: simple environmental awareness; personal conduct knowledge; and, true environmental literacy.

Simple environmental awareness refers to the state in which people just know or have heard that a particular environmental subject is existent or important. In other words, they have basic information or simple familiarity with the topic with little real understanding of its deeper causes and implications Coyle (2005: xiii). As Coyle (2005: xiii) states, “The research demonstrates that environmental awareness by itself has limited lasting effect on environmental stewardship attitudes (although it can reinforce existing sentiments) and by itself has little effect on ‘environmentally-friendly’ behavior. The main advantage of widespread environmental awareness is its contribution to public support for government action in environmental policy and management. The main tool for creating such awareness is, by far, the public media.”

Personal conduct knowledge indicates the state in which people understand particular environmental issues. People can make a connection between the environment and their own behaviors. Importantly, they are also willing to take action or adjust their habits toward some simple pro-environmental behaviors such as saving electricity, gasoline, and water, reducing and recycling some solid waste, buying green products. Generally, this level of environmental education and awareness also requires no in-depth knowledge of causal sequences of personal behaviors and environmental impacts because most of the connections are simple and straightforward.

True environmental literacy means the state in which people are well-informed and knowledgeable about the environmental issues. They thoroughly understand how to relate the knowledge and understanding they have to the real-world situations. Most importantly, persons who are environmentally literate are more likely to engage in a wider set of pro-environment attitudes and behaviors than those who are not. Accordingly, this level of awareness is distinct from the previous two levels, especially in terms of the deeper information and the better skills (thinking and doing) that are involved. More specifically, as Coyle (2005: xiii) describes, “It starts out with framed information but also involves imparting the subject's underlying principles, the skills needed to investigate the subject, and an understanding of how to apply that information.” In view of that fact, it takes time to develop true environmental literacy. Consequently, as research reveals, only around 1% to 2% of American adults have sufficient environmental knowledge and skill to be considered environmentally literate” (Coyle 2005: xiii).

Last but not least, Coyle (2005: xv) also recommends that environmental education and literacy can be supported by a more effective deployment of off-site places, or out-of-classroom settings, such as zoos, aquariums, museums, arboreta, botanical gardens, nature centers, natural parks and refuges, school yards and garden.

2.7 Scientific knowledge and aesthetic appreciation of landscapes

The aesthetic value of urban landscapes in American cities has varied over time. It evolved from the idealistic models based on philosophical conceptions to the realistic schemes for solving physical and social conditions of the cities in the nineteenth and twentieth centuries. Since the mid-twentieth century, according to Carroll (1993: 244), "philosophical interest in the aesthetic appreciation of nature has been gaining momentum." One of the most prominent and powerful theories is that aesthetic appreciation of landscape is based on psychological models, of which Allen Carlson is regarded as the key scholar (Carroll 1993: 244; Matthews 2002:37). According to Carlson (2011, 2012), the aesthetic appreciation of environment can be classified into two models—cognitive and non-cognitive appreciation. For cognitive model, knowledge or information about nature and environment is the basis of aesthetic appreciation. In contrast, non-cognitive aesthetics is based solely on emotive perception.

In light of Carlson's work—especially Carlson (1979a, 1979b, 1981, 1985a, 1985b, 1986, 1995, 2011, 2012), and also Sadler and Carlson (1982)—the idea that aesthetic appreciation of nature is a matter of scientific knowledge has been widely accepted (Carroll 1993: 244). Carlson (1995: 393) also emphasizes the idea that nature needs "appropriate aesthetic appreciation." In particular, Carlson (1995: 393) "suggest[s] that the appreciation of any object, from the noblest to the most mundane, requires information about it and, by the same token, that the appropriate aesthetic appreciation of nature requires knowledge of the natural world." In other words, since "we cannot appropriately appreciate what we do not understand" (Rolston 1995: 377), we need scientific knowledge to help us understand how nature appears as what we see and how it is important to our lives. As Carlson (1995: 393) vividly explains, the aesthetic appreciation of the starry heavens is certainly grounded and enriched by knowledge of astronomy.

This particular idea can also explain aesthetic appreciation of art. According to Kendall Walton's well-known "Categories of Art," relevant knowledge of art history and philosophy allows us to perceive the artwork in an appropriate category (Matthews 2002: 37). In short, as Rolston (1995: 377) notes, "Things need to be appreciated in the right categories." Thus, relevant scientific knowledge—particularly that of natural science, ecology, and natural history, for example—is necessary for us to correctly categorize landscapes and fully appreciate them. The examples of categories of landscapes—which differ with regard to their intrinsic properties resulting from human manipulation and intervention—include landscape art, parks and gardens, managed urban/ suburban landscapes, managed rural landscapes (primarily farms but also mines or other "worked" nonurban areas), relatively pristine managed landscapes, and relatively unpristine managed landscapes (Eaton 1997: 97).

In addition, as Rolston (195: 376) notes, we need scientific knowledge to appreciate nature and landscapes because: "Science helps us to see the landscape as free as possible from our subjective human preferences." According to Nassauer (1995: 161), we do not know how to directly see ecological quality; we actually see ecological quality through our cultural lenses. In other words, we often determine the beauty of nature based on pictorial conventions, especially the picturesque (Howett 1988: 1-12). Importantly, as Nassauer (1995: 161) points out: "Picturesque conventions seem so intrinsic to nature that they are mistaken for ecological quality." For that reason, knowledge provided by natural and environmental science can appropriately reveal aesthetic quality of nature and ecological landscapes. As Nassauer (1997: 8) also notes: "Ecological knowledge will also lead to more discerning human experiences, in which ecologically destructive phenomena are not mistaken for beautiful nature." Giving that, aesthetics framed only in terms of the picturesque attenuate landscape appreciation (Carlson 2011; Carlson 2012). Instead, this research contends scientific information and knowledge of the natural or ecological environment enhances the beauty or aesthetic quality of the landscapes.

Although aesthetics of environment can be approached in two different modes—one stands on scientific knowledge basis and another depends on emotional basis, these approaches do not necessarily conflict with each other. In point of fact, they can work together and supplement one another because both feeling and knowing can enhance aesthetic experience of environment (Carlson 2011; Carlson 2012). In brief, scientific knowledge significantly supplements the emotive appreciation of landscapes.

2.8 Urban landscapes as pedagogy of ecological science and conscience

In general, much learning is serendipitous, and environmental learning particularly so. According to Antunes and Gadotti (2005: 135): "Education is connected with space and time where relationships between the human being and the environment actually take place. They happen primarily at the emotional level, much more than at the conscious level. Thus, they happen much more in our subconscious; we do not realize them, and many times we do not know how they happen." Hence, the promotion of public education through serendipitous interactions with the public landscape has gained considerable traction.

Actually, urban open spaces have long been considered a tool for teaching or elevating American behaviors and mindsets. In particular, Olmsted and Vaux emphasized this idea when they were working on the design of Central Park. As they had a shared idea that the social conditions in mid-nineteenth century cities hindered a thriving republic, they promulgated the notion that parks could be an essential tool in elevating the lives of urban dwellers. Specifically, they proposed that parks could provide opportunities for "an education to refinement and taste and the mental and moral capital of the gentlemen" (quoted in Schuyler 1986: 7). In other words, apart from their intention to create spaces for physical recreation and aesthetic pleasure, Olmsted and Vaux also aspired that these places could play a role in raising the level of American civilization. Therefore, they intended to design the parks for all classes and hoped that this could provide occasions for the poor and the lower-class residents to absorb and emulate the behaviors of the upper classes (Schuyler 1986: 6-7).

Building on this optimistic of paternalistic nineteenth-century idea, in our contemporary environmentally conscious age, several landscape scholars have emphasized that the values people hold in regard to landscapes are crucial to the sustainability of the cities and the information or knowledge people have in regard to their local ecosystems significantly helps them develop an apt attitude toward values of ecological landscapes. As Hester (1995: 4) describes: “Designing, building and inhabiting a sustainable American city... depends less on developing a better natural science understanding of city form than it does on reversing the entangled values people hold in regard to the built environment.” Furthermore, Hester also puts forward the idea of the relationship between landscape cognizance and ecological awareness: “As residents acknowledge sacredness in their locality, they explicate an awareness of the fundamental nature of the community; of the values and virtues they hold dearest; of the direct relationship between the inhabited landscape and orientation, worldview, identity, and rootness; and of the wholeness of the community” (Hester 2010: 125).

Beginning since the late-twentieth century, theories of ecological landscape design (e.g. Laurie 1989: 50; Nassauer 1997: 8; France 2002: 245; Gobster, Nassauer, Daniel, and Fry 2007: 957-972; Echols 2007: 6; Echols and Pennypacker 2008a: 24, Pennypacker and Echols 2008: 28-39; Nassauer and Opdam 2008: 633; Hester 2010: 327; Nassauer 2012: 221-229) have reiterated the idea that ecological landscape design can help transfer ecological knowledge to society and then establish desirable relationships between aesthetics and ecology. This particularly emphasizes the elevation of ecological knowledge resulting in the development of environmental ethics, new appreciation of ecological landscapes, and behaviors in support of an environmentally sustainable future.

Conceivably, one of the most renowned statements supporting this idea is David Orr’s statement in *The Nature of Design: Ecology, Culture and Human Intention* (2002: 31):

> “If it is not become simply a more efficient way to do the old things, ***ecological design must become a kind of public pedagogy built into the structure of daily life***. There is little sense in only selling greener products to a consumer whose mind is still pre-ecological. Sooner or later the person with find environmentalism inconvenient, or incomprehensible, or too costly, and will opt out. The goal is to calibrate human behavior with ecology which requires a public that understands ecological possibilities and limits. To the end, we must begin to see our houses, buildings, farms, businesses, energy technologies, transportations, landscapes, and communities in much the same that we regard classrooms. In fact, they instruct in more fundamental ways because they structure what we see, how we move, what we eat, our sense of time and space, how we relate to each other, our sense of security, and how we experience the particular places in which we live. More important, by their scale and power they structure how we think, often limiting our ability to imagine better alternatives.”

Correspondingly, landscape scholars have increasingly discussed the issue of “how the landscape itself can be a means of environmental education,” as Nassauer (1997: 8) notes.

Nassauer (2012: 221-229) proposes that landscapes can act as medium and method for both informing ecological science and enhancing landscape aesthetics.

In view of this idea, designers considered how urban landscape design could support environmental education, helping people make connections between knowledge and action. As Laurie (1989: 50) describes, "Ecological expressionism responds to the importance of sense of place and expression of the original natural processes of a site before urbanization. These can be revived in symbolic segments to remind us where we are, serving an educational purpose and framed as a work of art so that there is no confusion about what is nature and what is not."

Urban public landscapes do not fit the institutional stereotype of educational settings (Southworth 1970: 17). Since the concentration of education happens in organized learning edifices, everyday urban settings are likely to be disregarded as an educational opportunity, except by professionals in both ecological design and environmental education fields. As Nassauer and Opdam (2008: 633) note, "Landscape ecological science has produced knowledge about the relationship between landscape pattern and landscape processes, but it has been less effective in transferring this knowledge to society." As a result, making such places more effectively educative has been considered a daunting task and, importantly, has still been understudied.

Most typically, the on-site education is done through providing an interpretive signage system. According to the recent *Recommendations for Developing Interpretive Signs* provided by the South Dakota State Historical Society (2015), interpretive signs can serve a variety of functions for communities, such as:

> "1. Interpretive signs illuminate the power of place. Clear educational messages and content inform the public of each site's historic significance.
>
> 2. Interpretive panels do more than provide just dates and facts. They also inspire a feeling of stewardship in site visitors, strengthening awareness of cultural and natural resources.
>
> 3. Thoughtful and well-designed signage programs demonstrate community pride in local heritage.
>
> 4. Interpretive signage is self-sufficient: it provides a high-quality interpretive experience without the requirements of staff or facilities to maintain.
>
> 5. They are a consistent message available to many visitors at one time, can be viewed at the visitors' convenience, and are available 24 hours a day."
>
> 6. Interpretive signage enhances visitor perceptions of a site, city, or region. By drawing attention to an area's unique history and identity, tourists better appreciate the story of a new place. Captivating interpretive signs and exhibits can become destinations in their own right."

Realizing the benefits of interpretive signs, nearly all national parks, national forests, nature reserves, wildlife preserves, and many ecological restoration projects, the series of interpretive stands serve users with information and knowledge about historical background, ecological significance, and preservation and restoration efforts. In spite of their ubiquity, design professionals chafe at the use of interpretive signage, and wish that somehow the landscape designs could speak for themselves.

In addition to issues regarding which educational medium is appropriate and effective, the matter of individual initiative and interest in learning in urban spaces also complicates challenge of providing education opportunities in the ecological facilities. This challenge can be explained by the "concept of purpose"—each place holds distinctive purpose of action (Canter 1991: 191-207; Gärling 1991: 337). People may not want to learn while visiting and using these kind of places; rather, they simply want to enjoy and relax in the places. This may be the greatest challenge to effecting educational experiences in urban landscapes. Though not feasible in most urban landscapes, orchestrated site visits to ecologically designed sites can address this. A case in point is the American Society of Landscape Architects (ASLA) Headquarters green roof in Washington D.C. which provides site visit programs for both laypeople and professionals to experience and learn about the ecological performance and benefits of green roofs.

While many urban landscapes with explicit goals of environmental education have been implemented in many American cities, very few empirical studies have been done in order to examine their effectiveness or learning performance. In consequence, knowledge relevant to the advancement of innovative design principles for promoting both public appreciation and education of the ecological landscapes is very limited.

Chapter 3

Stormwater Management, Design, and Education

3.1 Urban stormwater ecosystem and crisis

In natural science, stormwater is water that originates from precipitation, rain and snow, and also melted ice and soaks into the soil, evaporates into the air, stays on the surface, or flows on ground and then discharges into nearby streams, rivers, or other waterbodies. Stormwater often specifically refers to urban runoff, which is water from precipitation travels across roadways, parking lots, lawns, gardens, roofs, and other surfaces within cities, and causes various threats to human and ecological health.

The rapid urbanization of the last one hundred and fifty years has resulted in significant change to the stormwater flow system. The transformation of land cover from soils and plants to impervious surfaces, along with the introduction of a constructed drainage network which inevitably accompany the urban development, profoundly disturbs the hydrologic regime both during and following the storm events (National Research Council of the National Academies 2008: 1-5). In natural landscapes, rainfall typically is evapotranspirated by vegetation or infiltrates into the ground (National Research Council of the National Academies 2008: 4). However, these two processes are severely restricted in urban areas. The decrease of vegetation and the increase of impermeable surfaces creates a larger volume and velocity of discharge and results in flood problems in many cities (US EPA 2003: 1).

Furthermore, urban development affects not only the quantity of discharge, but also the quality of water because it is a significant cause of polluted stormwater runoff. As rainfall cannot well percolate into the ground, most of water becomes runoff that flows across the impervious surfaces—which include roads, parking lots, sidewalks, and rooftops, for example. This flow also washes a variety of pollutants from these surfaces into nearby streams (US EPA 2003: 1). According to the US EPA (2001, 2), “Some of the principal contaminants found in storm water runoff include heavy metals, toxic chemicals, organic compounds, pesticides and herbicides, pathogens, nutrients, sediments, and salts and other deicing compounds.” These pollutants can cause various adverse effects which lead to not only the degradation of water quality, but also the deterioration of various wildlife habitats in the United States.

3.2 Sanitary service and urban stormwater management in American cities

In the early period of American urban development, including the Colonial period, almost all water management efforts in the country were concentrated on water supply rather than wastewater disposal. Commonly, urban dwellers in the United States, like their contemporaries in European cities, threw away their refuse to the streets so that the streets were filled with garbage and fecal matter (Melosi 2000: 18; Novotny and Brown 2007: xiv). As a result, the cities were odorous, dirty, and unsightly. Moreover, as Melosi (2000: 41) notes, a key problem was the impact of wastewater flowing from private property into street gutters. Because street gutters at that time were intentionally designed to drain stormwater or stagnant pools rather than carrying off wastewater, they were not at all efficient in dealing with household wastewater. Even though street gutters were intended to convey only liquid wastes, solid refuse as well as fecal matter were often dropped into them. Accordingly, this unsanitary situation led to epidemic disease and high rates of mortality. Nonetheless, few people had a sense of the relationship between these diseases and the unsanitary conditions of cities (Melosi 2000: 19-20).

Understanding of the link between sanitation and public health emerged in the mid-nineteenth century under the influence of Edwin Chadwick, an English social and public health reformer (Melosi 2000; 43-57). The idea that epidemics were the result of God's wrath had gradually been discarded and replaced with sanitary science (Melosi 2000; 58-72). In Britain and the United States, the occurrences of several severe epidemics attention to the issue of public health and sanitary services. According to Melosi 2000: 47, "For Chadwick, the appropriate technological response for dealing with unhealthy conditions was to be found in improved public works, including waterworks, sewers, paved streets, and ventilated buildings." These European sanitation techniques—especially the practices in Britain—very much influenced the way the Americans implemented these new public works. In addition to constructing these public works, cities implemented new remedial actions (such as streets cleaning) and regulatory authority (such as the ban of casting out any refuse into streets). However, in the United States, as Charles Chapin (1902: 234 cited in Melosi 2000: 61) notes: "The practical reforms brought about by Chadwick and his followers in improved housing for poor, improved water supplies, certainly resulted in increased comfort, and constituted a decided advance in what we call 'civilization.' But they did not exterminate the infectious diseases as had been hoped and promised." As a result, cities paid attention to managing street cleaning with the aim of alleviating nuisance and providing spaces for daily functions—especially traffic uses, fire services, and social activities (Melosi 2000: 41-42). Nevertheless, through the end of the nineteenth century efforts to supply water were still ahead of those of disposal and stormwater drainage still depended on street gutters.

By the late-nineteenth century, the negative impacts from the rapid industrial expansion of American cities were dramatically obvious. The quality of urban life declined as many cities were very dense, crowded, and polluted. As a result, epidemic diseases as well as other health problems, both mental and physical, became increasingly evident. According to Melosi (2000: 149-174), in the period 1880-1920 cities focused on the development of sewerage systems to provide better sanitary conditions. Furthermore, since urbanization in the country had also increased impervious surfaces resulting in serious flooding problems, cities built underground pipe networks for collecting and conveying both household wastewater and stormwater (Novotny and Brown 2007: xiv). The main goal of this system was to rapidly remove runoff from the cities. This network can be classified into two systems—combine system and separate system. Specifically, while the former system refers to the system that conveys both wastewater and stormwater in the same set of pipes, the latter system refers to the system that conveys wastewater and stormwater separately. Obviously, of these two types, the combined one was more prevalently implemented because it was more cost-efficient than the separate system. Cities eventually recognized that the combined system led to the increase of raw sewage in local water bodies, and considered the combined system as ineffective and inefficient in dealing with climatic and storm patterns in the United States. The decision to implement the separate systems in the City of Memphis marked a shift in perspective towards these two systems (Melosi 2000: 153-154). Nonetheless, many cities still chose to build the combined systems due to the issue of cost effectiveness.

As Melosi (2000: 235-260) discusses, the issue of the disposal wastewater and stormwater into local water bodies came to light during 1920-1945 because of the degradation of water quality in watercourses, lakes, bays, and also oceans. Accordingly, the pollution control along with the treatment of pollution from both combined and separate emerged. Beginning in the early twentieth century, water treatment technologies rapidly developed, and cities began building water treatment plants at an accelerated rate in the interwar period. In addition to the development of treatment technologies, regional planning efforts considered issues of sewage control and treatment as conflicts between upstream and downstream cities forced upstream communities to treat their sewage before discharging to watercourses. These regional planning efforts include, for example, the classification in Pennsylvania of streams into Class I (preserved in nearly natural condition), Class II (for sewage disposal after treatment and water supplies after treatment), and Class III (for sewage disposal after treatment as not to create a nuisance); the development of common plans for sewage disposal in Portland and sixty-five other communities; and the establishment of Metropolitan Sewer District of communities surrounding Lake Washington in Seattle (Melosi 2000: 246-247).

Throughout history, stormwater has been considered as excess, dirty water which creates several adverse effects—particularly standing water on roads that causes accidents, floodwater that damages homes and other properties, and contaminated water that threatens public health. Therefore, the primary concern of governmental agencies in managing stormwater has been to provide excellent efficiency for urban drainage systems. As a result, cities constructed highly engineered networks of underground pipes along with surface trenches in order to collect and remove stormwater runoff from the city surface as rapidly as possible. This conventional practice has put stormwater management out of sight and out of mind (Calabria 1995; Hough 1995; Wong and Eadie 2000). Consequently, urban stormwater management has long been invisible to the public.

In the late twentieth century, the advancement of ecological and hydrological science brought to light that stormwater is a major source of water pollution and needs proper management. As sustainability became a global mainstream interest, environmental scientists, engineers, planners and designers highlighted urban stormwater ecosystem. Specifically, ecological problems—especially the degradation of water quality and the deterioration of various ecosystems—caused by stormwater runoff had inspired these related professionals to think about how to deal with urban runoff in a more ecological or sustainable way. As a result, various city, state, and federal agencies introduced a novel stormwater management approach—also known as low impact development (LID)—to manage runoff and sustain water ecosystems (US EPA 2000b: 1). Through LID, stormwater management paradigm has gradually shifted from engineer-based facilities to landscapes-based facilities. Importantly, this shift has moved underground stormwater facilities to the surface.

3.3 Sustainable stormwater management and low impact development (LID)

In the United States, the idea of sustainable stormwater management[1] is widely called low impact development or LID. Generally, LID is the term used in the United States and Canada to describe an ecological landscape-based approach to manage stormwater runoff.

As US EPA (2000b: 1) defines, "LID is a site design strategy with a goal of maintaining or replicating the pre-development hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape." In particular, as Coffman (2002, 97-98) describes, "This new approach combines a variety of conservation strategies, minimization measures, strategic timing techniques, integrated small scale site-level management practices, and pollution prevention measures to achieve desired stormwater management or ecosystem protection goals." LID can be applied to all kinds of projects—whether new development, redevelopment, or as retrofits to existing development—and can also be adapted to everywhere and to varieties of land uses—whether high density urban settings or low-density development (US EPA, 2013).

In addition, the idea of LID fits within the concept of urban "green infrastructure" which is defined, according to US EPA (2008: 5), as the "management approaches and technologies that utilize, enhance and/or mimic the natural hydrologic cycle processes of infiltration, evapotranspiration and reuse." It is important to note that as "green infrastructure" often centers on stormwater management efforts, it is sometimes called "blue infrastructure."

According to Urban Design Tools (2013), "Development of LID principles began with the introduction of bioretention technology in Prince George's County, Maryland, in the mid-1980s. LID was pioneered to help Prince George's County address the growing economic and environmental limitations of conventional stormwater management practices. LID allows for greater development potential with less environmental impacts through the use of smarter designs and advanced technologies that achieve a better balance between conservation, growth, ecosystem protection, and public health/quality of life." Bioretention is just one technique of the LID (Urban Design Tools 2013) and several more LID techniques have been developed and implemented within the United States in order to,

[1] In other countries, the idea of sustainable stormwater management is also known as natural drainage system or NDS and sustainable urban drainage system or SUDS, for example (Hill 2009: 143).

according to US EPA (2000b: 4), "perform both runoff volume reduction and pollutant filtering functions."

The techniques used to manage the quantity and improve the quality of stormwater runoff in LID projects are widely called Best Management Practices or BMPs. Like LID, the term BMPs is used in the United States and Canada. As engineered systems had also typically provided for controlling or reducing pollutants contaminating stormwater runoff, the term BMPs emerged to describe landscape-based techniques to treat stormwater runoff before draining into engineered systems. According to Libtan and Murase (2002: 131), "The physical forms of these techniques are almost infinite." Today, landscape features widely used as BMPs in LID or green infrastructure projects include bioretention facilities or rain gardens, vegetated swales and channels, vegetated rooftops or green roofs, rain barrels and cisterns, porous or permeable pavements, riparian buffers, and constructed wetlands (US EPA 2000b: 4; 2008: 5).

In the United States, the Environmental Protection Agency (US EPA) promotes both principles and guidelines for implementing sustainable stormwater management, particularly LID and BMPs. In addition, several professional agencies—especially those related to the fields of landscape design and environmental engineering which are very much involved in the management of stormwater—also serve as key advocates of this effort.

3.4 Stormwater regulation in the United States

Since the mid-twentieth century, regulatory requirements have been the key driver of sustainable stormwater management in the United States. Federal laws aimed to protect American waters and ecosystems—particularly the Federal Water Pollution Control Act (1948), the Clean Water Act (1972), and the Endangered Species Act (1973). In response to these laws, municipalities across the country sought to alleviate negative impacts from polluted runoff on sensitive water ecosystems (Liptan and Murase 2002: 125; Novotny and Hill 2007: 1-9; Hill 2009: 141).

In 1948, Congress enacted the Federal Water Pollution Control Act (FWPCA) with the goal of maintaining and restoring the chemical, physical, and biological integrity of waters in the United States (National Research Council of the National Academies 2008: 39). This law was considerably reorganized and expanded in 1972 and became the Clean Water Act (CWA) (Karvonen 2011: 9). According to Roy et al (2008:346): "The Clean Water Act (CWA) of 1972 marked a major shift in management of US waters, providing regulatory requirements to address water quality problems. Specifically, it gave the US EPA the authority to regulate effluent by requiring permits for point source discharges through the National Pollution Discharge Elimination System (NPDES) program." Despite the fact that the CWA led to the reduction of water pollution, the problems of degraded water still existed. With the aim of emphasizing the role of stormwater in causing or contributing to water quality impairments, the National Pollution Discharge Elimination System (NPDES) Stormwater Program was initiated in 1987 by the US EPA under the CWA (National

Research Council of the National Academies 2008: 1). The NPDES Stormwater Program focuses chiefly on controlling toxic pollutants discharged to American waters with the purpose of protecting water resources and ecosystems of the country. Today, the NPDES rules are playing a very important role in sustainable stormwater management practices in the United States.

Notwithstanding that the quality of American waters has dramatically increased since the enactment of the NPDES Stormwater Program, problems regarding degraded and polluted waters still remain in the United States. In order to cope with this longstanding issue, the US EPA issued the Phase I Stormwater Rules in 1990. In this phase, the major focus is centered at the National Pollutant Discharge Elimination System (NPDES) permit which regulates discharges from three main sources: medium and large Municipal Separate Storm Sewer Systems (MS4)[2] generally serving a population of 100,000 or greater; construction activity disturbing 5 acres of land or greater; and, ten categories industrial activity (US EPA 2005a). Hence, the Phase I regulation focused mainly on point source pollution[3] discharges which, at that time, constituted the major water quality threats.

According to National Research Council of the National Academies (2008: 18), "Over the years, the greatest successes in improving the nation's waters have been in abating the often severe impairments caused by municipal and industrial point source discharges." Nonetheless, it became obvious that the problem regarding water quality degradation persisted. In particular, several environmental reports along with monitoring efforts, as the National Research Council of the National Academies (2008: 17) notes, "confirmed widespread impairments related to diffuse sources of pollution."

Primarily, after the National Water Quality Inventory (1996) revealed that polluted stormwater runoff is the greatest threat of water in the country, nonpoint source (NPS) pollution[4] became widely understood as a cause of concern. The US EPA promulgated the stormwater program Phase II in 1999. This second phase expands the former phase in which

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[2] Municipal Separate Storm Sewer System (MS4) refers to a water conveyance or system of water conveyances that is owned by a state, city, town, village, or other public entity that discharges to waters of the country. MS4 is designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.), but it is not a combined sewer and not a part of a Publicly Owned Treatment Works or sewage treatment plant (US EPA 2000a: 4-2). The MS4s can be operated by municipalities, counties, drainage districts, military bases, universities, colleges, hospitals, or prisons, for examples.

[3] Point source pollution is polluted water from conveyances such as such as pipes, ditches or channels which is discharged into waterbodies such as lakes, streams, rivers, or oceans at a specific location (US EPA 2010: 1-7).

[4] Nonpoint source (NPS) pollution is polluted stormwater runoff that carries away pollutants (including oil and geese from roadways, pesticides from lawns and gardens, sediment from construction sites, and various carelessly discarded trash) into lakes, rivers, wetlands, seas and also ground waters (US EPA 2000a: A-3).

it requires additional control of NPS pollution from the smaller MS4s in urbanized areas[5] and the smaller construction sites[6] (US EPA 2005a).

As the US EPA intended to further the reduction of negative impacts from polluted runoff to the water quality, the Phase II also addresses that all small MS4s need to reduce the discharge of pollutants to the maximum extent practicable (MEP) standard, protect water quality, and satisfy the water quality requirement of the CWA (US EPA 2005b). In order to direct ways to achieve this goal, the Phase II promulgates each MS4 to conduct stormwater management program. This small MS4 stormwater management program refers to "a program comprising six elements that, when implemented in concert, are expected to result in significant reduction of pollutants discharged into receiving waterbodies (US EPA 2005b). These six MS4 elements, also termed as "minimum control measures," are: public education and outreach; public participation/involvement; illicit discharge detection and elimination; construction site runoff control; post-construction runoff control; and, pollution prevention/ good housekeeping (US EPA 2005b).

3.5 Stormwater education and outreach programs

In considering the minimum control measures described above, the US EPA obviously realized that people are the key advocates and actors in stormwater management programs. In particular, the US EPA recognized that people's improper and careless behaviors significantly exacerbate problems related to polluted runoff and, importantly, considered people's understanding and awareness of their everyday actions a crucial mechanism for reducing adverse impacts on water quality. As the US EPA (2014) notes:

> "Because stormwater runoff is generated from dispersed land surfaces—pavements, yards, driveways, and roofs—efforts to control stormwater pollution must consider individual, household, and public behaviors and activities that can generate pollution from these surfaces… It takes individual behavior change and proper practices to control such pollution. Therefore, it is important to make the public sufficiently aware and concerned about the significance of their behavior for stormwater pollution, through information and education, that they change improper behaviors."

[5] According to US EPA (2008: 60), "A small MS4 is defined as an MS4 not already covered by an MS4 permit as a medium or large MS4, or is located in "urbanized areas" as defined by the Bureau of the Census (unless waived by the NPDES permitting authority), or is designated by the NPDES permitting authority on a case-by-case basis if situated outside of urbanized areas."

[6] In the Phase II Rule, according to US EPA (2008: 60), the regulations lowered the construction activities regulatory threshold for permit coverage for stormwater discharges from five acres to one acre (US EPA 2008: 60).

Seeing that, the US EPA declared *Public Education and Outreach* as the first element of the Phase II's six MS4 elements. The goal of this element is to build knowledgeable and informed communities (US EPA 2005c). More specifically, a well-informed public is fundamental to achieving a successful stormwater management program because it can enhance greater support for the program—especially in the form of funding initiatives and voluntary works as the public understands its necessity and importance—and greater compliance with the program—especially in terms of changing behavior and taking action to protect and improve the water quality as they becomes aware of their personal responsibilities (US EPA 2005c).

As per the explanation stated in the US EPA fact sheet (US EPA 2005c), all small MS4s are required to implement public programs to educate their citizens about the impacts of polluted stormwater runoff in order to increase their awareness of actions that affect water quality. Significantly, they are also required to give clear guidance on specific ways and actions that the public can do to reduce their stormwater pollution. This fact sheet also describes the basic requirements and guidelines for fulfilling this measure.

To meet the measure's requisition, each small MS4 is required to: implement a program to distribute educational materials to the community, or provide comparable outreach activities relative to the impacts of stormwater discharges on local waterbodies and the ways to minimize stormwater pollution; and, to determine the appropriate best management practices (BMPs) and measurable goals for this minimum control element.

The EPA suggest three major actions—forming partnerships, using educational materials and strategies, and reaching diverse audiences—as guidance for achieving public education and outreach implementation. For the first action, forming partnerships, operators of regulated small MS4s are encouraged to collaborate with other governmental entities and nongovernmental organizations as many of them already have educational materials and perform outreach activities. Accordingly, working in collaboration is considered particularly beneficial and effective. The next recommendation is that instead of developing new materials, the operators may use existing materials of stormwater educational information provided by their State, the US EPA, or any other organizations. However, the operators must keep in mind that they need to make the materials and activities relevant to their local situations and issues. Some examples of educational materials and strategies include: brochures or fact sheets that provide general public and specific audiences with necessary information; recreational guides for educating special groups such as golfers, hikers, climbers, campers, and so on; alternative information sources, especially web sites, signs, poster, bumper stickers, refrigerator magnets, posters, and restaurant placemats; libraries or learning corners which provide educational materials for community and school groups; voluntary staffs who run public education tasks; special event with educational displays; educational programs for school-age children; storm drain stencils which messages such as 'Do Not Dump—Drains Directly to Lake;' stormwater hotlines for information and for citizen reporting of polluters; and, economic incentives to citizens and businesses such as rebates. For the last guidance, operators should consider varieties of their audiences so that they should provide mixture of materials and strategies to fulfill requirement of diverse audiences.

As a result of this public education and outreach minimum control measure, since the beginning of the twenty-first century local authorities have carried out numerous efforts focused on providing information materials and outreach programs to the public.

3.6 Landscape design for stormwater education

Despite the fact that supplying educational materials and activities is a common means for generating knowledge of sustainable stormwater management, many scholars also support the idea that stormwater management facilities can be utilized as on-site demonstrations for advancing citizens' stormwater education. As France (2002: 245) noted, "water is an element that easily lends itself to instructional use for learning about how the environment functions and how humans interact with nature." In view of that idea, stormwater management facilities or LID sites should be able to provide learning opportunities for their visitors.

The idea that stormwater management facilities possess educational opportunities has been significantly emphasized in a novel, inspiring approach to stormwater management called *Artful Rainwater Design*[7], a term coined in 2000s by two landscape professors of Pennsylvania State University—Eliza Pennypacker and Stuart Echols. The focus of this concept is that LID facilities should be promoted as urban amenities which can offer other benefits besides their stormwater management functions. According to Echols (2007: 2): "Innovative rainwater design can be used to create places recognized as beautiful, meaningful, and educational—from lush rain gardens to plazas that artfully expose how rain water flows across and infiltrates into land. This new focus on muti-objectivities can transform stormwater management facilities into artful rainwater designs that increase property values and function as community amenities, whether people learn about our hydrologic cycle and ecological systems or simply enjoy an attractive design." To be brief, this emerging idea suggests that stormwater management facilities, as Echols and Pennypacker (2008b: 1) succinctly note, "can be designed in such a way as to create site amenities; that is, the rainwater itself becomes a feature that can engage, educate, and even entertain visitors." Based on an analysis of tewnty exemplary cases, Echols and Pennypacker (2008a: 268-290) classified amenity goals of stormwater design projects into five categories—which are education, recreation, safety, public relations, and aesthetic richness.

According to Echols and Pennypacker (2008a: 273), "education is understood as creating favorable conditions for learning about rain water and related issues." In addition,

[7] According to Echols and Pennypacker (2008b: 1), "The concept of 'artful rainwater design' is based on the premise that new stormwater management techniques focusing on non-point source pollution, water balance, and small storm hydrology can also be used to create new site amenities."

Pennypacker and Echols (2008: 28) also describe that "An on-site stormwater management system can be an engaging opportunity to educate people about rainwater issues from promoting awareness of stormwater best management practices strategies to the site's historical water condition."

To achieve this educational goal, making the stormwater management features visible and legible in order to encourage people to notice is the keystone (Echols and Pennypacker 2008a: 274). Through their extensive analysis of case studies, Echols and Pennypacker discovered the two basic techniques or strategies effectively resulting in visible and legible stormwater management efforts—one is to provide straightforward didactic lessons in the site and another one is to create stunning or thought-provoking elements (Pennypacker and Echols 2008: 28-39). In consequence, they later proposed that on-site stormwater education can be addressed through these two basic strategies.

For the first strategy, an interpretive signage system is considered an essential means to provide straightforward didactic lessons so as to enrich educational opportunities and to provide useful information for users or visitors of the site. Apparently, the design effort at Pierce County Environmental Services in Chambers Creek, Washington exemplifies the use of this educational strategy. At this site, a well-designed rainwater trail system displays a variety of stormwater management strategies. In addition, effective informative signs are also provided at strategic spots in order to augment the educational impact (Echols and Pennypacker 2008a: 274). With this strategic design, Pierce County Environmental Services became, as Pennypacker and Echols (2008: 36) state, "a nationally recognized green facility that goes to great lengths to teach the visiting public about sustainable design and construction." Another example is the stormwater wetland park in Abbotsford, a small city located in the Fraser Valley of British Columbia, Canada. In this park, interpretive signs are provided to explain history of the place, ecological performances of water, vegetation, and wildlife in the site, and also overall design concept of the park (Berris 2002: 193-204). This information helps visitors appreciate both ecosystem itself and the design effort. Apart from these two excellent cases, several sites in which stormwater management measures are implemented also employ an interpretive signage system as a strategic technique to enhance their visitors' stormwater education. Prominent among them are Canal Park in Washington, DC; The Edge Park in Brooklyn, New York; San Pablo Rain Gardens in El Cerrito, California; Brisbane City Hall in Brisbane, California; Thornton Place in Seattle, Washington; and the SW 12th Avenue Green Street, Oregon Museum of Science and Industry (OMSI), Water Pollution Control Laboratory of the Bureau of Environmental Services (BES), and Portland Community College (PCC) Stormwater Education Plaza, all in Portland, Oregon.

The second strategy—creating stunning or thought-provoking elements—emphasizes the role that artistic qualities can play in calling attention to stormwater management efforts. As Pennypacker and Echols (2008: 36) point out: "The designer can encourage the visitor to discover something about rainwater through a puzzling or thought-provoking design." The plaza of Stephen Epler Hall at Portland State University in Oregon demonstrates the use of this educational strategy. By providing iconic stormwater management features—

particularly the raised concrete basins filled with river rock and the three runnels lining across the plaza, visitors are encouraged to decipher the intriguing puzzle of the site's stormwater management system (Pennypacker and Echols 2008: 36). Like the plaza of Stephen Epler Hall, the courtyard of 10th@Hoyt apartment in the Pearl District of Portland also provides intriguing features with the aim of stimulating visitors' interest in stormwater management system of the place. These features include copper downspouts, stepped concrete runnels, raised concrete basins filled with river rocks, and sculptural metal boxes pierced by glass buttons to allow interior lights to illuminate (Echols and Pennypacker 2006: 36). Another example of this strategy is the water garden at the Water Pollution Control Laboratory of the Bureau of Environmental Services (BES) in Portland. This water garden functions as an upland catchment or detention cell for accommodating the peak flow during a storm event (Libtan and Murase 2002: 142-147). The well-designed structures of this water garden—especially a circular stone wall and a curvilinear flume—certainly inspire visitors to explore the marvelous stormwater management technique of this place. In addition to these examples, there are also several more projects which make use of eye-catching and thought-provoking artworks to arouse visitors' curiosity about stormwater management systems. The interesting cases include the Rain Drums at the Cedar River Watershed Education Center in North Bend, Washington; the infiltration area of Maple Valley Library in King County, Washington; the Water Glass and Water Table of Ellington Condominium in Seattle, Washington; the landscape of the Oregon Convention Center in Portland, Oregon; and the Outwash Basin at the Ray and Maria Stata Center on the MIT campus in Cambridge, Massachusetts.

Obviously, many recently built stormwater facilities have intentionally provided learning opportunities for people with the aim of enhancing public knowledge of stormwater management. Nevertheless, there is little information and insight on the efficacy of these design techniques in terms of encouraging stormwater education through the experience of landscapes which encompass stormwater management facilities.

Chapter 4

Study of Attitudes toward Landscape Design and Stormwater Education

Many research questions in landscape design are intertwined with the issues regarding human perception, cognition, and action towards physical environments—how individuals perceive, learn, and behave in a specific environmental setting (Henry and Dietz 2012: 238), particularly those effecting attitudes toward the environment. Unfortunately, these questions tend to be understudied and undertheorized, even though the understanding of this subject matter is extremely crucial, especially given environmental concerns, as they can provide foundational insights for both design and policy relative to boosting people's environmental knowledge, appreciation, and consciousness.

This chapter aims to provide some key fundamentals pertinent to the study of attitudes toward landscape design and stormwater education. The focus of this chapter is on the frameworks for measuring attitudes as well as the methods for collecting and analyzing attitude data. Furthermore, some pertinent research precedents—particularly those of 1) research in environmental psychology and landscape design, and 2) survey of water and stormwater knowledge, attitude, and behavior—are also reviewed.

4.1 Attitude measurement and scales

Literally, attitude means "A settled way of thinking or feeling about someone or something, typically one that is reflected in a person's behavior" (Oxford Dictionaries 2015). With its subjective and intangible characteristics, the term "attitude" has long been considered ambiguous and confusing to many researchers interested in studying attitudes. Read Bain was a key person who critically examined the concept of attitude. Based on his analysis, he defines attitude as "the relatively stable overt behavior of a person which affects his status" (Bain 1928: 940). In addition, he also points out that "Attitudes which are common to a group are thus social attitudes" (Bain 1928: 940).

It is irrefutable that studying attitudes, especially social attitudes, is considered an onerous task. However, it is also widely accepted that attitudes can be investigated and measured. Louis Leon Thurstone was a pioneer who developed the idea regarding the frequency distribution of attitudes and the possibility of using scales to measure attitudes. As he succinctly summarizes the concept, "the distribution of attitude of a group on a specified issue may be represented in the form of a frequency distribution. The base line represents ideally the whole range of opinions from those at one end who are most strongly in favor of the issue to those at the other end of the scale who are as strongly against it. Somewhere between the two extremes on the base line will be a neutral zone representing indifferent attitudes on the issue in question." (Thurstone 1928: 529). As an example, figure 4.1 provides an illustration of the frequency distribution on a linear, continuous range of attitudes from extreme pacifism on one continuum to extreme militarism on the other. In this figure, the points (a-f) on the scale represent individuals' different attitudes on militarism-pacifism while the ordinates of the distribution indicate the frequency, which also implies relative popularity, of each attitude along the scale.

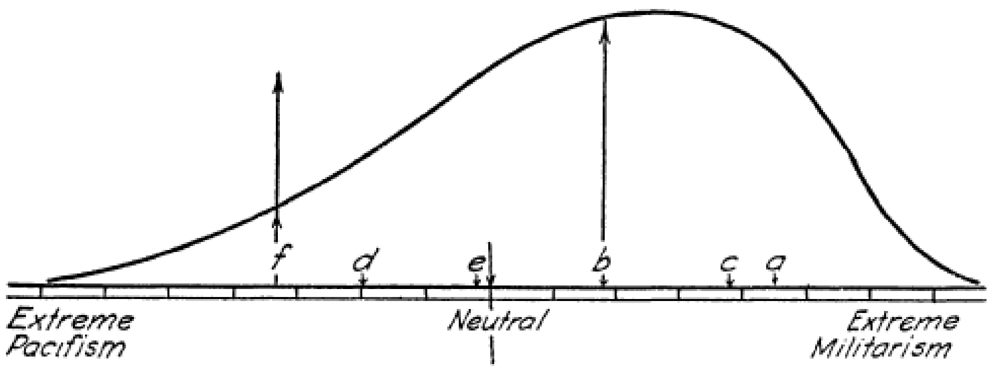


Figure 4.1 Frequency distribution of attitudes on an attitude scale
(Thurstone 1928: 537)

For several decades, scales had been developed as an attempt to objectively measure attitudes, of which the scale developed by Thurstone in 1928 is considered a prototype. Today, scales are widely used in psychological and behavioral research. According to Sommer and Sommer (2002: 159)

> …a scale represents a series of ordered steps at fixed intervals used as a standard of measurement. Scales are used to rank people's judgments of objects, events, or other people from low to high or from poor to good. Commonly used in behavioral research include attitude scales designed to measure people's opinions on social issues, employee rating scales to measure job-related performance, scales for determining socioeconomic status used in sociological research, product rating scales used in customer research, and sensory evaluations scales to judge the quality of food, air, and other phenomena. These scales provide numerical scores that can be used to compare individuals or groups.

In addition, as Sommer and Sommer (2002: 162) also describes: "An attitude scale is a special kind of questionnaire designed to produce scores indicating the intensity and direction (for or against) of a person's feeling about and object or event." Researcher have developed and used a number of attitude scales, yet the most common ones are the Likert scale and the semantic differential scale.

A Likert scale is a type of attitude measurement developed by a psychologist Rensis Likert (1903-1981). According to McLeod (2008), "A Likert-type scale assumes that the strength/intensity of experience is linear, i.e. on a continuum from strongly agree to strongly disagree, and makes the assumption that attitudes can be measured." Typically, a Likert scale is used for asking the respondents to indicate a degree of agreement and disagreement with a particular statement. The scale usually has 5, yet sometimes 7 or even 9, categories ranging from strongly disagree to strongly agree with the neutral point at the middle. Generally, the numerical scores are also assigned to each category of the Likert scale. For instance, the scores ranging from 1 to 5 or -2 to +2 are often assigned to the 5-point Likert scale.

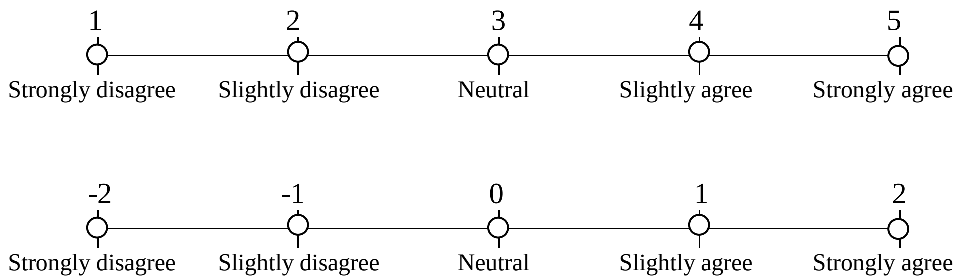


Figure 4.2 Examples of a 5-point Likert scale

A semantic differential scale is commonly defined by a pair of adjectives which have opposite meaning—such as bad-good, weak-strong, ugly-beautiful, etc.—at either end of the continuum. This type of scale was developed by psychologist Charles Osgood and his associates as a procedure to measure the meaning[1] of concepts (Osgood, May, and Miron 1975 cited in Sommer and Sommer 2002: 165). According to Sommer and Sommer (2002: 165), "The semantic differential scale is a good instrument for exploring or measuring the connotative meaning of things. Connotation refers to, the personal meaning of something, as distinct from its physical characteristic." The three major categories of connotative meaning include value, strength, and activity Sommer and Sommer (2002: 166). Sometimes, the numerical score are also assigned to each category of the semantic differential scale.

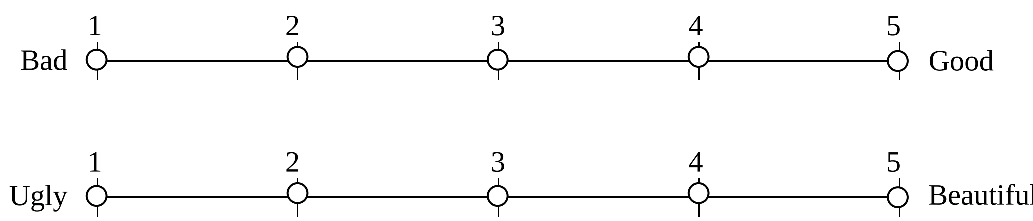


Figure 4.3 Examples of a 5-point semantic differential scale

[1] Fundamentally, there are two aspects of meaning of concepts or words—denotation and connotation. More specifically, denotation refers to the name of a concept or the literal meaning of a word while connotation refers to the emotional and imaginative associations attached to a concept or a word.

4.2 Research methods for attitude studies

Generally, attitude studies rely chiefly on research methods in behavioral sciences. However, survey methods widely-used for data collection and statistical tools are very powerful for data analysis and hypothesis testing.

4.2.1 Survey methods for data collection

Indisputably, data collection forms a singular and significant step of any research study. The inaccurate and insufficient collected data can impact the results of the research and ultimately can lead to the invalid findings. Even though techniques can be used for extracting and collecting data from individuals are abundant, selecting the appropriate one(s) specific to the context of a certain project is not an easy, yet crucial, task. Generally, surveys are widely used as a technique for collecting attitude data.

Surveys can be classified into two broad categories—the questionnaire and the interview. The distinction between the two categories is that questionnaires are usually completed by the respondents while interviews are typically completed by the interviewer based on the information provided by the respondents. For many research fields, especially, psychology, sociology, and marketing, for example, survey has long been widely used as a quantitative method for collecting data, particularly public behaviors and opinions, from the sample of a population in order to make statistical inferences about that population.

During the past decades, survey research has changed dramatically according to the advancement of technology. In consequence, paper-and-pencil instrument is not the only way of administering a survey. As Trochim (2006) writes:

> “We have automated telephone surveys that use random dialing methods. There are computerized kiosks in public places that allows people to ask for input. A whole new variation of group interview has evolved as focus group methodology. Increasingly, survey research is tightly integrated with the delivery of service. Your hotel room has a survey on the desk. Your waiter presents a short customer satisfaction survey with your check. You get a call for an interview several days after your last call to a computer company for technical assistance. You're asked to complete a short survey when you visit a web site.”

Today, the most common ways of administering a survey include telephone survey, online survey, mail survey, household drop-off survey, personal in-home survey, personal mall or street intercept survey, and group administered survey. Furthermore, in some cases, researches use hybrids of these techniques.

Important to note, in the field of landscape design and visual analysis, researchers use photo-elicitation technique or photo-questionnaire which include photos or images of the certain character of landscape as representatives of the actual environment as taking subjects to the real place is considered costly and time consuming (Zube, Brush, and Fabos 1975; Smardon, Palmer, and Felleman 1986; Hyman and Stiftel 1988).

4.2.2 Statistical tools for data analysis and hypothesis testing

Statistics is a particularly useful branch of mathematics that refers to the science of collecting, analyzing and making inference from quantitative data. In psychological and social sciences, the outstanding merit of statistics is its procedures that researchers can employ to analyze data from surveys and test hypotheses in order to understand and describe phenomena and draw reliable conclusions about them. Generally, there are two main branches of statistics—descriptive statistics and inferential statistics (Nolan and Heinzen 2011: 2).

Descriptive statistics are used to provide simple summaries, both numerical and graphical, of the qualitative data. As Trochim (2006) succinctly notes, "Descriptive statistics help us to simplify large amounts of data in a sensible way. Each descriptive statistic reduces lots of data into a simpler summary." In statistical analysis, descriptive statistics usually involves in univariate analysis and bivariate analysis. For univariate analysis, descriptive statistics are used to examine the characteristics of a single variable. The three main characteristics of a particular variable typically examined include distribution (frequency, percentage), central tendency (mean, median, mode), and dispersion (range, variance, standard deviation). For bivariate analysis, descriptive statistics are employed to describe the relationships between two different variables. According to Babbie (2013: 438), the results of bivariate analyses often are presented in the form of contingency tables, which are constructed to reveal the effects of the independent variables on the dependent variable." Correlation coefficient (such as such as Pearson's *r* and Spearman's rho) and scatter plots are also usually used in displaying the results of bivariate analyses.

Inferential statistics, unlike descriptive statistics, allow researchers to make general estimates about a population[2] by using data from a sample[3] or samples, which draw from selected populations. In other words, with inferential statistics, researchers are able to draw conclusions that extend beyond the immediate data they have (Trochim, 2006). Inferential statistics, thus, are very useful for testing research hypotheses. As Nolan and Heinzen (2011: 10) notes, "hypothesis testing is the process of drawing conclusions about whether a particular relation between variables is supported by the evidence. Typically, when we test a hypothesis, we examine data from a sample to draw conclusions about a population." Principally, inferential statistics for hypothesis testing can be classified into two types—parametric hypothesis test and nonparametric hypothesis test. A parametric test is an inferential statistical analysis that is based on the assumptions about the parameters or population; on the contrary, a nonparametric test is an inferential statistical analysis which

[2] A population "includes all possible observations about which we'd like to know something" (Nolan and Heinzen 2011: 2).
[3] A sample is "a set of observations drawn from the population of interest" (Nolan and Heinzen 2011: 2).

makes no such assumptions or which is not based on the assumptions about the population (Nolan and Heinzen 2011: 173).

For parametric tests, according to Nolan and Heinzen (2011: 173), "… it is important to explore the ideal conditions under which hypothesis testing takes place." These ideal conditions are known as "assumptions," which, in statistics, refers to "the characteristics that we ideally require the population from which we are sampling to have so that we can make accurate inferences" (Nolan and Heinzen, 2011: 173). The three main assumptions for parametric tests include (1) the dependent variable is considered a scale variable, (2) the population is normally distributed or there are at least 30 participants[4], and (3) the participants are randomly selected; if they are not, generalization must be done with caution (Nolan and Heinzen 2011: 174).

With these assumptions in mind, as Norman (2010: 625) write, "Reviewers of research reports frequently criticize the choice of statistical methods. While some of these criticisms are well-founded, frequently the use of various parametric methods such as analysis of variance, regression, correlation are faulted because: (a) the sample size is too small, (b) the data may not be normally distributed, or (c) the data are from Likert scales, which are ordinal, so parametric statistics cannot be used." In view of that fact, Norman explored this issue and demonstrated that "many studies, dating back to the 1930s consistently show that parametric statistics are robust with respect to violations of these assumptions" (Norman 2010: 625). In other words, as Norman (2010: 631) declare, "Parametric statistics can be used with Likert data, with small sample sizes, with unequal variances, and with non-normal distributions, with no fear of 'coming to the wrong conclusion.' These findings are consistent with empirical literature dating back nearly 80 years. The controversy can cease (but likely won't)."

The statistical tools which are widely used in parametric tests are the *z* test, the *t* test, ANOVA, and Pearson correlation test. For nonparametric tests, the statistical tools that are widely used are chi-square test, Spearman rank-order correlation test, Wilcoxon singed-rank test, Mann-Whitney *U* test, and Kruskal-Wallis *H* test.

4.3 Pertinent research precedents

In order to get clearer picture about attitude research, this section reviews several pertinent previous studies. These studies can be classified into two major areas: research in environmental psychology and landscape design; and, survey of stormwater knowledge, attitudes, and behaviors.

[4] According to Nolan and Heinzen (2011: 174), "Because hypothesis tests deal with sample means rather than individual scores, as long as the sample size is at least 30 (in most cases, based on the central limit theorem), it is likely that this assumption is met."

4.3.1 Research in environmental psychology and landscape design

A large number of empirical studies related to environmental psychology and landscape design have been published. In particular, they can be found mostly in form of books and journal articles in the fields of environmental psychology as well as landscape planning and design—particularly *Journal of Environmental Psychology, Environmental and Behavior, Landscape Journal, Landscape and Urban Planning, and Journal of Landscape Architecture*. Moreover, not a few of them are also found in *Place, Landscape Ecology, Journal of Ecological Anthropology, Journal of Environmental Planning and Management, Journal of geography, and Journal of Forestry*.

Even though many empirical studies exist, a relatively small number of those focus on the assessment or evaluation of design intent or recognition of ecological design intent. Instead, the majority of them fall into the topics related to visual aesthetic and landscape appreciation. The four research projects considered pertinent are reviewed below.

1) Visitor perception of ecological design at the Crosby Arboretum

The study conducted by Robert Brzuszek and James Clark (2009) is a unique work aiming to test the validity of ecological design principles as actually perceived by general public. In this study, the researchers claim that although many landscape design scholars have developed and proposed principles for ecological design in order to achieve publically perceived aesthetics and values of ecological design (e.g. Thayer 1989; Eaton 1990; Nassauer 1995; Treib 1995; for example), they considered the principles provided by Mozingo (1997) a complete set in this regard. They assessed that Mozingo had critically summarized and deliberately combined each of those prior concepts into a comprehensive set of five principles—visibility, temporality, reiterated form expression, and metaphor. Inspired by these principles, the main purpose of this study was to test their validity.

The selected Crosby Arboretum in Picayune, Mississippi, to be the study site because it has been called, as Brzuszek and Clark noted, the "first fully-realized ecological arboretum in the country." Before testing the validity of Mozingo's principles with the public, the researchers had carefully analyzed the study site and argued that each of these five premises was addressed in the design of Crosby Arboretum. Accordingly, it was considered qualified to serve as the case study for this research.

The central question raised in this study is how the five premises proposed by Mozingo are important to the general public, and perceived by the general public. The researchers gatherd data using a three-page questionnaire. The questions were structured in two main parts: (1) opinions on importance of the five elements (visibility, temporality, reiterated form expression, and metaphor) in the design of Crosby Arboretum, and (2) evaluation on evidence of these elements at Crosby Arboretum. A 5-point Likert agreement scale with "3" representing neutral was used to ask visitor to give their reactions to each item. The format of questions included on the survey is shown in figure 4.4. In addition, the survey also gathered demographics of the respondents. The researchers conducted on-site interviews at the Crosby Arboretum during spring 2005. The questionnaires were distributed to visitors with a total of 65, and 63 were completed, representing a 97% response rate.

Questions included on the survey administered to visitors.

How does the Crosby Arboretum, MSU-ES relate in appearance to its immediate surroundings?

1	2	3	4	5
Blends into surroundings				Is much different than surroundings

How do you think that a landscape that you visit should relate in appearance to its surroundings?

1	2	3	4	5
Should blend into its surroundings				Should appear different than

Does the Crosby Arboretum, MSU-ES appear neat and cared for?

1	2	3	4	5
Not cared for				Appears cared for

Do you think that a landscape should appear neat and cared for?

1	2	3	4	5
Should not appear cared for				Should appear cared for

Does the Crosby Arboretum, MSU-ES have orderly planting patterns?

1	2	3	4	5
Not ordered				Very ordered

Do you think that a landscape should have orderly planting patterns (i.e., rows of trees, shrubs, or clear planting patterns)?

1	2	3	4	5
Need not be orderly				Should be very orderly

Does the Crosby Arboretum, MSU-ES have forms of art, buildings, or other cultural expressions?

1	2	3	4	5
None to very little forms				Has many forms

Do you think landscapes should have forms of art, buildings, or other cultural expressions?

1	2	3	4	5
Should not have				Should have

Is the Crosby Arboretum, MSU-ES meaningful to you in any way?

1	2	3	4	5
Not meaningful				Very meaningful

Do you think that a landscape should be meaningful?

1	2	3	4	5
Not important				Very important

Note: For each survey question a 5-point Likert scale was used to quantify responses; 3 was considered neutral.

Figure 4.4 Questions in the survey administered to
visitors of Crosby Arboretum (Brzuszek and Clark 2009: 102)

The results of this study revealed that the respondents, visitors of Crosby Arboretum, seemed to understand the overall intent of the landscape design; yet this finding does not imply that all ecologically designed landscapes can be recognized by their visitors or the general public (Brzuszek and Clark 2009: 103). Regarding the responses to the five landscape principles, it appeared that the visitors "1) believe that a landscape should blend into its surrounding environment and see this at Crosby; 2) believe that a landscape should appear cared for and find Crosby to be well cared for; 3) believe that landscapes need not be necessarily orderly in their appearance and find Crosby to be somewhat too orderly; 4) are somewhat neutral on the question of having human forms of expression in the landscape but detected a modest presence at Crosby; and 5) place high value on the need for meaning in the landscape and give Crosby high marks" (Brzuszek and Clark 2009: 104).

2) Evaluation of Easter Hill Village design solutions

The book by Clare C. Cooper, *Easter Hill Village: Some Social Implication of Design* (1975), is regarded as a classic and pioneering work on user evaluation of design solutions. The aim of this book is fourfold—1) user evaluation of designer's specific design solutions, 2) ethnographic analysis of how poor people use building and space in order to address design guidelines, 3) sociological analysis of impact of physical environment on people's behavior and attitude, and 4) community analysis of poor people's life. It is, thus, both behavioral science study and designers' handbook. Moreover, the major contribution of this book is the development of research and policy perspective which is sympathetic to the needs and interests of users of designed environments.

This study centered on investigating possible discrepancies between designers' assumptions about what residents want in public housing and what residents actually wanted. Specifically, it explored people's views of buildings and spaces of Easter Hill Village, a 300-unit residential development in Richmond, California finished in 1954 and cited as one of the "Ten Buildings in America's Future." The study was conducted in spring of 1964. The first step of study involved interviewing the designers to ascertain the social objectives of their design and the physical design means that they utilized in order to fulfill these objectives. Lacking any empirical data, the designers were forced to make two sets of assumptions: postulation of residents' needs and translation of those needs into physical solutions. This interview revealed several specific ideas the designer had regarding what people want; these included avoiding the institutional image of public-housing projects, providing each family of a home of its own, giving each family control over private outdoor space, providing mean for the expression of individuality, fostering neighborliness and casual encounters among residents, creating self-identified subgroup in community, and fulfilling children's need for an interesting and stimulating environment to play in. In addition, designers also added that budget limitations were a key major constraint in the design so that to keep cost to the minimum was considered a design goal.

The best way to evaluate the assumptions and design solutions that the designer had made was to ask the tenants. Cooper devised a questionnaire and interviewed fifty-two 52 persons. Findings revealed that: "The designers wrongly assumed that lay people see buildings and spaces the same way as trained professionals" (Cooper 1975: xiv). This is because though the majority did indeed respond very favorably to the idea of a home of one's own and also could see individualization as an integral part of this conception, they could not notice various attempts at individualization of exterior appearance made by the designers. The only thing they could perceive was variation in color. Even though some conclusion seemed rather elementary—e.g. residents expressed a preference for a detached, single-family house, this study was regarded as a beginning of the inquiry into users' evaluation of design solutions.

3) Perception of suburban residential landscape alternatives and the association with knowledge about ecological systems

The research work of Joan Iverson Nassauer (e.g. Nassauer 1988a, 1988b, 1993) are remarkable studies on perception of ecological landscapes. In these studies, she investigated people's appreciation of various landscape appearance. Specifically, she tested her hypothesis on vernacular aesthetic expectations or preferences of neat and cared for landscape appearance. Among these works, a prominent one is her study that explored residents' perception of aesthetic and maintenance characteristics of suburban residential landscape alternatives (Nassauer 1993).

This study surveyed 234 adults living in suburbs of the Minneapolis-St.Paul metropolitan area. Using a seven-point semantic differential scales on five perceived characteristics—attractiveness, care, neatness, naturalness, and apparent need for maintenance—they were asked to rate color slides of seven different alternatives of residential front yard appearance. These alternatives included 1) conventional lawn, 2) conventional lawn with native trees and shrubs, 3) replace 50% of the front lawn with prairie garden, 4) replace 75% of the front lawn with prairie grass, 5) replace 50% of the front lawn with oak savanna shrubs, 6) replace 75% of the front lawn with prairie garden and woody shrubs, and 7) conventional lawn without mowing or pruning (the weedy lawn), see figure 4.5. The findings clearly showed that respondents held high appreciation of conventional lawn along with neat and cared landscape (Nassauer 1993: 58-60).

Another interesting part of this study is the test of the hypothesis regarding the association between knowledge about ecological systems and perception of suburban residential landscape alternatives. Of the 234 respondents, 67 were members of the state's native plant society or a group concerned with the use of native plants, representing those who were more knowledgeable about indigenous plants than the rest 177 people. The results suggested that the two groups expressed some significant differences regarding their perception of the five characteristics of the landscape alternatives. Specifically, as Nassauer (1993: 58) summarized, "In general, the conventional lawn was perceived as more aesthetically pleasing by respondents with no special knowledge of indigenous plants, while treatments replacing 75 percent of the turf tended to be perceived as more aesthetically pleasing by those with knowledge of indigenous plants. It appears that, within the context of this study, ecological knowledge does make a difference in perceptions of landscapes."

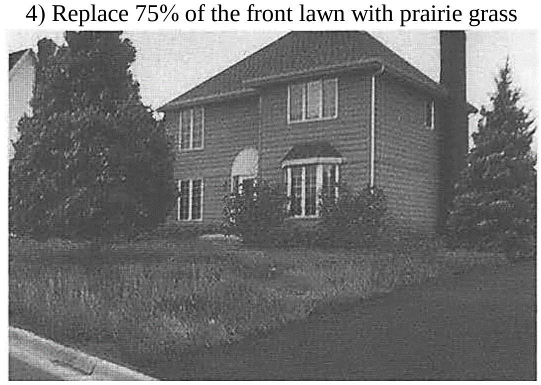
1) Conventional lawn

2) Conventional lawn with native trees and shrubs

3) Replace 50% of the front lawn with prairie garden

4) Replace 75% of the front lawn with prairie grass

5) Replace 50% of the front lawn with oak savanna shrubs



6) Replace 75% of the front lawn with prairie garden And woody shrubs.

7) Conventional lawn without mowing or pruning: the weedy lawn.

Figure 4.5 The seven different alternatives of residential front yard appearance (Nassauer 1995: 166-167)

4) Visions of nature in urban park restoration

The research by Paul H. Gobster (2001) explores and identifies different types of vision individuals have regarding restoring the naturalness of urban open spaces. As issues related to natural or ecological restoration are intertwined with social and cultural values, understanding which landscape features holding iconic status to each type of individuals is important for the social acceptance of the restoration design and management projects.

The goal of this study was to develop a successful planning for Montrose Point Restoration Project in Lincoln Park, Chicago. Thus, this study examines three key issues: 1) the different visions of nature of the site that the stakeholders had; 2) the appropriate ways to restore or manage the natural and cultural elements of the landscape as to be compatible with those visions; and 3) the patterns of agreement and disagreement across different stakeholder groups.

Focus group discussions were conducted in the fall of 1997 with six groups of individuals identified as principal stakeholders of the site and its adjacent area. These groups included 1) birders and other environmentalists, 2) historic preservationists and landscape architects, 3) passive users, 4) volleyball players, 5) anglers, and 6) yacht club members. The purpose of these focus group discussions was to get an initial idea of how different people envisioned the proper future characteristic of nature at Montrose Point. Each session began with a field trip tour of the point followed by a discussion which lasted about an hour and covered topics related to uses and values, problems and concerns, and restoration and change. In addition of the discussions with stakeholders, a follow-up focus group with park district staff representing different professional and administrative functions was organized in the spring of 1998. Moreover, a workshop focusing on balancing environmental and historic preservation goals for Montrose Point was also held in the winter of 1999. This workshop brought together representatives from stakeholder groups, park district staff and outside experts.

Visions of nature expressed by Montrose Point stakeholders

Criteria	Designed landscape	Critical habitat	Recreation	Pre-European settlement
Function	Aesthetic experience, enclosure, sense of infinite, mystery	Primary focus on birds	Nature as substance and backdrop	Emulate pre-settlement ecosystems and processes
Structure	Native plant palette, multi-layered masses	Food and cover, less of a concern if it is native	Natural appearance	Native plant communities
Values	Landscape art	Uniqueness, bird diversity	Nature appreciation, wildness, special place	Biodiversity, endangered species, nature experience
Use	Passive-appreciative	Limit use except for birders	Balance nature with use	Active (restoration) appreciative
Icons	The meadow, the long view	The Magic Hedge	Beach, harbor, "hook", revetment	Entire landscape

Figure 4.6 Four types of visions of nature expressed by Montrose Point stakeholders (Gobster 2001: 40)

Results were drawn on the transcribed records and notes from the public meetings described above and revealed four major visions of nature: 1) nature as designed landscape, 2) nature as critical habitat, 3) nature as recreation, and 4) nature as pre-European settlement landscape. These different visions were constructed based on five criteria—function, structure, values, use, and icons—which are presented in figure 4.6.

4.3.2 Survey of water and stormwater knowledge, attitude, and behavior

As a response to the global water crisis, research has focused on water conservation attitudes and behaviors of the general public. Governmental authorities, non-governmental organizations, and individual researchers have conducted a number of surveys with the aim of understanding the existing level of awareness and possible strategies to raise public awareness to address and alleviate the problems.

In this vein, public perception and preference of approaches or alternatives in landscape design and planning related to watershed management, river restoration, stormwater control, and so on has long been a topic of interest. Such information is vital to generate public support for design and planning processes that address issues of watershed management. In addition, studies of public perceptions and attitudes toward some particular water and stormwater management features, especially wetlands, marshlands, bogs, detention basins, riparian buffers have also been of interest to researchers. This is critical as certain landscape features are often perceived negatively by the public and, most importantly, successful protection and management of such features relies greatly on positive public perception and valuation. Similar to research in environmental psychology and landscape design, surveys are used for collecting data from the public. In particular, asking people to rate photographs or photographic simulations by using attitude rating scales is a common technique to obtain data regarding respondents' visual and aesthetic preferences for the different types of landscapes or proposed scenarios. Also, asking people to rank or sort photographs or photographic simulations is another popular technique in this regard. Examples of these surveys and studies are abundant (e.g. Kaplan 1977; Hemmitt 1983; Lee 1983; Nasar 1987; Sullivan 1994; Ryan 1998; Asakawa, Yoshida, and Yabe 2004; Nassauer 2004; Junker and Buchecker 2008; Kenwick, Shammin, and Sullivan 2009; Schaich 2009; Kaplowitz and Lupi 2012; Dobbie 2013; Dobbie and Green 2013).

After the promulgation of the US EPA Phase II rule in 1999, the number of studies on stormwater knowledge, attitude, and behavior has increased dramatically. Generally, the main goal of these studies is to understand and determine residents' baseline knowledge relative to stormwater runoff pollution as well as their attitudes and behaviors associated with stormwater management. They also aim to provide information for setting the educational and outreach campaigns or programs, especially in terms of content of knowledge needed to be emphasized when the citizens misunderstand or do not know the purposed of proposed projects. The ultimate goal of these educational efforts is to raise people' knowledge and understanding relative to water and stormwater issues and to change their attitudes and behaviors which result in adverse impacts on local water resources.

Below, two excellent survey series are reviewed. The first one is the survey of Canadian water attitudes commissioned by the Royal Bank of Canada (RBC). Another one is the stormwater survey conducted for the City of San Diego.

1) RCB Canadian water attitudes study

Realizing the crisis of global water resource, the Royal Bank of Canada (RBC) launched the RBC Blue Water Project in 2007 with the aim of helping protect the world's freshwater resources. In 2008, RCB started to commission the study of Canadian water attitudes in order to reveal the current situations of this subject matter and to find ways to promote sustainable water behaviors in Canada. As Lynn Patterson, Director of Corporate Responsibility at RBC, notes, "We soon learned that many Canadians take water for granted. So in 2008, we started polling them about their attitudes towards water—to see if the serious water issues around the world and emerging ones at home were having an impact on how we use and think about this precious resource, and if our grants were making a difference" Royal Bank of Canada (2015: 2).

The study uses a yearly online survey as the research technique for gathering the data. Each survey included a sample of approximately 2,000-2,500 Canadian adults (Royal Bank of Canada 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015). Data derived from these surveys were analyzed using statistical procedure to reveal current stage and change in water attitudes of Canadians. Overall, the findings of this study series consistently demonstrate that a majority Canadian adults hold limited knowledge as well as concern and awareness with regard to fresh water resources. In the first 2008 study, the statistical analysis of the survey data led to the conclusion that "Canadians are concerned about the supply of fresh water in this country. But it appears that the concern has not reached a critical point" (Royal Bank of Canada 2008: 3). In the next year, the second study revealed that "There is still a way to go to raise the profile of water as a top environmental issue in the minds of Canadians. When prompted, Canadians are concerned about the quality and quantity of Canada's freshwater supply, yet when judged against other environmental concerns, water quality/pollution comes in third behind climate change and air pollution" (Royal Bank of Canada 2009: 3). In addition, the 2010 study found that "More Canadians admit to trying reasonably hard to conserve electricity than water, despite the fact that they say they're making reasonable efforts to conserve. And while they give themselves good grades, governments, businesses and other Canadians are apparently doing a lousy job" (Royal Bank of Canada 2010: 6). In 2011, the fourth study found that "Significantly more Canadians now say that fresh water is Canada's most important natural resource, and most are still quite concerned about both its quality and its availability" (Royal Bank of Canada 2011: 1). Nonetheless, Canadians' water illiteracy along with their misunderstandings and unaware behaviors regarding the issue of water resources still prevailed. As the 2015 study revealed: "Only one in ten Canadians think that the water treatment or storm water systems in their community require major investments. However, 46% admit to having no knowledge of the condition of water treatment systems, and 50% have no knowledge of the condition of storm water systems (Royal Bank of Canada 2015: 5).

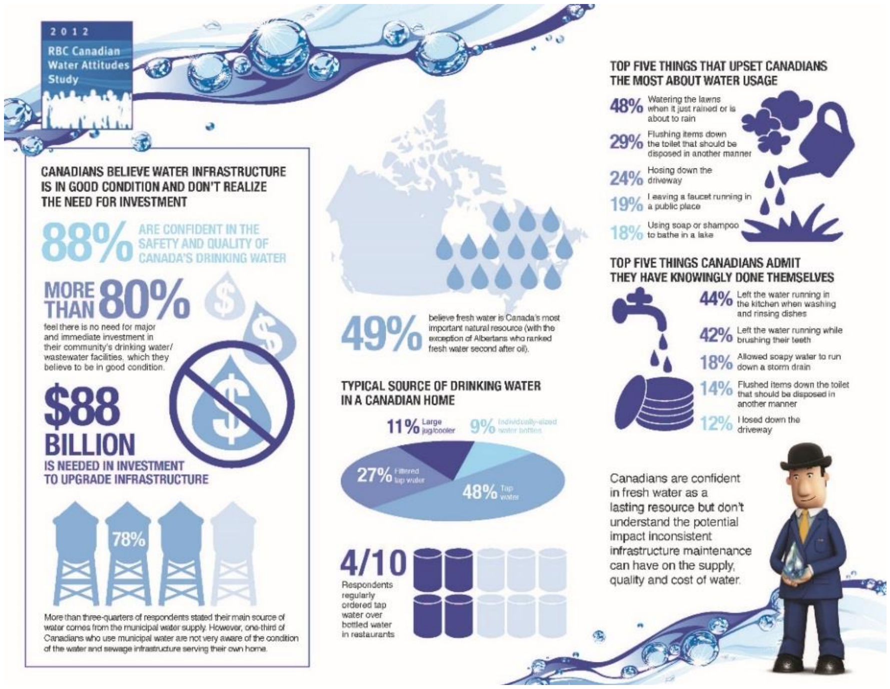


Figure 4.7 The infographic presenting the key finding of the 2012 RBC Canadian Water Attitudes Study (Picture source: http://www.rbc.com/newsroom/news/2012/20120322-water-study.html, retrieved August 20, 2015)

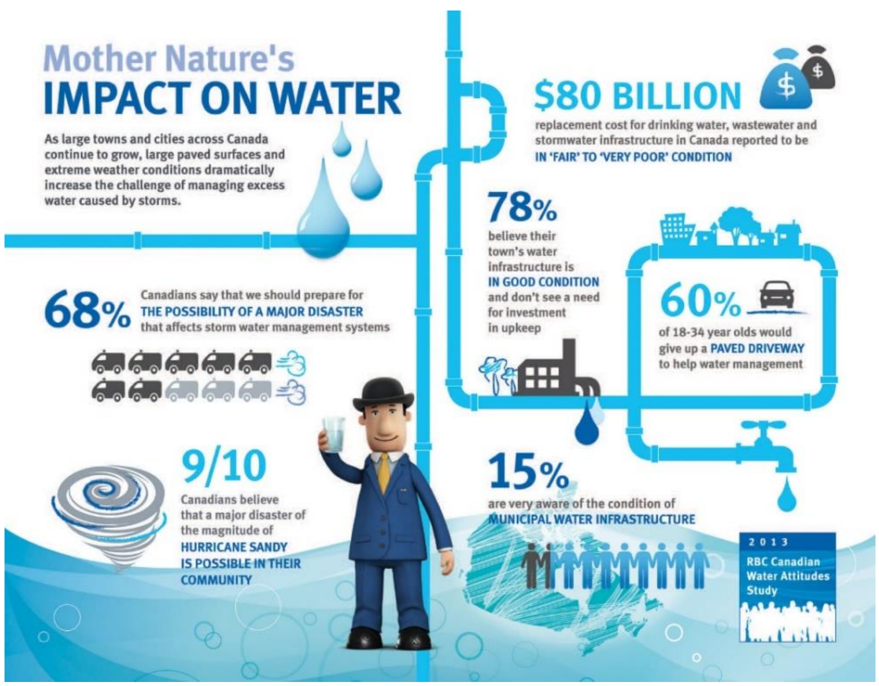


Figure 4.8 The infographic presenting the key finding of the 2013 RBC Canadian Water Attitudes Study (Picture source: http://photos.newswire.ca/images/download/ 20130314_C4837_ PHOTO_EN_24547.jpg, retrieved August 20, 2015)

2) City of San Diego's stormwater survey

As a public agency, the City of San Diego has been notably out front in using surveys to understand how their residents regard and understand stormwater issues. In 2001, the city's Storm Water Pollution Program hired JD Franz Research, Inc. to conduct a survey project. The main purpose of this survey was to provide a baseline measure of awareness, attitudes, and behaviors regarding storm water pollution in the city. The survey instrument used in this research was designed, modified, and pretested. The final version of the instrument was used for telephone interview implemented between June 19 and July 28, 2001 (JD Franz Research, Inc. 2001: 1). The surveyors selected respondents using a random digit dialing (RDD) telephone sample designed to represent all households in the City of San Diego. All interviewers were intensively trained. The total number of completed interviews was 443. Answers form all interviews were coded and statistically analyzed using SPSS software. The results of this survey led to the conclusion that because few people know facts about stormwater pollution, "the City of San Diego will be confronting a number of challenges in working toward the prevention of storm water pollution" and "the City will need to impart basic knowledge" (JD Franz Research, Inc. 2001: 29).

In addition to the baseline survey completed in 2001, three ensuing surveys were conducted annually with the purpose of serving as follow-up measure of the same topic. The first follow-up survey was conducted in July and August of 2002 while the second follow-up survey was conducted in July and August of 2003 and the third follow-up survey was conducted in July 2004. Most of the questions used in each year were identical to those asked in the 2001 baseline survey; however, some questions were updated and added in order to explore more in some specific or new issues. Telephone survey by trained interviewers was also used in all follow-up projects with which their sample sizes are much in the same range. The sample size was 405 for the year 2002, 428 for the year 2003, and 400 for the year 2004 (JD Franz Research, Inc. 2002: 1, 2003: 1, 2004: 1). Data gathered in each year was analyzed in the same way and some distinctive between answers from surveys of different years were compared. According to the results of these follow-up studies, it appeared that the awareness along with behavior with regard to stormwater management of the residents had been positively changed over time.

Following the above series of stormwater survey, another stormwater survey series of the City of San Diego was launched in 2007. For this survey series, Think Blue San Diego, which is a program of the San Diego Storm Water Pollution Prevention Division, contracted with Goodwin Simon Victoria Research (GSVR)), and then Goodwin Simon Strategic Research (GSSR), to annually conduct the stormwater survey. Although the purposes of the surveys were described slightly different each year, the same direction was defined, which is to explore the residents' opinions about stormwater pollution and also Think Blue outreach activities (Goodwin Simon Victoria Research 2007, 2008, 2009, Goodwin Simon Strategic Research 2010, 2011, 2012, 2013). Each year, data were conducted by using a telephone survey with the sample size of about eight hundred. Respondents were adult residents identified randomly from across the city using a random digit dial (RDD) from a list of all active household telephone numbers.

In the 2007 survey, the first in this series, findings revealed that residents of San Diego hold a high level of awareness about stormwater issues along with a high level of willingness to help solve the problems. Encouragingly, this survey also states that in addition "The high level of awareness and concern about the problem of storm water pollution suggests that residents are open to learning more about how to address it" (Goodwin Simon Victoria Research 2007: 11). The similar results were found in the next year's survey. As reported in the 2008 survey: "Similar to 2007, the survey shows clearly that residents of San Diego take storm water pollution quite seriously, and see it as a major problem facing the city. Fully 76% say that pollution of the city's oceans, bays, and beaches is a "very important" issue, and 77% say that polluted water in storm drains is an important problem. These figures are nearly equivalent to concerns about the quality of public education and far exceed the proportion who said that traffic was a very important issue for the city" (Goodwin Simon Victoria Research 2008: 10). The 2009 survey found a significant relationship between concern over the impacts of storm drain pollution and willingness to change behaviors resulting in such pollution. In particular,

> "people were concerned about the negative effect of storm drain pollution on children's health, on the city's beaches, and on the health and safety of wildlife. Most residents, and particularly those who were most concerned about the consequences of water pollution, said they were willing to make changes that would reduce pollution, especially sweeping driveways instead of hosing them, cleaning up yard waste (or instructing their gardener to do so), picking up litter in front of their homes, and keeping sprinklers from washing chemicals into the street. Those most concerned about pollution were also more likely to recognize many common neighborhood trash items such as cigarette butts, dog droppings, and grass clippings as serious pollutants (Goodwin Simon Victoria Research 2009: 3).

In all following surveys found a high level of concern among city residents about stormwater crisis along with a high level of willingness to change behaviors which result in such crisis. Important to note, these surveys also suggested that knowledge and information about the adverse impacts of stormwater pollution can play a role in motivating behavioral change. According to the seventh survey conducted in 2013, "Very high proportions of residents say they have made behavioral changes *as a direct result of seeing any information about how polluted water in storm drains affects local creeks, the beaches, and the ocean*" (Goodwin Simon Strategic Research 2013: 10).

Chapter 5

Sustainable Stormwater Management in San Francisco Bay Area

In view of the unique and critical stormwater situations of San Francisco Bay Area, various agencies and non-profits have introduced and promoted sustainable stormwater management principles and practices. Hence, the landscape-based design—widely known as Low Impact Development (LID) design—along with its features—widely called Best Management Practices (BMPs)—has been implemented to function as stormwater management facilities throughout the region. The main purpose of this endeavor is to help manage runoff and sustain water ecosystems of the region. Although San Francisco Bay Area is one of the regions in the United States most concerned about promoting and implementing sustainable stormwater management, it is not clear whether many inhabitants are able to recognize these efforts that are put into practice in their surroundings. Accordingly, San Francisco Bay Area is a strategic study area for this dissertation research.

This chapter describes some fundamental, essential information, in order to provide basic understanding, about stormwater ecosystems and management practices in San Francisco Bay Area. Most importantly, this chapter also provides ideas about concepts and criteria for selecting the research test sites. In addition, it presents information about each selected test site.

5.1 Stormwater ecosystems and crisis in San Francisco Bay Area

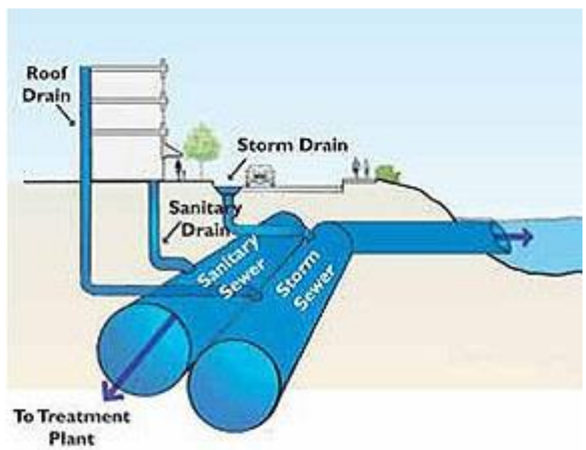
Located in Northern California with Pacific Ocean to the West, San Francisco Bay Area, commonly referred to as the Bay Area, surrounds San Francisco Bay and also several other bays including San Leandro Bay, Suisun Bay, San Rafael Bay, Richardson Bay, Grizzly Bay, and Honker Bay. The Bay Area encompasses nine counties—Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma. The major cities are San Francisco, San Jose, and Oakland. Apart from the metropolitan areas, the Bay Area also comprises smaller urban and rural areas. Prominent among them are Berkeley, Concord, Daly City, Emeryville, Fremont, Hayward, Napa, and San Mateo, for example. Home to over 7 million people (US Census Bureau 2014), this approximately 7,000 square miles region is considered one of the populated regions in the United States. Moreover, San Francisco Bay Area is also regarded as one of the world’s best regions to live and visit.

Similar to many major regions all over the United States, urbanization in San Francisco Bay Area is a key cause of change to its stormwater ecosystem. In particular, since the cities in the Bay Area have rapidly urbanized, stormwater ecosystem has been unavoidably disturbed—particularly by the increase of impervious surfaces including roads, parking lots, and rooftops, for example—resulting in flood events and erosion problems. In addition, stormwater runoff from impervious surfaces also conveys many varieties of pollutants to nearby streams and rivers. This circumstance has caused not only the degradation of water quality, but also the deterioration of regional ecosystems.

Apart from the effect of urbanization, the region's climate also poses a unique characteristic that creates a critical challenge for its stormwater drainage and management. The Bay Area has a Mediterranean climate—dry summers and wet winters—and the majority of rain falls in winter, especially between November to March (Null 1995), making its cities frequently face peak flooding problems during the rainy season.

For the City of San Francisco, the most prominent city of the region, its topography and existing stormwater infrastructure are also specific factors which make its stormwater drainage and management efforts even more difficult (City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 23-25). Due to steep slopes, clay soils, and shallow depths to bedrock and high water table in many areas of the city, the infiltration rate is considered very limited. Because of its aging combined sewage system, the city has long suffered from serious water pollution problems due to the combined sewer overflows (CSOs) during heavy rainfall periods. Notably, seismic hazard and climate change—sea level rise and more intense storm events—are also considered the key concerns of the city's stormwater management.

Combined sewer system



Separated sewer system

Figure 5.1 A combined sewer system (left) serves the majority of San Francisco (90%), while a separated sewer system (right) services only some parts (10%) of the city (Picture source: City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 25).

5.2 Sustainable stormwater management practices in San Francisco Bay Area

For decades, a number of policies and projects have been created and implemented in an effort to effectively manage stormwater and also sustainably maintain the significant ecological systems of the San Francisco Bay region. This section provides some key information regarding sustainable stormwater management practices in San Francisco Bay—

which include regulatory requirements, implementing agencies, design guidelines, cases and pilot projects, and also public education and outreach.

5.2.1 Regulatory requirements

San Francisco Bay Area, like other areas in the United States, is regulated under the National Pollutant Discharge Elimination System (NPDES) program of the federal Clean Water Act (CWA). The California State Water Resources Control Board (SWRCB)[1], particularly the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB)[2], is responsible for administering the NPDES program throughout the region. As State Water Resources Control Board (2015a) explains:

> The NPDES program is a federal permit program under the Clean Water Act that is administered in the Bay Area by the Regional Board. The program requires that any discharge of wastewaters to surface water needs a permit. The permits set limits on the quality of the wastewater and require monitoring. All permits are adopted in public hearings and are designed to protect the beneficial uses of the receiving waters. All sewage treatment plants and large industries have permits. Smaller industries that discharge to sewer systems are regulated by the local systems. The discharge of contaminated groundwater is also regulated by NPDES permits. Stormwater is also covered by NPDES permits.

The jurisdiction of the California SWRCB along with the jurisdiction of the SFBRWQCB is shown in figure 5.2. Under the NPDES stormwater program, the operators of regulated MS4s are required to develop and implement a Stormwater Management Program (SWMP), which identifies potential sources of their stormwater runoff pollution and effective control measures to be implemented in order to reduce pollutants in their stormwater discharges. Importantly, these operators are also required to submit permit

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[1] The California State Water Resources Control Board (SWRCB) is the state water board of California and has jurisdiction throughout California. According to California Water Boards (2013a: 1-2), "the Board protects water quality by setting statewide policy, coordinating and supporting the Regional Water Board efforts, and reviewing petitions that contest Regional Board actions. There are nine regional water quality control boards that exercise rulemaking and regulatory activities by basins." The nine regional water quality control boards are 1) North Coast Regional Water Quality Control Board, 2) San Francisco Regional Water Quality Control Board, 3) Central Coast Regional Water Quality Control Board, 4) Los Angeles Regional Water Quality Control Board, 5) Central Valley Regional Water Quality Control Board, 6) Lahontan Regional Water Quality Control Board, 7) Colorado River Regional Water Quality Control Board, 8) Santa Ana Regional Water Quality Control Board, and 9) San Diego Regional Water Quality Control Board.

[2] The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) serves nine counties of the Bay Area including Alameda, Contra Costa, San Francisco, Santa Clara (north of Morgan Hill), San Mateo, Marin, Sonoma, Napa, and Solano (California Water Boards 2013b: 1-2).

applications in order to obtain NPDES permits for their stormwater discharges. While the Phase I MS4 permits are generally individual NPDES permits—which are written specifically for the issued permittees or co-permittees, the Phase II MS4 permits are often covered by a general permit—which is issued to a broad range of permittees (Gentile, Tinger, Kosco, Ganter, and Collins 2003: 134). The NPDES stormwater program, furthermore, also requires the MS4 operators to implement certain practices—including municipal maintenance (e.g. street sweeping, drainage equipment repair), issued stormwater permits monitoring, low impact development (LID) design and best management practices (BMPs) implementation, commercial and industrial inspection, new development review, and public education and participation (e.g. outreach programs, stormwater workshops), for example—in order to minimize stormwater runoff and pollution. Note that the MS4s of medium and large municipalities (serving populations of 100,000 or more) in the Bay Area—including the counties of Alameda, Contra Costa, San Mateo, and Santa Clara, and the cities of Fairfield, Suisun City, and Vallejo (State Water Resources Control Board 2015b)—are regulated under the NPDES Phase I, whereas the MS4s of small municipalities (serving populations less than 100,000) located in urbanized areas of the Bay Area—including Marin county and its cities, Napa county and its cities, city and county of San Francisco, Solano county and the City of Benicia, Sonoma county along with the City of Petaluma and the City of Sonoma, and also the non-traditional facilities that can include universities, prisons, hospitals, military bases, parks and office building complexes (State Water Resources Control Board 2015b)—are regulated under the NPDES Phase II.

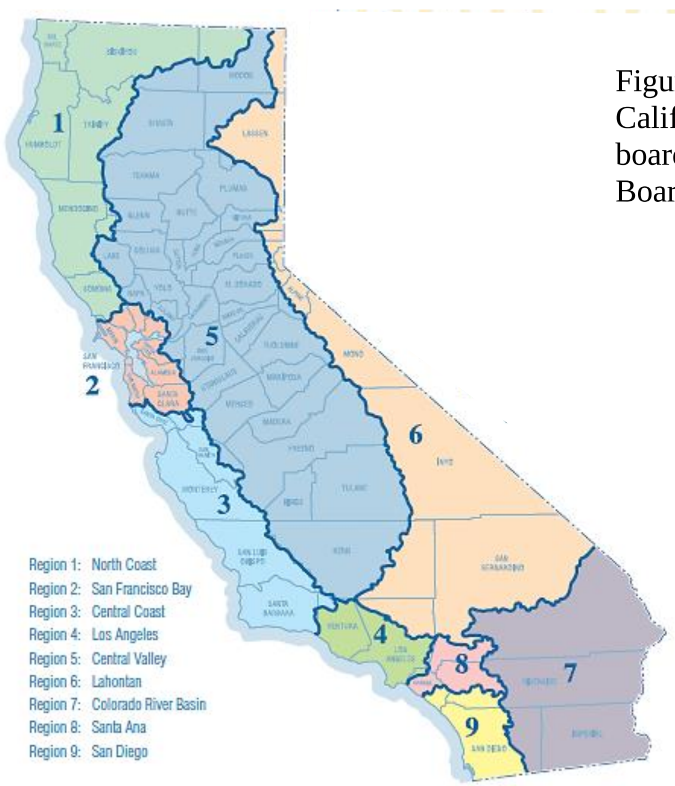


Figure 5.2 The jurisdiction of the nine California's regional water quality control boards (Picture source: California Water Boards n.d.: 2)

Apart from regulating municipal stormwater discharges, the NPDES stormwater program also regulates stormwater leaving certain industrial and construction sites in the Bay Area. More specifically, stormwater discharges from industrial facilities, which include manufacturing facilities, transportation facilities, wastewater treatment facilities, and landfills, for example, are regulated under the Industrial General Permit (State Water Resources Control Board 2015c). Besides, stormwater discharges from construction sites which disturb one or more acres of soil are regulated under the Construction General Permit (State Water Resources Control Board 2015d). In compliance with these Permits, the operators of these certain industrial and construction activities are required to develop and implement a site-specific Storm Water Pollution Prevention Plan (SWPPP), or Stormwater Management Program (SWMP). Crucially, they are also responsible for applying and obtaining NPDES permit coverage for their stormwater discharges (State Water Resources Control Board 2015c, 2015d).

In addition to NPDES stormwater regulations, in the City of San Francisco, particularly, the Stormwater Management Ordinance has been effective since May 22, 2010 (SFPUC 2015a). This Ordinance, amending the San Francisco Public Works Code, requires that projects disturbing 5,000 square feet or more of ground surface must control their stormwater runoff and pollution (SFPUC 2010: 1). Specifically, the operators of any projects that trigger this Ordinance must fulfill the following three steps (SFPUC 2013: 1). Firstly, they must determine if their projects are located in the area served by the combined sewer or the area served by the separate sewer and then meet the applicable performance measure. For the sites located in combined sewer areas with existing imperviousness of less than or equal to 50%, their stormwater runoff rate and volume shall not exceed pre-development conditions for the 1- and 2-year 24-hour design storm. For the sites located in combined sewer areas with existing imperviousness of greater than 50%, their stormwater runoff rate and volume shall be decreased by 25% from the 2-year 24-hour design storm. For the projects located in separates sewer areas, the rainfall from a design storm of 0.75 inches must be captured and treated. Second, they must develop a stormwater management plan, a so-called Stormwater Control Plan (SCP), and submit it to SFUC, or Urban Watershed Management Program (UWMP) of SFPUC in particular, for review and approval before receiving the building permits. As recommended, the stormwater controls can be fulfilled using Low Impact Development (LID) approach and Best Management Practices (BMPs) measures. Lastly, they must also develop an operation and maintenance plan for all proposed stormwater controls and submit it as part of their SCP.

5.2.2 Implementing agencies

Apart from the State Board and the Regional Board, there are also several local agencies working on administering NPDES permits as well as implementing and promoting sustainable stormwater management practices in the San Francisco Bay Area. Prominent among them are the eight municipal stormwater programs—including Alameda Countywide Clean Water Program, Contra Costa Clean Water Program, Fairfield-Suisun Urban Runoff Management Program, Marin County Stormwater Pollution Prevention Program, San Mateo Countywide Water Pollution Prevention Program, Santa Clara Valley Urban Runoff

Management Program, Sonoma County Water Agency, and Vallejo Sanitation and Flood Control District. Note that these municipal stormwater programs have also joined together to form a regional alliance—the Bay Area Stormwater Management Agencies Association (BASMAA). In particular, BASMAA is a consortium of eight municipal stormwater programs in San Francisco Bay Area, which is, as BASMAA (2015) describes, "designed to encourage information sharing and cooperation, and to develop products and programs that would be more cost-effective done regionally than could be accomplished locally." Although BASMAA started as a joint organization which promotes collaborative working among the members, it has eventually also worked in collaboration with agencies and organizations outside of BASMAA itself, especially the California Department of Transportation (Caltrans) and the City and County of San Francisco (BASMAA 2015). According to BASMAA (2015): "Together, these agencies represent more than 90 agencies, including 79 cities and 6 counties, and the bulk of the watershed immediately surrounding San Francisco Bay."

The Port of San Francisco and San Francisco Public Utilities Commission (SFUC) are the two major agencies that enforce NPDES stormwater rules in the City and County of San Francisco. According to Port of San Francisco (2003: i) and SFPUC (2004: i), the ownership of the MS4s within the City and County of San Francisco is divided between the Port for areas along the City waterfront and SFPUC for all other areas within the City's jurisdiction. Subjected to the statewide general permit for Phase II MS4s, the Port and SFPUC, as the owners of the regulated small MS4s, developed the Stormwater Management Plans (SWMPs) describing the measures to be implemented to reduce pollution in stormwater runoff of their MS4 areas. The Port's SWMP covers areas of the City under jurisdiction of the Port, while the SFPUC's SWMP covers non-Port areas of the City. As Port of San Francisco (2003: i) and SFPUC (2004: i) explains, "The reason for two separate plans and programs is that land use and activities of concern for storm water within the two areas are quite different." Specifically, the MS4s owned by SFPUC are almost exclusively small drainages within several of the City's parks, while the MS4s under the Port's authority are almost entirely commercial and industrial facilities, in which a number of them are also subject to the statewide general permit for industrial activities.

In the eastern side of San Francisco Bay, the East Bay Municipal Utility District (EBMUD) also adopted NPDES stormwater regulations. EBMUD is actually a major provider of drinking water and wastewater treatment service in Alameda and Contra Costa counties. According to EBMUD (2015a), "EBMUD's water system serves approximately 1.3 million people in a 331-square-mile area extending from Crockett on the north, southward to San Lorenzo (encompassing the major cities of Oakland and Berkeley), eastward from San Francisco to Walnut Creek, and south through the San Ramon Valley. Our wastewater system serves approximately 650,000 people in an 88-square-mile area of Alameda and Contra Costa counties along the Bay's east shore, extending from Richmond on the north, southward to San Leandro." Even though EBMUD does not work directly on stormwater management, it has taken up NPDES stormwater requirements, especially those related to the construction projects. In particular, the District requires that the applicants for the installation of water services or main on development sites must prepare and implement appropriate measures to prevent adverse impacts from stormwater pollution. As EBMUD (n.d.: 1) describes, "Since installing new services or mains on development sites necessarily involves soil-disturbance, the District will not work on sites without stormwater controls to avoid contributing to a non-compliant discharge from the site. Specifically, for all projects, regardless of size, the applicant must ensure that adequate stormwater pollution prevention measures are in place at the site in order that the District will begin its work (EBMUD n.d.: 2). For the projects disturbing one or more acres of soil, the applicant must declare proof that the appropriate forms have been filed with the State Board and the Regional Board in order that the District will begin its work (EBMUD n.d.: 2).

5.2.3 Design guidelines

In 2009, the Port and SFPUC publicized the *San Francisco Stormwater Design Guidelines* developed in response to the federal CWA and the statewide NPDES regulations. As stated in the Guidelines, "The Guidelines are intended to lead developers, engineers, and architects through a planning and design process that incorporates stormwater controls into site design" (City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 3). In particular:

> "The Guidelines function as both policy document and design tool. They explain the environmental and regulatory drivers behind stormwater management, demonstrate the concepts that inform the design of stormwater controls, describe the benefits that green stormwater infrastructure bring to San Francisco, and take project applicants through the process of creating a Stormwater Control Plan (SCP) to comply with stormwater regulations. The Guidelines are specific to San Francisco's environment; they reflect the city's density, climate, diversity of land uses, and varying topography" (City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 6).

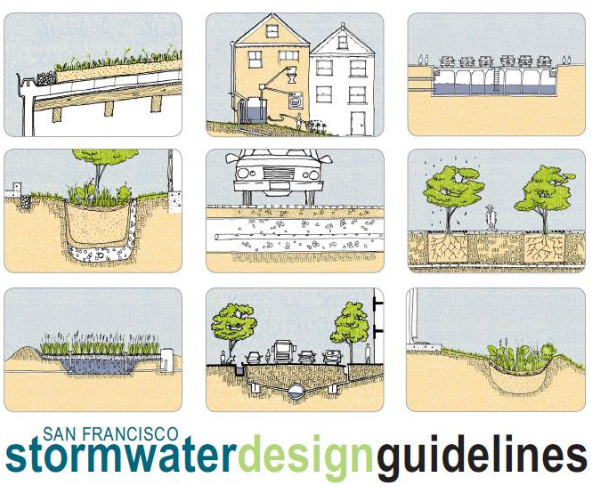


Figure 5.3 The front page of San Francisco Stormwater Design Guidelines (Picture source: http://www.sfwater.org/indexaspx?page=446, retrieved August 25, 2015)

In the Guidelines, the LID approach is underlined as a strategy to sustainably manage stormwater in the City and the landscape-based BMPs are highlighted as effective measures to decelerate, capture, and filter stormwater runoff, resulting in the reduction of runoff volume and pollution. Importantly, the Guidelines emphasizes the application of LID and BMPs in careful site design: “The more that stormwater management is integrated into the design process, the easier it is to create a successful and multi-purpose stormwater management strategy for a given site” (City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 26).

Multi-purpose design is another strategy emphasized in the Guidelines in order to meet stormwater requirements in San Francisco’s urban setting. More specifically, the Guidelines accentuate that stormwater management facilities not only can help protect water ecosystems of the City, but can also help enhance the safety and aesthetics of the City while also advance the environmental knowledge and integrity of the citizens. Stormwater design, therefore, should be integrated into the design of the City’s urban amenities—parks, plazas, streets, sidewalks, parking lots, just to name a few. One prominent example would be the integration of stormwater design into streetscape design. As the Guidelines mention:

> “Integrating LID into the streetscape yields a more attractive pedestrian realm through the inclusion of vegetated curb extensions, sidewalk planters, street trees, pervious surfaces, and other stormwater BMPs that add attractive, pedestrian-scale details. These elements can simultaneously achieve stormwater management goals and improve streets for pedestrians and local residents by encouraging walking, reducing noise, and calming traffic. They can improve neighborhood aesthetics, safety, quality of life, and even property values” (City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 34).

Since the San Francisco Stormwater Management Ordinance was issued in 2010, the Port and SFPUC require that projects disturbing 5,000 square feet or more comply with stormwater performance measures set within the Guidelines. Although the Guidelines are created to work within the context of the City of San Francisco, other cities in the Bay Area have also adopted and used this document as guidelines.

5.2.4 Cases and pilot projects

Over the years, a number of projects implementating sustainable stormwater management or LID design strategies have been constructed in San Francisco Bay Area. One of the most famous cases is a 2.5-acre green Living Roof of the California Academy of Science, a Platinum LEED-certified building located in the heart of San Francisco's Golden Gate Park. Designed by SWA Group, the Living Roof, is not only exceptionally beautiful, but it also provides several ecological benefits, making it received the Honor Award from the American Society of Landscape Architects (ASLA) in 2009. Considering its stormwater management performance, the Living Roof captures almost all of rainwater from the roof so that it helps reduce runoff volume and pollutants, thereby minimizing flooding and stress on the sewage system of the city (California Academy of Science 2015a).

Figure 5.4 The green Living Roof located atop the California Academy of Science (Picture source: http://www.calacademy.org/our-green-building, retrieved October 10, 2015)

The SFPUC Headquarters is also a Platinum LEED-certified building located in the City of San Francisco. The building contains two smart water systems—the wastewater treatment system, the Living Machine, and the rainwater harvesting system (SFPUC 2014: 4). The Living Machine, by making use of the series of engineered wetlands located both outside and inside the building, treats all of wastewater in building. The treated water is used to supply the entire water for toilet flushing, thereby reducing the building's potable water consumption by approximately 65% (SFPUC 2014: 4). For the rainwater harvesting system, a 25,000-gallon cistern harvests rainwater from the building's roof and children day care center's play area. This harvested water is treated and then used for irrigating non-Living Machine plantings and street trees (SFPUC 2014: 4).

Figure 5.5-5.6 The engineered wetlands located both outside and inside the building are parts of the Living Machine at the SFPUC Headquarters

Figure 5.7 The rain gardens in Mint Plaza (Picture source: http://mintplazasf.com/team.php, retrieved October 10, 2015)

Mint Plaza is considered an epitome of urban stormwater management best practices in the Bay Area. The plaza's two rain gardens along with the underground system help capture, absorb, and filter the site's stormwater runoff. Additionally, the plaza's cozy space located on the 5th Street in the heart of City of San Francisco also serves as a community and city gathering spot (Local Ecologist 2008). Because of its ecological and social benefits, Mint Plaza received the Smart Growth Award for Civic Spaces from the U.S. EPA and also the Merit Award in Urban Design from American Society of Landscape Architects (ASLA) in 2010.

Figure 5.8 Stormwater management facility at Brisbane City Hall (Picture source: http://www. flowstobay.org/ssbrisbane, retrieved October 10, 2015)

Figure 5.9 Stormwater management facility at El Cerrito City Hall (Picture source: http://bluegreen bldg.org/wp-content/uploads/2008/09/bgeccity hallbioretentionoverall.jpg, retrieved October 10, 2015)

The landscape design of two city halls—El Cerrito City Hall and Brisbane City Hall—are also the superior examples of stormwater treatment facilities. Rain gardens, or bioretention planters, along with bioswales provided at these two places significantly help collect and filter stormwater runoff from their building roofs and parking lots. Additionally, these stormwater facilities also function as the recreational spaces for their employees and visitors.

Figure 5.10 Bioretention planters at Leland Avenue (Picture source: http://www.vmwp.com/projects/leland-avenue-streetscape.php, retrieved October 10, 2015)

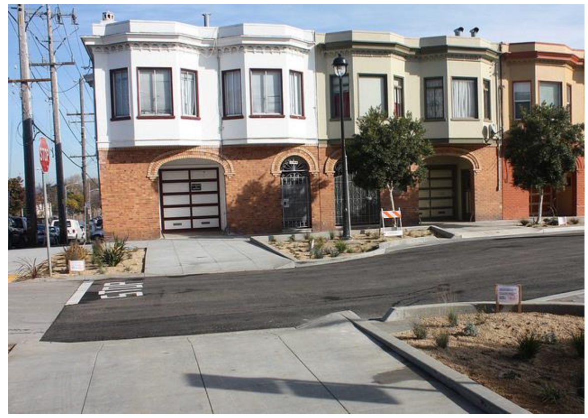


Figure 5.11 Bioretention planters at Newcomb Avenue (Picture source: http://sf.streetsblog.org/category/issues-campaigns/greenstreets-issues-campaigns-2/, retrieved October 10, 2015)

Streets and sidewalks are also valuable spaces in cities where stormwater control measures can be installed. Importantly, stormwater control measures are also mentioned as important streetscape elements in San Francisco Better Streets Plan—a guiding document for street improvement or redesign in order to serve not only the City's transportation needs, but also an array of social, cultural, recreational, and ecological needs. These stormwater control measures, which include permeable paving, infiltration facilities, bioretention planters, bioswales, and so on, can help reduce runoff volume and pollution entering the City's combined or separate stormwater systems. In addition to their stormwater management benefits, they can also help enhance the aesthetics of the streets and the City (San Francisco Planning Department 2010: v). Leland Avenue is the first streetscape redesign as part of San Francisco Better Streets program. Newcomb Avenue and Chesar Chavez Street are also pilot projects of street improvements providing stormwater management facilities. In the eastern side of the Bay, the installation of rain gardens on the sidewalks of San Pablo Avenue in El Cerrito was one of the first large-scale green infrastructure projects in the East Bay.

The long/lawn goodbye

Love your yard but hate the maintenance? EBMUD wants you to have the backyard of your dreams and we're willing to help you pay for it. EBMUD has $200,000 to give to customers who remove their lawns and replace them with a more sustainable landscape. Apply now to receive federal assistance for your landscape remodel and follow these steps to remove your lawn this summer in time for planting season this fall.

- First, schedule an appointment with an EBMUD water conservation technician. The technician will need to see your lawn (at least partially alive) in order to qualify you for the rebate of .50¢ per square foot. Email *waterconservation@ebmud.com* or call 866-403-2683 today to schedule your appointment.
- Once a technician has entered you into the rebate system, you are ready to remove your lawn. Stop watering. Then start digging a 3-inch-deep trench wherever your lawn meets a cement surface.
- Next, start the sheet mulching process to suppress weeds and grass and break down your lawn naturally. Cover the entire lawn with two layers of cardboard so the sun won't get through, making sure to pull the cardboard over the trench you've dug. Wet the cardboard, then add at least three inches of compost or mulch. The process could take up to six weeks.
- While you wait for the cardboard to do its job, take time to brainstorm landscaping options. EBMUD technicians have seen a myriad of conversion ideas transform run-of-the-mill grassy yards into beautiful, unique outdoor reprieves. EBMUD customers have created everything from herb and vegetable gardens to patios with wood-burning pizza ovens, to desert succulent gardens, to romantic wildflower beds.
- Get a copy of the EBMUD's award-winning "Plants and Landscapes for Summer-Dry Climates" book at *www.ebmud.com/about/publications* for inspiration on what to plant. Also, visit the "residential pollution prevention" link off the "Water & Wastewater" tab at *www.ebmud.com* for a guide on gardening supplements that steer away from fertilizers, herbicides and pesticides that are toxic.
- Come fall, you will be ready to introduce new plants and designs to your yard.

Get a discount on your mulch purchase today!
Download this mulch coupon at *www.ebmud.com/mulchme*.

Ways to pay

For your convenience, EBMUD offers various ways for you to pay your water bill.

To pay by credit, debit or e-check, either call 800-690-4798 or visit the "customers" tab at *www.ebmud.com*. Or, you can sign up to view and pay your bill online at *www.mycheckfree.com*.

EBMUD pay stations are located throughout the service area. While checks no longer are accepted at pay stations, some drop boxes will accept debit card payments. For more information on where to drop off your payment, visit the "customers" tab on *www.ebmud.com*. From there, follow the "ways to pay" link and download the list of pay stations and drop box locations.

EAST BAY MUNICIPAL UTILITY DISTRICT
P.O. Box 24055 • Oakland, CA 94623
1-866-40-EBMUD (1-866-403-2683)
www.ebmud.com

EBMUD Mission Statement
To manage the natural resources with which the District is entrusted; to provide reliable, high-quality water and wastewater services at fair and reasonable rates for the people of the East Bay; and to preserve and protect the environment for future generations.

Figure 5.12 The brochure explaining about the EBMUD's lawn goodbye campaign

Figure 5.13-14 Examples of planting and landscaping which can replace lawns (Picture source: https://www.ebmud.com/water-and-drought/conservation-and-rebates/watersmart-gardener/lawn-goodbye-landscape-gallery/, retrieved August 25, 2015)

Another interesting initiative is the EBMUD's lawn goodbye program. Through this program, EBMUD intends to encourage residents in its service area to remove their lawns and replace them with a more sustainable, water efficient landscape by offering a rebate. More specifically, the breakup of lawn can be eligible for "a rebate of .50 a square foot, and .25 more for drip irrigation" (EBMUD 2015b). EBMUD also offer a discount on the purchase of mulch used for letting the lawns go. Although this program aims to help save water for irrigating grass and other plants, several practices, particularly the installation of permeable pavements and rain gardens, also help absorb, retain, and filter stormwater runoff.

5.2.5 Public education and outreach

In compliance with the requirements of the NPDES stormwater program, the operators of regulated MS4s in the Bay Area must provide public education and outreach—one of the NPDES Phase II's six minimum control measures, to increase the knowledge of their citizens regarding the negative impacts of stormwater pollution and the effective solutions to alleviate them.

The Phase I medium and large MS4s—including those within Alameda Countywide Clean Water Program, Contra Costa Clean Water Program, San Mateo Countywide Water Pollution Prevention Program, Santa Clara Valley Urban Runoff Management Program, Fairfield-Suisun Urban Runoff Management Program, and Vallejo Sanitation and Flood Control District—are regulated under the NPDES Permit No.CAS612008 (Order R2-2009-0074) issued on October 14, 2009. According to this Permit, there are nine tasks recommended to be conducted by its permittees in order to provide public information and outreach. In particular, the permittees shall, as stated in the Permit,

> "… mark and maintain at least 80 percent of municipally-maintained storm drain inlets with an appropriate stormwater pollution prevention message, such as "No dumping, drains to Bay" or equivalent… participate in or contribute to advertising campaigns on trash/litter in waterways and pesticides with the goal of significantly increasing overall awareness of stormwater runoff pollution prevention messages and behavior changes in target audience… maximize use of free media/media coverage with the objective of significantly increasing the overall awareness of stormwater pollution prevention messages and associated behavior change in target audiences, and to achieve public goals… individually or collectively create and maintain a point of contact, e.g., phone number or website, to provide the public with information on watershed characteristics and stormwater pollution prevention alternatives… participate in and/or host events such as fairs, shows, workshops, (e.g., community events, street fairs, and farmers' markets), to reach a broad spectrum of the community with both general and specific stormwater runoff pollution prevention messages... individually or collectively encourage and support watershed stewardship collaborative efforts of community groups… individually or collectively, support citizen involvement events, which provide the opportunity for citizens

> to directly participate in water quality and aquatic habitat improvement… individually or collectively implement outreach activities designed to increase awareness of stormwater and/or watershed message(s) in school-age children (K through 12)… conduct outreach to municipal officials" (California Regional Water Quality Control Board 2009: 59-63).

For the Phase II small MS4s, they are regulated under the statewide General Permit No. CAS000004 (ORDER No. 2013-0001-DWQ) effective on July 1, 2013. According to this General Permit, all permittees shall conduct at least one of the four options within the first year of the effective date of the permit. These four options include:

> "1) Contributing to a countywide storm water program, as determined appropriate by the Permittee members, so that the countywide storm water program conducts outreach and education on behalf of its members; or 2) Contributing to a regional outreach and education collaborative effort (a regional outreach and education collaborative effort occurs when all or a majority of the Permittees collaborate to conduct regional outreach and education. Regional outreach and education collaboration includes Permittees defining a uniform and consistent message, deciding how best to communicate the message, and how to facilitate behavioral changes, then collaboratively apply what is learned through local jurisdiction groups, pooling resources and skills.); or 3) Fulfilling outreach and education requirements within their jurisdictional boundaries on their own; or 4) A combination of the previous options, so that all requirements are fulfilled" (State Water Resource Control Board 2013: 24).

In addition, this General Permit also states that the permittees shall develop and implement a comprehensive storm water public education and outreach program within the second year of the effective date of the permit. Particularly,

> "The public education and outreach program shall be designed to reduce pollutant discharges in storm water runoff and non-storm water discharges to the MS4 through increased storm water knowledge and awareness in target communities. The Public Education and Outreach Program shall be designed to measurably increase the knowledge and awareness of targeted audience regarding the municipal storm drain system, impacts of urban runoff and non-storm water discharges on receiving waters, and potential BMP solutions for the target audiences, thereby reducing pollutant releases to the MS4 and the environment" (State Water Resource Control Board 2013: 24).

Significantly, apart from complying with the requirements of the Permits, some MS4s operators in the Bay Area also conducted surveys in order to understand their citizens' baseline, and sometimes also their citizens' change of, knowledge, attitude, and behavior regarding stormwater management and related issues. One excellent example is the survey conducted for San Mateo Countywide Stormwater Pollution Prevention Program in 2001. Note that this survey followed a study conducted in 1996 which already generated some baseline attitudes of the county residents on issues relating to stormwater pollution so that, as the report stares, “The primary goal of the 2001 survey was to detect any changes in public perceptions over the past five years as a result of public education efforts undertaken by the County, as well as by other agencies concerned with stormwater pollution” (Fairbank, Maslin, Maullin & Associates 2001: 3). For this case, 400 adult residents of San Mateo County were randomly selected to participate in the telephone survey. Overall, the results revealed that the residents’ stormwater knowledge, attitude, and behavior did not dramatically and positively changed over the past five years. As one example, as the report summarizes, “While county residents continue to rate “chemical waste from factories” as the most serious threat to the county’s waterways, residents see “individuals dumping pollutants into storm drains” as somewhat less of a serious problem than was the case in 1996. In 1996, 54 percent of those polled viewed such dumping by individuals as a “very serious threat” to county waterways, a proportion which fell to 37 percent in this year’s survey” (Fairbank, Maslin, Maullin & Associates 2001: 4). In 2009, another survey of San Mateo County residents’ attitudes toward stormwater pollution was conducted for the San Mateo County Environmental Health Services Division. Again, 400 adult residents of San Mateo County were randomly selected to participate in the telephone survey. The results revealed that the county’s residents had somewhat better understanding and awareness of issues related to stormwater pollution, compared to the results of the 2001 survey. Nonetheless, it appeared that some the 2001 and 2009 results are not dramatically different from each other. For example, as the report concludes, “Just over half the respondents know water from storm drains flows directly to the Bay, Ocean or creeks. 20% believe this water is treated first. Results were very similar to the 2001 responses” (SA Opinion Research 2009: 14).

Apart from a series of attitude surveys conducted in San Mateo County, the one of Contra Costa County is also an exemplar. According to Contra Costa Clear Water Program (2015), “As part of National Pollutant Discharge Elimination System (NPDES) Permit requirements, the Contra Costa Clean Water Program conducts an annual survey to measure changes in public awareness and actions. The survey measures public attitudes, perceptions, and behaviors that would be helpful to the Clean Water Program in the continuing development and implementation of outreach efforts.” The survey that established a baseline measurement of public attitudes and behaviors towards stormwater issues in Contra Costa County was conducted in 2000. Following the 2000 study, several surveys were conducted in order to measure changes in this regard. The results from these surveys revealed that Contra Costa County residents’ awareness of water pollution issue has been increased over time. As the 2007 survey reveals, “When asked about the most serious environmental problems facing Contra Costa County, Air Pollution (32%) was perceived as the most serious problem for the past four years in a row and a slight increase from 2006 (29%). Following in second place is Water Pollution at 26% of the total responses. This is an improvement for 2006 in which Transportation was 24% of total responses and in second place. These findings show that there were some changes in the perceptions of the most serious environmental issues” ASTONE (2007: 12). And in the next years survey, water pollution issue came the first. As the 2008 survey points out, “The environmental problems considered most serious in Contra Costa County were Water Pollution, Growth, Transportation, Climate Change and Air Pollution respectively. This differs significantly in ranking from the 2007 in which residents ranked the issues as follows; Air Pollution, Water

Pollution, Transportation, Growth and Open Space respectively" ASTONE (2008: 5). In addition to conducting telephone interviews, Contra Costa Clean Water Program also conducted four focus groups in 2009. Forty-eight Contra Costa County residents were recruited to be participants, but thirty-nine of them actually participated. The aim of conducting these focus groups was "to better understand local residents' knowledge and understanding of the storm drain system, the effects of street litter on our waterways; and plastic bag bans" (Nichols and Lopez 2009: 3). Importantly, "Insights from the research will be used to inform the public outreach campaign for residents" (Nichols and Lopez 2009: 3). The results from these focus groups revealed that water pollution and conservation was the first issue the participants mentioned when they were asked about the main environmental issues facing Contra Costa County (Nichols and Lopez 2009: 9). Importantly, these participants also thought that education is necessary and also a key to promoting and motivating appropriate attitudes and behaviors related to water pollution prevention and water conservation (Nichols and Lopez 2009: 9).

In the City and County of San Francisco, the educational merit of stormwater management facilities is also a part of a multi-purpose design strategy recommended in its Stormwater Design Guidelines. In particular, the Guidelines proposes that LID facilities in urban settings should not only provide stormwater management functions, but should also provide other benefits including educational opportunity for people. According to the Guidelines,

> "LID can also be a useful tool for environmental education when it is integrated into school curricula, public outreach, or interpretive signs. LID concepts can be presented at many different levels of complexity, from an introduction to watersheds to an explanation of the hydrologic cycle and environmental stewardship. LID concepts touch upon numerous disciplines, including biology, ecology, watershed planning, engineering, design, and resource management" (City of San Francisco, San Francisco Public Utilities Commission, and Port of San Francisco 2009: 35).

The Guidelines call out the EcoCenter at Heron's Head Park. The living roof and rain water harvesting at the Center provide inspirational, educational experiences for visitors. Rainwater that falls on the roof of the Center is absorbed by the living roof and harvested by cisterns for supplying the living roof and surrounding landscapes (EcoCenter at Heron's Head Park 2015).

Figure 5.15 The Eco-Center at Heron's Head Park (Picture source: http://www.baycrossings.com/dispnews.php?id=2703, retrieved October 6, 2015)

Other than the efforts conducted in relation to the regulatory requirements or recommendations described above, several agencies provide specific learning opportunities and educational programs with the aim of advancing public knowledge and understanding about issues related to stormwater pollution and management. The Living Roof at the California Academy of Science is regarded as an outdoor classroom. Interpretive signs, educational activities, and tour programs offer visitors a variety of opportunities to experience the natural world—"From stargazing and eclipse watches to close investigations of the much-smaller world of bees," as California Academy of Science (2015b) states.

The SFPUC Headquarters also provides opportunities for visitors to take tour—whether a scheduled tour or a self-guided tour—in order to learn about sustainable practices implemented in the building. Interestingly, there is also a massive, interactive panoramic video wall installed at the lobby of the SFPUC Headquarters to provide educational information about water management and conservation to visitors.

Figure 5.16-5.17 The Living Roof at the California Academy of Science—an outdoor classroom, providing a variety of interpretive signs, educational activities, and tour programs for visitors to learn about stormwater management and other issues related to the natural world (Picture source: http://landscapevoice.com/california-academy-of-sciences-green-roof/, retrieved October 5, 2015)

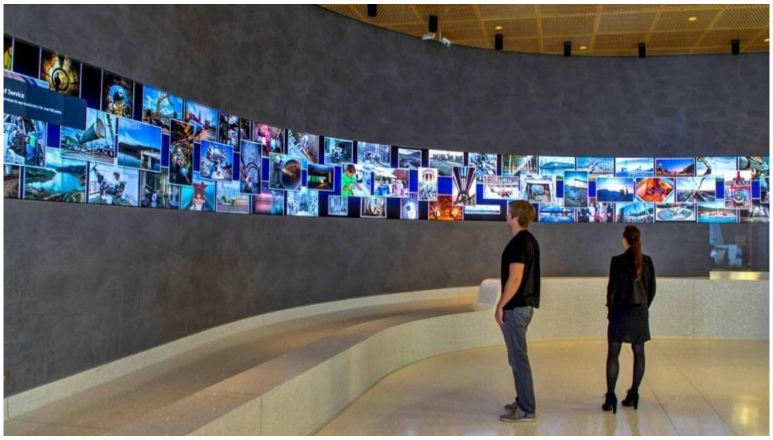


Figure 5.18 The interactive panoramic video wall installed at the lobby of the SFPUC Headquarters (Picture source: http://screenmediadaily.com/massive-interactive-video-wall-installed-at-sf-public-utilities-commission/, retrieved October 6, 2015)

Likewise, the interpretive signs about the functions and benefits of rain gardens installed at Brisbane City Hall and San Pablo Avenue in El Cerrito provide clear and easily understood educational opportunities to a wide range of people.

EBMUD is another water agency in the Bay Area realizing the importance of providing education. EBMUD's outdoor classrooms offer children experiences that help them better understand the issues regarding water ecosystems and also other related environmental issues (EBMUD 2015c). Furthermore, EBMUD also offers other educational resources for schools, colleges, and universities. The prominent ones are comic books for students to learn about issues regarding water pollution prevention along with the guides for teachers which are available for free to teachers in the EBMUD service area (EBMUD 2015d).

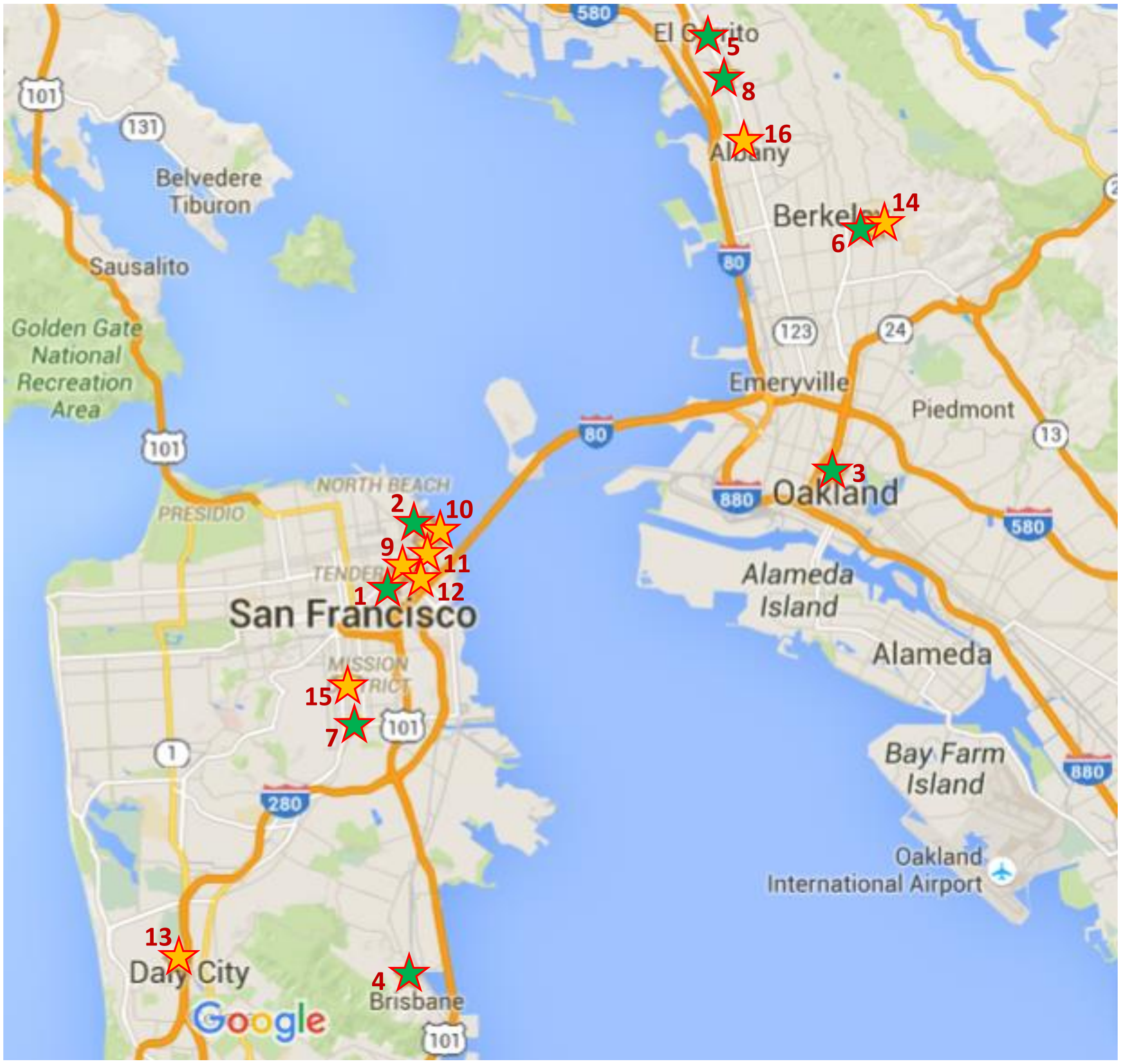
Figure 5.19 Examples of EBMUD's comic books for students (Picture source: https://www.ebmud.com/store/classroom-products/, retrieved August 25, 2015)

5.3 Study sites

Through an extensive literature review and field surveys, eight projects, which demonstrate a range of LID designs, were selected as the test sites for this dissertation. In addition to the LID projects, eight places representing different design characteristics of urban landscapes were also selected as the control sites.

The study sites are classified into four types—1) city and community open spaces, 2) city hall landscapes, 3) university open spaces, and streets and sidewalks. Each of which includes test and control sites, or LID and non-LID sites, which are selected to match up each other in order to allow the comparison and exploration of the differences between their users' attitudes toward them. More specifically, each pair or group of test and control sites are selected based on the criteria that they are comparable whether in terms of size, location, function, design components, and users, yet different regarding whether they implemented the LID design or not.

For the first type—city and community open spaces, Mint Plaza and Jessie Square are selected as test and control sites. In addition, two more LID projects and three additional non-LID places are also selected in order to allow further exploration of landscape attributes which are significant or meaningful to the respondents' attitudes toward the landscapes. The two additional LID sites are Davis Court and Fox Square because they hold some more distinctive design characteristics than Mint Plaza; Davis Court has a water feature and a more orderly look, while Fox square contains more curvilinear forms and weedy plants. The three added control sites—Justin Herman Plaza, S.D. Bechtel Plaza, and Yerba Buena Gardens—represent a myriad of conventional urban landscapes in the region. These three sites and Jessie Square provide a set of different aspects and elements of landscape design from the LID sites. Specifically, the presence of lawns, big trees and colorful shrubs, water features, and vast pavement areas, for example, in these four sites is considered central to the exploration of the landscape attributes which are significant or meaningful to the respondents' attitudes toward them.



Test Sites (LID Sites)

1) Mint Plaza, San Francisco
2) Davis Court, San Francisco
3) Fox Square, Oakland
4) Brisbane City Hall, Brisbane
5) El Cerrito City Hall, ElCerrito
6) New Sproul Plaza, Berkeley
7) Cesar Chavez Green Street, San Francisco
8) San Pablo Green Street, El Cerrito

Control Sites (Non-LID Sites)

9) Jessie Square, San Francisco
10) Justin Herman Plaza, San Francisco
11) S.D. Bechtel Plaza, San Francisco
12) Yerba Buena Gardens, San Francisco
13) Daly City Civic Center, Daly City
14) Sproul Plaza, Berkeley
15) Valencia Street, San Francisco
16) San Pablo Avenue, Albany

Figure 5.20 Graphic locations of the study sites
(Source of base map: https://www.google.com/maps, retrieved October 5, 2015)

Table 5.1 List of the selected study sites

Landscape types	Control sites Non-LID	Test sites LID	Test sites LID with Signage
1. City and Community Open Spaces	Jessie Square	Mint Plaza	
	Justin Herman Plaza S.D. Bechtel Plaza Yerba Buena Gardens	David Court Fox Square	
2. City Hall Landscapes	Daly City Civic Center	El Cerrito City Hall	Brisbane City Hall
3. University Open Spaces	Upper Sproul Plaza	New Lower Sproul Plaza	
4. Streets and Sidewalks	Valencia St.	Cesar Chavez St.	
	San Pablo Ave. (Albany)		San Pablo Ave. (El Cerrito)

The sixteen study sites are listed in table 5.1 whereas their locations are presented in figure 5.19. The basic information of each selected sites is provided below.

Considering the city hall landscapes, the Daly City Civic Center is selected as control site while two places—Brisbane City Hall and El Cerrito City Hall—are to be the test sites as the former one provides interpretive signage whereas the latter does not. For the open spaces of the university, the Upper Sproul Plaza and the New Lower Sproul Plaza of the University of California at Berkeley are selected as control and test sites, respectively. For the streets and sidewalks, two pairs of control and test sites are picked. One is Valencia Street and Cesar Chavez Street in San Francisco. The other is the two sections of San Pablo Avenue in the East Bay—one is in Albany and another one is in El Cerrito.

5.3.1 Test sites (sites with LID design)

1) Mint Plaza, San Francisco

The award-wining design of Mint Plaza, located on the 5th Street in the City of San Francisco, is now one of the brilliant urban places of the city. In addition to offering a vibrant open space for people, Mint Plaza also provides stormwater control measures for the City. The major stormwater management features in Mint Plaza are the two rain gardens and the underground distribution system, which help retain and filter runoff from the Plaza's 20,000 square feet surface and, therefore, help protect the ecological health of the San Francisco Bay (Mint Plaza 2015).

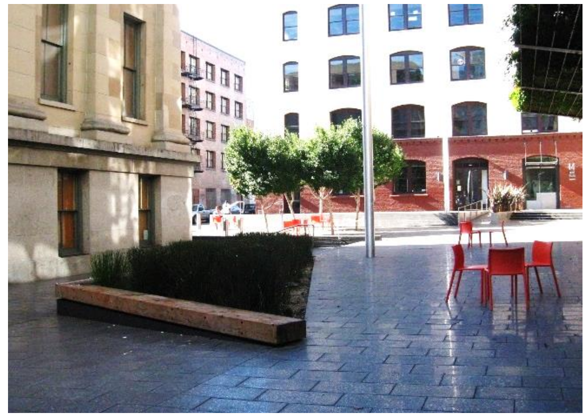


Figure 5.21-5.22 The two rain gardens at Mint Plaza

2) Davis Court, San Francisco

In addition to creating a more friendly space for both pedestrians and vehicles, the purpose of the design of Davis Court was to create a unique stormwater collection, conveyance, treatment, and groundwater infiltration system. Runoff from the stone paved plaza is drained to the bioretention planters located along both sides of the plaza, where it is treated and allowed to infiltrate into the soil beneath the site (Sherwood Design Engineers 2015). The stainless steel sculpture located at one end of Davis Court is another interesting site feature. At the central void of this sculpture, mist sometimes emerges and then disappears, making it attractive to visitors and passersby.

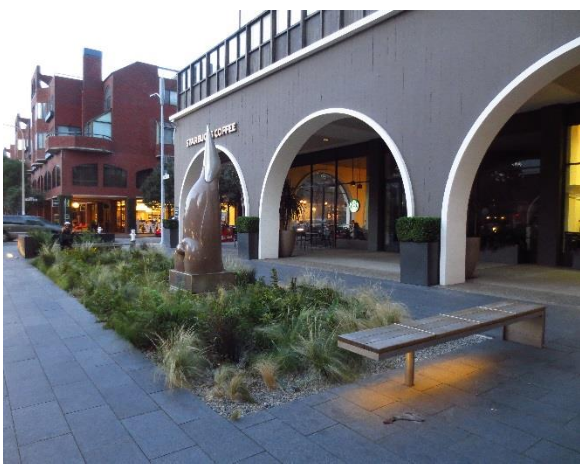


Figure 5.23 Bioretention planter and bench at Davis Court

Figure 5.24 The water sculpture located at one end of Davis Court

3) Fox Square, Oakland

Fox Square, also known as the Henry J. Kaiser Memorial Park where the Remember Them: Champions for Humanity Monument was installed in 2011, contains an outdoor area with abundant seating along with a children's playground with vibrant playing equipment. In addition, a large, curve-shaped bioswale runs through the Square in order to function as a site's stormwater control feature. The bioswale captures, retains, absorbs, and treats stormwater runoff from hard surfaces of the Square. Besides, this stormwater management feature is also considered an interesting and attractive asset to the site (ASLA 2015a).

Figure 5.25-5.26 The bioswale at Fox Square

4) Brisbane City Hall, Brisbane

The parking lot redesign at Brisbane City Hall obviously demonstrates best practices of sustainable stormwater management. The project transformed an awful paved parking lot to an attractive landscaped parking space with a large bioretention basin or rain garden. Stormwater runoff from the parking area as well as the roof of the building is drained to this rain garden where it is filtered and allowed to soak into the soil. The interpretative signage installed at the rain garden plays a vital part in informing visitors of the stormwater management function of the rain garden (ASLA 2015b).

Figure 5.27 Rain garden or bioretention basin at Brisbane City Hall

Figure 5.28 Interpretive signage at Brisbane City Hall

5) El Cerrito City Hall, El Cerrito

At the entrance plaza and the parking space of El Cerrito City Hall, well-designed stormwater control features—particularly bioretention basins and bioswales—are provided to help lessen the impact of the site's runoff on the municipal drainage systems, nearby creeks, and the Bay (ASLA 2015c). The design of the entrance plaza also offers a highly aesthetic space for community and civic events as well as educational opportunities. Additionally, the runnel installed at the entrance plaza is considered a water feature that makes the place attractive to its workers and visitors.

Figure 5.29 A runnel at the entrance plaza of El Cerrito City Hall

Figure 5.30 A bioswale at the parking area of El Cerrito City Hall

6) New Lower Sproul Plaza, Berkeley

As part of the redevelopment of Lower Sproul Plaza in UC Berkeley, a large rain garden was installed at the west end of Cesar Chavez Student Center. This rain garden helps protect ecological health of Strawberry Creek as rainwater from its nearby hard surfaces is collected and treated in this rain garden before entering the Creek (University of California, Berkeley 2015). Over the rain garden, a wooden boardwalk was provided as a pathway in order to allow people to walk across it and experience it closely.

Figure 5.31 A rain garden located next to Cesar Chavez Student Center

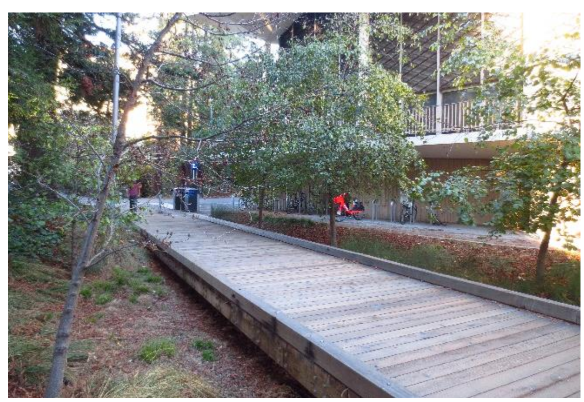


Figure 5.32 A wooden boardwalk laying over the rain garden

7) Cesar Chavez Green Street, San Francisco

As part of Cesar Chavez Streetscape Improvement Project, a number of bioretention planters were installed along Cesar Chavez Street. Stormwater runoff from the street and its sidewalk is drained to these planters in order to be naturally absorbed and filtered by soils and plants (SFPUC 2015b). These planters function as stormwater management facilities which help reduce stress on drainage systems of the City of San Francisco. In addition, they also help reduce impact of stormwater runoff on the water quality of the Bay.

Figure 5.33-5.34 Bioretention planters at Cesar Chavez Green Street

8) San Pablo Green Street, El Cerrito

San Pablo Avenue is one of major transportation corridors in El Cerrito City. At some sections of this street, a number of bioretention planters or rain gardens were installed as part of the El Cerrito Green Streets Pilot Project. This pilot aimed not only to promote sustainable stormwater management approach, but also to promote the public's awareness of stormwater pollution (San Francisco Estuary Partnership 2012: 5). Thus, interpretive signage was also provided at the site to inform visitors and passersby about the functions and benefits of the rain gardens.

Figure 5.35 Bioretention planters at San Pablo Avenue in El Cerrito

Figure 5.36 Interpretive signage at San Pablo Green Street in El Cerrito

5.3.2 Control sites (sites without LID design)

1) Jessie Square, San Francisco

Jessie Square is an urban plaza located just adjacent to St. Patrick's Church and the Contemporary Jewish Museum and just across from Yerba Buena Gardens in San Francisco. The design of this plaza includes water, grass, and planting to create an inviting public space for visitors and passersby. The gradual slope of this plaza becomes a step-free pathway which perfectly connects the Contemporary Jewish Museum with the sidewalk of Mission Street. In the plaza, several wood benches are also provided to serve as seating elements and also as aesthetic features.

Figure 5.37 Green lawns at Jessie Square

Figure 5.38 The pond at Jessie Square

2) Justin Herman Plaza, San Francisco

Located at the eastern end of Market Street, Justin Herman Plaza is one of the main open spaces in San Francisco. The large paved area of this plaza offers a flexible space for a wide range of activities, while the green grassy area and the palm trees at its edge make the plaza more pleasant to those who visit it. he open aspect of this plaza also offers a spectacular view of the Ferry Building tower. The Vaillancourt Fountain, a huge precast concrete sculpture, located at the northern side of the plaza is also an exceptionally outstanding element in Justin Herman Plaza.

Figure 5.39 A large, flexible, open, paved area of Justin Herman Plaza

Figure 5.40 The Vaillancourt Fountain at Justin Herman Plaza

3) S.D. Bechtel Plaza, San Francisco

S.D. Bechtel Plaza is a semi-public plaza located on Beale Street in the financial district of San Francisco. Enclosed by raised planters and trees, the plaza is very peaceful and pleasant, offering a lunchtime place for office workers and passersby. Inside the plaza, there exists an approximately-60-feet-long railroad car which was once home to the Bechtel family at remote construction sites. This restored vintage railroad car is now the WaaTeeKaa Bechtel Museum exhibiting the story about the legacy of the Bechtel family and company.

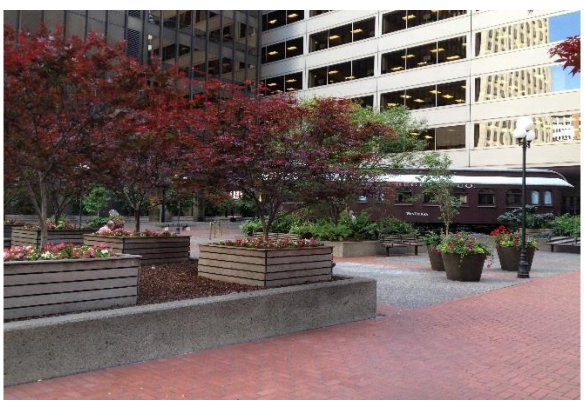


Figure 5.41 Varieties of planters and plants at S.D. Bechtel Plaza

Figure 5.42 WaaTeeKaa Bechtel Museum in S.D. Bechtel Plaza

4) Yerba Buena Gardens, San Francisco

Yerba Buena Gardens is one of the renowned green open spaces in San Francisco. For both residents and tourists, a vast green lawn at Yerba Buena Gardens offers an exceptionally pleasant place to relax and enjoy sunlight. In addition, a number of big trees inside the area also offer abundant shady alternatives. The gigantic wall of cascading water along with the reflecting pool located at the south eastern side of the site is another iconic and attractive element. This waterfall creates roaring noise which blocks out the sounds of the city, offering a relaxing and peaceful ambience for its users.

Figure 5.43 The lawn and water fountain at Yerba Buena Gardens

Figure 5.44 The green open space of Yerba Buena Gardens

5) Daly City Civic Center, Daly City

The landscape surrounding the Daly City Civic Center looks very neat, well-maintained, and beautiful. The green grassy areas offers nice open spaces around the building. The big trees help make the place even more green and pleasant for both workers and visitors. Trenches, gutter, and storm drains are well installed everywhere, including in the parking lots, in order to conventionally manage the site's runoff—the runoff is drained through the site's underground pipe systems and then to the City's stormwater drainage systems.

Figure 5.45 The large lawn surrounding the Daly City Civic Center building

Figure 5.46 The conventional-designed planters at the parking area of Daly City Civic Center

6) Upper Sproul Plaza, Berkeley

The Upper Sproul Plaza, located to the west of Sproul Hall, is one major open space of the University of California, Berkeley. This large paved plaza functions as a year-round meeting, gathering, and relaxing place for students. The stairway along with the sloped, grassy areas in front of Sproul Hall is also a very popular place for the students. The prominent attribute of this plaza is the double-row corridor of the London Plane trees, running from Sather Gate to the north to Bancroft Way to the south. At the middle of the plaza, there is a water fountain, Ludwig's Fountain, which is another iconic element of the plaza and the campus.

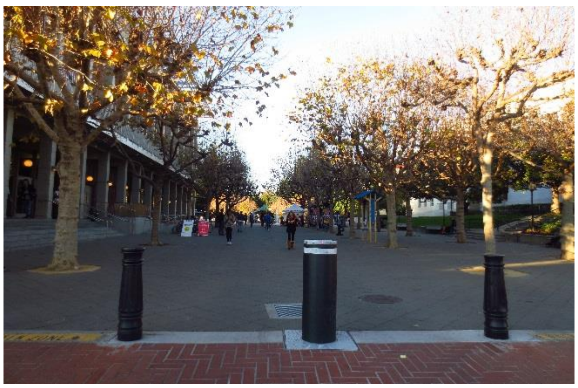


Figure 5.47 The rows of London Plane trees at the Upper Sproul Plaza

Figure 5.48 The Ludwig's Fountain at the Upper Sproul Plaza

7) Valencia Street, San Francisco

Valencia Street is situated in Mission District of San Francisco. Over recent years, this street has been transformed from a forbidding area filled with auto repair shops to a fashionable area filled with trendy shops and restaurants. Even though its typical-designed street and sidewalk look is un-extraordinary, the street’s parklets, which extend sidewalk to provide vibrant spaces for pedestrians, are considered very attractive.

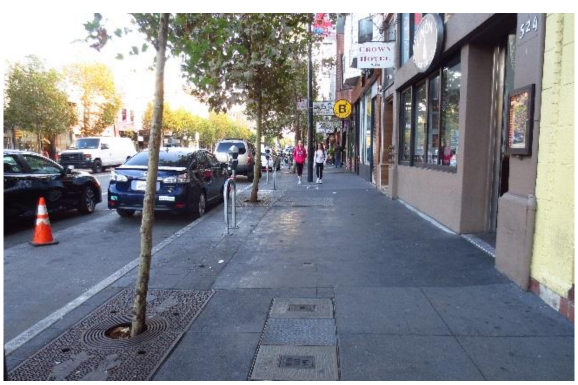


Figure 5.49 The typical-designed sidewalk at Valencia Street

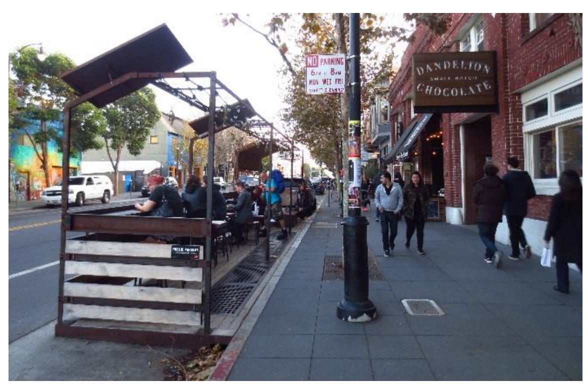


Figure 5.50 One of the parklets installed at Valencia Street

8) San Pablo Avenue, Albany

In the eastern side of the Bay, San Pablo Avenue is a major north–south street running along through many cities including Oakland, Emeryville, Berkeley, Albany, El Cerrito and Richmond. Generally, the street as well as its sidewalk looks very typical of the state highway in the United States; only some sections of the street have special design aspects. For this section in Albany, there is no distinctive design aspects.

Figure 5.51 The median strip at San Pablo Avenue in Albany

Figure 5.52 The pedestrian sidewalk of San Pablo Avenue in Albany

Chapter 6
Survey Procedures for Data Collection

6.1 Questionnaire survey

For the case of this dissertation, the classic paper questionnaire is selected as a survey instrument and the hybrid of several data collection techniques is framed. This is because this research focuses on respondents' opinions which are specific to the sites so that it is important that the respondents are recruited at the sites to ensure that they all have ever had direct, actual experience with the sites. Accordingly, the other advanced technological methods such as phone calls or online instruments are almost impossible.

In addition, based on preliminary field observations, users of the urban sustainable stormwater management or LID facilities generally do not spend a long time in the sites—the majority of them are pedestrians or passersby. Thus, a paper questionnaire is considered an appropriate instrument and personal street intercept is considered the most plausible and suitable data collection technique for this case.

Notably, asking people to spend time concentrating on responses to a bunch of questions is very difficult. Accordingly, the dissertation employs a hybrid technique. More specifically, those who are not able to complete the surveys at the sites received a questionnaire along with a stamped envelope in order to returning the completed form.

6.2 Pilot studies

In preparation to conduct this dissertation research, two preliminary research projects explored stormwater attitudes and knowledge held by the public in San Francisco Bay Area. Importantly, they also aimed to test the methods and instruments of the dissertation.

The first project is *Public Appreciation and Recognition of Sustainable Stormwater Management: A Comparative Study of Mint Plaza and Jessie Square in San Francisco.*[1] The aim of this project was to examine people's perception of sustainable stormwater management design in urban landscapes. The specific research question was whether people appreciate and recognize LID design in the urban plazas of San Francisco, and what visual clues can make people appreciate and recognize this kind of landscape design. Mint Plaza and Jessie Square were selected to be the test sites for this study because they are located close to each other and the former was designed by implementing sustainable stormwater management practice while the latter was not. The site survey, which included measuring the sites' physical conditions, observing users' behaviors, and also interviewing users were conducted in order to provide some basic insights. Then, the survey form was created. It was

[1] This research was conducted by Wilasinee Suksawang and Amna Alruheili as a part of LA241, Research Methods in Environmental Design, class (Fall 2012).

a two-page survey which fits into a sheet of letter-size paper, see appendix C. The first page consisted of questions about familiarity, appreciation, and opinions about the design performance in dealing with heavy rain, while the second page consisted of rating questions of the six landscape elements—tank, grass, pavers, trench, planter, and pond—for dealing with heavy rain. Respondents were asked to rate these strategies in term of their desirability and the effectiveness of each strategy in dealing with heavy rain. Street survey was conducted to get 60 responses—30 from Mint Plaza and 30 from Jessie Square. Some respondents completed the survey by themselves while some asked the researchers to fill it out based on the information provided by them. The research results revealed that the LID design of Mint Plaza was unlikely to attain people's appreciation of its aesthetics and recognition of its functions, compared to the non-LID design of Jessie Square. This finding also tended to support the research hypothesis that sustainable stormwater management design falls short of enhancing people's appreciation of its aesthetics and recognition of its functions. In addition, the results also showed that grass, pavers, planters, and ponds were both desirable and perceived as effective elements for managing urban stormwater. For trenches, the study found a controversy as a trench was unlikely to be a desirable element, but it was perceived as an effective element for stormwater management. Not surprisingly, tanks received the lowest score in terms of both desirability and perceived storm water management effectiveness. These research findings provide initial information and insight regarding visual clues that professionals can use to enhance people's appreciation and recognition of sustainable stormwater management in the public urban open spaces of San Francisco, and other cities.

The second pilot study is *Knowledge-Based Landscape Perception: Does Knowledge Affect Perception of Sustainable Stormwater Management Design?*[2] This project aimed to examine the relationship between knowledge of sustainable stormwater management and attitudes toward this kind of effort. The questionnaire form was created and used for data collection. This form comprised three parts, see Appendix D. In the first part, questions collected demographic data of the respondents. The second part was designed to be tool for classifying respondents into different groups based on their knowledge of sustainable stormwater management. In particular, fourteen topics related to sustainable stormwater management were listed in order to ask the respondents to indicate whether they have any knowledge on each of these topics. In the last part, eight examples of urban stormwater management elements—water tank/ cistern, lawn/ grass, pavers, planter, pool/ pond, swale, paving surface, and trench/ gutter—were listed in order to ask respondents to rate them in terms of their attractiveness, sustainability, and recognizability by using seven-point attitude scales. Sixty-four participants voluntarily filled out questionnaires. Half of them were students in LA130 class, which covered issues on sustainable stormwater management, and another half of them were students in PSY101 class, which did not address any issue on that topic. The results revealed that participants from the two classes had significantly different levels of knowledge of sustainable stormwater management. In addition, after reclassifying all participants into three groups based on their knowledge on sustainable stormwater

[2] This research was conducted by Wilasinee Suksawang as a part of PSY101, Research and Data Analysis in Psychology, class (Summer 2013).

management—low, medium and high level of knowledge, the findings tended to support the research hypothesis that people with different levels of knowledge of sustainable stormwater management have different perceptual attitudes and opinions towards stormwater management design elements.

6.3 Survey instrument and questionnaire pretests

The dissertation survey instrument consists of eight parts and contains a combination of different types of questions—particularly open-ended, close-ended, rating scale (attitude scale), and photographic elucidation—for extracting information from each respondent. The main ideas of questions in each part are presented below.

- *Part I: Relationship with and appreciation of the site*

This part is composed of three close-ended questions aiming to examine the relationship, in terms of familiarity, between respondents and the site. These three questions are length of time knowing the site, frequency of visiting the site, and purpose of visiting the site. In addition to these three questions, this part also contains a question asking respondents to rate their appreciation in terms of aesthetic attractiveness, functional efficiency, and ecological performance of the site by using a 5-point attitude scale.

- *Part II: Conception of ecological problems and ecological landscapes*

In this part, the respondents are asked to indicate the extent to which they are concerned about each of the seven ecological problems in San Francisco Bay Area by using a 5-point attitude scale. The main purpose of this part is to examine if the water pollution and water shortage receive less concern from the public, compared to the other environmental problems such as global warming, sea level rise, air pollution, energy shortage, waste management, soil contamination, and wildlife habitat degradation. Moreover, the respondents are also asked to specify the place(s) that hold ecological benefits in order to investigate if the LID facilities are mentioned as places holding ecological benefits, compared to those with other prominent benefits such as national parks, nature reserves, and wildlife habitats, for example.

- *Part III: Conception of water pollution and sustainable stormwater management*

In this part, the respondents are asked to indicate the extent to which they think that each of the possible sources has impact on water pollution in the Bay Area by using a 5-point attitude scale. The main purpose of this part is to examine if runoff is perceived as having less impact, compared to discharge from industrial uses and from waste treatment plants. In addition, this part also asks the respondents to specify the sustainable ways to manage urban stormwater in order to explore their conception of sustainable stormwater management. Furthermore, aiming to investigate if the respondents are knowledgeable about LID facilities, they are asked to specify the place(s) that implement sustainable stormwater management.

- *Part IV: Perception of Sustainable Stormwater management*

This part asks the respondents to rate the extent to which the landscape design of each site is sustainable in terms of stormwater management by using a 5-point attitude scale. The key objective of this question is to test whether the LID and non-LID design have the same rating, based on people's perception, of their sustainable stormwater management performance. Moreover, the respondents are also asked to specify the landscape features in each site which help manage urban stormwater in a sustainable way. The answers of this question are useful to the exploration of landscape cues that help people recognize the sustainable stormwater management efforts.

- *Part V: Experience and knowledge of Sustainable Stormwater management*

The first question in this part asks the respondents to indicate if they have ever learned or received any information about sustainable stormwater management. And if so, they are also asked to identify how or where they have learned or received the information about this particular topic. Likewise, the second question asks the respondents if they have participated any programs about sustainable stormwater management. And if so, they are also asked to specify the program(s) which they had participated. For the third question, twenty-five topics are listed in order to ask the respondents to indicate the extent to which they think they are knowledgeable about these topics by using a 5-point attitude scale. The main purpose of this question is to examine if the respondents hold limited knowledge and understanding about sustainable stormwater management.

- *Part VI: Interest in learning more about Sustainable Stormwater management*

In this part, the respondents are asked to indicate the extent to which they are interested in learning more about sustainable stormwater management. Moreover, the respondents are also asked to indicate the extent to which they are likely to do any of the learning options in order to learn more about sustainable stormwater management. A 5-point attitude scale is used in this part as well.

- *Part VII: Evaluation of landscape elements' performances*

The aim of this part is to explore how people think about the performances of the landscape elements. In the part, the respondents are asked to rate twelve landscape elements regarding their four performances—including attractiveness (to what extent you think that the element is aesthetically attractive), effectiveness (to what extent you think that the element is effective in terms of stormwater management), sustainability (to what extent you think that the element is sustainable in terms of stormwater management), and recognizability (to what extent you recognize the stormwater management function of the element). The twelve landscape elements include 1) water tank/ cistern, 2) lawn/ grass/ turf, 3) pavers, 4) paving surface, 5) bioretention planter or rain garden, 6) bioswale or vegetated swale, 7) trench, gutter or storm drain, 8) green street, 9) green roof, 10) green wall, 11) pool or pond, and 12) constructed wetland. It should be noted that the term "pavers" is intended to denote the permeable surface while the term "paving surface" implies the impermeable pavement. In addition to the terminologies, the 1"x1.5" color thumbnails are also provided in the questionnaire as representative images of the tested elements, to help the respondents have better ideas regarding the physical aspects of each element.

- *Part VIII: Respondent's personal demographics*

In the last part of the questionnaire, five questions are listed to collect information related to respondents' demographics. These questions ask each respondent to indicate his or her basic demographic information which include gender, age, educational attainment, educational field, and occupational field.

During the development of the questionnaire, several colleagues, friends, neighbors, and relatives of the researcher, of diverse ages, educational levels, study fields, and occupations, were asked to fill out and give comments to the drafts. Then, the final draft was pretested at five study sites—Sproul Plaza, Justin Herman Plaza, Mint Plaza, Jessie Square, and Yerba Buena Park. Five people in each pretest site, a total of twenty-five people, were selected to fill out and give comments to this draft. After scrutinizing the pretest results, some words and pictures were changed in order to be easily understood by the public. The final version to be used as instrument for collecting data is presented in appendix B.

6.4 Sampling method and sample size

Collecting data from a sample that represents the population is considered significant to any research. Samples can be classified into two types—random sample and convenience sample. According to Nolan and Heinzen (2012: 103), "A random sample is one in which every member of the population has an equal chance of being selected into the study. A convenience sample is one that uses participants who are readily available." Even though to get data from random samples is the ideal, as Nolan and Heinzen (2012: 104) noted, "Random samples are almost never used in the social sciences because we almost never have access to the whole population from which to select our sample… In the behavioral science, we are often unable to identify the entire population of interest." In view of that fact, respondents of this research will be selected from users or visitors of each study site.

Apart from the sampling method, sample size is also a crucial issue. Based on the central limit theorem, a sample size of at least 30 approximates the normal distribution, which is one key assumption of many parametric tests (Nolan and Heinzen 2012: 174). Thus, many researchers have long regarded a sample size of at least 30 as a rule of thumb. In addition to the central limit theorem that suggests the magic number of 30, several statistical studies have also demonstrated that the sample size of greater than 25 or 30 is enough to generate valid statistics for environmental studies. The prominent study by Arthur E. Stamps (1992: 220-222) found that about 25 to 30 respondents could produce statistically effective rating data. In consideration of these statistical rationales for selecting sample size, 30 is determined as the minimum number of responses to be collected from each site for this dissertation. Note that based on the response rates of several previous questionnaire surveys, only around 25-35% of the distributed questionnaires would be successfully completed and returned. As a result, in order to get enough data, approximately 80-100 survey forms will be distributed with the expectation for the return of at least 30 completed responses for each site.

6.5 Survey distribution and response

During summer and fall of 2014, the distribution of questionnaires was conducted. In particular, after receiving the notice of approval for human research (see appendix A) on June 3, 2014, the survey distribution process began on June 5, 2014. Generally, street intercept method was employed. Users or visitors presenting themselves at the sites were approached in a friendly manner and asked to participate the research by the researcher. Surprisingly, approximately 80 percent of people who were approached accepted. The majority of them preferred the option of sending the completed questionnaire back to the researcher. For the case of the three city halls, some of the questionnaires were distributed to their employees and visitors with the generous help of staff of each place.

Table 6.1 Survey distribution and response rate

Study Site	Number of Distributed Surveys				Number of Returned Surveys				Response Rate (%)
	1st Try	2nd Try	3rd Try	Total	1st Try	2nd Try	3rd Try	Total	
1. Mint Plaza	50	40		90	19	12		31	34.44
2. Davis Court	55	39		94	19	14		33	35.11
3. Fox Square	50	45	1	96	14	15	1	30	31.25
4. Brisbane City	50	35		85	18	13		31	36.47
5. El Cerrito City	50	35		85	24	12		36	42.35
6. New Sproul	60	29		89	14	16		30	33.71
7. Cesar Chavez	50	45		95	11	20		31	32.63
8. San Pablo (El)	60	30		90	21	13		34	37.78
9. Jessie Square	60	30		90	20	12		32	35.56
10. Justin Herman	60	25	3	88	19	8	3	30	34.09
11. S.D. Bechtel	60	35		95	16	15		31	32.63
12.Yerba Buena	60	30	2	92	19	9	2	30	32.61
13. Daly City	78			78	20	11		31	39.74
14. Sproul Plaza	50	30	6	86	16	8	6	30	34.88
15. Valencia Street	50	40		90	11	21		32	35.56
16. San Pablo (Al)	55	30	3	88	17	11	2	30	34.09
Total				1,431				502	35.08

The distribution of the questionnaire was divided into three phases. The first phase was conducted during June 5 – July 15, 2014. After finishing the first try, the returned surveys were collected and counted on July 20 in order to adjust the plan for the second attempt which was conducted during July 25 – August 15, 2014. The total number of questionnaires distributed during these two phases are 1,403. Even though the end of October was indicated as the deadline to return the questionnaire back, the researcher waited for the returns until the end of November. The result showed that 479 surveys or 34.14% of the distributed surveys were completed and returned. Nonetheless, as the total number of the returned surveys of five study sites—Fox Square, Justin Herman Plaza, Yerba Buena Park, Sproul Plaza, and San Pablo Avenue in Albany—did not meet the minimum requirement (at least 30), the third try was conducted during December 2014. Table 6.1 presents the numbers of distributed and returned surveys for each site.

Finally, a total of 1,431 questionnaires were distributed and 502 surveys or 35.08% of the distributed surveys were returned. Of 16 study sites, the response rate of Fox Square is the lowest (31.25%) while the response rate of El Cerrito City Hall is the highest 42.35%. Of the 502 returned surveys, most of them were well completed, while some of them were not—some questions were left blank. Overall, empty responses were found for those of personal demographic questions, which are the last five questions of the questionnaire. Interesting enough, some respondents also remarked that they intended to leave some questions blank because they have no idea or insufficient knowledge to answer them. Nonetheless, these missing data are considered minor so that no unfinished survey was excluded—yet all empty or considered ambiguous answers were culled out of the database, while those considered useable were retained.

6.6 Respondents' demographic information

Aiming to provide broad ideas in regard to basic characteristics of the respondents, the results of the last five questions (Q8.1-Q8.5) in the survey are reported. These results include gender, age, educational attainment, educational field, and occupational field of the respondents.

6.6.1. Gender (Q8.1)

Overall, the total number of female respondents is slightly higher than the total number of male respondents. Specifically, of 502 respondents, there are 253 (50.4%) women, 238 (47.4%) men, and 11 (2.2%) missing answers.

Table 6.2 Gender of respondents

Sites	Total	Male	Female	Missing
1. Mint Plaza	31	19 (61.3%)	12 (38.7%)	0
2. Davis Court	33	15 (45.5%)	18 (54.4%)	0
3. Fox Square	30	8 (26.7%)	22 (73.3%)	0
4. Brisbane City	31	12 (38.7%)	19 (61.3%)	0
5. El Cerrito City	36	19 (52.8%)	16 (44.4%)	1 (2.8%)
6. New Sproul	30	12 (40.0%)	18 (60.0%)	0
7. Cesar Chavez	31	15 (48.4%)	16 (51.6%)	0
8. San Pablo (El)	34	19 (55.9%)	15 (44.1%)	0
9. Jessie Plaza	32	11 (34.3%)	20 (62.5%)	1 (3.1%)
10. Justin Herman	30	22 (73.3%)	7 (23.3%)	1 (3.3%)
11. S.D. Bechtel	31	20 (64.5%)	9 (29.0%)	2 (6.5%)
12.Yerba Buena	30	13 (43.3%)	16 (53.3%)	1 (3.3%)
13. Daly City	31	10 (32.3%)	19 (61.3%)	2 (6.5%)
14. Sproul Plaza	30	16 (53.3%)	14 (46.7%)	0
15. Valencia Street	32	13 (40.6%)	16 (50.0%)	3 (9.4%)
16. San Pablo (Al)	30	14 (46.7%)	16 (53.3%)	0
All	502	238 (47.4%)	253 (50.4%)	11 (2.2%)

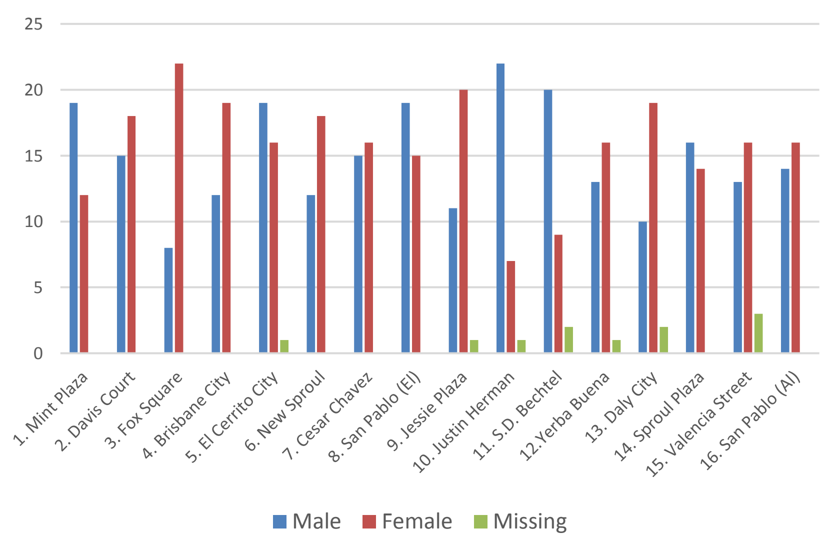


Figure 6.1 Distribution of respondents by gender

When the sites are viewed separately (see table 6.2 and figure 6.1), it appears that the numbers of female and male respondents are quite different in some sites. The sites whose the number of female respondents is slightly higher than the number of male respondents (the proportion is around 55%:45%) are Davis Court, Cesar Chavez Green Street, Yerba Buena Gardens, Valencia Street, and San Pablo Avenue in Albany. The sites whose the number of female respondents is slightly lower than the number of male respondents (the proportion is around 45%:55%) are El Cerrito City Hall, San Pablo Green Street in El Cerrito and Sproul Plaza. For New Sproul Plaza, Jessie Square, Brisbane City Hall, and Daly City Civic Center Hall, the number of female respondents is higher than the number of male respondents (the proportion is around 60%:40%). Only Mint Plaza shows that the number of male respondents is higher than the number of female respondents (the proportion is around 40%:60%). There are three sites that hold an unequal proportion of female and male respondents. In particular, while the proportion of female and male respondents is around 70%:30% for the Fox Square, this proportion is reverse (30%:70%) for Justin Herman Plaza and S.D. Bechtel Plaza.

Markedly, in some cases, the difference between the numbers of female and male respondents may suggest the gender proportion of users or visitors of the sites. As some examples, supplemented by field observations, men were found more than women in Mint Plaza, Justin Herman Plaza, and S.D. Bechtel Plaza, which are urban spaces, while, in contrast, women were found more than men in Fox Square, which is located in a residential community. For sites which are parks and streets, the numbers of male and female visitors are quite in an equal ratio. However, this is just presumption. The difference of respondents' gender proportion found between the test sites of this research might be the effect of other factors. For instance, women returned the questionnaires back more than men for some sites, and vice versa for the others.

6.6.2. Age (Q8.2)

The respondents, viewed as a whole, were concentrated in the early middle age (31-40) and young adult (21-30).

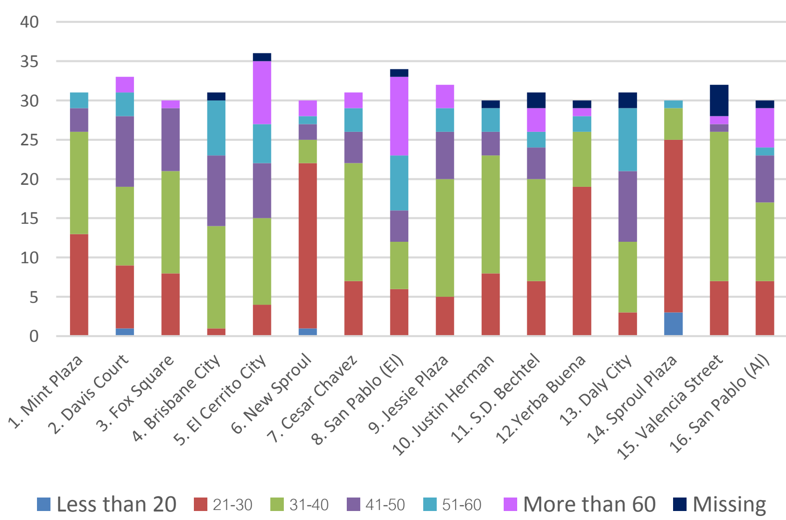


Figure 6.2 Distribution of respondents by age

Table 6.3 Age of respondents

Sites	Total	Less than 20	21-30	31-40	41-50	51-60	more than 60	Missing
1. Mint Plaza	31	0	13 (41.9%)	13 (41.9%)	3 (9.7%)	2 (6.5%)	0	0
2. Davis Court	33	1 (3.0%)	8 (24.2%)	10 (30.3%)	9 (27.3%)	3 (9.1%)	2 (6.1%)	0
3. Fox Square	30	0	8 (26.7%)	13 (43.3%)	8 (26.7%)	0	1 (3.3%)	0
4. Brisbane City	31	0	1 (3.2%)	13 (41.9%)	9 (29.0%)	7 (22.6%)	0	1 (3.2%)
5. El Cerrito City	36	0	4 (11.1%)	11 (30.6%)	7 (19.4%)	5 (13.9%)	8 (22.2%)	1
6. New Sproul	30	1 (3.3%)	21 (70.0%)	3 (10.0%)	2 (6.7%)	1 (3.3%)	2 (6.7%)	0
7. Cesar Chavez	31	0	7 (22.6%)	15 (48.4%)	4 (12.9%)	3 (9.7%)	2 (6.5%)	0
8. San Pablo (El)	34	0	6 (17.6%)	6 (17.6%)	4 (11.8%)	7 (20.6%)	10 (29.4%)	1 (2.9%)
9. Jessie Plaza	32	0	5 (15.6%)	15 (46.9%)	6 (18.8%)	3 (9.4%)	3 (9.4%)	0
10. Justin Herman	30	0	8 (26.7%)	15 (50.0%)	3 (10.0%)	3 (10.0%)	0	1 (3.3%)
11. S.D. Bechtel	31	0	7 (22.6%)	13 (41.9%)	4 (12.9%)	2 (6.5%)	3 (9.7%)	2 (6.5%)
12.Yerba Buena	30	0	19 (63.3%)	7 (23.3%)	0	2 (6.7%)	1 (3.3%)	1 (3.3%)
13. Daly City	31	0	3 (9.7%)	9 (29.0%)	9 (29.0%)	8 (25.8%)	0	2 (6.5%)
14. Sproul Plaza	30	3 (10.0%)	22 (73.3%)	4 (13.3%)	0	1 (3.3%)	0	0
15. Valencia Street	32	0	7 (21.9%)	19 (59.4%)	1 (3.1%)	0	1 (3.1%)	4 (12.5%)
16. San Pablo (Al)	30	0	7 (23.3%)	10 (33.3%)	6 (20.0%)	1 (3.3%)	5 (16.7%)	1 (3.3%)
All	502	5 (1.0%)	146 (29.1%)	176 (35.1%)	75 (14.9%)	48 (9.6%)	38 (7.6%)	14 (2.8%)

In more details, of 502 respondents, 176 people (35.1%) were between 31-40 years old, 146 people (29.1%) were between 21-30 years old, 75 people (14.9%) were between 41-50 years old, 48 people (9.6%) were between 51-60 years old, 38 people (7.6%) were more than 60 years old, 5 people (1.0%) were less than 20 years old, and 14 people (2.8%) did not indicate their age range. For most of the study sites (see table 6.3 and figure 6.2), the number of respondents in each age category follows the overall pattern and proportion summarized above. Only 3 sites—which are Yerba Buena Park and the two sites in UC Berkeley (Sproul Plaza and New Sproul Plaza)—report the most in the young adult group (21-30 years old).

6.6.3. Educational attainment (Q8.3)

Considering respondents' educational attainment, it is not surprising that this is a quite well-educated respondent group, as more than half of them or 291 out of 502 respondents (58.0%) reporting a bachelor or college degree, 128 respondents (25.5%) possessing a master degree, 25 respondents (5.0%) indicating a doctoral degree, only 11 respondents (2.2%) reporting a high school level or lower, and 47 respondents (9.4%) reporting nothing (missing answers). This overall pattern also appears in those of all test sites, when they are viewed separately (see table 6.4 and figure 6.3).

Table 6.4 Educational attainment of respondents

Sites	Total	High school or lower	College degree	Master degree	Doctoral degree	Missing
1. Mint Plaza	31	0	21 (67.7%)	6 (19.4%)	1 (3.2%)	3 (9.7%)
2. Davis Court	33	0	25 (75.8%)	5 (15.2%)	1 (3.0%)	2 (6.1%)
3. Fox Square	30	0	16 (53.3%)	6 (20.0%)	3 (10.0%)	5 (16.7%)
4. Brisbane City	31	4 (12.9%)	12 (38.7%)	8 (25.8%)	0	7 (22.6%)
5. El Cerrito City	36	2 (5.6%)	14 (38.9%)	15 (41.7%)	1 (2.8%)	4 (11.1%)
6. New Sproul	30	0	22 (73.3%)	4 (13.3%)	3 (10.0%)	1 (3.3%)
7. Cesar Chavez	31	1 (3.2%)	16 (51.5%)	10 (32.3%)	2 (6.5%)	2 (6.5%)
8. San Pablo (El)	34	1 (2.9%)	17 (50.0%)	10 (29.4%)	3 (8.8%)	3 (8.8%)
9. Jessie Plaza	32	0	20 (62.5%)	9 (28.1%)	2 (6.3%)	1 (3.1%)
10. Justin Herman	30	1 (3.3%)	15 (50.0%)	11 (36.7%)	2 (6.7%)	1 (3.3%)
11. S.D. Bechtel	31	1 (3.2%)	19 (61.3%	5 (16.1%)	2 (6.5%)	4 (12.9%)
12.Yerba Buena	30	0	23 (76.7%)	6 (20.0%)	0	1 (3.3%)
13. Daly City	31	0	19 (61.3%)	7 (22.6%)	0	5 (16.1%)
14. Sproul Plaza	30	0	19 (63.3%)	10 (33.3%)	1 (3.3%)	0
15. Valencia Street	32	0	17 (53.1%)	9 (28.1%)	0	6 (18.8%)
16. San Pablo (Al)	30	1	16 (53.3%)	7 (23.3%)	4 (13.3%)	2 (6.7%)
All	502	11 (2.2%)	291 (58.0%)	128 (25.5%)	25 (5.0%)	47 (9.4%)

This survey result does not infer that visitors or users of these test sites are mostly well-educated persons. As one plausible presumption, that the vast majority of this research respondents are well-educated might be because they were more likely to take the distributed survey forms and return the completed ones back, while who are not highly educated tended to refuse or ignore to participate in this research. As a result and most importantly, as this set of data is not from the random selection and does not represent the typical population, generalizing the findings must be done with caution.

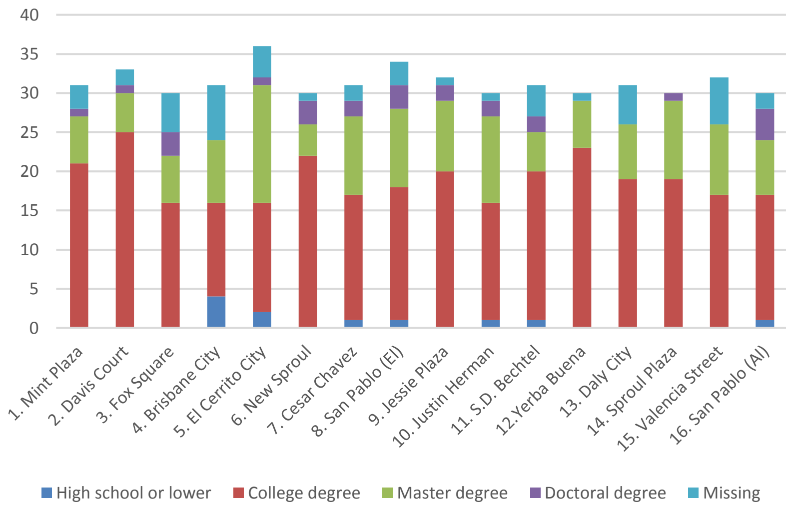


Figure 6.3 Distribution of respondents by educational attainment

6.6.4. Educational field (Q8.4)

For the response to the question asking about respondents' educational field, only 281 out of 502 respondents or 56% of all respondents answered this question, while 221 respondents or 44% of all respondents did not. This overall proportion also applies to most of test sites, when they are viewed separately, and also to the response of the next question, the last of the survey, which asked about respondents' occupational field. To make a simple conjecture, the low rate of response to these two questions might be because they are the last two questions of the survey and they are open-ended so that most respondents might feel tried or just ignore to answer them.

Considering all the specified educational fields, it appears that they can be classified into 13 categories, which include 1) environmental planning, design, and management, 2) art and design, 3) social science, 4) education, 5) administration and management, 6) mass communication, 7) economics and business, 8) science, 9) engineering and technology, 10) laws and politics, 11) health and medical science, 12) hospitality service and management, and 13) human service and social work. Note that table 6.7 provide information regarding the subcategories of each category.

The frequency distributions of respondents' educational fields are displayed in table 6.5. The overall proportion of respondents' educational fields is illustrated in figure 6.4 while the proportion of respondents' educational fields of each site is illustrated in figure 6.5.

Table 6.5 Respondents’ educational fields

Sites	Total	Environmental Design	Art & Design	Social Science	Education	Administration & Management	Mass Communication	Economics & business	Science	Engineering & Technology	Laws & Politics	Health & Medical Science	Hospitality Service & Management	Human Service & Social Work	Missing
1. Mint Plaza	31	0	2 (6.5%)	4 (12.9%)	0	0	2 (6.5%)	2 (6.5%)	0	5 (16.1%)	2 (6.5%)	0	0	1 (3.2%)	13 (41.9%)
2. Davis Court	33	0	3 (9.1%)	2 (6.2%)	0	1 (3.0%)	1 (3.0%)	6 (18.2%)	3 (9.1%)	2 (6.2%)	0	0	1 (3.0%)	1 (3.0%)	13 (39.4%)
3. Fox Square	30	2 (6.7%)	0	2 (6.7%)	2 (6.7%)	0	0	3 (10.0%)	1 (3.3%)	2 (6.7%)	1 (3.3%)	1 (3.3%)	0	1 (3.3%)	15 (50.0%)
4. Brisbane City	31	3 (9.7%)	1 (3.2%)	1 (3.2%)	0	0	0	5 (16.1%)	2 (6.5%)	2 (6.5%)	0	0	0	0	17 (54.8%)
5. El Cerrito City	36	8 (22.2%)	1 (2.8%)	0	1 (2.8%)	1 (2.8%)	0	1 (2.8%)	2 (5.6%)	3 (8.3%)	1 (2.8%)	1 (2.8%)	0	1 (2.8%)	16 (44.4%)
6. New Sproul	30	6 (20.0%)	1 (3.3%)	7 (23.3%)	0	0	0	1 (3.3%)	3 (10.0%)	0	0	1 (3.3%)	0	0	11 (36.7%)
7. Cesar Chavez	31	2 (6.5%)	3 (9.7%)	0	0	0	0	4 (12.9%)	1 (3.2%)	0	1 (3.2%)	2 (6.5%)	1 (3.2%)	0	17 (54.8%)
8. San Pablo (El)	34	0	3 (8.8%)	5 (14.7%)	3 (8.8%)	0	0	0	2 (5.9%)	3 (8.8%)	1 (2.9%)	1 (2.9%)	0	1 (2.9%)	15 (44.1%)
9. Jessie Plaza	32	0	3 (9.4%)	2 (6.3%)	1 (3.1%)	0	2 (6.3%)	4 (12.5%)	0	2 (6.3%)	0	1 (3.1%)	0	1 (3.1%)	16 (50.0%)
10. Justin Herman	30	0	3 (10.0%)	0	0	0	1 (3.3%)	11 (36.7%)	1 (3.3%)	4 (13.3%)	2 (6.7%)	0	0	0	8 (26.7%)
11. S.D. Bechtel	31	0	0	3 (9.7%)	0	0	0	5 (16.1%)	2 (6.5%)	3 (9.7%)	2 (6.5%)	0	0	0	16 (51.6%)
12.Yerba Buena	30	0	4 (13.3%)	1 (3.3%)	0	0	4 (13.3%)	1 (3.3%)	0	2 (6.7%)	0	0	2 (6.7%)	2 (6.7%)	14 (46.7%)
13. Daly City	31	2 (6.5%)	0	0	2 (6.5%)	0	1 (3.2%)	3 (9.7%)	2 (6.5%)	0	1 (3.2%)	0	0	6 (19.4%)	14 (45.2%)
14. Sproul Plaza	30	17 (56.7%)	0	1 (3.3%)	0	0	0	2 (6.7%)	1 (3.3%)	1 (3.3%)	1 (3.3%)	0	0	0	7 (23.3%)
15. Valencia Street	32	3 (9.4%)	1 (3.1%)	1 (3.1%)	3 (9.4%)	0	0	0	0	2 (6.3%)	2 (6.3%)	2 (6.3%)	0	0	18 (56.3%)
16. San Pablo (Al)	30	5 (16.7%)	0	3 (10.0%)	2 (6.7%)	0	0	5 (16.7%)	0	3 (10.0%)	0	0	1 (3.3%)	0	11 (36.7%)
All	502	48 (9.6%)	25 (5.0%)	32 (6.4%)	14 (2.8%)	2 (0.4%)	11 (2.2%)	53 (10.6%)	20 (4.0%)	34 (6.8%)	14 (2.8%)	9 (1.8%)	5 (1.0%)	14 (2.8%)	221 (44.0%)

Table 6.6 Respondents' occupational field

Sites	Environmental Design	Art & Design	Education	Administration & Management	Mass Communication	Economics & business	Science	Engineering & Technology	Laws & Politics	Health & Medical Science	Hospitality Service & Management	Human Service & Social Work	Student	Retired	Unemployed	Labor Worker	Missing
1. Mint Plaza	0	0	0	2 (6.5%)	0	6 (19.4%)	0	7 (22.6%)	1 (3.2%)	1 (3.2%)	0	2 (6.5%)	0	0	0	0	12 (38.7%)
2. Davis Court	0	2 (6.1%)	1 (3.0%)	1 (3.0%)	2 (6.1%)	6 (18.2%)	1 (3.0%)	3 (9.1%)	0	1 (3.0%)	0	0	2 (6.1%)	0	0	3 (9.1%)	11 (33.3%)
3. Fox Square	1 (3.3%)	0	4 (13.3%)	1 (3.3%)	0	3 (10.0%)	0	0	1 (3.3%)	0	0	2 (6.7%)	1 (3.3%)	0	0	1 (3.3%)	16 (53.3%)
4. Brisbane City	2 (6.5%)	1 (3.2%)	0	3 (9.7%)	0	3 (9.7%)	1 (3.2%)	2 (6.5%)	1 (3.2%)	0	0	0	1 (3.2%)	0	0	0	17 (54.8%)
5. El Cerrito City	7 (19.4%)	0	0	1 (2.8%)	0	2 (5.6%)	1 (2.8%)	4 (11.1%)	0	1 (2.8%)	0	2 (5.6%)	1 (2.8%)	3 (8.3%)	0	0	14 (38.9%)
6. New Sproul	0	2 (6.7%)	1 (3.3%)	3 (10.0%)	0	1 (3.3%)	0	0	0	1 (3.3%)	0	0	9 (30.0%)	0	0	2 (6.7%)	11 (36.7%)
7. Cesar Chavez	4 (12.9%)	0	2 (6.5%)	1 (3.2%)	2 (6.5%)	3 (9.7%)	0	0	1 (3.2%)	1 (3.2%)	0	1 (3.2%)	1 (3.2%)	0	0	0	15 (48.4%)
8. San Pablo (El)	2 (5.9%)	2 (5.9%)	3 (8.8%)	0	2 (5.9%)	0	0	1 (2.9%)	1 (2.9%)	2 (5.9%)	0	1 (2.9%)	1 (2.9%)	3 (8.8%)	0	1 (2.9%)	15 (44.1%)
9. Jessie Plaza	0	2 (6.3%)	2 (6.3%)	0	1 (3.1%)	5 (15.6%)	0	2 (6.3%)	0	1 (3.1%)	0	0	1 (3.1%)	1 (3.1%)	1 (3.1%)	0	16 (50.0%)
10. Justin Herman	1 (3.3%)	0	1 (3.3%)	0	2 (6.7%)	10 (33.3%)	0	4 (13.3%)	1 (3.3%)	1 (3.3%)	0	0	2 (6.7%)	0	0	0	8 (26.7%)
11. S.D. Bechtel	0	0	0	0	0	2 (6.5%)	1 (3.2%)	6 (19.4%)	3 (9.7%)	0	0	0	0	0	0	3 (9.7%)	16 (51.6%)
12.Yerba Buena	0	1 (3.3%)	2 (6.7%)	2 (6.7%)	3 (10.0%)	1 (3.3%)	0	3 (10.0%)	0	0	1 (3.3%)	2 (6.7%)	1 (3.3%)	0	0	1 (3.3%)	13 (43.3%)
13. Daly City	2 (6.5%)	0	0	4 (12.9%)	1 (3.2%)	0	0	0	5 (16.1%)	0	0	6 (19.4%)	0	0	0	0	13 (41.9%)
14. Sproul Plaza	4 (13.3%)	0	1 (3.3%)	1 (3.3%)	0	0	0	0	0	0	0	0	18 (60.0%)	0	1 (3.3%)	0	5 (16.7%)
15. Valencia St.	2 (6.3%)	1 (3.1%)	2 (6.3%)	2 (6.3%)	0	1 (3.1%)	0	1 (3.1%)	0	2 (6.3%)	0	0	0	0	1 (3.1%)	2 (6.3%)	18 (56.3%)
16. San Pablo (Al)	3 (10.0%)	0	3 (10.0%)	0	0	2 (6.7%)	0	1 (3.3%)	0	0	2 (6.7%)	0	6 (20.0%)	1 (3.3%)	0	1 (3.3%)	11 (36.7%)
All	28 (5.6%)	11 (2.2%)	22 (4.4%)	21 (4.2%)	13 (2.6%)	45 (9.0%)	4 (0.8%)	34 (6.8%)	14 (2.8%)	11 (2.2%)	3 (0.6%)	16 (3.2%)	44 (8.8%)	8 (1.6%)	3 (0.6%)	14 (2.8%)	211 (42.0%)

Table 6.7 Respondents' educational and occupational fields

Categories (Study Field)	**Subcategories (Study Field)**	**Categories (Occupational field)**	**Subcategories (Occupation Area)**
11: Environmental Design and Planning	111: Environmental Science 112: Conservation/Resource Studies/Sustainable Studies 113: Landscape Arch 114: Urban/City/Regional/Recreation Planning 115: Architecture	11: Environmental Design and Planning	111: Environmental Scientist 113: Landscape Architect 114: Urban/City/Regional/Recreation Planner 115: Architect
12: Arts and Design	121: Fine Arts 122: Visual Arts 123: Graphic Design /Product Design 124: Photography/Film/Music/Dancing/Performance Arts 125: Fashion Design 126: Interior/Lighting Design	12: Arts and Design	121: Artist 123: Graphic Designer/Product Designer 124: Photographer/Film Maker/Musician/Dancer/Actor 125: Fashion Designer 126: Interior Designer/Lighting Designer
20: Education	201: Education/Elementary Education 202: Academic Counseling 203: Librarianship/Library service	20: Education	201: Professor/Teacher /Educational Director/Researcher 203: Academic Counselor/Academic Advisor 204: Librarian/Curator
30: Social Science	301: History 302: Psychology/Sociology/Humanity/Anthropology 303: Language/English/Writing/Letters & Science/ Literature 304: Asian Studies/American Studies/Inter Studies		
40: Administration and Management	401: Management 402: Administration	40: Administration and Management	401: Management Analyst/Manager 402: Administrator/Clerk
51: Mass Communication	511: Mass Communication 512: Media Studies 513: Broadcasting/Telecommunications 514: Journalism/Publishing 515: Marketing/Advertising	51: Mass Communication	511: Producer 512: Media Analyst/Media Producer 514: Editor/ Writer/Author/Publishing 515: Marketing Analyst
52: Economics and Business	521: Business/Commercial Studies 522: Economics/Finance 523: Accounting 524: Marketing 525: Banking 526: Real Estate	52: Economics and Business	521: Business Coordinator/Commercial Analyst/Buyer 522: Financial Analyst 523: Accountant 524: Marketing Analyst/Band Manager 525: Banker 526: Real Estate Developer/Construction Contractor
61: Science	611: Mathematics/Statistics 612: Physics/Astronomy 613: Chemistry 614: Biology 615: Geography 616: Energy Studies/Fire Science	61: Science	611: Mathematician/Statistician 612: Physician 614: Biologist 615: Geologist 616: Energy Technician/ Fire Inspector
62: Engineering and Technology	621: Electrical Engineering /Mechanical Engineering 622: Civil Engineering 623: Computer Science/Programing/Software/IT	62: Engineering and Technology	621: Electrical Engineer/Mechanical Engineer 622: Civil Engineer/Contractor 623: Computer, Software, IT Technician, Engineer/Programmer
70: Laws and Political Science	701: Laws 702: Political Science 703: Criminal Justice	70: Laws and Political Science	701: Lawyer/Attorney/Judge/ Legal Consultant 702: Policeman 703: Criminal Researcher
80: Health and Medical Science	801: Health Science 802: Medicine/Cardiology/Pathology/Optometry/Dentistry 803: Nursing 804: Child Care/ Physical Therapy	80: Health and Medical Science	801: Health Consultant 802: Doctor/Dentist/Specialist 803: Nurse 804: Therapist
91: Human Service and Social Work	911: Social Work 912: Human Service	91: Human Service and Social Work	911: Social Worker
92: Hospitality Service and Management	921: Hotel Industry/Hospitality Management 922: Culinary Arts/Restaurant Management	92: Hospitality Service and Management	921: Hotel Manager 922: Restaurant Manager/Chef
00: Missing		00: Missing 01: Student 02: Retired 03: Unemployed	04: Labor Worker (Sales/Cashier/waiter/Insurance Agent)

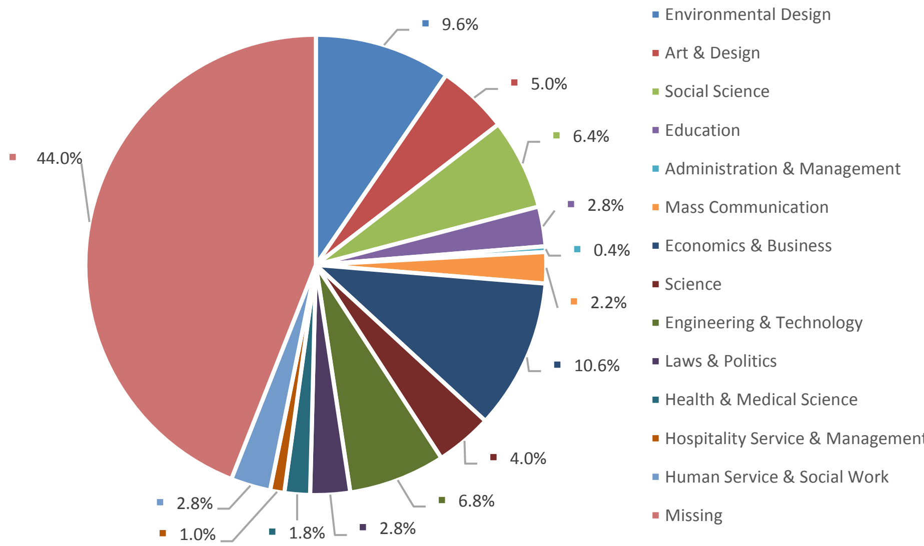


Figure 6.4 Pie chart illustrating the overall respondents' educational fields

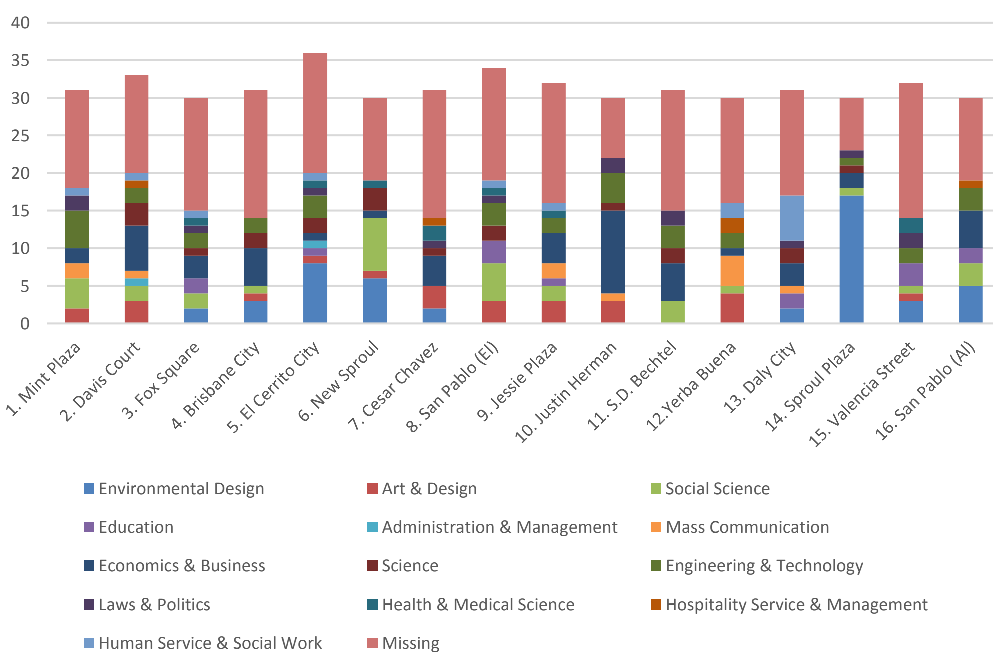


Figure 6.5 Respondents' educational fields of each study site

6.6.5 Occupational field (Q8.5)

Overall, similar to the situation of the previous question, only 291 out of 502 respondents or 58% of all respondents answered this question, while 211 respondents or 42% of all respondents did not. Considering all the specified occupational fields, 16 categories—which include 1) environmental planning, design, and management, 2) art and design, 3) education, 4) administration and management, 5) mass communication, 6) economics and business, 7) science, 8) engineering and technology, 9) laws and politics, 10) health and medical science, 11) hospitality service and management, 12) human service and social work, 13) Student, 14) retirement, 15) unemployment, and 16) labor work—are classified. Note that information regarding the subcategories of each category is also provided in table 6.7. In table 6.6, the frequency distributions of respondents' occupational fields are displayed. For the proportion of respondents' occupational fields, figure 6.6 illustrates the overall one while figure 6.7 illustrates the site specific one.

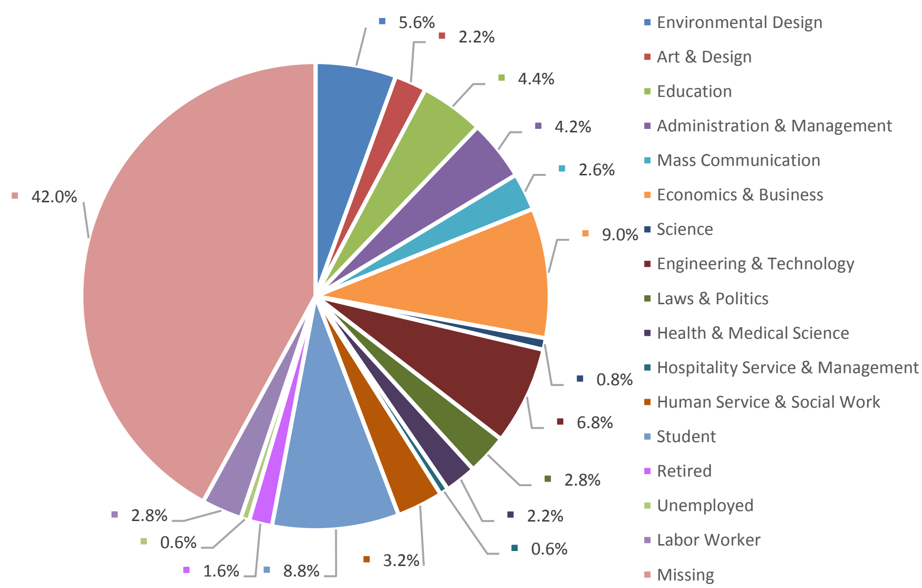


Figure 6.6 Pie chart illustrating the overall respondents' occupational fields

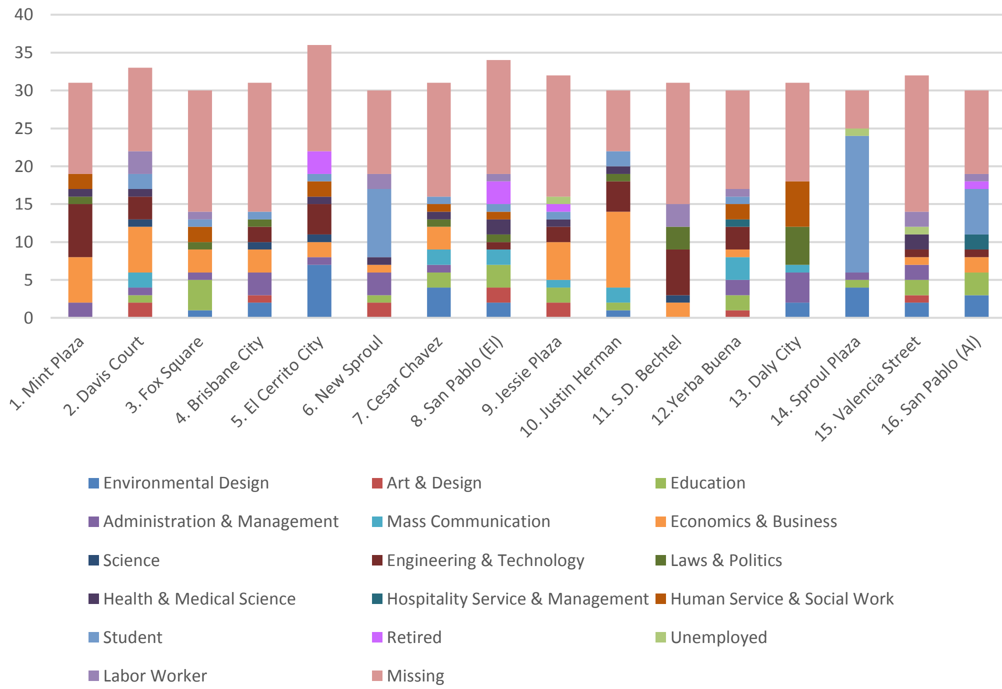


Figure 6.7 Respondents' occupational fields of each study site

Interestingly, most of the respondents of this survey were professional workers; very few of them were service workers. This situation, again, does not infer that visitors or users of these test sites are mostly professional workers. Perhaps it might be because labor workers were those who were more likely to refuse to do the survey than professional workers. Therefore, the generalization of the survey results must be done with caution because this set of data does not represent the typical population.

6.7 Respondents' relationship with the study sites

Principally, this section reports the answers of the first three questions (Q1.1-Q1.3) of the questionnaire in order to display basic statistics regarding the respondents' relationships with each study site. These relationships include the length of time the respondents have known the site, the frequency they usually visit the site, and also the purpose of their visiting.

6.7.1 Length of time knowing the sites (Q1.1)

For each study site, generally, the majority of the respondents reported that they have known the site for more than a year, followed by less than a year. Only few respondents of each site reported that they have known the site for less than a month or just visited the site for the first time. Table 6.8 and figure 6.8 visually display this information.

Table 6.8 Length of time knowing the site

Sites	Total	first visit	Less than a month	Less than a year	More than a year	Missing
1. Mint Plaza	31	0	0	7 (22.6%)	24 (77.4%)	0
2. Davis Court	33	0	1 (3.0%)	6 (18.2%)	26 (78.8%)	0
3. Fox Square	30	2 (6.7%)	2 (6.7%)	7 (23.3%)	19 (63.3%)	0
4. Brisbane City	31	0	0	2 (6.5%)	29 (93.5%)	0
5. El Cerrito City	36	1 (2.8%)	1 (2.8%)	4 (11.1%)	30 (83.3%)	0
6. New Sproul	30	3 (10.0%)	6 (20.0%)	7 (23.3%)	14 (46.7%)	0
7. Cesar Chavez	31	0	0	4 (12.9%)	27 (87.1%)	0
8. San Pablo (El)	34	1 (2.9%)	0	2 (5.9%)	31 (91.2%)	0
9. Jessie Plaza	32	3 (9.4%)	1 (3.1%)	2 (6.3%)	26 (81.3%)	0
10. Justin Herman	30	1 (3.3%)	0	5 (16.7%)	24 (80.0%)	0
11. S.D. Bechtel	31	0	1 (3.2%)	3 (9.7%)	27 (87.1%)	0
12.Yerba Buena	30	5 (16.7%)	0	5 (16.7%)	20 (66.7%)	0
13. Daly City	31	0	0	2 (6.5%)	29 (93.5%)	0
14. Sproul Plaza	30	4 (13.3%)	1 (3.3%)	2 (6.7%)	23 (76.7%)	0
15. Valencia Street	32	1 (3.1%)	2 (6.3%)	1 (3.1%)	28 (87.5%)	0
16. San Pablo (Al)	30	0	1 (3.3%)	4 (13.3%)	25 (83.3%)	0

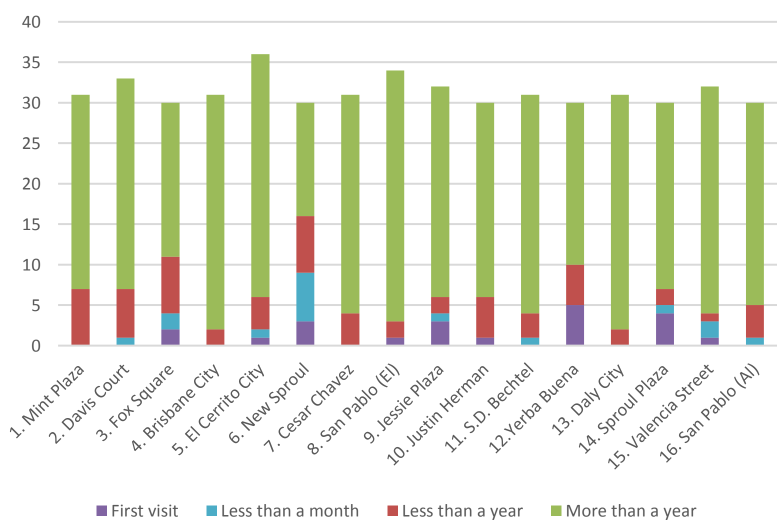


Figure 6.8 Distribution of length of time the respondents have known the site

6.7.2 Frequency of visiting the sites (Q1.2)

The respondents of each study site gave varied answers regarding how often they usually visit the site. As table 6.9 and figure 6.9 demonstrate, some respondents reported that they rarely visit the site, while some respondents reported that they routinely visit the site—daily, weekly, or few times a month.

Table 6.9 Frequency of visiting the site

Sites	Total	Daily	Weekly	Few times a month	Rarely	Missing
1. Mint Plaza	31	15 (48.4%)	6 (19.4%)	6 (19.4%)	4 (12.9%)	0
2. Davis Court	33	15 (45.5%)	6 (18.2%)	5 (15.2%)	6 (18.2%)	1 (3.0%)
3. Fox Square	30	11 (36.7%)	5 (16.7%)	5 (16.7%)	9 (30.0%)	0
4. Brisbane City	31	17 (54.8%)	6 (19.4%)	2 (6.5%)	6 (19.4%)	0
5. El Cerrito City	36	6 (16.7%)	6 (16.7%)	14 (38.9%)	10 (27.8%)	0
6. New Sproul	30	6 (20.0%)	8 (26.7%)	3 (10.0%)	13 (43.3%)	0
7. Cesar Chavez	31	19 (61.3%)	8 (25.8%)	4 (12.9%)	0	0
8. San Pablo (El)	34	3 (8.8%)	12 (35.3%)	18 (52.9%)	1 (2.9%)	0
9. Jessie Square	32	3 (9.4%)	6 (18.8%)	9 (28.1%)	14 (43.8%)	0
10. Justin Herman	30	7 (23.3%)	11 (36.7%)	8 (26.7%)	4 (13.3%)	0
11. S.D. Bechtel	31	21 (67.7%)	6 (19.4%)	2 (6.5%)	2 (6.5%)	0
12.Yerba Buena	30	7 (23.3%)	6 (20.0%)	9 (30.0%)	8 (26.7%)	0
13. Daly City	31	13 (41.9%)	5 (16.1%)	7 (22.6%)	6 (19.4%)	0
14. Sproul Plaza	30	6 (20.0%)	14 (46.7%)	4 (13.3%)	6 (20.0%)	0
15. Valencia Street	32	6 (18.8%)	13 (40.6%)	3 (9.4%)	10 (31.3%)	0
16. San Pablo (Al)	30	15 (50.0%)	11 (36.7%)	4 (13.3%)	0	0

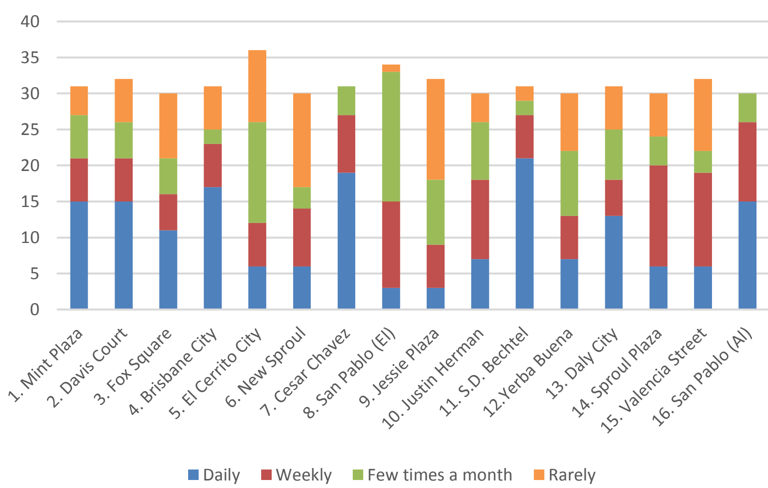


Figure 6.9 Distribution of frequency of visiting the site

6.7.3 Purposes of visiting the sites (Q1.3)

Overall, the respondents of each study site had visited the site for diverse purposes. Moreover, most of them also reported more than one purpose.

Table 6.10 Purpose of visiting the site

Sites	Total	Pass by	Rest/ relax	Eat/ drink	Meet friends	Join events	Work	Others
1. Mint Plaza	31	16 (51.6%)	16 (51.6%)	26 (83.9%)	13 (41.9%)	3 (9.7%)	3 (9.7%)	2 (6.5%)
2. Davis Court	33	29 (87.9%)	6 (18.2%)	10 (30.3%)	4 (12.1%)	1 (3.0%)	2 (6.1%)	0
3. Fox Square	30	26 (86.7%)	4 (13.3%)	10 (33.3%)	6 (20.0%)	3 (10.0%)	2 (6.7%)	2 (6.7%)
4. Brisbane City	31	10 (32.3%)	2 (6.5%)	0	0	3 (9.7%)	19 (61.3%)	0
5. El Cerrito City	36	18 (50.0%)	8 (22.2%)	0	0	9 (25.0%)	14 (38.9%)	1 (2.8%)
6. New Sproul	30	29 (96.7%)	2 (6.7%)	2 (6.7%)	3 (10.0%)	2 (6.7%)	1 (3.3%)	1 (3.3%)
7. Cesar Chavez	31	23 (74.2%)	5 (16.1%)	4 (12.9%)	1 (3.2%)	0	2 6.5%)	4 (12.9%)
8. San Pablo (El)	34	14 (41.2%)	2 (5.9%)	25 (73.5%)	2 (5.9%)	1 (2.9%)	2 (5.9%)	3 (8.8%)
9. Jessie Plaza	32	25 (78.1%)	22 (68.8%)	11 (34.4%)	4 (12.5%)	0	1 (3.1%)	4 (12.5%)
10. Justin Herman	30	10 (33.3%)	12 (40.0%)	26 (86.7%)	5 (16.7%)	5 (16.7%)	1 (3.3%)	0
11. S.D. Bechtel	31	21 (67.7%)	23 (74.2%)	14 (45.2%)	7 (22.6%)	0	0	2 (6.5%)
12.Yerba Buena	30	9 (30.0%)	21 (70.0%)	19 (63.3%)	11 (36.7%)	1 (3.3%)	1 (3.3%)	0
13. Daly City	31	5 (16.1%)	3 (9.7%)	1 (3.2%)	1 (3.2%)	5 (16.1%)	23 (74.2%)	2 (6.5%)
14. Sproul Plaza	30	28 (93.3%)	9 (30.0%)	9 (30.0%)	10 (33.3%)	2 (6.7%)	0	1 (3.3%)
15. Valencia Street	32	20 (62.5%)	7 (21.9%)	28 (87.5%)	15 (46.9%)	9 (28.1%)	4 (12.5%)	1 (3.1%)
16. San Pablo (Al)	30	20 (66.7%)	8 (26.7%)	19 (63.3%)	11 (36.7%)	5 (16.7%)	3 (10.0%)	3 (10.0%)

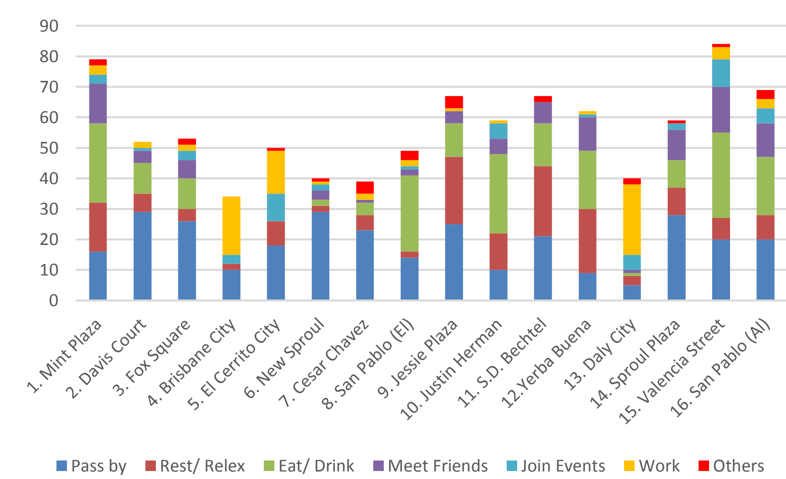


Figure 6.10 Distribution of proposes of visiting the site

In particular, as table 6.10 and figure 6.10 show, passing by, relaxing, and eating or drinking are the main purposes of visiting each site. Nonetheless, for the three city hall sites, work was reported as the main purpose. For those listed as other purposes, visiting places nearby the sites was mostly specified. Interestingly, most of what specified as others for Jessie Square was to walk dogs, and for S.D. Bechtel plaza was to smoke.

Chapter 7

Statistical Tools for Data Analysis and Hypothesis Testing

This chapter aims to provide basic ideas of the statistical tools to be used for analyzing survey data and testing research hypotheses of this dissertation. These tools include both descriptive statistics—frequency distribution, central tendency, and measures of dispersion—and inferential statistics—independent-samples *t* test, paired-samples *t* test, one-way between-groups ANOVA, one-way within-groups ANOVA, Pearson correlation, and partial correlation. Note that the information in this chapter is based on the book of Susan A. Nolan and Thomas E. Heinzen, *Statistics for the Behavioral Sciences* (2011), which is regarded as the key statistics textbook of this dissertation. At the end of this chapter, most importantly, the summary of the appropriate statistical tools for testing each hypothesis is provided along with the information about the specific section discussing the results of each hypothesis test.

7.1 Descriptive statistics

For most cases, the process of statistical analysis starts off with the use of descriptive statistics to simply organize, summarize, and visualize data from survey. Three major descriptive statistics to be use in this research include frequency distribution, central tendency, and measures of dispersion.

7.1.1 Frequency distribution

Typically, raw scores are considered the basic ingredients of a data set. These raw scores are often organized into a frequency distribution in order to display counts or proportions, which demonstrate how often different scores occur within that set of data, so that the information about the data can be examined more easily. There are varieties of ways in which the data can be organized in terms of frequency distribution; however, creating frequency tables is regarded as a starting point (Nolan and Heinzen 2011: 25). Frequency histograms and frequency polygons, which are the graph forms of frequency tables, are also very beneficial because they help visualize the overall pattern of the data.

The shape of a distribution is also an important issue because it can provide distinctive information about the data. There are two different shapes of distributions—normal distributions and skewed distributions. A normal distribution refers to a certain type of distribution in which has a symmetric, bell-shaped form so that it is informally called the bell curve. Based on probability theory, the central limit theorem makes normal distribution is remarkably useful for statistical analysis. More specifically, the central limit theorem states that if the sample size is large enough, the shape of a distribution will be normal or nearly normal. Moreover, the central limit theorem also declares that a distribution of means tends to be a more normal distribution than a distribution of scores, even when the population distribution is non-normal. According to (Nolan and Heinzen 2011: 147), "distributions of means computed from samples of at least 30 usually produce an approximately normal curve." Accordingly, a minimum number of 30 became widely used as a rule of thumb for determining the sample size.

For skewed distributions, they are "distribution in which one of the tails of the distribution is pulled away from the center" (Nolan and Heinzen 2011: 36). There are two different types of skewed distributions—the positively and the negatively skewed distributions. The positively skewed distributions are those in which their tails extend to the right, in a positive direction. In contrast, the negatively skewed distributions are those in which their tails extend to the left, in a negative direction.

7.1.2 Central tendency

According to Nolan and Heinzen (2011: 80-81), "Central tendency refers to the descriptive statistic that best represents the center of a data set, the particular value that the other data seem to be gathering around… The central tendency is usually at (or near) the highest point in the histogram or the polygon, but the specific way that data cluster around a distribution's central tendency can be measured three different ways: mean, median, and mode."

Mean or the arithmetic average is calculated by summing all the scores and dividing that sum by the total number of scores. Median or the middle score is simply identified by arranging all scores in an ascending (or descending) order. If there are two middle scores, the median is the means of these two scores. Mode or the most common score in the data set which can be simply picked out by looking at the frequency table or histogram. The unimodal distribution has only one mode while the bimodal distribution has two modes and the multimodal distribution has more than two modes.

7.1.3 Measures of variability

As Nolan and Heinzen (2011: 88) succinctly notes, "In statistics, variability is a numerical way of describing how much spread there is in a distribution… One way to numerically describe the variability of a distribution is by computing range. A second and more common way to describe the variability of a distribution is by computing variance and its square root, known as standard deviation."

Range is the distance between the highest score and the lowest score. Basically, we can just simply subtract the lowest score from the highest score in order to calculate the range. Variance refers to the average of the squared deviations from the mean. The basic concept is that, as Nolan and Heinzen (2011: 89) describe, "When something varies, it must vary from (or be different from) some standard. That standard is the mean. So when we compute variance, the number we arrive at is a number that describes the degree to which a distribution varies with respect to the mean. A small number indicates a small amount of spread or deviation around the mean, and a larger number indicates a great deal of spread or deviation around the mean." Even though the variance is useful, it is not so easy to understand because it is based on squared deviation, not actual deviations, so that it is too large. Accordingly, the standard deviation, which is known as the square root of variance, is much more useful than the variance because it indicates the typical amount that each score deviates from the mean (Nolan and Heinzen 2011: 90-91).

7.2 Inferential statistics

As inferential statistics allow us to make general estimates or to draw conclusions that extend beyond the data we have, they are very useful for testing research hypotheses. Note that because each procedure has its own strengths and weaknesses, selecting the appropriate statistical test with the characteristics of the data and the research question to be explored is considered important. The descriptions of the key inferential statistics to be used to analyze data and test hypotheses in this dissertation are listed as follows.

7.2.1 Independent-samples *t* test

The independent-samples *t* test is used to test for differences between two independent groups. Specifically, for a situation in which each participant is assigned to only one condition or a between-groups design, the independent-samples *t* test is used to compare two means, by making use of the distribution of differences between means.

According to Nolan and Heinzen (2011: 281), “As with all hypothesis tests, it is recommended that the results be supplemented with an effect size that provides information about the importance of the results. For an independent-samples *t* test, as with other *t* tests, we can use Cohen’s *d* as a measure of effect size.” As Nolan and Heinzen (2011: 207) also note, “Jacob Cohen published guidelines (or conventions), based on the overlap between two distributions, to help researchers determine whether an effect is small, medium, or large. These number are not cutoffs, merely rough guidelines to aid researchers in their interpretation of results.” The Cohen’s convention for each effect size is displayed in the table below.

Table 7.1 Cohen’s conventions for each effect sizes; *d* (Nolan and Heinzen 2011: 207)

Effect Size	Cohen’s *d*	Overlap
Small	0.2	85%
Medium	0.5	67%
Large	0.8	53%

7.2.2 Paired-samples *t* test

Basically, the paired-samples *t* test is also called dependent-samples *t* test. This test is used to compare two means for a situation in which every participant is in both samples—within-groups design. For most of the cases, this test is used in before/after research designs; however, other kinds of studies can also make use of this test (Nolan and Heinzen 2011: 251). The major difference between the independent-samples *t* test and the paired-samples *t* test is that the independent-samples *t* test looks at the distribution of differences between means while the paired-samples *t* test looks at the distribution of mean differences. As with an independent-samples *t* test, the effect size (Cohen's *d*) to provide information about the importance of the results.

7.2.3 One-way between-groups ANOVA

ANOVA or analysis of variance refers to a hypothesis test which is based on F statistic, which is the ratio of between-groups variance to within-groups variance. According to Nolan and Heinzen (2011: 325), "The F statistics is calculated by dividing a measure of the differences among samples means (between-groups variance) by a measure of variability within the samples (within-groups variance)."

When making comparisons among three or more groups, we use ANOVA instead of conducting many *t* tests. This is because ANOVA allows us to test differences among three or more groups in just one test so that the possibility of making a Type I error[1] is decreased. According to Nolan and Heinzen (2011: 300-301), "The word ANOVA is almost always preceded by two adjectives, one indicating the number of independent variables and one indicating whether the participants are in one condition (between-groups) or all conditions (within-groups). Accordingly, a one-way between-group ANOVA is used to compare more than two means for the situation in which there is only one independent variable with more than two levels, the dependent variable is a scale variable, and each participant is assigned to only one condition.

In addition, Nolan and Heinzen (2011: 301) also note that "Regardless of the type of ANOVA, they all share the same assumptions. The assumptions for ANOVA represent the optimal conditions for a valid analysis of the data." The first assumption is random selection. This assumption is vital to the generalization of the results—if the samples are not randomly selected, the external validity or the ability to generalize beyond the samples is considered limited. However, as Nolan and Heinzen (2011: 301) describe, "Because it is often impossible from a practical standpoint to use random selection, most researchers use ANOVA even when this assumption is violated." The second assumption is normal distribution. This assumption is important because ANOVA makes use of normal curve to draw conclusion about the data. Note that, as Nolan and Heinzen (2011: 301) writes, "…adherence to a normal curve becomes less important as the sizes of our samples increase." The last assumption is homoscedasticity or homogeneity of variance, which refers to the situation in which all samples come from population with similar variance.

Regarding the effect size for ANOVA, we use R^2 (pronounced "r squared") or η^2 (pronounced "eta squared"), which can be interpreted in the same way. Table 7.2 provides guidelines for determining the importance of the effect size.

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[1] A type I error is the situation in which we reject the null hypothesis, but the null hypothesis is correct. In the opposite way, a type II error is the situation in which we fail to reject the null hypothesis, but the null hypothesis is false (Nolan and Heinzen 2011: 118-119).

Table 7.2 Cohen's conventions for each effect sizes: R^2 (Nolan and Heinzen 2011: 318)

Effect Size	R^2 or η^2
Small	0.01
Medium	0.06
Large	0.14

In addition, as ANOVA can only let us know that if there is a difference between at least one pair of means in the study, we need to conduct a post-hoc test to find out where the differences are. According to Nolan and Heinzen (2011: 320), "The Tukey HSD test is a widely used post-hoc test that determines the differences between means… HSD stands for 'honestly significant difference'… The Tukey HSD test involves (1) the calculation of differences between each pair of means and (2) the division of each difference by the standard error…" The HSD value calculated is compared to a critical value (*q* value at a certain *p* level) in order to determine if the difference between that pair of means is statistically significant.

7.2.4 One-way within-groups ANOVA

Principally, as Nolan and Heinzen (2011: 339) summarize, "One-way within-groups ANOVA is used when we have one independent variable with at least three levels, a scale dependent variable, and participants who are in every group." In addition, Nolan and Heinzen (2011: 339) also succinctly note that, "The calculations for a one-way within-groups ANOVA are similar to those for a one-way between-groups ANOVA, but we now calculate a subject sum of squares in addition to the between-groups, within-groups, and total sums of squares. The subjects sum of squares reduces the within-groups sum of squares by removing variability associated with participants' differences across groups."

For the calculation and interpretation of the effect size of a one-way within-groups ANOVA, they are similar to those of a one-way between-groups ANOVA. Likewise, a one-way within-groups ANOVA also relies on the same procedure for conducting a post-hoc test, or a Tukey HSD test, used for a one-way between-groups ANOVA.

7.2.5 Pearson correlation test

Generally, a correlation refers to a co-relation between two variables. According to Nolan and Heinzen (2011: 403), "The number that we calculate when we quantify a correlation is called a coefficient. Specifically, a correlation coefficient is a statistic that quantifies a relation between two variables." The three main characteristics of a correlation coefficient (*r*) include (1) it can be either positive or negative, (2) it always falls between -1.00 and 1.00, and (3) its size indicates strength or magnitude of the correlation, not its sign. Therefore, the sign indicates only the direction of the correlation, positive or negative, not the magnitude of the correlation. More specifically, a positive correlation indicates the situation when people who are high on one variable tend to also be high on the other while a negative correlation indicates the situation when people who are high on one variable are likely to be low on the other. The Pearson correlation coefficient, actually, is one of various kinds of correlation coefficients. In particular, the Pearson correlation coefficient is "a statistic that quantifies a linear relation between two scale variables" (Nolan and Heinzen 2011: 410).

In statistics, "correlation can be used as a descriptive statistic to simply describe a relationship between two variables, and as an inferential statistic" (Nolan and Heinzen 2011: 414) to test hypothesis and draw conclusion about the population. As Nolan and Heinzen (2011: 414) notes, "Usually, when we conduct hypothesis testing with correlation, we want to test whether a correlation is statistically significantly different from no correlation—an *r* of 0." Specifically, we can conduct hypothesis testing by comparing the correlation coefficient to the critical values on the *r* distribution. It is important to note that correlation does not indicate causation. This is because, as Nolan and Heinzen (2011: 414) explain, "Just because two variables are related doesn't mean one causes the other. It could be that the first causes the second, the second causes the first, or a third variable causes both."

7.2.6 Partial correlation test

For the cases in which there are multiple variables involve, partial correlation is very helpful and beneficial as it allows us to qualify the relation between two variables while controlling the influence of a third variable on each of those two variables of interest. In particular, partial correlation refers to, as Nolan and Heinzen (2011: 419) note, "a technique that quantifies the degree of association between two variables after statistically removing the association of a third variable with both of those two variables." Nolan and Heinzen (2011: 419-420) also succinctly note in this regard that "Partial correlation allows us to examine the association between two variables when we suspect that there is a third variable at work. We can calculate a correlation coefficient that express the association between two variables, over and above the association of either of these variables with a third variable. Essentially, we subtract the influence of a third variable from the correlation coefficient. We usually use software to make these calculations." As with all correlations, we can compare the partial correlation coefficient to the critical values in order to test the research hypothesis and determine if the correlation is statistically significant.

7.3 Statistical tools for analyzing survey data and testing research hypotheses

This dissertation uses the Statistical Package for the Social Sciences (SPSS) software is used to analyze the survey data. The table below, table 7.3, displays the summary of the hypotheses to be tested along with the survey data and appropriate statistical tool(s) to be used for testing each of them. The results of the statistical analysis as well as the discussion of these results are provided in chapter 8-12, respective to each of the five research questions. The specific section discussing the results of each hypothesis test is also presented in table 7.3.

Table 7.3 Summary of the hypotheses to be tested along with survey data and appropriate statistical tool(s) to be used for testing each of the hypotheses

	Hypotheses	Survey data	Statistical tools	Results
Question 1:	*How do people appreciate the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?*			Chapter 8
H-1.1	The rating for aesthetic attractiveness of the urban landscapes with LID design is significantly lower than that of the urban landscapes without LID design.	Q1.4(1)	Frequency distribution Central tendency Independent-samples *t* test One-way between-groups ANOVA	8.1
H-1.2	The rating for functional efficiency of the urban landscapes with LID design is significantly lower than that of the urban landscapes without LID design.	Q1.4(2)		8.2
H-1.3	The rating for ecological performance of the urban landscapes with LID design is significantly higher than that of the urban landscapes without LID design.	Q1.4(3)		8.3
H-1.4	(1) For LID sites, the mean for aesthetic attractiveness is significantly higher than the mean for functional efficiency.	Q1.4(1), 1.4(2)	Paired-samples *t* test	8.4.1
	(2) For non-LID sites, the mean for aesthetic attractiveness is significantly higher than the mean for ecological performance.	Q1.4(1)-1.4(3)		8.4.2
H-1.5	(1) For both LID and non-LID sites, the rating for aesthetic attractiveness is correlated with appreciation rating for functional efficiency.	Q1.4(1), 1.4(2)	Pearson correlation Partial correlation	8.5.1
	(2) For both LID and non-LID sites, the rating for aesthetic attractiveness is correlated with appreciation rating for ecological performance.	Q1.4(1)-1.4(3)		8.5.2
Question 2:	*How do people evaluate the sustainable stormwater management function of the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?*			Chapter 9
H-2.1	Based on people's perception, both LID and non-LID design have the same rating for their sustainable stormwater management performance.	Q4.1	Frequency distribution Central tendency Independent-samples *t* test One-way between-groups ANOVA	9.1

	Hypotheses	Survey data	Statistical tools	Results
H-2.2	Some landscape features are perceived that they help manage urban stormwater in a sustainable way rather than the others.	Q4.2	Frequency distribution	9.2
H-2.3	For each of the study sites, the mean of the rating for sustainable stormwater management function is lower than the means of the appreciation ratings.	Q4.1 Q1.4(1)-(3)	Paired-samples *t* test	9.3
H-2.4	For each of the study sites, the rating for sustainable stormwater management function is positively correlated with the appreciation ratings.	Q4.1 Q1.4(1)-(3)	Pearson correlation Partial correlation	9.4
Question 3:	*How do people evaluate the landscape elements with regard to their attractiveness as well as their effectiveness, sustainability, and recognizability in terms of stormwater management?*			Chapter 10
H-3.1	(1) The landscape elements receive a low attractiveness rating.	Q7.1-7.12	Frequency distribution Central tendency Independent-samples *t* test One-way between-groups ANOVA	10.1.1
	(2) The landscape elements receive a low effectiveness rating.	Q7.1-7.12		10.1.2
	(3) The landscape elements receive a low sustainability rating.	Q7.1-7.12		10.1.3
	(4) The landscape elements receive a low recognizability rating.	Q7.1-7.12		10.1.4
H-3.2	The attractiveness rating is different from the other three ratings—effectiveness rating, sustainability rating, and recognizability rating.	Q7.1-7.12	Paired-samples *t* test	10.3
H-3.3	The four ratings—attractiveness rating, effectiveness rating, sustainability rating, and recognizability rating—of the landscape elements are correlated with each other.	Q7.1-7.12	Pearson correlation Partial correlation	10.2
Question 4:	*Do people hold misconceptions and limited knowledge about urban stormwater problems and management efforts?*			Chapter 11
H-4.1	The water pollution and shortage problem get less concern from the public, compared to the other environmental problems such as global warming, sea level rise, air pollution, energy shortage, waste management, soil contamination, and wildlife habitat degradation.	Q2.1	Frequency distribution Central tendency Paired-samples *t* test	11.1
H-4.2	Runoff is perceived as if it has less impact on a water pollution and degradation problem than discharge from industrial plants.	Q3.1		11.2
H-4.3	People tend to think that draining rainwater to sewer treatment plants is the most sustainable measure for urban stormwater management.	Q3.2	Frequency distribution	11.3

	Hypotheses	Survey data	Statistical tools	Results
H-4.4	People tend to not mention LID facilities as places holding ecological benefits.	Q2.2	Frequency distribution	11.4
H-4.5	People tend to not able to identify places with sustainable stormwater management benefits.	Q3.3		11.5
H-4.6	Overall, people think that they are not knowledgeable about each of the 25 sustainable stormwater management principles and practices.	Q5.3	Frequency distribution Central tendency	11.6
Question 5:	*Do people hold limited learning experiences and lack of interest in learning more about sustainable stormwater management?*			Chapter 12
H-5.1	The majority of people have never learned or received information about sustainable stormwater management.	Q5.1	Frequency distribution	12.1
H-5.2	The majority of people have never participated in sustainable stormwater management programs.	Q5.2		12.2
H-5.3	(1) People are not interested in learning more about sustainable stormwater management.	Q6.1	Frequency distribution Central tendency	12.3.1
	(2) Learning from the interpretive signs at the LID sites is quite preferable, compared to the other options.	Q6.2	Frequency distribution Central tendency Paired-samples *t* test	12.3.2

Chapter 8

Appreciation of the Landscape Design of the Study Sites

This chapter statistically analyzes and discusses the answers to question 1.4 of the questionnaire. The question asked the respondents to rate their appreciation with regard to 1) aesthetic attractiveness, 2) functional efficiency, and 3) ecological performance of the landscape design of each study site by using a 5-point attitude scale, given that 1 means do not appreciate at all and 5 means appreciate very much. The aim of this statistical analysis is to answer the first research question: *how do people appreciate the urban landscapes with and without the implementation of LID design?* More specifically, the ultimate goal of this chapter is to test if the urban landscapes with LID design in San Francisco Bay area fell short of achieving public appreciation—whether in terms of aesthetic attractiveness, functional efficiency, and ecological performance—compared to those without LID design, see section 8.1-8.3. Furthermore, this chapter also aims to examine if there exist the significant differences and correlations between the rating for aesthetic attractiveness and the other two ratings of each study site, see section 8.4-8.5.

8.1 The rating for aesthetic attractiveness of the study sites

8.1.1 Descriptive statistics of the rating for aesthetic attractiveness

Overall, 15 of 16 study sites received a quite positive rating for aesthetic attractiveness from the respondents—which means respondents were likely to appreciate the aesthetic quality of these sites. The only one site that received a slightly negative rating is San Pablo Avenue in Albany. As shown in figure 8.1.1, only the frequency distribution of the rating for this site shows that the majority of data are clustered in the negative rating side. Moreover, as shown in table 8.1.2, only the mean score of San Pablo Avenue in Albany, which is 2.74, is lower than 3.00—which, again, implies a slightly negative attitude toward its aesthetic attractiveness.

Considering the rating distributions of the eight LID sites, see also figure 8.1.1, six of them depict a quite similar shape of distribution in which their modes are 4, and their second and third most common scores are either 3 or 5. For the rest, both of them (Brisbane City Hall and San Pablo Avenue in El Cerrito) possess a slightly different shape of distribution from that of the six sites, yet their distributions are very similar to each other, in which their modes are 5 while their second, third, and forth most common scores are 4, 3 and 2, respectively, and none of 1 is presented. Interesting enough, these sites are the only two study sites which provide the interpretive signage for their visitors. Perhaps it was a matter of their interpretive signage that increased the amount of the 5 (like very much) scores they received, thereby making their modes shift from 4 to 5. In particular, when looking at the distributions of these LID sites more closely, it seems like the interpretive signage resulted in the move of scores from 4 to 5 as while the amount of the 5 rating score obviously increased, the amount of the 4 rating score evidently decreased and the proportion of people who gave

4 and 5 rating scores seems unchanged. As shown in table 8.1.1, for the sites without interpretive signage, approximately 50-60% of their respondents gave them 4 while only 10-30% of respondents gave them 5. In contrast, for the sites with interpretive signage, the percentage of their respondents who gave them 4 and who gave them 5 are almost identical, approximately 35%. However, what is similar is that, for all eight LID sites, approximately 70-80% of their respondents gave them either 4 or 5 scores. One assumption in regard to this phenomenon is that interpretive signage might encourage those who appreciate the LID design to appreciate it more, but it seems to have less effect on those who did not or appreciated it less. In view of this initial discovery, the issue regarding the influence of interpretive signage on people's appreciation of LID design is considered intriguing and to be further investigated in the subsequent inquiries.

Table 8.1.1 Distribution of the rating scores for appreciation of aesthetic attractiveness of the study sites (1=do not like at all, 5=like very much)

Study Site	Frequency Distribution of Rating Scores					Missing	*n*
	1 (not at all)	2	3	4	5 (very much)		
1. Mint Plaza	0	1 (3.2%)	12 (38.7%)	**15 (48.4%)**	3 (9.7%)	0	31
2. Davis Court	0	3 (9.1%)	8 (24.2%)	**18 (54.5%)**	4 (12.1%)	0	33
3. Fox Square	1 (3.3%)	0	5 (16.7%)	**16 (53.3%)**	8 (26.7%)	0	30
4. Brisbane City	0	2 (6.5%)	6 (19.4%)	10 (32.3%)	**12 (38.7%)**	1 (3.2%)	31
5. El Cerrito City	1 (2.8%)	3 (8.3%)	5 (13.9%)	**18 (50.0%)**	9 (25.0%)	0	36
6. New Sproul	1 (3.3%)	2 (6.7%)	3 (10.0%)	**19 (63.3%)**	5 (16.7%)	0	30
7. Cesar Chavez	0	1 (3.2%)	4 (12.9%)	**16 (51.6%)**	10 (32.3%)	0	31
8. San Pablo (El)	0	4 (11.8%)	6 (17.6%)	**12 (35.3%)**	**12 (35.3%)**	0	34
9. Jessie Square	0	1 (3.1%)	4 (12.5%)	13 (40.6%)	**14 (43.8%)**	0	32
10. Justin Herman	2 (6.7%)	4 (13.3%)	**16 (53.3%)**	7 (23.3%)	1 (3.3%)	0	30
11. S.D. Bechtel	0	4 (12.9%)	**10 (32.3%)**	7 (22.6%)	**10 (32.3%)**	0	31
12.Yerba Buena	0	0	8 (26.7%)	**11 (36.7%)**	**11 (36.7%)**	0	30
13. Daly City	0	4 (12.9%)	8 (25.8%)	**17 (54.8%)**	2 (6.5%)	0	31
14. Upper Sproul	1 (3.3%)	4 (13.3%)	8 (26.7%)	**12 (40.0%)**	5 (16.7%)	0	30
15. Valencia Street	0	3 (9.4%)	10 (31.3%)	**15 (46.9%)**	3 (9.4%)	1 (3.1%)	32
16. San Pablo (Al)	4 (13.3%)	7 (23.3%)	**14 (46.7%)**	3(10.0%)	2 (6.7%)	0	30

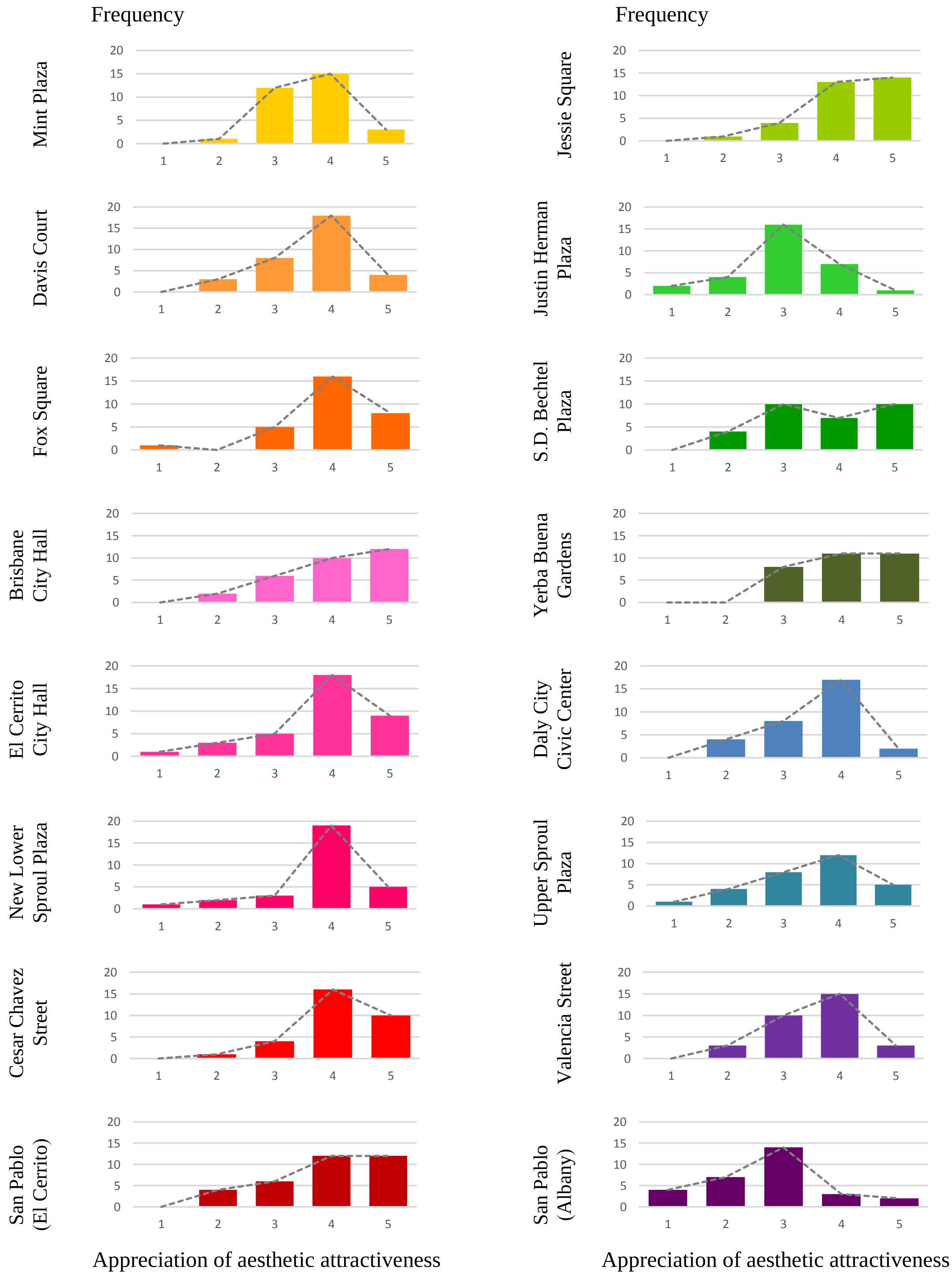
Table 8.1.2 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for appreciation of aesthetic attractiveness of the study sites

Study Site	*n*	Mean	Median	Mode	SD
1. Mint Plaza	31	3.65	4.00	4	0.709
2. Davis Court	33	3.70	4.00	4	0.810
3. Fox Square	30	4.00	4.00	4	0.871
4. Brisbane City	30	4.07	4.00	5	0.944
5. El Cerrito City	36	3.86	4.00	4	0.990
6. New Sproul	30	3.83	4.00	4	0.913
7. Cesar Chavez	31	4.13	4.00	4	0.763
8. San Pablo (El)	34	3.94	4.00	4,5	1.013
9. Jessie Square	32	**4.25**	4.00	5	0.803
10. Justin Herman	30	3.03	3.00	3	0.890
11. S.D. Bechtel	31	3.74	4.00	3,5	1.064
12.Yerba Buena	30	4.10	4.00	4,5	0.803
13. Daly City	31	3.55	4.00	4	0.810
14. Upper Sproul	30	3.53	4.00	4	1.042
15. Valencia Street	31	3.58	4.00	4	0.807
16. San Pablo (Al)	30	**2.73**	3.00	3	1.048

When looking at the distributions of the control sites, it is obvious that their distributions are varied and different from those of the LID sites, especially those of the four sites in the first landscape type (city and community open spaces)—which are Jessie Square, Justin Herman Plaza, S.D. Bechtel Plaza, and Yerba Buena Gardens, see table 5.1 in chapter 5. However, this is not a surprising result because these four sites possess quite different aspects and elements of landscape design from the LID sites and the rest four control sites, as explained in section 5.3 of chapter 5. In fact, that the patterns of the rating scores differ is certainly a positive sign as it suggests that the difference between the respondents' appreciation of the sites with and without LID design, and the sites with different landscape attributes seems to exist and is intriguing to be further explored.

In addition to the frequency distributions, the mean scores also reveal the disparity between the ratings of the LID and non-LID sites. In particular, the line graph, as shown in figure 8.1.2, illustrates that the mean scores for aesthetic appreciation of all LID sites are not quite different from each other, while those of the control sites dramatically differ, both among themselves and from the LID sites. Again, this circumstance can be simply explained in the same way as the case of frequency distributions. In brief, because the LID sites possess quite indifferent landscape design aspects and elements, it is not surprising that their means, as well as their frequency distributions, are not so different from each other.

Figure 8.1.1 Bar graphs illustrating the distributions of the rating scores for appreciation of aesthetic attractiveness of the study sites (1=do not like at all, 5=like very much)



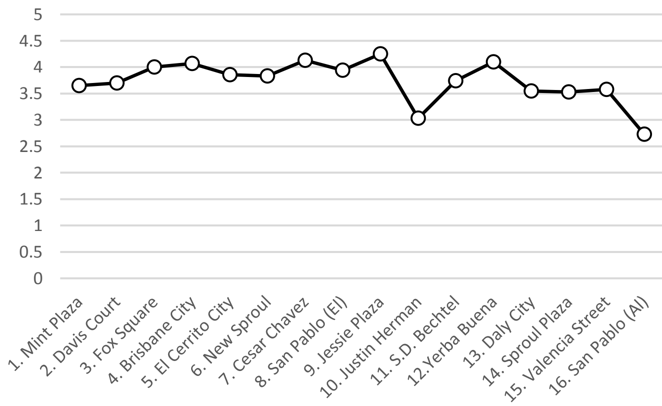


Figure 8.1.2 Line graph illustrating the mean scores for appreciation of aesthetic attractiveness of the study sites

In contrast, because the non-LID sites possess quite different landscape design aspects and elements, their means along with their frequency distributions are diverse. Another interesting point in which the mean scores bring to light is that, as shown in table 8.1.2 and figure 8.1.2, the means of the LID sites are not only indifferent to each other, but they are also quite high—the lowest is 3.65. In contrast, for the sites without LID design, their means do not only swing, but some of them are also quite low—the lowest is 2.73. Moreover, when looking at the frequency distribution graphs again, for the sites without LID design, the amount of scores in the negative side (1 and 2) are likely to be more than those in the positive side (4 and 5), and also more than those in the negative side of the LID sites. Seeing that, it appears like the sites with LID design received a higher aesthetic appreciation rating than those without LID design.

According to these preliminary evidences, the assumption that urban landscapes with LID design in San Francisco Bay area fell short of achieving public appreciation compared to those without LID design might be rejected. In other words, the sites with LID design seem to be more aesthetically attractive or appealing than those without LID design. The further examination of this assumption is presented in the following section.

8.1.2 Difference between the means of the rating for aesthetic attractiveness of the study sites with and without LID design

As the frequency distributions and mean scores suggest some disparities between aesthetic appreciation for the sites with and without LID design, this section intends to investigate whether these differences statistically significant.

The outputs from the independent-sample *t* tests (*p*-level at 0.05, two-tailed test) reveal that, of the four pairwise comparisons, only the comparison between Mint Plaza and Jessie Square presents the situation in which the site with LID design significantly failed to satisfy their respondents with its aesthetic attractiveness, compared to the site without LID design (see table 8.1.3, $t(61) = -3.164$, $p < 0.05$, Cohen's d = -0.792, which is considered an almost large effect size). For the rest three comparisons, findings demonstrate that the sites with LID design did not fail to fulfill their visitors' aesthetic appreciation; instead, they were considered more aesthetically attractive than their control sites, those without LID design. As statistics display, Cesar Chavez Street (LID site) received a significantly higher rating for its aesthetic attractiveness than Valencia Street (non-LID site) with an almost large effect size; $t(60) = 2.748$, $p < 0.05$ and Cohen's d = 0.700. Likewise, the statistics also manifest that San Pablo Avenue in El Cerrito (LID site) received a significantly higher rating for its aesthetic attractiveness than San Pablo Avenue in Albany, yet for this case the effect size is considered very large; $t(62) = 4.682$, $p < 0.05$ and Cohen's d = 1.174. For the case of the New Lower Sproul Plaza and the Upper Sproul Plaza, the difference between their means is not statistically significant; $t(58) = 1.186$, $p > 0.05$ and Cohen's d = 0.306.

Table 8.1.3 Independent-samples *t* tests elucidating if there is any statistically significant difference between the means for appreciation of aesthetic attractiveness of the sites with and without LID design

Independent-samples *t* test (LID site *x* non-LID site)	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Mint Plaza *x* Jessie Square	61	-3.164	**0.002***	-0.792; large
New Lower Sproul Plaza *x* Upper Sproul Plaza	58	1.186	0.240	0.306; small-medium
Cesar Chavez St. *x* Valencia St.	60	2.748	**0.008***	0.700; almost large
San Pablo Ave. (El) *x* San Pablo Ave. (Al)	62	4.682	**0.000***	1.174; very large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

In addition to the four tests described above, three independent-sample *t* tests are also conducted in order to examine if there is any significant difference among the means of the three city hall sites. As shown in table 8.1.4, although both LID sites (Brisbane City Hall and El Cerrito City Hall) received a higher level of aesthetic appreciation than the non-LID site (Daly City Civic Center), only the mean of Brisbane City Hall, which is the LID site with interpretive signage, is significantly higher than that of Daly City Civic Center, while the mean of El Cerrito City Hall, which is the LID site without interpretive signage, is not. In addition, despite the fact that there is not enough evidence to say that the mean difference between the two LID sites is statistically significant, the mean of Brisbane City Hall, which is the LID site with interpretive signage, is also higher than the mean of El Cerrito City Hall, which is the LID site without interpretive signage. Accordingly, it seems like, by some chance, interpretive signage could play a part in enhancing aesthetic appreciation of the LID landscapes.

Table 8.1.4 Independent-samples *t* tests elucidating if there is any statistically significant difference among the means for appreciation of aesthetic attractiveness of the city hall sites

Independent-samples *t* test	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Brisbane (LID with signage) *x* Daly City (non-LID)	59	2.303	**0.025***	0.591; medium
El Cerrito (LID) *x* Daly City (non-LID)	65	1.401	0.166	0.343; small- medium
Brisbane (LID with signage) *x* El Cerrito (LID)	64	0.858	0.394	0.217; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 8.1.5 One-way between-groups ANOVA test elucidating if there is any statistically significant difference between the means for appreciation of aesthetic attractiveness of the seven sites in the first landscape type **(**city and community open space**)**

One-way between-groups ANOVA	*df*	*F*	*p*-value (Sig.)	Effect Size (Eta Squared)	Homogeneity Test (Sig.)
Mint Plaza *x* Davis Court *x* Fox Square *x* Jessie Square *x* Justin Herman Plaza *x* S.D.Betchel Plaza *x* Yerba Buena Gardens	6	6.640	**0.000***	0.159; large	0.089

* $p < 0.05$; F-value is significant at the 0.05 level.

Table 8.1.6 Tukey HSD tests (post-hoc tests) elucidating that there are five statistically significant differences between the means for appreciation of aesthetic attractiveness of the sites in the first landscape type **(**city and community open space**)**

p-value (Sig.)	Mint Plaza	Davis Court	Fox Square	Jessie Square	Justin Herman	S.D. Bechtel	Yerba Buena
Mint Plaza		1.000	0.670	0.079	0.082	0.999	0.371
Davis Court	1.000		0.799	0.129	**0.038***	1.000	0.504
Fox Square	0.670	0.799		0.912	**0.000***	0.902	0.999
Jessie Square	0.079	0.129	0.912		**0.000***	0.223	0.993
Justin Herman	0.082	**0.038***	**0.000***	**0.000***		**0.024***	**0.000***
S.D. Bechtel	0.999	1.000	0.902	0.223	**0.024***		0.660
Yerba Buena	0.371	0.504	0.999	0.993	**0.000***	0.660	

* $p < 0.05$; HSD is significant at the 0.05 level (2-tailed).

Apart from the independent-sample *t* tests, a one-way between-groups ANOVA test is also conducted in order to examine the difference between the means of the seven sites in the first landscape type **(**city and community open space). Before conducting this ANOVA test, the test of homogeneity of variance was conducted and found that the *p*- value is greater than the critical level, $p > 0.05$, so that this test meets the assumption of homogeneity of variance.

As shown in table 8.1.5, the outputs of the ANOVA test suggest that there is at least one significant mean difference by the study sites with a large effect size because the *F* statistic is beyond the critical value; $F(6) = 6.640$, $p < 0.05$ and the eta squared is 0.159. In view of these statistics, post-hoc tests, Tukey HSD tests, are performed to determine where the statistically significant differences really are. The results from Tukey HSD tests reveal that there are five significant differences in this ANOVA test; as shown in table 8.1.6, there are five *p*-values which are lower than 0.05. Interestingly, all of these significant differences are the cases of Justin Herman Plaza. In particular, the mean for aesthetic attractiveness of Justin Herman Plaza is significantly lower than the mean of Davis Court, Fox Square, Jessie Square, S.D. Bechtel Plaza, and Yerba Buena Gardens. The only one site that there is not enough evidence to say that its mean is significantly higher than that of Justin Herman Plaza is Mint Plaza. Seeing that, the significant mean differences are found not only between the LID and non-LID sites, but also among the non-LID sites as their landscape characteristics and features are diverse.

In consideration of the statistical outputs presented in this section, it appears that we can reject the first research hypothesis because it is quite clear that the LID sites did not disappoint people with regard to their aesthetic attractiveness. On the contrary, it looks as if the LID design could help increase the aesthetic attractiveness of these urban places. In particular, only the case of the first landscape category—city and community open space—presents the situation in which the LID sites received a lower rating than the non-LID sites. For other cases, it appears that the LID sites received a higher rating than their control, non-LID sites.

Additionally, it is worth to emphasize two interesting issues—one is about the potential influence of the interpretive signage and another one is about the nature of the different landscape types. For the former issue, it seems like the interpretive signage played a part in increasing rating scores for aesthetic attractiveness of the LID sites. Considering the case of the three city hall sites, Brisbane City Hall, at which the interpretive signs are provided, received higher scores than El Cerrito City Hall, at which no interpretive signage is provided. Likewise, for the case of the streetscape type, the San Pablo green street project in El Cerrito, at which the interpretive signs are provided, received higher scores than the green street project of Cesar Chaves street, at which no interpretive signage is provided.

For the latter issue, it appears that the patterns of the differences between the means for aesthetic attractiveness of the LID sites and the non-LID sites are varied among the four landscape types. Considering the first landscape type, the means for aesthetic attractiveness of the study sites in this category are quite high, whether those of the sites with or without LID design. As one plausible explanation, it might be because these sites are not the typical places of the city or community; instead they are considered the notable ones so that the design of these sites are certainly extraordinary, making they look pretty nice to the eyes of the public. In addition, it is also fairly obvious that the means of the LID sites are not quite varying, while those of the non-LID sites are fluctuating. For the second type, as all sites in this category are certainly well designed and maintained so that the means for aesthetic attractiveness of the LID and the non-LID city hall sites are quite high. Nevertheless, it appears that the means of the two LID sites are higher than the mean of the non-LID site. Like the situation of the second landscape type, the means of the two UC Berkeley's plaza are quite high and not significantly different. However, such high means might be the effect of the confounding variables. In particular, for the case of the New Lower Sproul Plaza, it might be because the site was just constructed so that it is quite new, making it look very nice and receive a high rating. For the case of the Upper Sproul Plaza, that it received a high level of appreciation might be because it is regarded as one of the iconic places on campus, but not because of the actual quality of its physical landscape. Lastly, it becomes obvious that the streets and sidewalks with LID design received a significantly higher appreciation with regard to their aesthetic attractiveness than those without LID design. For the case of this landscape category, it looks like the LID design could help improve the appearance of the typical streetscapes, especially making these places look different—more special actually—than those ordinary, standard designs.

8.2 The rating for functional efficiency of the study sites

8.2.1 Descriptive statistics of the rating for functional efficiency

Generally, the distributions of the rating scores for appreciation of functional efficiency of the study sites are varied among themselves, see figure 8.2.1; unlike those of aesthetic attractiveness in which most of them depict a quite similar distribution shape, as described in section 8.1.1. Considering this, perhaps it might be because the functional performance of an urban place is more tangible or empirical than the aesthetic quality, making the ratings fluctuate as a result of different activities people did, or spaces and features people used specifically in that place.

Table 8.2.1 Distribution of the rating scores for appreciation of functional efficiency of the study sites (1=do not like at all, 5=like very much)

Study Site	Frequency Distribution of Rating Scores					Missing	*n*
	1 (not at all)	2	3	4	5 (very much)		
1. Mint Plaza	0	0	9 (29.0%)	**21 (67.7%)**	1 (3.2%)	0	31
2. Davis Court	0	2 (6.1%)	**15 (45.5%)**	**15 (45.5%)**	1 (3.0%)	0	33
3. Fox Square	0	1 (3.3%)	5 (16.7%)	**16 (53.3%)**	7 (23.3%)	1 (3.3%)	30
4. Brisbane City	0	0	5 (16.1%)	**13 (41.9%)**	**13 (41.9%)**	0	31
5. El Cerrito City	1 (2.8%)	5 (13.9%)	8 (22.2%)	**13 (36.1%)**	9 (25.0%)	0	36
6. New Sproul	0	2 (6.7%)	6 (20.0%)	**16 (53.3%)**	6 (20.0%)	0	30
7. Cesar Chavez	0	1 (3.2%)	7 (22.6%)	**17 (54.8%)**	6 (19.4%)	0	31
8. San Pablo (El)	1 (2.9%)	4 (11.8%)	**12 (35.3%)**	7 (20.6%)	9 (26.5%)	1 (2.9%)	34
9. Jessie Square	0	2 (6.3%)	8 (25.0%)	**14 (43.8%)**	7 (21.9%)	1 (3.1%)	32
10. Justin Herman	1 (3.3%)	4 (13.3%)	**12 (40.0%)**	11 (36.7%)	2 (6.7%)	0	30
11. S.D. Bechtel	0	0	**15 (48.4%)**	8 (25.8%)	8 (25.8%)	0	31
12.Yerba Buena	0	2 (6.7%)	6 (6.7%)	**13 (43.3%)**	9 (30.0%)	0	30
13. Daly City	1 (3.2%)	1 (3.2%)	**18 (58.1%)**	11 (35.5%)	0	0	31
14. Upper Sproul	0	1 (3.3%)	5 (16.7%)	**20 (66.7%)**	4 (13.3%)	0	30
15. Valencia Street	0	2 (6.3%)	**14 (43.8%)**	13 (40.6%)	2 (6.3%)	1 (3.1%)	32
16. San Pablo (Al)	1 (3.3%)	6 (20.0%)	**16 (53.3%)**	5 (16.7%)	2 (6.7%)	0	30

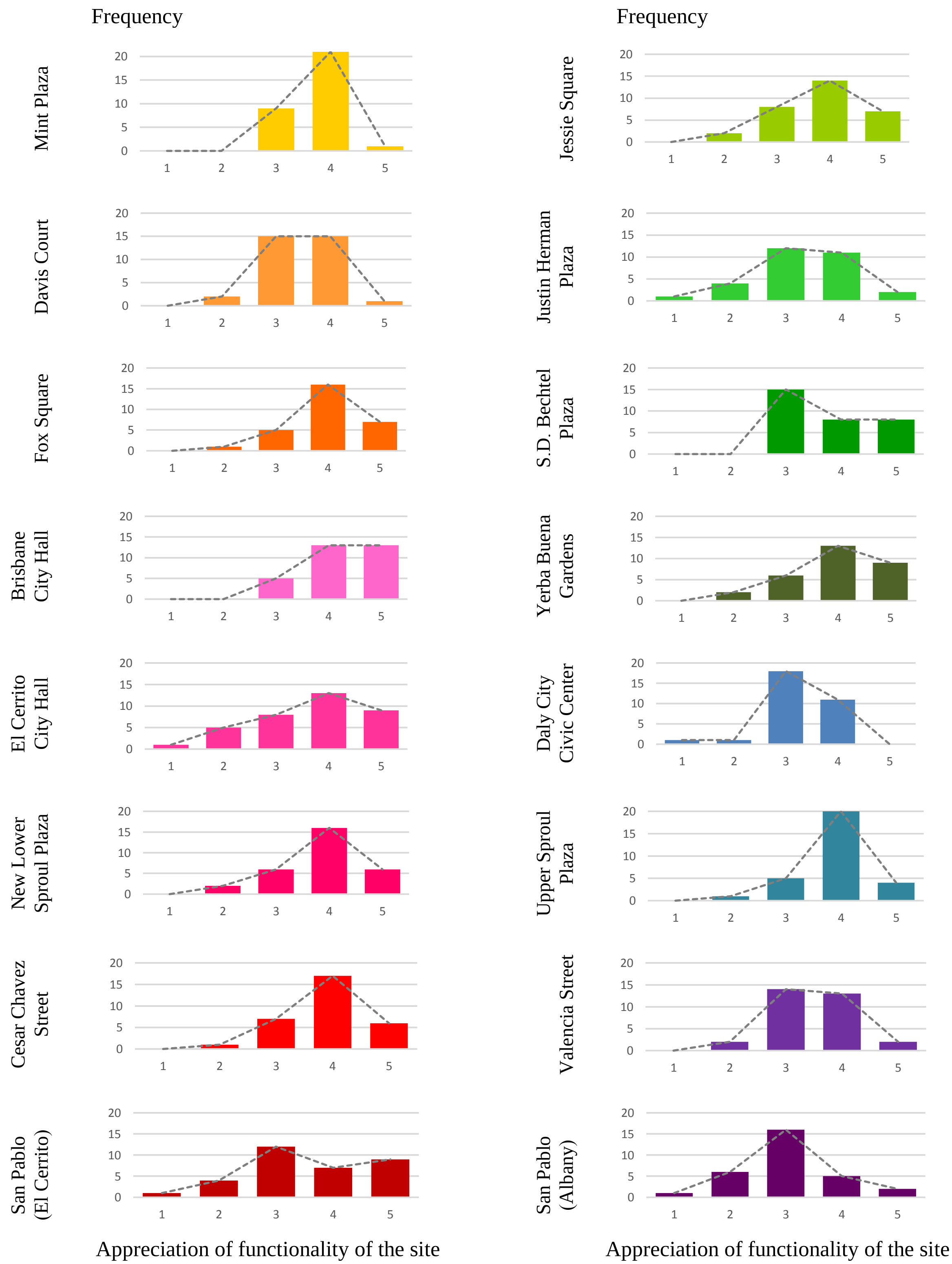
As the judgment of landscape aesthetics is more likely to be based on a conventional paradigm of landscape beauty rather than an actual experience with the place, the ratings for aesthetic attractiveness of the different sites are quite commensurate because it is fairly obvious that the overall characteristics of these study sites are not so widely divergent; only the sites which have the presence of some distinctive attributes did the respondents rated them differently, as also pointed out in section 8.1.1.

In contrast to the case of frequency distributions, when looking at the mean scores for appreciation of functional efficiency, it appears that they are not quite varying. Besides, they are also relatively high as all of them are higher than 3.00; that is to say that the respondents were positive toward the functionality of every site. However, it seems like the overall mean scores of the LID sites are slightly higher than those of the non-LID sites; some of the mean scores of the LID sites are higher than 4.00 while no mean score of the non-LID sites is higher than 4.00. In addition, most of the modes of the LID sites are 4 while half of the non-LID sites are 3 and the other half are 4. Seeing that, it looks as if the LID sites received a higher rating than the non-LID sites. Therefore, we might be able to reject the assumption that the LID design impedes the functional performance of the urban landscapes. The following section further examines this assumption.

Table 8.2.2 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for appreciation of functional efficiency of the study sites

Study Site	*n*	Mean	Median	Mode	SD
1. Mint Plaza	31	3.74	4.00	4	0.514
2. Davis Court	33	3.45	3.00	3,4	0.666
3. Fox Square	29	4.00	4.00	4	0.756
4. Brisbane City	31	**4.26**	4.00	4,5	0.729
5. El Cerrito City	36	3.67	4.00	4	1.095
6. New Sproul	30	3.87	4.00	4	0.819
7. Cesar Chavez	31	3.90	4.00	4	0.746
8. San Pablo (El)	33	3.58	3.00	3	1.119
9. Jessie Square	31	3.84	4.00	4	0.860
10. Justin Herman	30	3.30	3.00	3	0.915
11. S.D. Bechtel	31	3.77	4.00	3	0.845
12.Yerba Buena	30	3.97	4.00	4	0.890
13. Daly City	31	3.26	3.00	3	0.682
14. Upper Sproul	30	3.90	4.00	4	0.662
15. Valencia Street	31	3.48	3.00	3	0.724
16. San Pablo (Al)	30	**3.03**	3.00	3	0.890

Figure 8.2.1 Bar graphs illustrating the distributions of the rating scores for appreciation of functional efficiency of the study sites (1=do not like at all, 5=like very much)



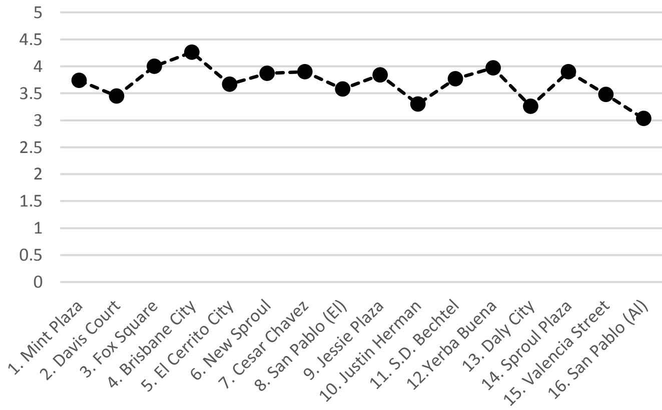


Figure 8.2.2 Line graph illustrating the mean scores for appreciation of functional efficiency of the study site

8.2.2 Difference between the means of the rating for functional efficiency of the study sites with and without LID design

Taking into account that the frequency distributions as well as the mean scores ambiguously communicate the differences between the rating for appreciation of functional efficiency of the study sites with and without LID design, this section aims to investigate if there exists any statistically significant difference.

Table 8.2.3 Independent-samples *t* tests elucidating if there is any statistically significant difference between the means for appreciation of functional efficiency of the sites with and without LID design

Independent-samples *t* test (LID site *x* non-LID site)	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Mint Plaza *x* Jessie Square	60	-0.538	0.593	-0.141; small
New Lower Sproul Plaza *x* Upper Sproul Plaza	58	-0.173	0.863	-0.040; very small
Cesar Chavez St. *x* Valencia St.	60	2.245	**0.028***	0.571; medium
San Pablo Ave. (El) *x* San Pablo Ave. (Al)	61	2.115	**0.038***	0.544; medium

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

According to the outputs from the independent-sample *t* tests (*p*-level at 0.05, two-tailed test), two LID sites (Mint Plaza and New Lower Sproul Plaza) received a lower rating than their control sites (Jessie Square and Upper Sproul Plaza, respectively) while the other two LID sites (Cesar Chavez Street and San Pablo Avenue in El Cerrito) received a higher rating than their control sites (Valencia Street and San Pablo Avenue in El Cerrito, respectively). However, what is interesting is that whereas the lower ratings the LID sites received are not statistically significant, the higher ratings the LID sites received are statistically significant, as shown in table 8.2.3.

Table 8.2.4 Independent-samples *t* tests elucidating if there is any statistically significant difference among the means for appreciation of functional efficiency of the city hall sites

Independent-samples *t* test	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Brisbane (LID with signage) *x* Daly City (non-LID)	60	5.580	**0.000***	1.417; very large
El Cerrito (LID) *x* Daly City (non-LID)	65	1.798	0.077	0.445; almost medium
Brisbane (LID with signage) *x* El Cerrito (LID)	65	2.557	**0.013***	0.634; medium

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For the case of the three city hall sites, the outputs from the independent-sample *t* tests also reveal that the mean scores for appreciation of functional efficiency of the two LID sites (Brisbane City Hall and El Cerrito City Hall) are higher than that of the non-LID site (Daly City Civic Center), see table 8.2.4. Interesting again, the mean score of Brisbane City Hall, which is the LID site with interpretive signage, is significantly higher than those of the others. In view of these statistics, it also crucial to highlight that it might be the role of the interpretive signage that help increase respondents' appreciation of the landscapes.

Table 8.2.5 One-way between-groups ANOVA test elucidating if there is any statistically significant difference between the means for appreciation of functional efficiency of the seven sites in the first landscape type **(**city and community open space**)**

One-way between-groups ANOVA	*df*	*F*	*p*-value (Sig.)	Effect Size (Eta Squared)	Homogeneity Test (Sig.)
Mint Plaza *x* Davis Court *x* Fox Square *x* Jessie Square *x* Justin Herman Plaza *x* S.D.Betchel Plaza *x* Yerba Buena Gardens	6	3.294	**0.004***	0.087; medium	0.052

* $p < 0.05$; F-value is significant at the 0.05 level.

In addition to those statistics from independent-sample *t* tests, the outputs of the one-way between-groups ANOVA test also reveal that there is at least one difference between the means of the seven sites within the city and community open space category ($F(6) = 3.294$, $p < 0.05$) with a medium effect size (eta squared is 0.087), as shown in table 8.2.5. This test meets the assumption of homogeneity of variance because the *p*-value calculated from the test of homogeneity of variance is greater than 0.05. According to the, post-hoc tests, only one statistically significant difference is detected. Again, this difference is the case of Justin Herman Plaza. More specifically, the mean score for appreciation of functional efficiency of Justin Herman Plaza is significantly lower than that of Fox Square, see table 8.2.6.

As statistics elicit, it appears that the LID sites did not fail to achieve their users' appreciation of their functional efficiency. Besides, like the case of aesthetic attractiveness, it seems as if the LID design could play a role in increasing people's appreciation of the sites' functional efficiency.

Table 8.2.6 Tukey HSD tests (post-hoc tests) elucidating that there is one statistically significant difference between the means for appreciation of functional efficiency of the sites in the first landscape type **(**city and community open space**)**

p-value (Sig.)	Mint Plaza	Davis Court	Fox Square	Jessie Square	Justin Herman	S.D. Bechtel	Yerba Buena
Mint Plaza		0.769	0.866	0.999	0.305	1.000	0.923
Davis Court	0.769		0.098	0.450	0.987	0.668	0.138
Fox Square	0.866	0.098		0.985	**0.013***	0.925	1.000
Jessie Square	0.999	0.450	0.985		0.111	1.000	0.996
Justin Herman	0.305	0.987	**0.013***	0.111		0.225	0.021
S.D. Bechtel	1.000	0.668	0.925	1.000	0.225		0.968
Yerba Buena	0.923	0.138	1.000	0.996	0.021	0.968	

* $p < 0.05$; HSD is significant at the 0.05 level (2-tailed).

8.3 The rating for ecological performance of the study sites

8.3.1 Descriptive statistics of the rating for ecological performance

For each study site, the distribution of the rating scores for appreciation of ecological performance is quite different from the previous two distributions. In particular, it appears that, for each study site, the distribution of the rating for ecological performance tends to skew to the negative side, compared to the distribution of the rating for aesthetic attractiveness and the distribution of the rating for functional efficiency, see figure 8.1.1, 8.2.1, and 8.3.1. This pattern implies the situation in which the respondents were likely to less appreciate the ecological performance than the aesthetic attractiveness and functional efficiency of each certain site. However, this kind of situation cannot apply to two sites—Brisbane City Hall and San Pablo Avenue El Cerrito—as it fairly obvious that the distributions of the scores for appreciation of ecological performance of these two sites are slightly skewed to the positive side rather than their distributions of scores for aesthetic and functional performances. Besides, when considering their means and modes, it also appears that they are the two highest ones, see figure 8.3.2. It should also be noted that only the means for appreciation of ecological performance of these two sites are higher than their means for appreciation of aesthetic and functional performances, as shown in table 8.1.2, 8.2.2, 8.3.2 and figure 8.1.2, 8.2.2, 8.3.2. Notably, Brisbane City Hall and San Pablo Avenue El Cerrito are the two LID sites in which the interpretive signage is provided. Again, this might account for the rise of the appreciation of the rating for ecological performance of the landscape designs.

Table 8.3.1 Distribution of the rating scores for appreciation of ecological performance of the study sites (1=do not like at all, 5=like very much)

Study Site	Frequency Distribution of Rating Scores					Missing	*n*
	1 (not at all)	2	3	4	5 (very much)		
1. Mint Plaza	0	5 (16.1%)	**20 (64.5%)**	5 (16.1%)	0	1 (3.2%)	31
2. Davis Court	1 (3.0%)	6 (18.2%)	11 (33.3%)	**13 (39.4%)**	1 (3.0%)	1 (3.0%)	33
3. Fox Square	0	2 (6.7%)	**13 (43.3%)**	12 (40.0%)	2 (6.7%)	1 (3.3%)	30
4. Brisbane City	0	0	5 (16.1%)	12 (38.7%)	**13 (41.9%)**	1 (3.2%)	31
5. El Cerrito City	1 (2.8%)	3 (8.3%)	8 (22.2%)	**17 (47.2%)**	7 (19.4%)	0	36
6. New Sproul	1 (3.3%)	0	8 (26.7%)	**18 (60.0%)**	2 (6.7%)	1 (3.3%)	30
7. Cesar Chavez	0	2 (6.5%)	**14 (45.2%)**	7 (22.6%)	6 (19.4%)	2 (6.5%)	31
8. San Pablo (El)	0	0	11 (32.4%)	10 (29.4%)	**12 (35.3%)**	1 (2.9%)	34
9. Jessie Square	0	6 (18.8%)	**14 (43.8%)**	6 (18.8%)	4 (12.5%)	2 (6.3%)	32
10. Justin Herman	3	8 (26.7%)	**10 (33.3%)**	8 (26.7%)	0	1 (3.3%)	30
11. S.D. Bechtel	1 (3.2%)	5 (16.1%)	**12 (38.7%)**	8 (25.8%)	5 (16.1%)	0	31
12.Yerba Buena	0	2 (6.7%)	11 (36.7%)	**12 (40.0%)**	4 (13.3%)	1 (3.3%)	30
13. Daly City	1 (3.2%)	5 (16.1%)	**20 (64.5%)**	5 (16.1%)	0	0	31
14. Upper Sproul	2 (6.7%)	8 (26.7%)	**13 (43.3%)**	5 (16.7%)	2 (6.7%)	0	30
15. Valencia Street	2 (6.3%)	11 (34.4%)	**15 (46.9%)**	2 (6.3%)	0	2 (6.3%)	32
16. San Pablo (Al)	3 (10.0%)	10 (33.3%)	**13 (43.3%)**	2 (6.7%)	1 (3.3%)	1 (3.3%)	30

In addition to the discrepancies between the ratings for ecological performance and those for aesthetic attractiveness and functional efficiency, the distributions and mean scores for appreciation of ecological performance of the study sites are also slightly different from each other, see figure 8.3.1 and 8.3.2. Accordingly, it is intriguing to further investigate whether or not the differences between the means for appreciation of ecological performance of the study sites with and without LID design are statistically significant.

Table 8.3.2 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for appreciation of ecological performance of the study sites

Study Site	*n*	Mean	Median	Mode	*SD*
1. Mint Plaza	30	3.00	3.00	3	0.587
2. Davis Court	32	3.22	3.00	4	0.906
3. Fox Square	29	3.48	3.00	3	0.738
4. Brisbane City	30	**4.27**	4.00	5	0.740
5. El Cerrito City	36	3.72	4.00	4	0.974
6. New Sproul	29	3.69	4.00	4	0.761
7. Cesar Chavez	29	3.59	3.00	3	0.907
8. San Pablo (El)	33	4.03	4.00	5	0.847
9. Jessie Square	30	3.27	3.00	3	0.944
10. Justin Herman	29	2.79	3.00	3	0.978
11. S.D. Bechtel	31	3.35	3.00	3	1.050
12.Yerba Buena	29	3.62	4.00	4	0.820
13. Daly City	31	2.94	3.00	3	0.680
14. Upper Sproul	30	2.90	3.00	3	0.995
15. Valencia Street	30	**2.57**	3.00	3	0.728
16. San Pablo (Al)	29	2.59	3.00	3	0.907

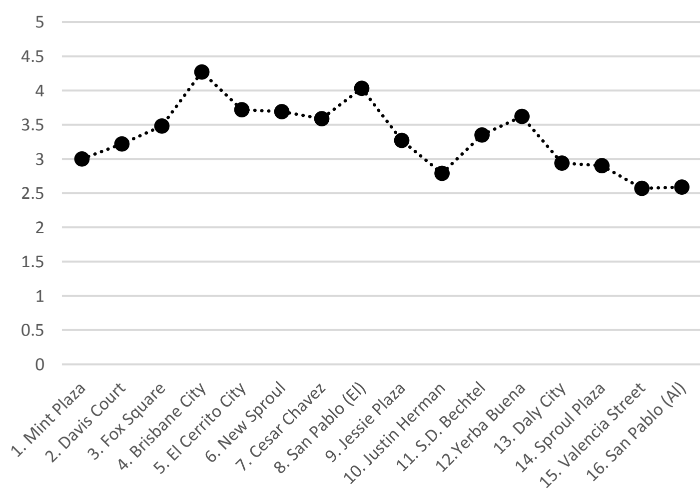
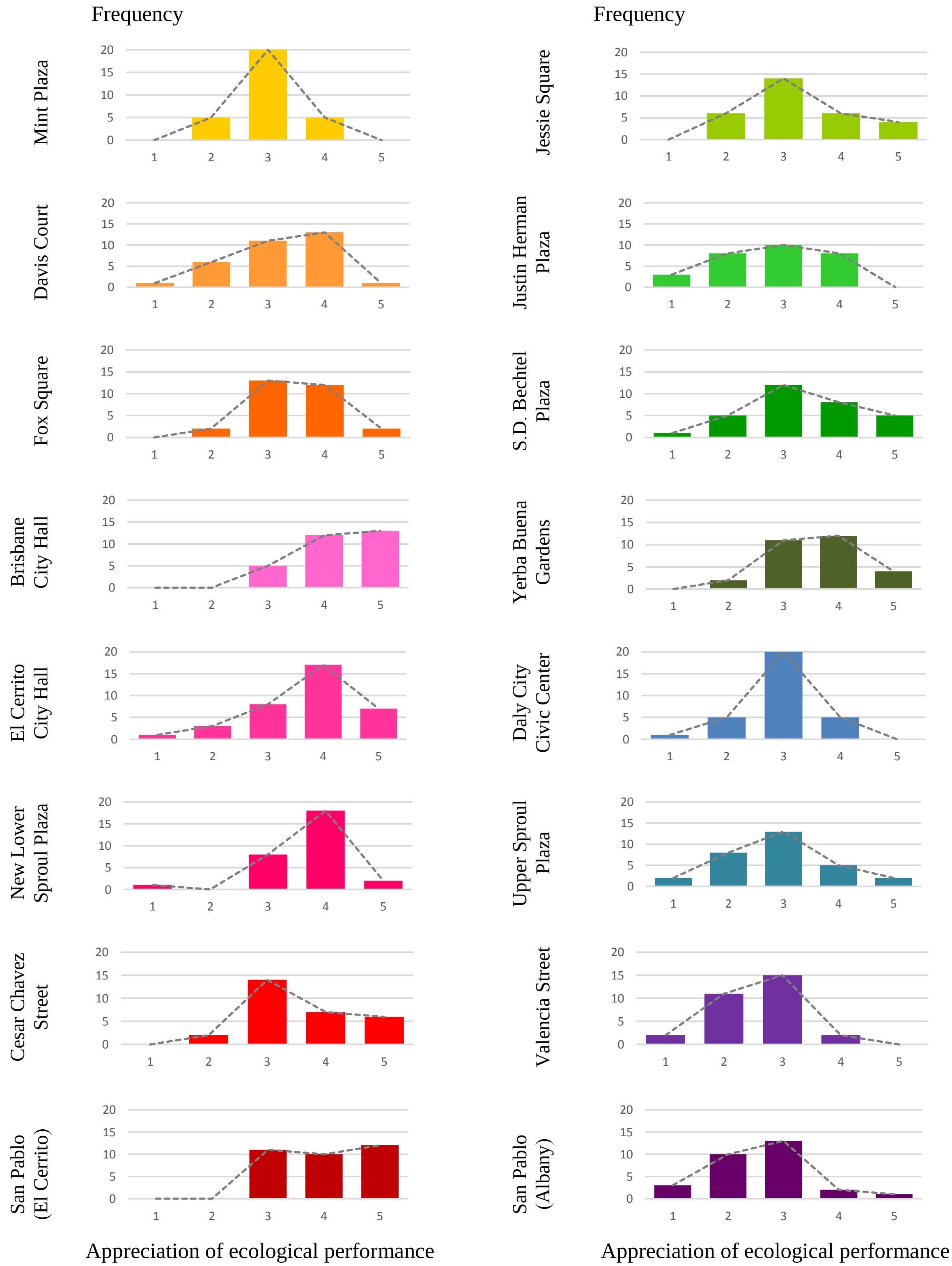


Figure 8.3.1 Line graph illustrating the mean scores for appreciation of ecological performance of the study site

Figure 8.3.2 Bar graphs illustrating the distributions of the rating scores for appreciation of ecological performance of the study sites (1=do not like at all, 5=like very much)



8.3.2 Difference between the means of the rating for ecological performance of the study sites with and without LID design

As shown in figure 8.3.2, the line graph signals that there might exist some differences between the means of the LID sites and their control, non-LID, sites. In particular, it seems like the means of the sites with LID design are higher than the means of the sites without LID design. Seeing that, the independent-sample *t* tests are conducted in order to examine if these differences are statistically significant.

Table 8.3.3 Independent-samples *t* test elucidating if there is any statistically significant difference between the means for appreciation of ecological performance of the sites with and without LID design

Independent-samples *t* test (LID site *x* non-LID site)	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Mint Plaza *x* Jessie Square	58	-1.313	0.194	-0.343; small
New Lower Sproul Plaza *x* Upper Sproul Plaza	57	3.416	**0.001***	0.892; large
Cesar Chavez St. *x* Valencia St.	57	4.770	**0.000***	1.240; very large
San Pablo Ave. (El) *x* San Pablo Ave. (Al)	60	6.479	**0.000***	1.641; very large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

According to the outputs of the tests shown in table 8.3.3, only Mint Plaza fell short of achieving respondents' satisfaction regarding its ecological performance, compared to its control site—Jessie Plaza. However, it appears that the mean score for appreciation of ecological performance of Mint Plaza is not significantly lower than that of Jessie Square; $t(58) = -1.313$, $p > 0.05$ with a quite small effect size (Cohen's d = -0.343). In the opposite way, for the other three LID sites (New Lower Sproul Plaza, Cesar Chavez Street, and San Pablo Avenue in El Cerrito), their mean scores are significantly higher than those of their control sites (Upper Sproul Plaza, Valencia Street, and San Pablo Avenue in Albany, respectively), see table 8.3.3. Likewise, for the case of the three city hall sites, the statistics from independent-samples *t* tests also reveal that the means of both LID sites (Brisbane City Hall and El Cerrito City Hall) are significantly higher than the mean of the non-LID site (Daly City Civic Center, see table 8.3.4. Moreover, it also appears that the LID site with interpretive signage (Brisbane City Hall) received a significantly higher rating for appreciation of ecological performance than the LID site without interpretive signage (El Cerrito City Hall); $t(64) = 2.515$, $p < 0.05$ with a medium effect size (Cohen's d = -0.636).

Table 8.3.4 Independent-samples *t* test elucidating if there is any statistically significant difference among the means for appreciation of ecological performance of the city hall sites

Independent-samples *t* test	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Brisbane (LID with signage) *x* Daly City (non-LID)	59	7.321	**0.000***	1.872; very large
El Cerrito (LID) *x* Daly City (non-LID)	65	3.772	**0.000***	0.929; large
Brisbane (LID with signage) *x* El Cerrito (LID)	64	2.515	**0.014***	0.636; medium

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For the case of the seven city and community open spaces, the outputs from a one-way between-groups ANOVA test suggests that there exists at least one significant difference between mean scores of these sites—as shown in table 8.3.5, $F(6) = 3.021$, $p < 0.05$, eta squared = 0.082 (medium effect size). However, it is important to note that this test does not meet the assumption of homoscedasticity because the *p*-value from the test of homogeneity of variance is lower than 0.05.

Table 8.3.5 One-way between-groups ANOVA test elucidating if there is any statistically significant difference between the means for appreciation of ecological performance of the seven sites in the first landscape type **(**city and community open space**)**

One-way between-groups ANOVA	*df*	*F*	*p*-value (Sig.)	Effect Size (Eta Squared)	Homogeneity Test (Sig.)
Mint Plaza *x* Davis Court *x* Fox Square *x* Jessie Square *x* Justin Herman Plaza *x* S.D.Betchel Plaza *x* Yerba Buena Gardens	6	3.021	**0.008***	0.082; medium	0.001*

* $p < 0.05$; F-value is significant at the 0.05 level.

In view of the statistically significant *F* value, a set of post-hoc tests are performed. As shown in table 8.3.6, the results from Tukey HSD tests show the statistically significant differences of the means for appreciation of ecological performance between two pairs of the study sites. Again, these two significant statistics are the cases of Justin Herman Plaza. More specifically, the mean for appreciation of ecological performance of Justin Herman Plaza is significantly lower than the mean of Fox Square and the mean of Yerba Buena Gardens.

Table 8.3.6 Tukey HSD tests (post-hoc tests) elucidating that there are two statistically significant differences between the means for appreciation of ecological performance of the sites in the first landscape type **(**city and community open space**)**

p-value (Sig.)	Mint Plaza	Davis Court	Fox Square	Jessie Square	Justin Herman	S.D. Bechtel	Yerba Buena
Mint Plaza		0.957	0.345	0.901	0.971	0.693	0.097
Davis Court	0.957		0.902	1.000	0.484	0.996	0.555
Fox Square	0.345	0.902		0.964	**0.047***	0.998	0.997
Jessie Square	0.901	1.000	0.964		0.369	1.000	0.711
Justin Herman	0.971	0.484	**0.047***	0.369		0.170	**0.007***
S.D. Bechtel	0.693	0.996	0.998	1.000	0.170		0.902
Yerba Buena	0.097	0.555	0.997	0.711	**0.007***	0.902	

* $p < 0.05$; HSD is significant at the 0.05 level (2-tailed).

As it is evident that, in most cases, the LID sites hold a mean for ecological performance which is higher than their control, non-LID sites, the hypothesis that LID design could enhance its users' appreciation of its ecological performance, compared to the non-LID design is likely to be retained.

8.4 Difference between the rating means of each study site

The aim of this section is to investigate if the respondents rated the aesthetic attractiveness different from the functional efficiency and the ecological performance. Overall, as presented in table 8.1.2 and 8.2.2, the difference between the mean for aesthetic attractiveness and the mean for the functional efficiency of each study site is quite small. The line graph in figure 8.4.1 also visually illustrates that these two means of each site are quite equivalent to each other.

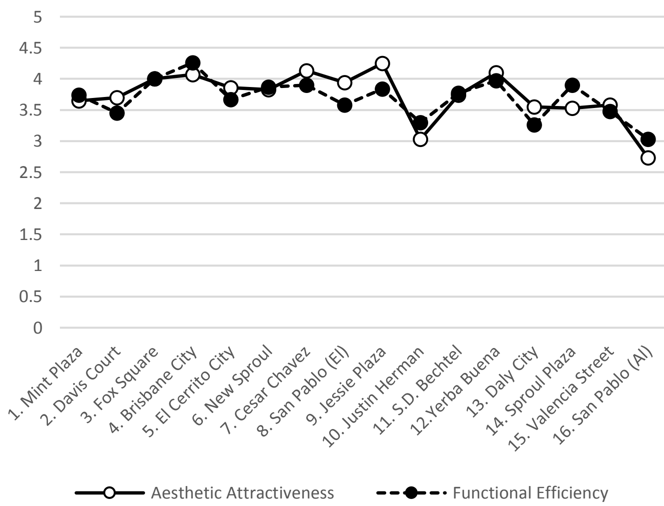


Figure 8.4.1 Line graph illustrating the mean scores for appreciation of aesthetic attractiveness in comparison with the mean scores for appreciation of functional efficiency of the study sites

For the case of the difference between the mean for aesthetic attractiveness and the mean for ecological performance of each study site, it is fairly obvious that, in most of the sites, the difference between this pair of means is greater than the difference between the former pair of means, see table 8.1.2, 8.3.2. As also shown in figure 8.4.1 and 8.4.2, the line graph of the means for appreciation of aesthetic attractiveness almost coincides with that of functional efficiency whereas the line graph of the means for appreciation of aesthetic attractiveness and that of ecological performance are visibly separable.

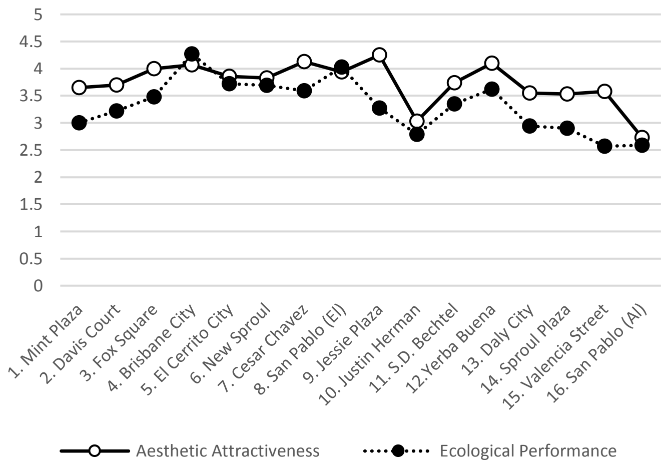


Figure 8.4.2 Line graph illustrating the mean scores for appreciation of aesthetic attractiveness in comparison with the mean scores for appreciation of ecological performance of the study sites

Table 8.4.1 Paired-samples *t* tests elucidating if the differences between the means for appreciation of aesthetic attractiveness and appreciation of functional efficiency of the study sites are statistically significant difference

Paired-samples *t* test (Aesthetics *x* Functionality)	df	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
1. Mint Plaza	30	-0.722	0.476	-0.145; small
2. Davis Court	32	1.543	0.133	0.337; small-medium
3. Fox Square	28	-0.226	0.823	-0.037; very small
4. Brisbane City	29	-1.191	0.243	-0.276; small
5. El Cerrito City	35	1.869	0.070	0.182; small
6. New Sproul	29	-0.171	0.865	-0.046; very small
7. Cesar Chavez	30	2.038	0.050	0.304; small
8. San Pablo (El)	32	2.701	**0.011***	0.401; medium
9. Jessie Square	30	2.528	**0.017***	0.547; medium
10. Justin Herman	29	-1.861	0.073	-0.299; small
11. S.D. Bechtel	30	-0.329	0.745	-0.0317; very small
12.Yerba Buena	29	1.072	0.293	0.153; small
13. Daly City	30	1.793	0.083	0.387; small-medium
14. Upper Sproul	29	-2.009	0.054	-0.424; medium
15. Valencia Street	30	1.000	0.325	0.130; small
16. San Pablo (Al)	29	-1.394	0.174	-0.309; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

The paired-samples *t* tests examine if the differences between the rating means of each site are statistically significant. The results, as shown in table 8.4.1, revealed that half of the LID sites (4 out of 8 sites) hold the mean for aesthetic attractiveness which is lower than the mean for functional efficiency. Likewise, for the case of the non-LID sites, half of them also hold the mean for aesthetic attractiveness which is lower than the mean for functional efficiency. However, most of these differences are not statistically significant. There are only 2 of 16 study sites in which the difference between the two means is significantly different. These two sites are San Pablo Avenue in El Cerrito and Jessie Square. Therefore, we are likely to be able to reject the hypothesis that the mean for aesthetic attractiveness of the LID site is higher than the mean for functional efficiency. This is because, in most cases, the overall rating people gave with regard to their appreciation of aesthetic attractiveness the study, whether the LID or non-LID, site, is not quite different from that of functional efficiency. This implies that most of the study sites did not fail to satisfy people with their functional efficiency, compared to their aesthetic attractiveness.

Table 8.4.2 Paired-samples *t* tests elucidating if the differences between the means for appreciation of aesthetic attractiveness and appreciation of ecological performance of the study sites are statistically significant difference

Paired-samples *t* test (Aesthetics *x* Ecological Performance)	df	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
1. Mint Plaza	29	4.325	**0.000***	1.028; very large
2. Davis Court	31	4.385	**0.000***	0.519; medium
3. Fox Square	28	2.738	0.011	0.609; medium
4. Brisbane City	29	-1.185	0.246	-0.236; small
5. El Cerrito City	35	1.405	0.169	0.143; small
6. New Sproul	28	0.891	0.380	0.165; small
7. Cesar Chavez	28	4.332	**0.000***	0.647; medium
8. San Pablo (El)	32	-0.205	0.839	-0.033; very small
9. Jessie Square	29	5.785	**0.000***	1.152; very large
10. Justin Herman	28	2.073	0.048	0.344; small
11. S.D. Bechtel	30	2.555	0.016	0.369; small
12.Yerba Buena	28	4.050	**0.000***	0.646; medium
13. Daly City	30	4.045	**0.000***	0.816; large
14. Upper Sproul	29	3.357	**0.002***	0.618; medium
15. Valencia Street	29	7.883	**0.000***	1.292; very large
16. San Pablo (Al)	28	0.386	0.702	0.074; very small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For the comparison of the mean for aesthetic attractiveness and the mean for ecological performance, the results reveal that there are 8 out of 16 study sites which hold a significant mean difference. Obviously, the number of significant statistics is relatively higher than the previous case. When carefully considering the results from the tests, two interesting points appear. The first one is that, for the non-LID sites, there is no case in which the mean of aesthetic attractiveness is lower than the mean of ecological performance. Besides, most of the cases are the situation in which the mean of aesthetic attractiveness is significantly higher than the mean of ecological performance. Therefore, it seems like we cannot reject the hypothesis that the mean for aesthetic attractiveness of the non-LID site is significantly higher than the mean for ecological performance. This implies that the non-LID sites are likely to fail to satisfy people with their ecological performance, compared to their aesthetic attractiveness, rather than the LID sites. Another interesting point is that there are only two sites whose mean of ecological performance is higher than its mean of aesthetic attractiveness, even though these differences are not statistically significant. Notably, these two sites are those LID sites with information signage. Seeing that, the role of information signage is again pointed out.

8.5 Correlation between the rating scores of each study site

In order to investigate the correlation between the rating for aesthetic attractiveness and the rating for functional efficiency of the landscape design, the coefficient of the correlation between these two ratings of each study site is calculated.

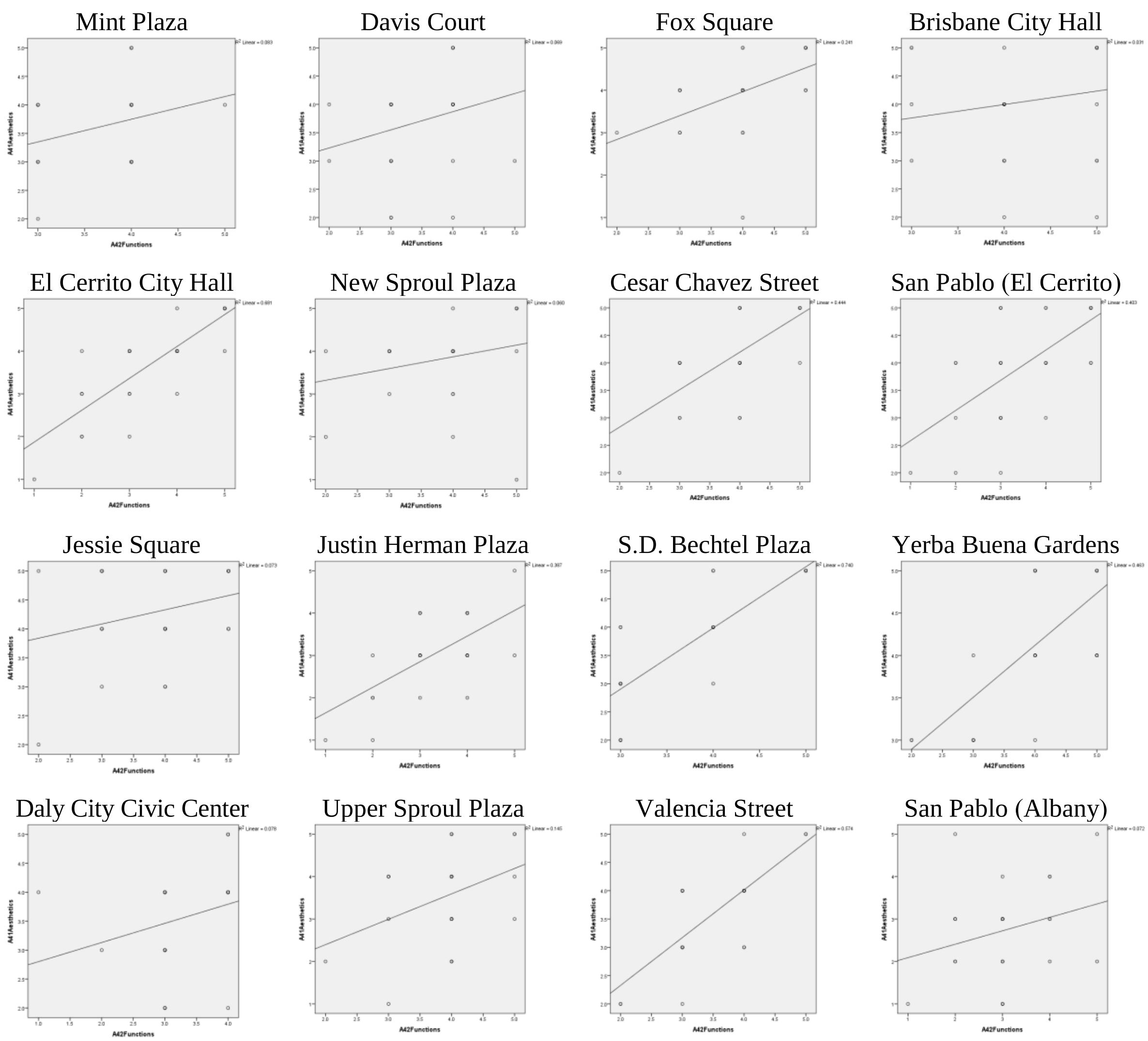
Table 8.5.1 Pearson and partial correlation coefficients elucidating if there is any statistically significant correlation between rating scores for appreciation of aesthetic attractiveness and appreciation of functional efficiency of each study site

Study Site	*df* (*N*-1)	Pearson correlation		Partial correlation	
		Coefficient (*r*)	*p*-value (Sig.)	Coefficient (r_s)	*p*-value (Sig.)
1. Mint Plaza	29	0.289	0.115	0.336	0.075
2. Davis Court	31	0.264	0.138	**-0.176**	0.342
3. Fox Square	27	0.491	**0.007***	0.416	**0.028***
4. Brisbane City	28	0.177	0.350	**-0.083**	0.669
5. El Cerrito City	34	0.825	**0.000***	0.600	**0.000***
6. New Sproul	28	0.246	0.190	0.194	0.322
7. Cesar Chavez	29	0.666	**0.000***	0.466	**0.012***
8. San Pablo (El)	31	0.635	**0.000***	0.371	**0.037***
9. Jessie Square	28	0.270	0.142	0.062	0.750
10. Justin Herman	28	0.622	**0.000***	0.360	0.060
11. S.D. Bechtel	29	0.860	**0.000***	0.735	**0.000***
12.Yerba Buena	28	0.680	**0.000***	0.371	0.052
13. Daly City	29	0.279	0.129	0.101	0.595
14. Upper Sproul	28	0.380	**0.038***	0.256	0.180
15. Valencia Street	29	0.758	**0.000***	0.672	**0.000***
16. San Pablo (Al)	28	0.269	0.151	0.307	0.113

* $p < 0.05$; r or r_s is significant at the 0.05 level (2-tailed).

As shown in table 8.5.1, the Pearson correlation coefficients of 9 out of 16 study sites are statistically significant, which implies the situation in which the two ratings of these sites are strongly correlated. In addition, as the value of every correlation coefficient is positive, it appears that the association between the rating for appreciation of aesthetic attractiveness and the rating for appreciation of functional efficiency of every study site depicts a positive correlation—which is an association in which respondents who gave high score on appreciation of aesthetic attractiveness were likely to also give high score on appreciation of functional efficiency of the site. The scatter plots in figure 8.5.1 visually show that every study site has a positive correlation between these certain two ratings as every line of best fit is sloping upward to the right.

Figure 8.5.1 Scatter plot graphs illustrating the correlations between the rating for appreciation of aesthetic attractiveness (y-axis) and the rating for appreciation of functional efficiency (x-axis) of the study sites



It is important to emphasize that the rating for appreciation of ecological performance is suspected as if it is the third factor for the correlation between the rating for appreciation of aesthetic attractiveness and the rating for appreciation of functional efficiency. Given that, for each study site, the partial correlation—the correlation between the rating for appreciation of aesthetic attractiveness and the rating for appreciation of functional efficiency while controlling for the effect of the rating for appreciation of ecological performance—is examined. The statistics from the partial correlation analysis express the situation in which most of the correlations between the rating for appreciation of aesthetic attractiveness and the rating for appreciation of functional efficiency are weaker, but still fairly substantial, after subtracting the influence of the rating for appreciation of ecological performance, see table 8.5.1. Interestingly, without the influence of appreciation of the ecological performance, two correlations (those of Davis Court and Brisbane City Hall) appear to be the negative ones. This circumstance brings out the supposition that the ecological performance of these two LID sites might play a very important role in enhancing their aesthetic attractiveness.

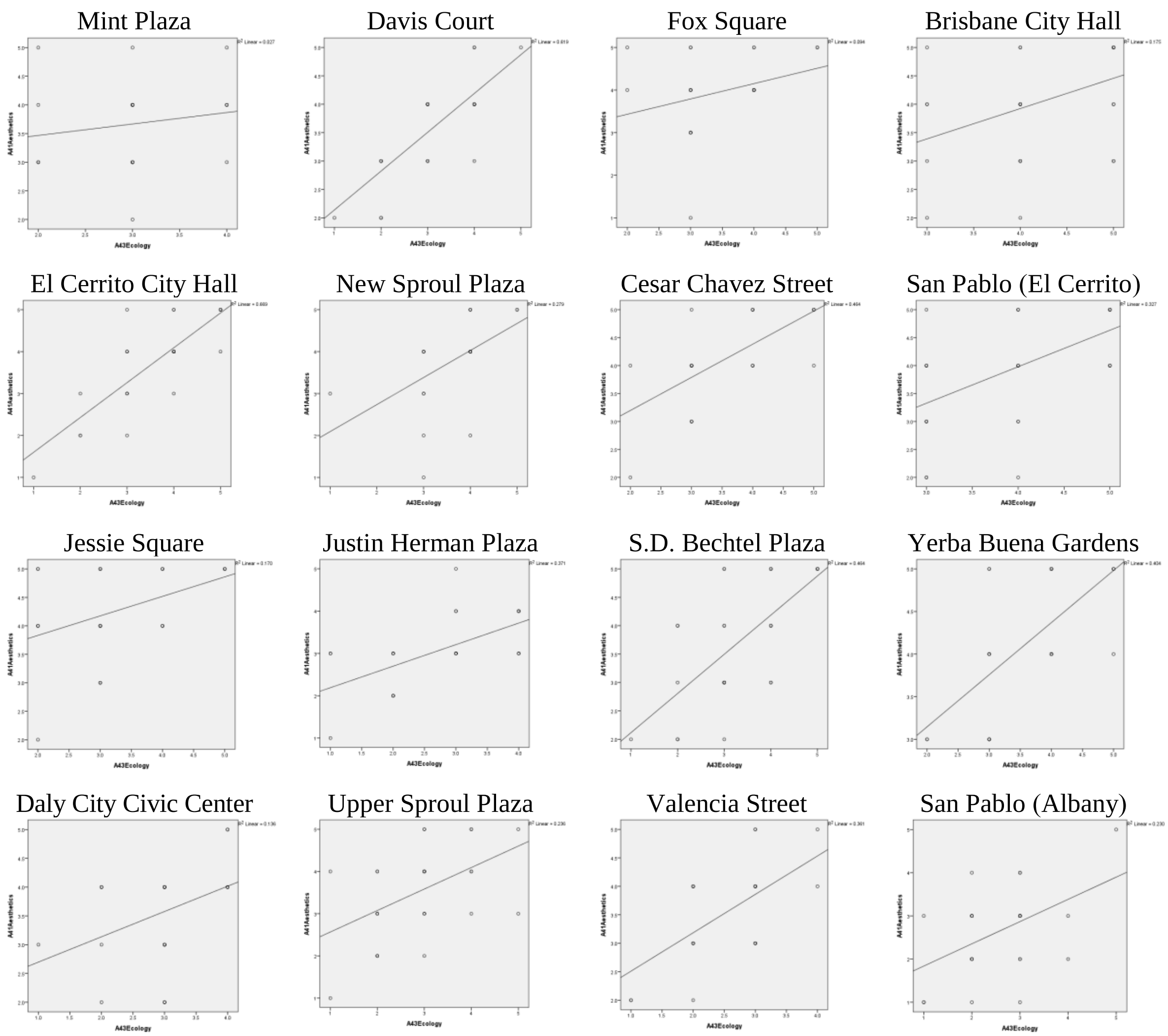
Table 8.5.2 Pearson and partial correlation coefficients elucidating if there is any statistically significant correlation between rating scores for appreciation of aesthetic attractiveness and appreciation of ecological performance of each study site

Study Site	*df* (*N*-1)	Pearson correlation		Partial correlation	
		Coefficient (*r*)	*p*-value (Sig.)	Coefficient (r_s)	*p*-value (Sig.)
1. Mint Plaza	28	0.165	0.383	0.212	0.270
2. Davis Court	30	0.787	**0.000***	0.781	**0.000***
3. Fox Square	27	0.307	0.106	0.111	0.574
4. Brisbane City	28	0.418	**0.022***	0.392	**0.035***
5. El Cerrito City	34	0.818	**0.000***	0.578	**0.000***
6. New Sproul	27	0.528	**0.003***	0.512	**0.005***
7. Cesar Chavez	27	0.681	**0.000***	0.411	**0.030***
8. San Pablo (El)	31	0.571	**0.001***	0.166	0.365
9. Jessie Square	28	0.412	**0.024***	0.351	0.062
10. Justin Herman	27	0.609	**0.000***	0.413	**0.029***
11. S.D. Bechtel	29	0.681	**0.000***	0.230	0.222
12.Yerba Buena	27	0.635	**0.000***	0.325	0.092
13. Daly City	29	0.369	**0.041***	0.270	0.148
14. Upper Sproul	28	0.486	**0.006***	0.407	**0.028***
15. Valencia Street	28	0.601	**0.000***	0.328	0.082
16. San Pablo (Al)	27	0.480	**0.008***	0.410	**0.030***

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Similar to the results from the above tests, the calculated Pearson correlation coefficients manifest the existence of a quite strong correlation between the rating for aesthetic attractiveness and the rating for ecological performance. Nevertheless, it looks like the correlation between these two ratings is even stronger than the former one because the coefficients of 14 out of 16 study sites are statistically significant, see table 8.5.2. Once again, the ratings for appreciation of aesthetic attractiveness and appreciation of ecological performance of all study sites are positively correlated as the value of Pearson correlation coefficients are all positive. This result also indicates the circumstance in which respondents who gave high score on appreciation of aesthetic attractiveness were likely to give high score on appreciation of ecological performance of the site. As shown in figure 8.5.2, the line of best fit in every scatter plot graph is sloping upward to the right, showing that every study site has a positive correlation between these particular two ratings.

Figure 8.5.2 Scatter plot graphs illustrating the correlations between the rating for appreciation of aesthetic attractiveness (y-axis) and the rating for appreciation of ecological performance (x-axis) of the study sites



As the rating for appreciation of functional efficiency is also suspected as if it is the third factor for the correlation between the rating for appreciation of aesthetic attractiveness and those of ecological performance of each study site, the partial correlation coefficients are calculated. The results demonstrate that most of the correlations between the rating for appreciation of aesthetic attractiveness and the rating for appreciation of ecological performance are weaker, but still quite substantial, when the ratings for appreciation of functional efficiency are controlled, see table 8.5.2.

According to the results of the partial correlation analysis, it appears that both ratings for appreciation of functional efficiency and ratings for appreciation of ecological performance have substantial correlation with ratings for appreciation of aesthetic attractiveness. Remarkably, it also appears that the partial correlation between appreciation of aesthetic attractiveness and appreciation of functional efficiency is not as strong as the partial correlation between appreciation of aesthetic attractiveness and appreciation of ecological performance. As shown in table 8.5.1 and 8.5.2, the number of statistically significant correlations between the former pairs is lower than the number of the latter pairs, and most of the *p*-values of the correlations between the former pairs are lower than those of the later pairs, respectively.

Perhaps, as one conjecture, the idea of aesthetic appreciation of nature might serve as a sound basis of this circumstance—the correlation between appreciation of aesthetic attractiveness and appreciation of ecological performance is stronger than the correlation with appreciation of functional efficiency. More specifically, as nature has a profound role in landscape beauty and preference, what looks natural often appears to be beautiful in people's eyes. Likewise, as nature is, undeniably, the ultimate ideal of healthy ecology, what looks natural is usually considered ecologically healthy. Thus, the natural appearance of landscapes is not only what people like, but also what they think is ecologically healthy. In view of that fact, the ideal characteristics of aesthetic attractiveness and ecological performance of landscapes are considerably shared—particularly, the presence of elements such as green plants, big trees, clear water, for instance. Additionally, in this environmental consciousness age, the role of urban landscapes as ecological services of cities has also become a crucial part of the perception of landscape values, making the appreciation landscape aesthetics and ecological benefits are increasingly related to each other. Seeing that, it appears that the assessment of these two landscape qualities is different from the assessment of functionality of the place. As mentioned in section 8.2.1, the evaluation of any certain landscape by its functionality or practicality is more likely to stand on the actual experience with the place than the evaluation of the aesthetic qualities, as well as the evaluation of ecological merits, in which the idealistic or conventional paradigm is more influential.

8.6 Summary of results from the hypothesis tests (H-1.1-1.5)

As statistics showed, the study sites with LID design were unlikely to fail to fulfill public satisfaction, compared to the study sites without LID design. In particular, the results reveal that most of the LID sites received a higher rating—whether in terms of aesthetic attractiveness, functional efficiency, or ecological performance—than their control, non-LID sites. Seeing that, the hypothesis that urban landscapes with LID design in San Francisco Bay area fell short of achieving public appreciation, compared to those without LID design is likely to be rejected. Important to note, the results also suggest that, by some chance, the interpretive signage could play a role in enhancing respondents' appreciation of the LID landscapes. When considering the three ratings of each study site, it appears that most of the study sites, whether with or without LID design, did not fail to satisfy people with their functional efficiency, compared to their aesthetic attractiveness. However, it is found that most of the non-LID sites and, in contrast, few of LID sites seem to fail to satisfy people with their ecological performance, compared to their aesthetic attractiveness. For the correlations between the rating scores for aesthetic attractiveness and those for the other two ratings that the respondents gave to each of the study sites, it appears that all of them are positive and most of them are statistically significant. These positive and significant correlations imply a situation in which the respondents who gave a high rating score on aesthetic attractiveness were likely to also give a high rating score on the others, and vice versa. Nonetheless, it is worth to note that, in most of the sites, it looks like the correlation between the scores for aesthetic attractiveness and the scores for ecological performance is stronger than the correlation between the scores for aesthetic attractiveness and the scores for functional efficiency.

Table 8.6.1 Summary of results from the hypothesis tests (H-1.1-1.5)

Hypotheses	**Results from the hypothesis tests**
Question 1:	*How do people appreciate the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?*
H-1.1	For most of the cases, the rating for aesthetic attractiveness of the urban landscapes with LID design is significantly higher than that of the urban landscapes without LID design.
H-1.2	For most of the cases, the rating for functional efficiency of the urban landscapes with LID design is significantly higher than that of the urban landscapes without LID design.
H-1.3	For most of the cases, the rating for ecological performance of the urban landscapes with LID design is significantly higher than that of the urban landscapes without LID design.
H-1.4	(1) For most of LID sites, the mean for aesthetic attractiveness is not significantly higher than the mean for functional efficiency.
	(2) For most of non-LID sites, the mean for aesthetic attractiveness is significantly higher than the mean for functional efficiency.
H-1.5	(1) For every study site, the rating for aesthetic attractiveness appear to be positively correlated with the rating for functional efficiency.
	(2) For every study site, the rating for aesthetic attractiveness appear to be positively correlated with the rating for functional efficiency.

Chapter 9

Perception of the Sustainable Stormwater Management Function of the Study Sites

This chapter statistically reports and analyzes the answers of question 4.1—the rating scores the respondents gave based on their own perception or opinion regarding the extent to which the landscape design of each study site is sustainable in terms of stormwater management, given that 1 means not sustainable at all and 5 means very sustainable. The aim of this data analysis is to answer the second research question: *how do people evaluate the sustainable stormwater management function of the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?* Realizing that the LID facilities usually looks invisible or illegible to the public because they often blend with their surroundings, the hypothesis to be tested in this chapter is that if the LID and non-LID design received the same rating for sustainable stormwater management function. In this chapter, the landscape features the respondents thought they help manage urban stormwater in a sustainable way—answers of question 4.2—are also explored. This chapter also investigates the differences and correlations between the rating of sustainable stormwater management and the three appreciation ratings—which are the rating of aesthetic attractiveness, the rating of functional efficiency, and the rating of ecological performance—of each study site.

9.1 The rating for sustainable stormwater management function of the study sites

9.1.1 Descriptive statistics of the rating for sustainable stormwater management function

The majority of the LID sites received a positive rating for their sustainable stormwater management function while the majority of the non-LID sites received a negative rating. As shown in table 9.1.1 and figure 9.1.1, most of the distributions of the LID sites show that the majority of the data are clustered in the positive rating side; in contrast, most of the distributions of the non-LID sites show that the majority of the data are clustered in the negative rating side. Considering the means, the situation in which the LID sites received a higher rating than the non-LID sites is demonstrated. As shown in table 9.1.2, only two LID sites have a mean which is lower than 3.00 while only one non-LID site has a mean which is higher than 3.00.

Table 9.1.1 Distribution of the rating scores for sustainable stormwater management function of the study sites (1=do not like at all, 5=like very much)

Study Site	Frequency Distribution of Rating Scores					Missing	*n*
	1 (not at all)	2	3	4	5 (very much)		
1. Mint Plaza	3 (9.7%)	6 (19.4%)	**14 (45.2%)**	3 (9.7%)	1 (3.2%)	4 (12.9%)	31
2. Davis Court	0	6 (18.2%)	**14 (42.4%)**	7 (21.2%)	0	6 (18.2%)	33
3. Fox Square	2 (6.7%)	**8 (26.7%)**	6 (20.0%)	6 (20.0%)	0	8 (26.7%)	30
4. Brisbane City	0	2 (6.5%)	7 (22.6%)	**13 (41.9%)**	6 (19.4%)	3 (9.7%)	31
5. El Cerrito City	1 (2.8%)	0	11 (30.6%)	**15 (41.7%)**	4 (11.1%)	5 (13.9%)	36
6. New Sproul	1 (3.3%)	2 (6.7%)	**14 (56.7%)**	8 (26.7%)	1 (3.3%)	4 (13.3%)	30
7. Cesar Chavez	0	1 (3.2%)	9 (29.0%)	**11 (35.5%)**	2 (6.5%)	8 (25.8%)	31
8. San Pablo (El)	1 (2.9%)	3 (8.8%)	**13 (38.2%)**	9 (26.5%)	4 (11.8%)	4 (11.8%)	34
9. Jessie Square	0	6 (18.8%)	**14 (43.8%)**	5 (15.6%)	0	7 (21.9%)	32
10. Justin Herman	5 (6.7%)	7 (23.3%)	**11 (36.7%)**	4 (13.3%)	0	3 (10.0%)	30
11. S.D. Bechtel	3 (9.7%)	5 (16.1%)	**14 (45.2%)**	6 (19.4%)	0	3 (9.7%)	31
12.Yerba Buena	0	1 (3.3%)	**18 (60.0%)**	5 (16.7%)	0	6 (20.0%)	30
13. Daly City	1 (3.2%)	8 (25.8%)	**17 (54.8%)**	2 (6.5%)	0	3 (9.7%)	31
14. Upper Sproul	2 (6.7%)	7 (23.3%)	**15 (50.0%)**	3 (10.0%)	0	3 (10.0%)	30
15. Valencia Street	3 (9.4%)	10 (31.3%)	**11 (34.4%)**	1 (3.1%)	0	7 (21.9%)	32
16. San Pablo (Al)	3 (10.0%)	6 (20.0%)	**16 (53.3%)**	2 (6.7%)	0	3 (10.0%)	30

The line graph in figure 9.1.2 also illustrates that the means for sustainable stormwater management function of the LID sites are quite high, compared to those of the non-LID sites. Remarkably, it is quite obvious that the three LID sites (Mint Plaza, Davis Court, and Fox Square) which are the city and community open spaces received a pretty low rating, compared to the other LID sites. According to these preliminary statistics, it seems like the LID and non-LID sites received a quite different rating for their sustainable stormwater management function. In particular, the LID sites tend to obtain a higher rating than the non-LID design. Thus, the hypothesis that the respondents could not recognize the sustainable stormwater management function of the LID sites might be rejected.

Table 9.1.2 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for sustainable stormwater management function of the study sites

Study Site	*n*	Mean	Median	Mode	SD
1. Mint Plaza	27	2.74	3.00	3	0.944
2. Davis Court	27	3.04	3.00	3	0.706
3. Fox Square	22	2.73	3.00	**2**	0.985
4. Brisbane City	28	**3.82**	4.00	4	0.863
5. El Cerrito City	31	3.68	4.00	4	0.832
6. New Sproul	26	3.23	3.00	3	0.815
7. Cesar Chavez	23	3.61	4.00	4	0.722
8. San Pablo (El)	30	3.40	3.00	3	0.968
9. Jessie Square	25	2.96	3.00	3	0.676
10. Justin Herman	27	2.52	3.00	3	0.975
11. S.D. Bechtel	28	2.82	3.00	3	0.905
12.Yerba Buena	24	3.17	3.00	3	0.482
13. Daly City	28	2.71	3.00	3	0.659
14. Upper Sproul	27	2.70	3.00	3	0.775
15. Valencia Street	25	**2.40**	2.00	3	0.764
16. San Pablo (Al)	27	2.63	3.00	3	0.792

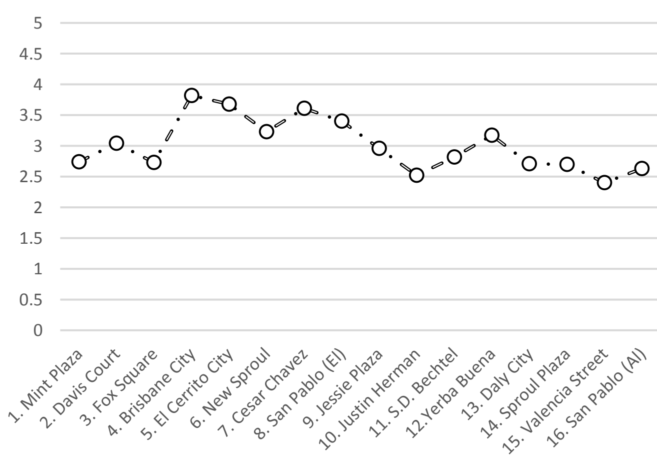
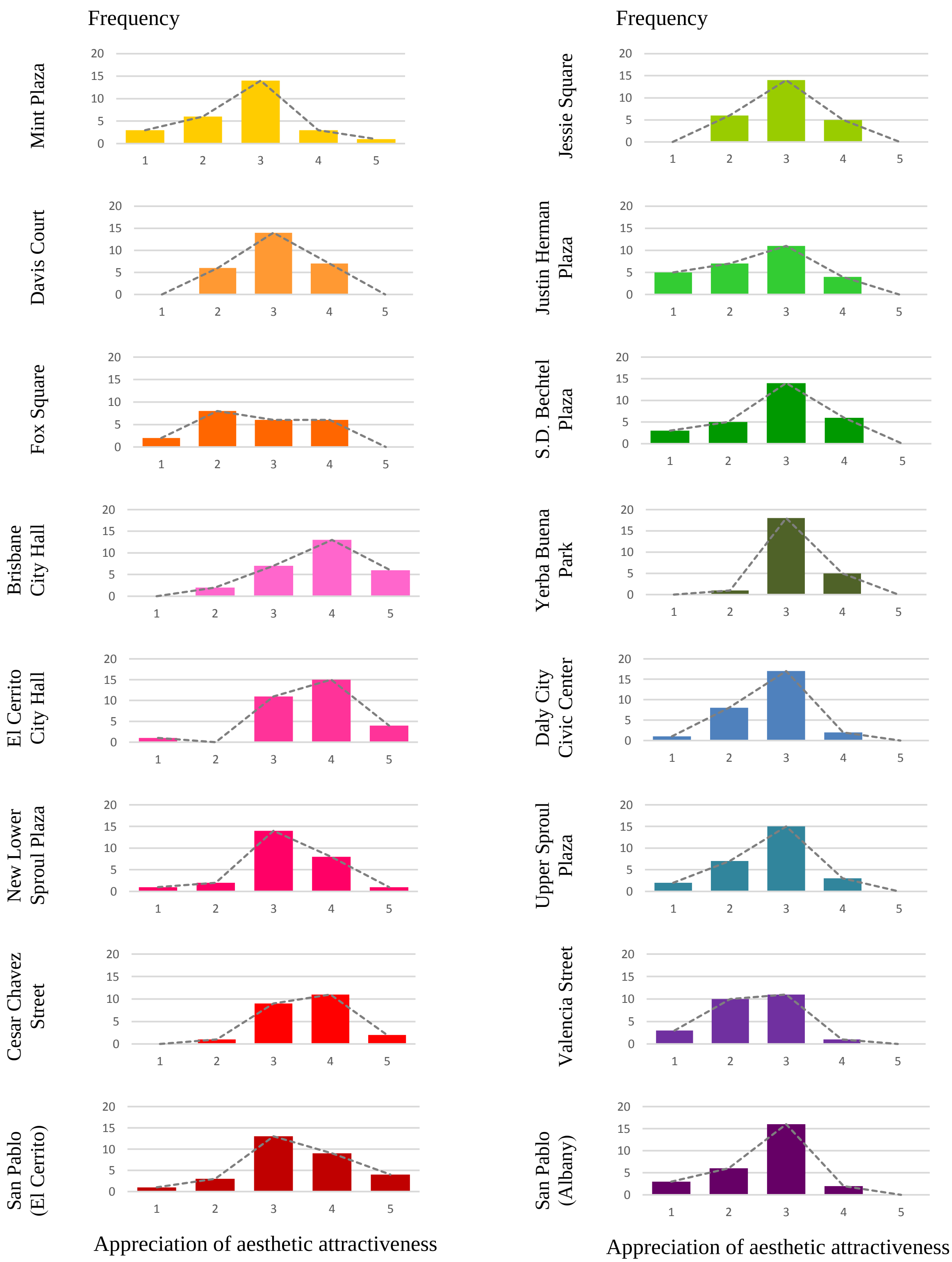


Figure 9.1.1 Line graph illustrating the mean scores for sustainable stormwater management function of the study sites

Figure 9.1.2 Bar graphs illustrating the distributions of the rating scores for sustainable stormwater management function of the study sites (1=do not like at all, 5=like very much)



9.1.2 Difference between means of the rating for sustainable stormwater management function of the study sites with LID design and without LID design

Since the descriptive statistics suggest the possible existence of some differences between the means of sustainable stormwater management function of the study sites with and without LID design, this section intends to investigate whether these differences statistically significant by conducting a series of *t* tests.

As shown in table 9.1.3, the *t* values of three out of four pairwise comparisons are statistically significant. This result reveals that, for each of these three pairs, the mean for sustainable stormwater management function of the LID site is significantly higher than the mean of its control site. The only one case in which the mean of the non-LID site is higher than that of the LID site is the case of Mint Plaza and Jessie Square. However, in this case, the *t* value is not statistically significant; $t(50) = -0.965$, $p > 0.05$.

Table 9.1.3 Independent-samples *t* test elucidating if there is any statistically significant difference between mean scores for sustainable stormwater management function of the LID site and the non-LID site

Independent-samples *t* test (LID site *x* non-LID site)	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Mint Plaza *x* Jessie Square	50	-0.956	0.344	-0.268; small
New Lower Sproul Plaza *x* Upper Sproul Plaza	51	2.412	**0.019***	0.666; medium
Cesar Chavez St**.** *x* Valencia St. St**.**	46	5.632	**0.000***	1.628; very large
San Pablo Ave**.** **(**El**)** *x* San Pablo Ave**.** (Al**)**	55	3.266	**0.002***	0.871; large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Considering the case of the three city hall landscapes, it is fairly obvious that the means of both LID sites (Brisbane City Hall and El Cerrito City Hall) are significantly higher than the mean of the non-LID site (Daly City Civic Center), see table 9.1.4. In addition, when considering the comparison between the means of the two LID sites, it appears that the mean of Brisbane City Hall, which is the LID site with interpretive signage, is higher than that of El Cerrito City Hall, which is the LID site without interpretive signage. Even though the difference between the means of these two LID sites is not statistically significant, the interpretive signage is suspected as if it plays a role in acknowledging respondents about the sustainable stormwater management function of the site.

Table 9.1.4 Independent-samples *t* test elucidating if there is any statistically significant difference among mean scores for sustainable stormwater management function of the three city hall landscapes

Independent-samples *t* test	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Brisbane (LID with signage) *x* Daly City (non-LID)	54	5.396	**0.000***	1.446; very large
El Cerrito (LID) *x* Daly City (non-LID)	57	4.893	**0.000***	1.292; very large
Brisbane (LID with signage) *x* El Cerrito (LID)	57	0.652	0.517	0.165; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For the seven sites in the first landscape type (city and community open space), the outputs of the ANOVA test, see table 9.1.5, reveal that the difference between their means is not statistically significant; $F(6) = 1.758$, $p > 0.05$. Note that this test does not meet the assumption called homoscedasticity because the calculated *p*-value of the homogeneity test is not greater than critical level; $p < 0.05$.

Table 9.1.5 One-way between-groups ANOVA test elucidating if there is any statistically significant difference between mean scores for sustainable stormwater management function of the seven sites in the first landscape type (city and community open space)

One-way between-groups ANOVA	*df*	*F*	*p*-value (Sig.)	Effect Size (Eta Squared)	Homogeneity Test (Sig.)
Mint Plaza *x* Davis Court *x* Fox Square *x* Jessie Square *x* Justin Herman Plaza *x* S.D.Betchel Plaza *x* Yerba Buena Park	6	1.758	0.110	0.057; medium	0.002*

* $p < 0.05$; F-value is significant at the 0.05 level.

In consideration of the statistical tests presented above, the hypothesis that the respondents could not recognize the sustainable stormwater management function of the LID sites is likely to be rejected for the case of the study sites of the city hall landscapes, university open spaces, and streets and sidewalks. This is because it becomes obvious that, within these three landscape types, the LID sites received a higher rating for their sustainable stormwater management function than their control sites. Nonetheless, for the case of the first landscape type, city and community open spaces, this hypothesis could not be rejected because there is not enough evidence to say that the mean differences between the LID and non-LID sites in this landscape type are statistically significant, see table 9.1.5 and 9.1.6. In addition, there also exist a lot of situations in which the non-LID sites received a higher rating than the LID sites. The obvious evidence is that, of the seven sites, Yerba Buena Park, which is the non-LID site, received the highest rating for sustainable stormwater management function. In addition, Jessie Square and S.D. Bechtel Plaza also received a higher rating than Mint Plaza and Fox Square. Perhaps it might be because the LID design in this landscape type is typically illegible, compared to the other landscape types. As one plausible explanation, as there are more various elements in this landscape type than the others, these elements might make the respondents misunderstand the sustainable stormwater management function of the sites. In other words, the presence green lawns, mass of plants, and water features are suspected that they triggered the respondents to misjudge the function in terms of sustainable stormwater management of the sites.

Table 9.1.6 Tukey HSD tests (post-hoc tests) showing that there is no statistically significant difference between the means for sustainable stormwater management function of the sites in the first landscape type **(**city and community open space**)**

p-value (Sig.)	Mint Plaza	Davis Court	Fox Square	Jessie Square	Justin Herman	S.D. Bechtel	Yerba Buena
Mint Plaza		0.847	1.000	0.964	0.957	1.000	0.533
Davis Court	0.847		0.853	1.000	0.254	0.962	0.998
Fox Square	1.000	0.853		0.962	0.976	1.000	0.557
Jessie Square	0.964	1.000	0.962		0.475	0.997	0.977
Justin Herman	0.957	0.254	0.976	0.475		0.827	0.086
S.D. Bechtel	1.000	0.962	1.000	0.997	0.827		0.749
Yerba Buena	0.533	0.998	0.557	0.977	0.086	0.749	

* $p < 0.05$; HSD is significant at the 0.05 level (2-tailed).

9.2 Perceived sustainable stormwater management landscape features in the study sites

In order to examine which landscape features are perceived to manage urban stormwater in a sustainable way, the answers of question 4.2 are statistically presented, see table 9.2.1. Overall, it seems like planting was the winner. As shown in figure 9.2.1, for almost all study sites, the bars of planting are the highest one or among the highest ones. Considering the case of the LID sites, the number of respondents who selected planting is, in most case, the highest, followed by planters. However, for Mint Plaza and Davis Court, the number of respondents who selected trenches/pipes is also obviously high. For Davis Court and El Cerrito City Hall—the only two LID sites in which there exist the water features, the number of respondents who selected water features is also noticeably high, compared to that of the other sites.

In consideration of the non-LID sites, even though the number of respondents who selected planting is still quite high, the number of respondents who selected planters is not, compared to the case of the LID sites. Nonetheless, the case of S.D. Bechtel Plaza is excluded, as it is obvious that the number of respondents of this site who selected planters is the highest. This might be because planters are the exceptionally prominent features of S.D. Bechtel Plaza. For the sites with the presence of lawn or grass—Jessie Square, Yerba Buena Park, and Daly City Civic Center, the rating of this feature is dramatically high. Likewise, For the sites with the presence of water features—Jessie Square, Justin Herman Plaza, and Yerba Buena Park, the rating of this feature is also very high.

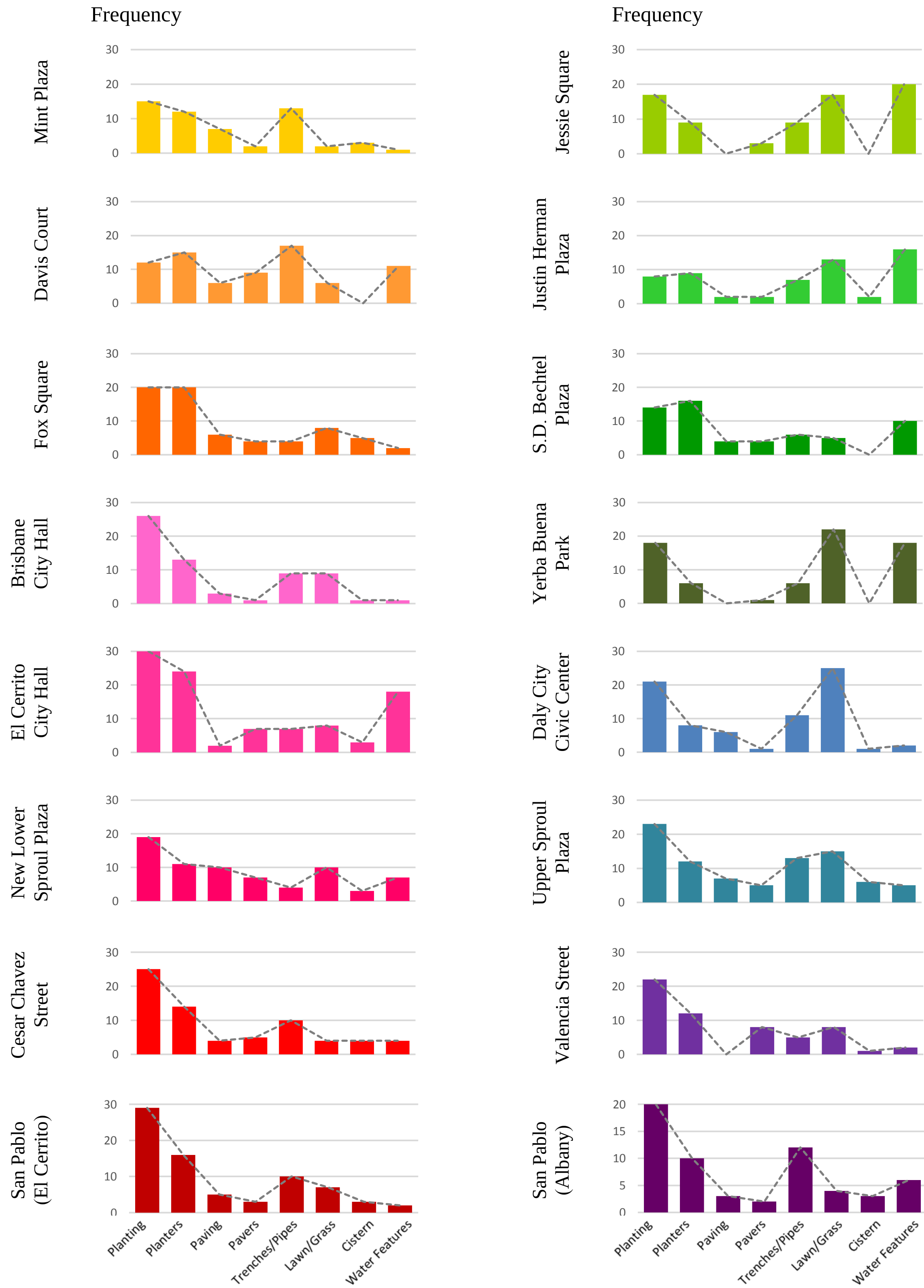
Interestingly, paving and pavers received an awfully low rating, whether for the case of LID or non-LID sites. In addition, as the scores these two features received are very equivalent to each other, it seems like respondents were not sensitive to the disadvantages of paving and the advantages of pavers. Specifically, paving implies impervious surface that impedes sustainable stormwater management processes while pavers indicates permeable surface that helps such certain functions. This makes the point that the distinction between permeable and impermeable surfaces remains obscure to users.

Another intriguing issue is that even though cistern is the feature that does not appear in any study sites, it was also perceived that they help manage urban stormwater in a sustainable way for almost all study sites. This kind of situation is also found for the case of some other features—especially lawns, trenches, and water features—as they received scores even though they were not visible in the sites. Accordingly, it seems like the landscape features that the respondents' perceived as sustainable stormwater management factors are not only the visual elements—the ones that people see, but also the cognitive elements—the ones that people know. Nonetheless, it is also importance to emphasize the merit of visibility. As mentioned earlier, the presence of the elements—particularly planters, lawns, trenches, and water features—in the sites can enhance respondents' perception of these elements or, in other words, it can make respondents become aware of the existence of such elements. Additionally, it is also worthwhile to note that the interpretive signage might be another means to help acknowledge respondents about the sustainable stormwater management features in the landscapes, even though the results of this research does not provide any sound evidence in this regard.

Table 9.2.1 Frequency at which respondents thought each of the eight landscape features helps manage urban stormwater in a sustainable way

Study Site	*n*	Planting	Planters	Paving	Pavers	Trenches/Pipes	Lawn/ Grass	Cistern	Water Features
1. Mint Plaza	31	**15**	12	7	2	13	2	3	1
2. Davis Court	33	12	15	6	9	**17**	6	0	11
3. Fox Square	30	**20**	**20**	6	4	4	8	5	2
4. Brisbane City	31	**26**	13	3	1	9	9	1	1
5. El Cerrito City	36	**30**	24	2	7	7	8	3	18
6. New Sproul	30	**19**	11	10	7	4	10	3	7
7. Cesar Chavez	31	**25**	14	4	5	10	4	4	4
8. San Pablo (El)	34	**29**	16	5	3	10	7	3	2
9. Jessie Square	32	17	9	0	3	9	17	0	**20**
10. Justin Herman	30	8	9	2	2	7	13	2	**16**
11. S.D. Bechtel	31	14	**16**	4	4	6	5	0	10
12.Yerba Buena	30	18	6	0	1	6	**22**	0	18
13. Daly City	31	21	8	6	1	11	**25**	1	2
14. Upper Sproul	30	**23**	12	7	5	13	15	6	5
15. Valencia Street	32	**22**	12	0	8	5	8	1	2
16. San Pablo (Al)	30	**20**	10	3	2	12	4	3	6

Figure 9.2.1 Bar graphs illustrating comparisons among landscape features with regard to their perceived sustainable stormwater management function



9.3 Difference between the mean of the sustainable stormwater management function rating and the means of the appreciation ratings of each study site

This part aims to investigate if the respondents of each study site rated the sustainable stormwater management function different from the aesthetic attractiveness, the functional efficiency and the ecological performance. According to the data presented in table 8.1.2, 8.2.2, 8.3.2, and 9.1.2, it appears that, the means for sustainable stormwater management function are relatively low, compared to the means for aesthetic attractiveness, the functional efficiency and the ecological performance. To visually display this circumstance, the line graphs are produced, see figure 9.3.1, 9.3.2, and 9.3.3. These line graphs clearly illustrate that, in most of the sites, the mean for sustainable stormwater management function rating is lower than the mean for aesthetic attractiveness, the mean for functional efficiency and the mean for ecological performance.

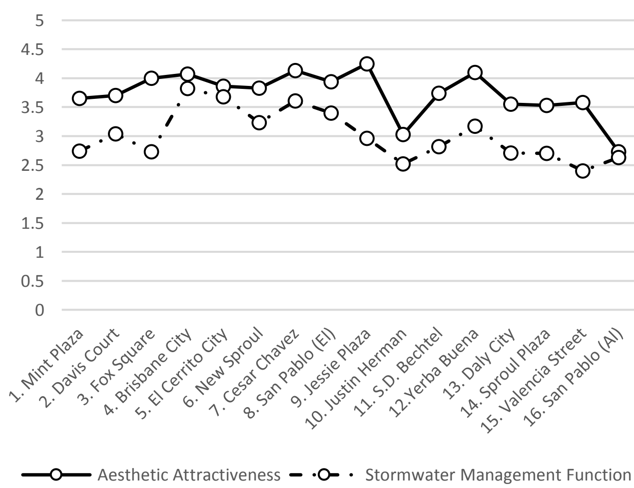


Figure 9.3.1 Line graphs depicting the mean scores for appreciation of aesthetic attractiveness and the mean scores for sustainable stormwater management function of the study sites

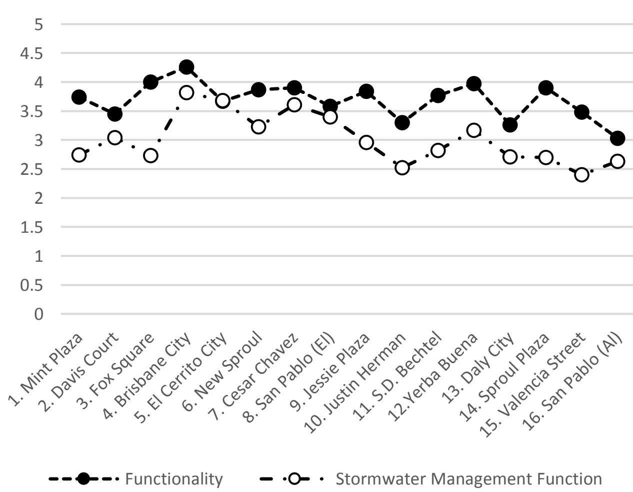


Figure 9.3.2 Line graphs depicting the mean scores for appreciation of aesthetic attractiveness and the mean scores for sustainable stormwater management function of the study sites

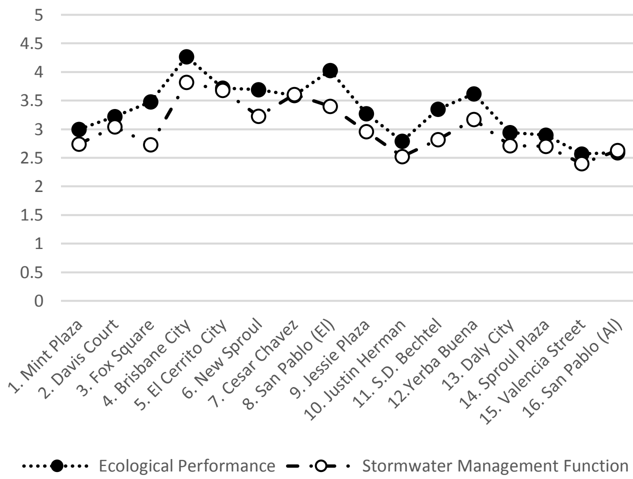


Figure 9.3.3 Line graphs depicting mean scores for appreciation of ecological performance and mean scores for sustainable stormwater management function of the study sites

To examine if the mean differences mentioned above are statistically significant, the paired-samples *t* tests are performed. The results of these tests are displayed in table 9.3.1, 9.3.2, and 9.3.3.

Table 9.3.1 Paired-samples *t* tests elucidating if the difference between the mean for sustainable stormwater management function and the mean for appreciation of aesthetic attractiveness of each study site is statistically significant

Paired-samples *t* test (Stormwater Management *x* Aesthetics)	df	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
1. Mint Plaza	26	-3.546	**0.002***	-1.100; very large
2. Davis Court	26	-4.878	**0.000***	-1.211; very large
3. Fox Square	21	-6.197	**0.000***	-1.727; very large
4. Brisbane City	27	-1.395	0.174	-0.334; small
5. El Cerrito City	30	-2.108	**0.043***	-0.283; small
6. New Sproul	25	-3.904	**0.001***	-0.731; almost large
7. Cesar Chavez	22	-2.313	**0.030***	-0.675; medium
8. San Pablo (El)	29	-2.408	**0.023***	-0.519; medium
9. Jessie Square	24	-7.000	**0.000***	-2.035; very large
10. Justin Herman	26	-3.238	**0.003***	-0.608; medium
11. S.D. Bechtel	27	-5.021	**0.000***	-0.918; large
12.Yerba Buena	23	-6.307	**0.000***	-1.379; very large
13. Daly City	27	-4.942	**0.000***	-1.241; very large
14. Upper Sproul	26	-4.878	**0.000***	-0.932; large
15. Valencia Street	24	-7.595	**0.000***	-1.634; very large
16. San Pablo (Al)	26	-0.462	0.648	-0.126; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Obviously, the test results reveal that the majority of the means for sustainable stormwater management function, 46 out of 48, are lower than the appreciation means with which they are compared. This implies the situation in which the sustainable stormwater management function of each of the study sites was less appreciated than the aesthetic attractiveness, functional efficiency, and ecological performance. Perhaps the possible explanation of this situation is either the design of these study sites did not do well, according to the respondents' view, regarding sustainable stormwater management function or such function was not easily perceptible, compared to the attractiveness, functional efficiency, and ecological performance, or both.

Table 9.3.2 Paired-samples *t* tests elucidating if the difference between the mean for sustainable stormwater management function and the mean for appreciation of functional efficiency of each study site is statistically significant

Paired-samples *t* test (Stormwater Management *x* Functionality)	df	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
1. Mint Plaza	26	-4.315	**0.000***	-1.247; very large
2. Davis Court	26	-2.383	**0.025***	-0.593; medium
3. Fox Square	21	-5.476	**0.000***	-1.482; very large
4. Brisbane City	27	-2.372	**0.025***	-0.594; medium
5. El Cerrito City	30	-0.421	0.677	-0.062; very small
6. New Sproul	25	-3.718	**0.001***	-0.919; large
7. Cesar Chavez	22	-1.187	0.248	-0.351; small
8. San Pablo (El)	29	-0.796	0.433	-0.161; small
9. Jessie Square	24	-6.124	**0.000***	-1.360; very large
10. Justin Herman	26	-4.665	**0.000***	-0.894; large
11. S.D. Bechtel	27	-5.227	**0.000***	-1.038; very large
12.Yerba Buena	23	-4.163	**0.000***	-1.087; very large
13. Daly City	27	-2.566	**0.016***	-0.794; almost large
14. Upper Sproul	26	-6.400	**0.000***	-1.673; very large
15. Valencia Street	24	-7.170	**0.000***	-1.515; very large
16. San Pablo (Al)	26	-1.847	0.076	-0.514; medium

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Considering the statistics presented in table 9.3.1, the majority of the study sites—7 out of 8 LID sites and also 7 out of 8 non-LID sites—hold a mean for sustainable stormwater management function which is significantly lower than a mean for aesthetic attractiveness. Brisbane City Hall and San Pablo Avenue in Albany are the two sites holding a mean for sustainable stormwater management function which is not significantly lower than a mean for aesthetic attractiveness. Likewise, the statistics, see table 9.3.2, also demonstrate that the majority of the study sites—5 out of 8 LID sites and also 7 out of 8 non-LID sites—hold a mean for sustainable stormwater management function which is significantly lower than a mean for functional effectiveness. Those holding a mean for sustainable stormwater management function which is not significantly lower than a mean for functional efficiency include three LID sites (El Cerrito City Hall, Cesar Chavez Street, and San Pablo Avenue in El Cerrito) and one non-LID sites (San Pablo Avenue in Albany)

Table 9.3.3 Paired-samples *t* tests elucidating if the difference between the mean for sustainable stormwater management function and the mean for appreciation of ecological performance of each study site is statistically significant

Paired-samples *t* test (Stormwater Management *x* Ecology)	df	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
1. Mint Plaza	26	-1.612	0.119	-0.427; small-medium
2. Davis Court	25	-1.617	0.118	-0.412; small-medium
3. Fox Square	21	-4.500	**0.000***	-0.914; large
4. Brisbane City	27	-2.194	**0.037***	-0.531; medium
5. El Cerrito City	30	-1.222	0.231	-0.181; small
6. New Sproul	25	-3.734	**0.001***	-0.521; medium
7. Cesar Chavez	20	0.000	1.000	0.000; none
8. San Pablo (El)	29	-3.597	**0.001***	-0.692; medium
9. Jessie Square	23	-1.664	0.110	-0.351; small
10. Justin Herman	26	-2.054	0.050	-0.267; small
11. S.D. Bechtel	27	-2.867	**0.008***	-0.499; medium
12.Yerba Buena	22	-3.148	**0.005***	-0.640; medium
13. Daly City	27	-1.236	0.227	-0.333; small
14. Upper Sproul	26	-1.154	0.259	-0.211; small
15. Valencia Street	23	-5.569	0.575	-0.103; small
16. San Pablo (Al)	26	0.196	0.846	0.049; very small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

In contrast to the former cases, the majority of the study sites, 10 out of 16, hold a mean for sustainable stormwater management function which is not significantly lower than a mean for ecological performance, see table 9.3.3. Besides, of these 10 sites, one of them (Cesar Chavez Street) hold a mean for sustainable stormwater management function which is equal to a mean for ecological performance and one of them (San Pablo Avenue in Albany) hold a mean for sustainable stormwater management function which is higher than a mean for ecological performance. In other words, only six study sites—four LID sites and two non-LID sites—hold a mean for sustainable stormwater management function which is significantly lower than a mean for ecological performance. These results demonstrate that the overall rating for sustainable stormwater management function are equivalent to the rating for ecological performance rather than the rating for aesthetic attractiveness and the rating for functional efficiency.

9.4 Correlation between the rating for sustainable stormwater management function and the appreciation ratings of each study site

In this part, the correlations between the rating for sustainable stormwater management function and the appreciation ratings—rating for aesthetic attractiveness, functional efficiency, and ecological performance—are examined. The results from Pearson correlation tests are presented in table 9.4.1.

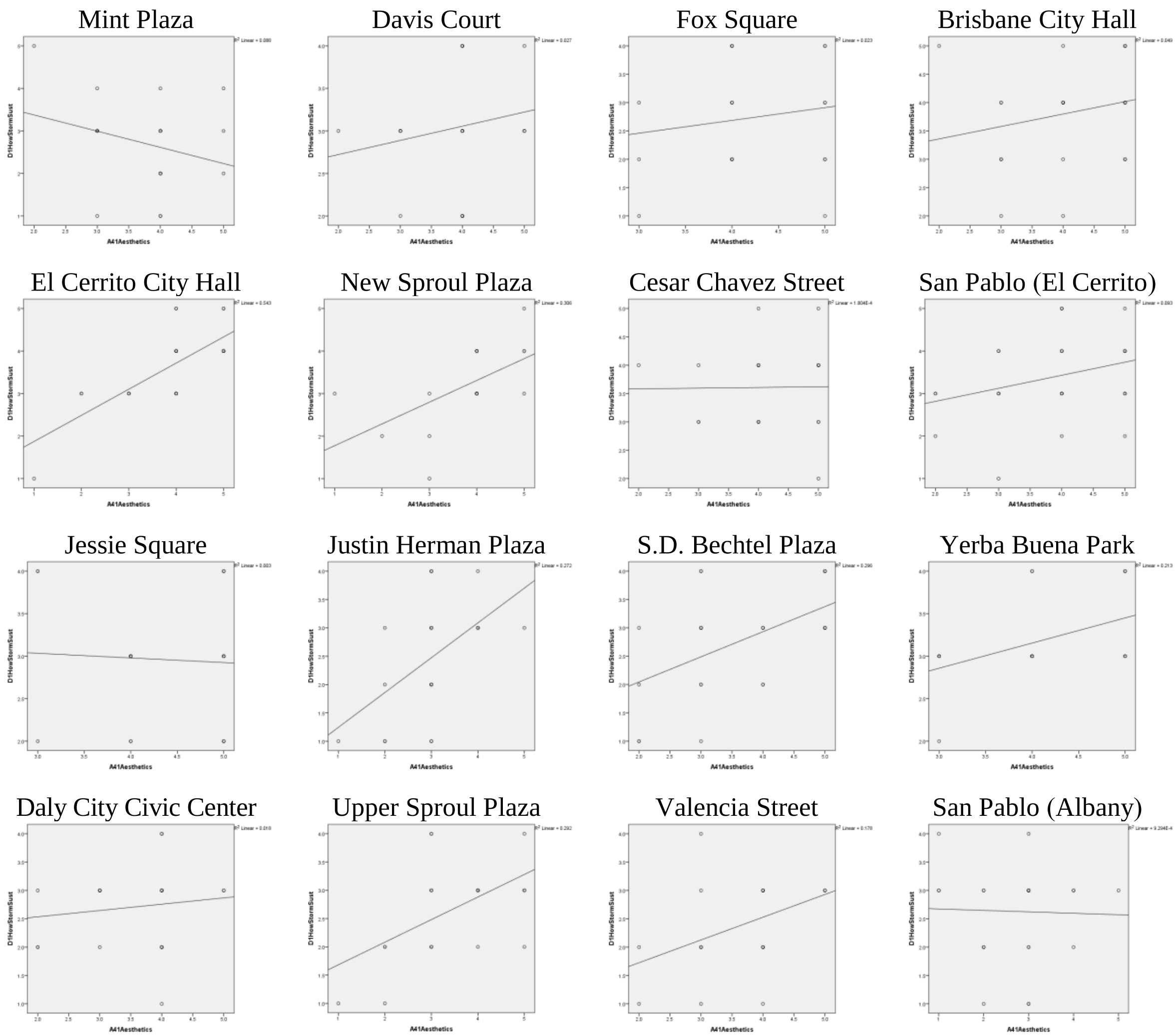
Table 9.4.1 Pearson correlation coefficients elucidating if there is any statistically significant correlation between rating for sustainable stormwater management function and the three appreciation ratings of each study site

Study Site	Aesthetic Attractiveness			Functional Efficiency			Ecological Performance		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (*r*)	*p*-value (Sig.)
1. Mint Plaza	25	-0.296	0.134	25	-0.156	0.437	25	0.038	0.849
2. Davis Court	25	0.165	0.412	25	0.132	0.511	24	0.185	0.366
3. Fox Square	20	0.152	0.499	20	0.201	0.369	20	0.560	**0.007***
4. Brisbane City	26	0.222	0.255	26	0.146	0.458	26	0.186	0.344
5. El Cerrito City	29	0.737	**0.000***	29	0.638	**0.000***	29	0.660	**0.000***
6. New Sproul	24	0.553	**0.003***	24	0.205	0.315	24	0.743	**0.000***
7. Cesar Chavez	21	0.013	0.952	21	-0.014	0.948	19	0.177	0.443
8. San Pablo (El)	28	0.304	0.102	28	0.414	**0.023***	28	0.444	**0.014***
9. Jessie Square	23	-0.056	0.789	23	0.387	0.056	22	0.484	**0.017***
10. Justin Herman	25	0.522	**0.005***	25	0.503	**0.007***	25	0.774	**0.000***
11. S.D. Bechtel	26	0.544	**0.003***	26	0.450	**0.016***	26	0.586	**0.001***
12.Yerba Buena	22	0.461	**0.023***	22	0.215	0.312	21	0.614	**0.002***
13. Daly City	26	0.133	0.500	26	-0.321	0.096	26	0.036	0.854
14.Upper Sproul	25	0.541	**0.004***	25	0.086	0.670	25	0.593	**0.001***
15. Valencia Street	23	0.422	**0.036***	23	0.443	**0.027***	22	0.575	**0.003***
16. San Pablo (Al)	25	-0.030	0.880	25	-0.067	0.741	25	0.284	0.152

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

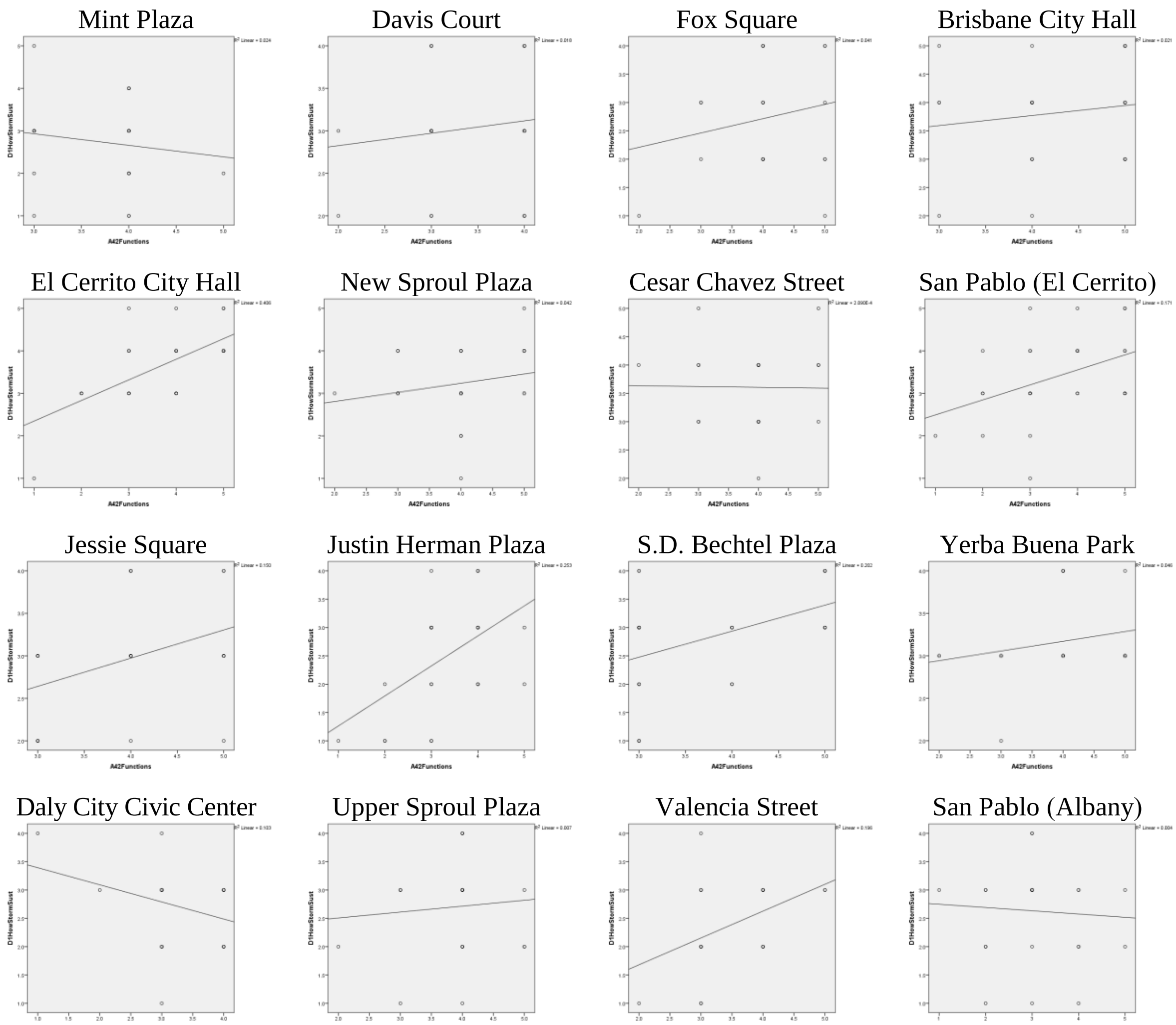
The results reveal that the correlations between the rating for sustainable stormwater management function and the rating for aesthetic attractiveness are varied among the study sites. In particular, even though the majority of the correlations are positive, some negative correlations are also revealed. The correlations of only 7 out of 16 study sites are statistically significant, 2 of them are those of the LID sites and 5 of them are those of the non-LID sites. The scatter plots in figure 9.4.1 visually show the diverse patterns of the correlations among the study sites; some lines of best fit are sloping upward to the right while some are sloping upward to the left and some are almost horizontal.

Figure 9.4.1 Scatter plot graphs illustrating the correlations between the rating for sustainable stormwater management function (y-axis) and the rating for appreciation of aesthetic attractiveness (x-axis) of the study sites



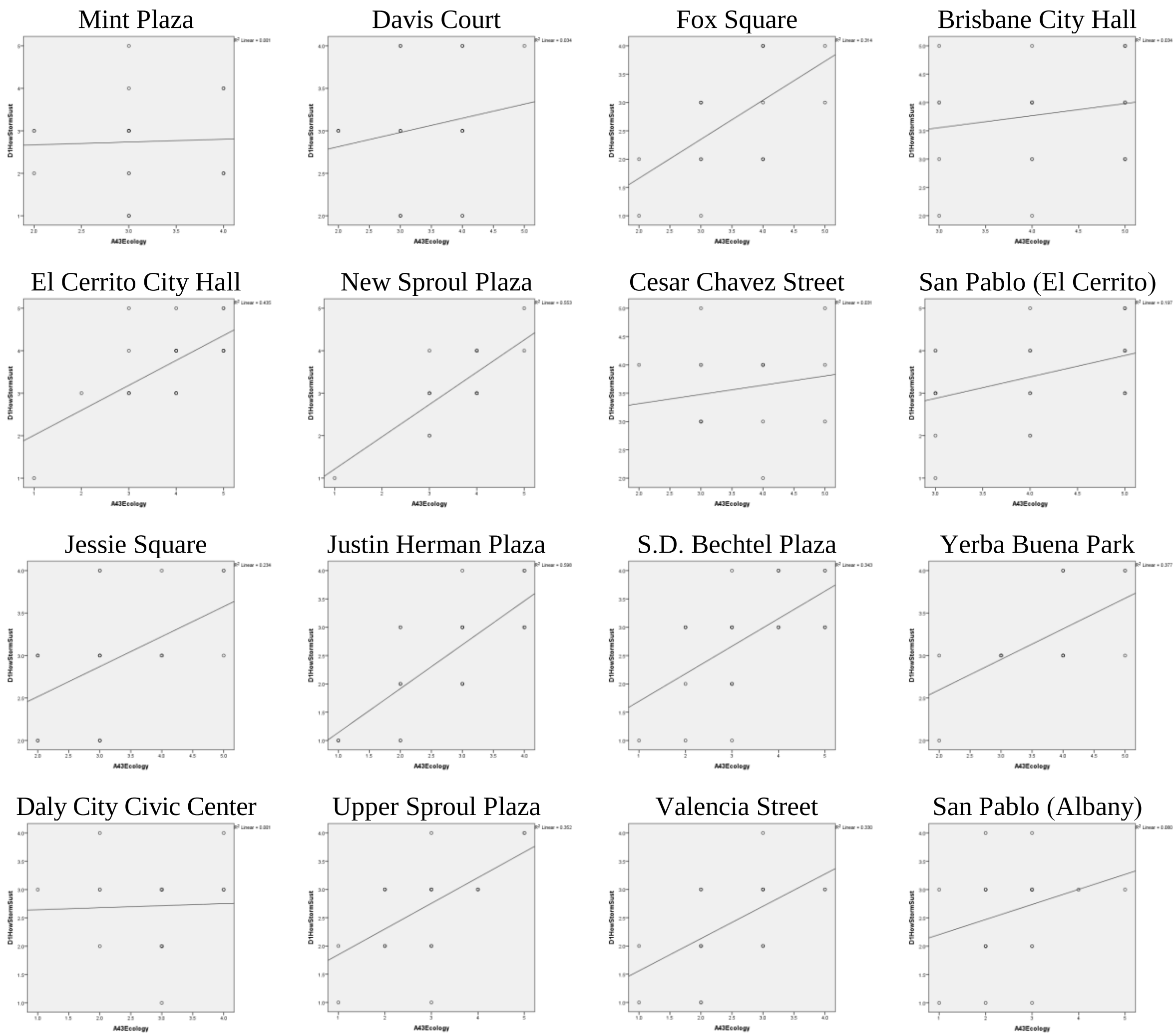
Also, the calculated coefficients also demonstrate that the correlations between the rating for sustainable stormwater management function and the rating for appreciation of functional efficiency are varied among the study sites. Moreover, they also reveal that the number of study sites which hold a significant correlation is quite low; only 5 out of 16 study sites hold a statistically significant correlation. In other words, in most of the study sites, the correlation between the rating for sustainable stormwater management function and the rating for appreciation of functional efficiency is not statistically significant. As shown in figure 9.4.2, most of the lines of best fit are not quite steep.

Figure 9.4.2 Scatter plot graphs illustrating the correlations between the rating for sustainable stormwater management function (y-axis) and the rating for appreciation of functional efficiency (x-axis) of the study sites



For the correlations between the rating for sustainable stormwater management function and the rating for appreciation of ecological performance, the Pearson coefficients demonstrate that those of 10 out of 16 study sites are statistically significant. Notable enough, all correlations are positive. The scatter plots in figure 9.4.3 illustrate, most of the lines of best fit are sloping upward to the right and quite steep. These results demonstrate that the overall rating for sustainable stormwater management function are correlated with the rating for ecological performance rather than the rating for aesthetic attractiveness and the rating for functional efficiency.

Figure 9.4.3 Scatter plot graphs illustrating the correlations between the rating for sustainable stormwater management function (y-axis) and the rating for appreciation of ecological performance (x-axis) of the study sites



9.5 Summary of results from the hypothesis tests (H-2.1-2.4)

As it appeared that the LID and non-LID design received a quite different rating for their sustainable stormwater management function, the hypothesis that the respondents were not able to recognize the sustainable stormwater management function of the LID sites can be rejected. Specifically, for the case of the study sites which are the city hall landscapes, university open spaces, and streets and sidewalks, it becomes obvious that the LID sites received a higher rating for their sustainable stormwater management function than their control sites. Nonetheless, for the case of the city and community open spaces, there is not enough evidence to say that the mean difference between the LID and non-LID sites in this landscape type is statistically significant so that this hypothesis could not be rejected. For the issue regarding the landscape features perceived as sustainable urban stormwater management elements, planting and planters were the winners while paving surface and pavers seemed to be the losers. However, for the sites with water features, it becomes obvious that water features received a noticeably high score and, for most of the cases, received a higher score than planting and planters. Interestingly, even though some elements—particularly cistern, lawns, trenches, and water features—are not visible in the sites, they were often mentioned that they help manage urban stormwater in a sustainable way. Seeing that, it seems like the landscape features that the respondents' perceived as sustainable stormwater management factors are not only the ones that people see, but also the ones that people know. Considering the correlation issue, the majority of ratings for sustainable stormwater management function appeared to be positively correlated with the appreciation ratings—whether those for aesthetic attractiveness, functional efficiency, or ecological performance.

Table 9.5.1 Summary of results from the hypothesis tests (H-2.1-2.4)

Hypotheses	**Results from the hypothesis tests**
Question 2:	*How do people evaluate the sustainable stormwater management function of the urban landscapes with the implementation of LID design, compared to those without the implementation of LID design?*
H-2.1	– For the study sites which are the city hall landscapes, university open spaces, and streets and sidewalks, the LID sites received a significantly higher rating for their sustainable stormwater management function than their control sites. – For the study sites which are the city and community open spaces, there is not enough evidence to say that the mean differences between the LID and non-LID sites are statistically significant.
H-2.2	Planting and planters seemed to be the elements people perceived that they help manage urban stormwater in a sustainable way, while paving surface and pavers seemed to be not. For the sites with water features, it becomes obvious that water features received a noticeably high score and, for most of the cases, received a higher score than planting and planters.
H-2.3	For most of the cases, the mean of the ratings for sustainable stormwater management function appear to be significantly lower than the mean of the rating for aesthetic attractiveness as well as functional efficiency and ecological performance.
H-2.4	For most of the cases, the rating scores for sustainable stormwater management function appear to be positively correlated with the rating scores for whether aesthetic attractiveness, functional efficiency, or ecological performance, yet quite few correlations are statistically significant.

Chapter 10

Evaluation of Attractiveness, Effectiveness, Sustainability, and Recognizability of the Landscape Elements

This chapter presents the analysis of the ratings given to question 7.1-7.12 of the questionnaire, which aims to investigate the respondents' attitudes toward twelve landscape elements, including 1) water tank/ cistern, 2) lawn/ grass/ turf, 3) pavers, 4) paving surface, 5) bioretention planter/ rain garden, 6) bioswale/ vegetated swale, 7) trench/ gutter/ storm drain, 8) green street, 9) green roof, 10) green wall, 11) pool/ pond, and 12) constructed wetland. In particular, the aim of this analysis is to answer the third research question: *how do people evaluate these landscape elements with regard to their attractiveness as well as their effectiveness, sustainability, and recognizability in terms of stormwater management?* This chapter, moreover, also presents the analysis of the differences and correlations between the ratings the respondents gave to these elements.

10.1 The ratings of the landscape elements

10.1.1 The rating for attractiveness

Overall, the majority of the twelve tested landscape elements received a quite positive rating for their attractiveness. Nonetheless, it is also quite clear that some tested landscape elements received a relatively negative rating for their attractiveness. As shown in table 10.1.1 and figure 10.1.1, the distributions of the rating for attractiveness of 7 out of twelve tested landscape elements are skewed to the right—which means the majority of data are clustered in the positive rating side. For the rest 5 elements, the distributions of water tank/ cistern and trench/ gutter/ storm drain are skewed to the negative rating side, while the distributions of paving surface, pavers, and bioswale seem to resemble a normal curve.

Considering the means, see table 10.1.2 and figure 10.1.2, pool/ pond received the highest mean (mean=4.40), followed by bioretention planter (mean=4.30), lawn/ grass/ turf (mean=4.09), green street (mean=4.04), green roof (mean=4.02), green wall (mean=3.90), and constructed wetland (mean=3.89). For the three elements—paving surface, pavers, and bioswale—in which their distributions resemble a normal curve, they received a quite moderate mean (approximately 3.00-3.50). For the case of the other two elements—water tank/ cistern (mean=1.85) and trench/ gutter/ storm drain (mean=2.63)—which are considered the conventional stormwater management elements, their means are very low. Markedly, it is fairly clear that respondents thought that water tank/ cistern is very unattractive in their opinion; as shown in table 10.1.2, its mode is 1 and its median is 2, which are very low, compared to those of the other elements.

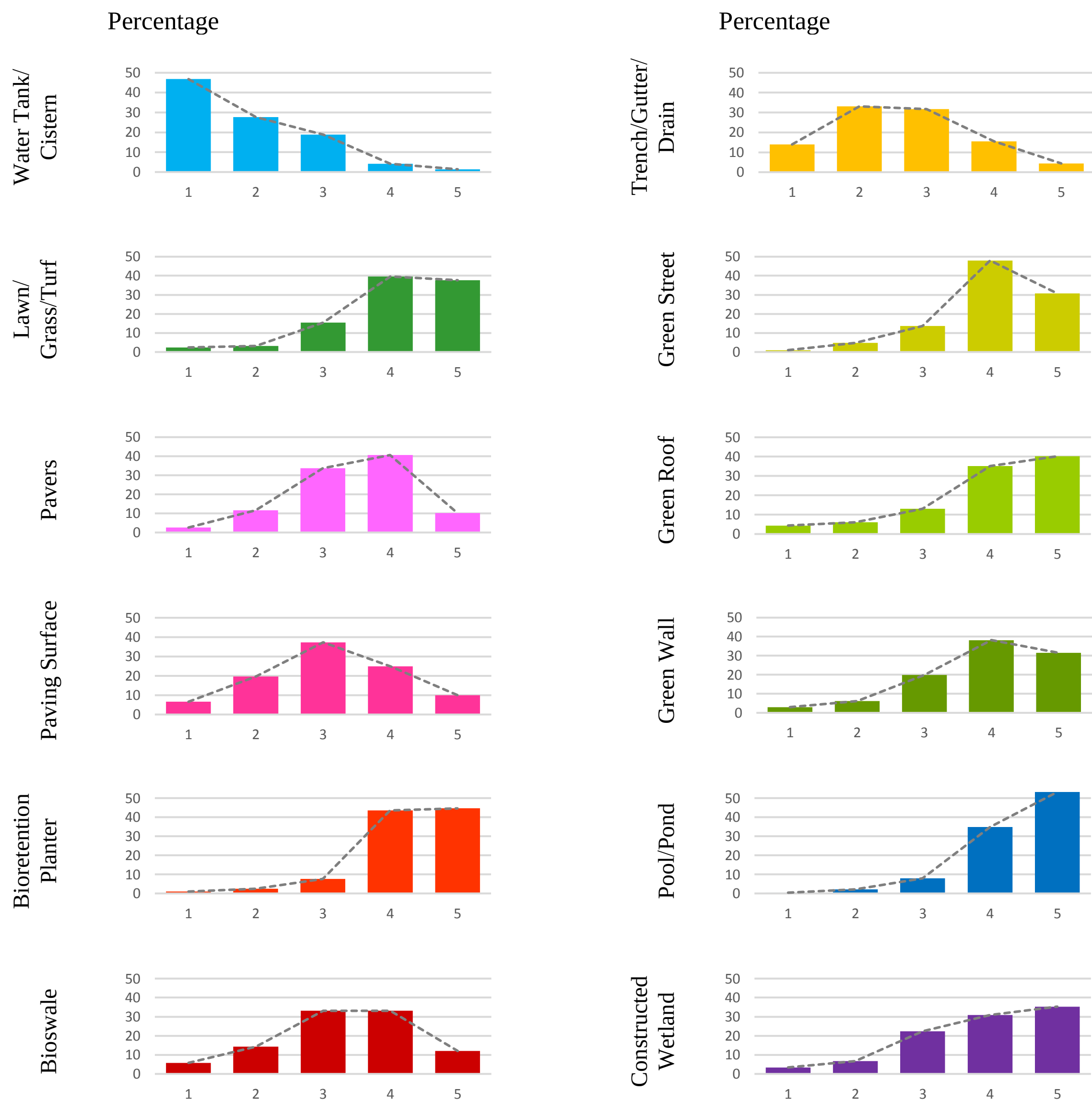
Table 10.1.1 Distribution of the rating scores for attractiveness of the landscape elements (1=not attractive, 5=most attractive)

Landscape Elements	Distribution of Rating Scores for Attractiveness					Missing	*n*
	1 (not attractive)	2	3	4	5 (most attractive)		
1. Water Tank/Cistern	**235 (46.8%)**	139 (27.7%)	95 (18.9%)	21 (4.2%)	7 (1.4%)	5 (1.0%)	497
2. Lawn/Grass/Turf	12 (2.4%)	16 (3.2%)	78 (15.5%)	**199 (39.6%)**	189 (37.6%)	8 (1.6%)	494
3. Pavers	13 (2.6%)	58 (11.6%)	169 (33.7%)	**204 (40.6%)**	51 (10.2%)	7 (1.4%)	495
4. Paving Surface	33 (6.6%)	99 (19.7%)	**187 (37.3%)**	125 (24.9%)	50 (10.0%)	8 (1.6%)	494
5. Bioretention Planter	5 (1.0%)	12 (2.4%)	38 (7.6%)	219 (43.6%)	**224 (44.6%)**	4 (0.8%)	498
6. Bioswale	29 (5.8%)	72 (14.3%)	**166 (33.1%)**	**166 (33.1%)**	60 (12.0%)	9 (1.8%)	493
7. Trench/Gutter/Drain	70 (13.9%)	**166 (33.1%)**	159 (31.7%)	78 (15.5%)	22 (4.4%)	7 (1.4%)	495
8. Green Street	5 (1.0%)	24 (4.8%)	69 (13.7%)	**241 (48.0%)**	154 (30.7%)	9 (1.8%)	493
9. Green Roof	22 (4.4%)	30 (6.0%)	66 (13.1%)	176 (35.1%)	**202 (40.2%)**	6 (1.2%)	496
10. Green Wall	15 (3.0%)	31 (6.2%)	100 (19.9%)	**192 (38.2%)**	158 (31.5%)	6 (1.2%)	496
11. Pool/Pond	2 (0.4%)	11 (2.2%)	40 (8.0%)	175 (34.9%)	**267 (53.2%)**	7 (1.4%)	495
12. Constructed Wetland	17 (3.4%)	34 (6.8%)	112 (22.3%)	**177 (35.3%)**	**177 (35.3%)**	7 (1.4%)	495

Table 10.1.2 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for attractiveness of the landscape elements

Landscape Elements	*n*	Mean	Median	Mode	*SD*
1. Water Tank/Cistern	497	**1.85**	2.00	1	0.968
2. Lawn/Grass/Turf	494	4.09	4.00	4	0.940
3. Pavers	495	3.45	4.00	4	0.920
4. Paving Surface	494	3.12	3.00	3	1.055
5. Bioretention Planter	498	4.30	4.00	5	0.792
6. Bioswale	493	3.32	3.00	3, 4	1.052
7. Trench/Gutter/Drain	495	2.63	3.00	2	1.049
8. Green Street	493	4.04	4.00	4	0.859
9. Green Roof	496	4.02	4.00	5	1.088
10. Green Wall	496	3.90	4.00	4	1.017
11. Pool/Pond	495	**4.40**	5.00	5	0.765
12. Constructed Wetland	495	3.89	4.00	5	1.076

Figure 10.1.1 Bar graphs illustrating distributions of the rating scores for attractiveness of the landscape elements (1=not attractive, 5=most attractive)



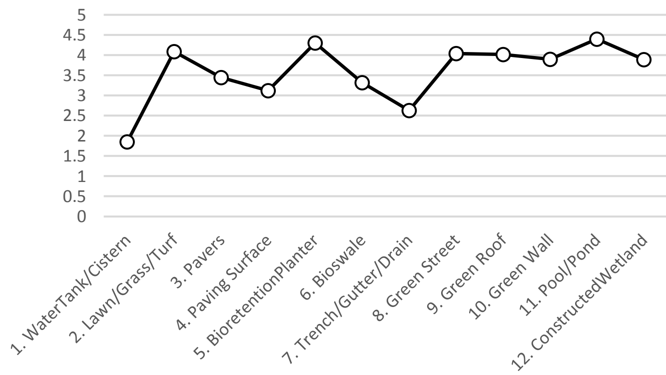


Figure 10.1.2 Line graph illustrating the means of the rating for attractiveness of the landscape elements

10.1.2 The rating for effectiveness

Considering the distributions of the ratings the respondents gave with regard to the effectiveness in terms of stormwater management of the landscape elements, see table 10.1.3 and figure 10.1.3, only paving surface has a distribution which skews to the negative side. Moreover, paving surface also holds the lowest mean and the only one mean which is lower than 3.00, see table 10.1.4. Accordingly, it is quite clear that the respondents recognized that paving surface is not effective in dealing with stormwater. Notably, it is very delighted that some respondents made note that paving surface implies impervious surface so that they thought it is not an element which effectively manage stormwater.

For the other 11 elements, their distributions skew to the positive side and their means are all higher than 3.00, see figure 10.1.4, implying that the respondents had a positive attitude toward their effectiveness in terms of stormwater management. Of all tested elements, constructed wetland received the highest mean (mean=4.20), followed by pool/ pond (mean=3.91), green roof (mean=3.83), bioretention planter (mean=3.82), water tank/ cistern (mean=3.75), bioswale (mean=3.72), trench/ gutter/ storm drain (mean=3.63), green street (mean=3.59), green wall (mean=3.50), lawn/ grass/ turf (mean=3.19), and pavers (mean=3.13). Notably, constructed wetland is the only one element whose mean is higher than 4.00 and whose mode is 5.

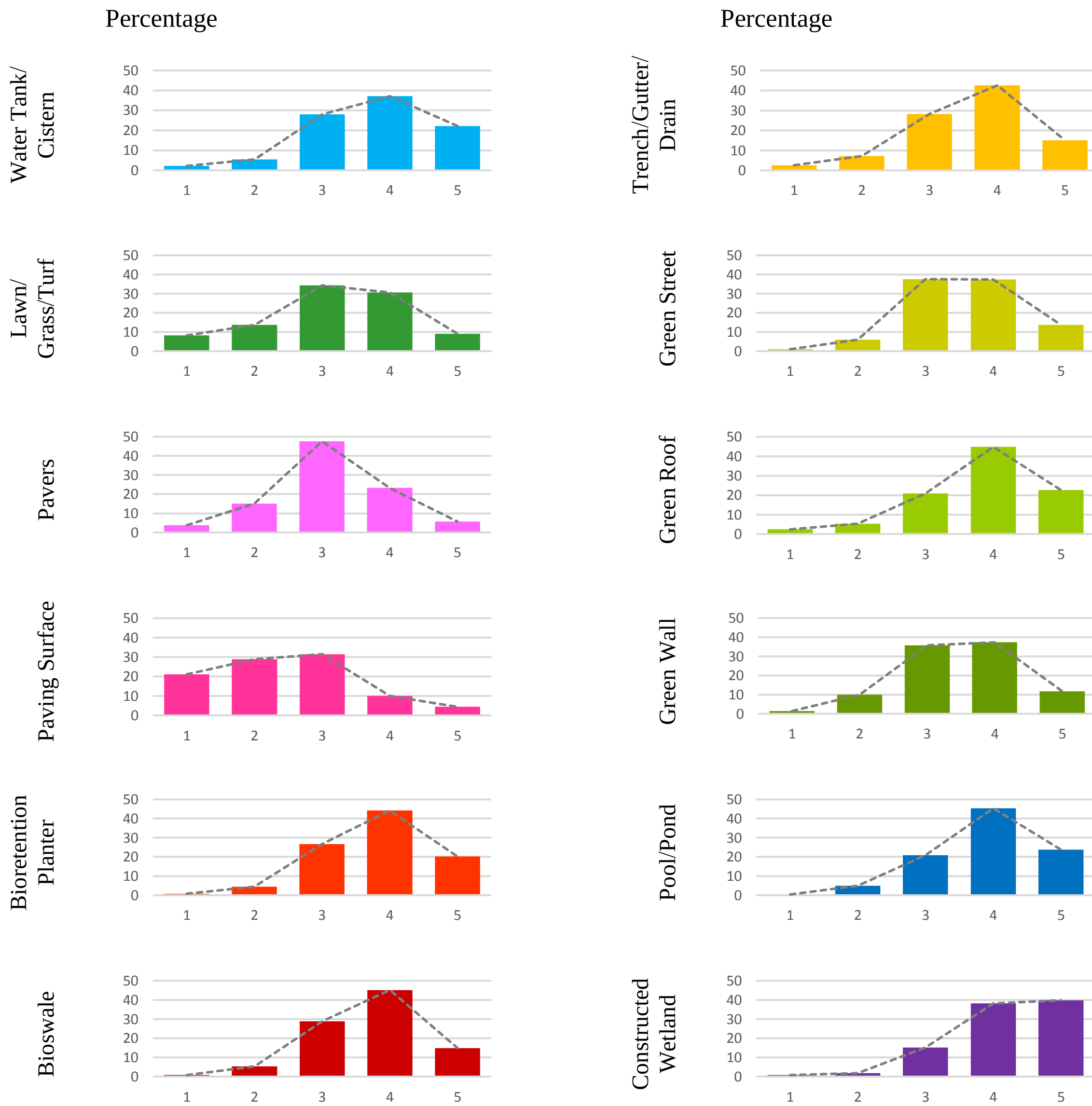
Table 10.1.3 Distribution of the rating scores for effectiveness of the landscape elements (1=not effective, 5=most effective)

Landscape Elements	Distribution of Rating Scores for Effectiveness					Missing	*N*
	1 (not effective)	2	3	4	5 (most effective)		
1. Water Tank/Cistern	11 (2.2%)	27 (5.4%)	141 (28.1%)	**186 (37.1%)**	111 (22.1%)	26 (5.2%)	476
2. Lawn/Grass/Turf	41 (8.2%)	69 (13.7%)	**172 (34.3%)**	154 (30.7%)	45 (9.0%)	21 (4.2%)	481
3. Pavers	19 (3.8%)	76 (15.1%)	**239 (47.6%)**	117 (23.3%)	29 (5.8%)	22 (4.4%)	480
4. Paving Surface	106 (21.1%)	145 (28.9%)	**158 (31.5%)**	50 (10.0%)	22 (4.4%)	21 (4.2%)	481
5. Bioretention Planter	4 (0.8%)	22 (4.4%)	134 (26.7%)	**222 (44.2%)**	102 (20.3%)	18 (3.6%)	484
6. Bioswale	4 (0.8%)	27 (5.4%)	145 (28.9%)	**227 (45.2%)**	75 (14.9%)	4.24 (4.8%)	478
7. Trench/Gutter/Drain	13 (2.6%)	36 (7.2%)	142 (28.3%)	**214 (42.6%)**	76 (15.1%)	21 (4.2%)	481
8. Green Street	5 (1.0%)	30 (6.0%)	**189 (37.6%)**	187 (37.4%)	69 (13.7%)	22 (4.4%)	480
9. Green Roof	12 (2.4%)	27 (5.4%)	105 (20.9%)	**225 (44.8%)**	114 (22.7%)	19 (3.8%)	483
10. Green Wall	7 (1.4%)	50 (10.0%)	179 (35.7%)	**187 (37.3%)**	59 (11.8%)	20 (4.0%)	482
11. Pool/Pond	2 (0.4%)	25 (5.0%)	105 (20.9%)	**228 (45.4%)**	119 (23.7%)	23 (4.6%)	479
12. Constructed Wetland	4 (0.8%)	9 (1.8%)	76 (15.1%)	192 (38.2%)	**200 (39.8%)**	21 (4.2%)	481

Table 10.1.4 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for effectiveness of the landscape elements

Landscape Elements	*N*	Mean	Median	Mode	*SD*
1. Water Tank/Cistern	476	3.75	4.00	4	0.952
2. Lawn/Grass/Turf	481	3.19	3.00	3	1.069
3. Pavers	480	3.13	3.00	3	0.887
4. Paving Surface	481	**2.45**	2.00	3	1.083
5. Bioretention Planter	484	3.82	4.00	4	0.844
6. Bioswale	478	3.72	4.00	4	0.826
7. Trench/Gutter/Drain	481	3.63	4.00	4	0.929
8. Green Street	480	3.59	4.00	3	0.847
9. Green Roof	483	3.83	4.00	4	0.935
10. Green Wall	482	3.50	4.00	4	0.889
11. Pool/Pond	479	3.91	4.00	4	0.841
12. Constructed Wetland	481	**4.20**	4.00	5	0.829

Figure 10.1.3 Bar graphs illustrating distributions of the rating scores for effectiveness of the landscape elements (1=not effective, 5=most effective)



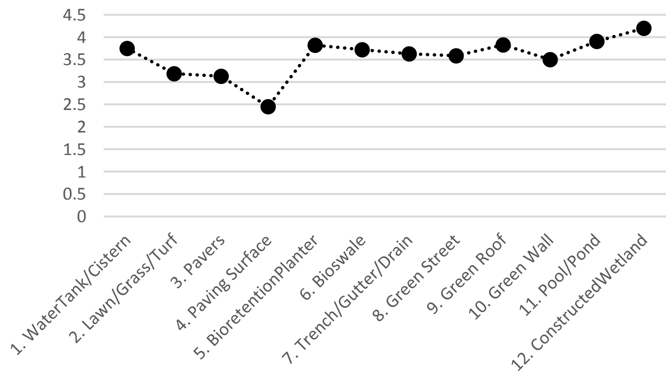


Figure 10.1.4 Line graph illustrating the means of the rating for effectiveness in terms of stormwater management of the landscape elements

10.1.3 The rating for sustainability

Overall, the pattern of sustainability rating is quite similar to that of the effectiveness rating. More specifically, constructed wetland received the highest mean for effectiveness rating as well as the highest mean for sustainability rating while paving surface received the lowest. Also, some respondents noted that paving surface implies impervious surface so that they thought it is not an element which sustainably manage stormwater.

Table 10.1.5 Distribution of the rating scores for sustainability of the landscape elements (1=not sustainable, 5=most sustainable)

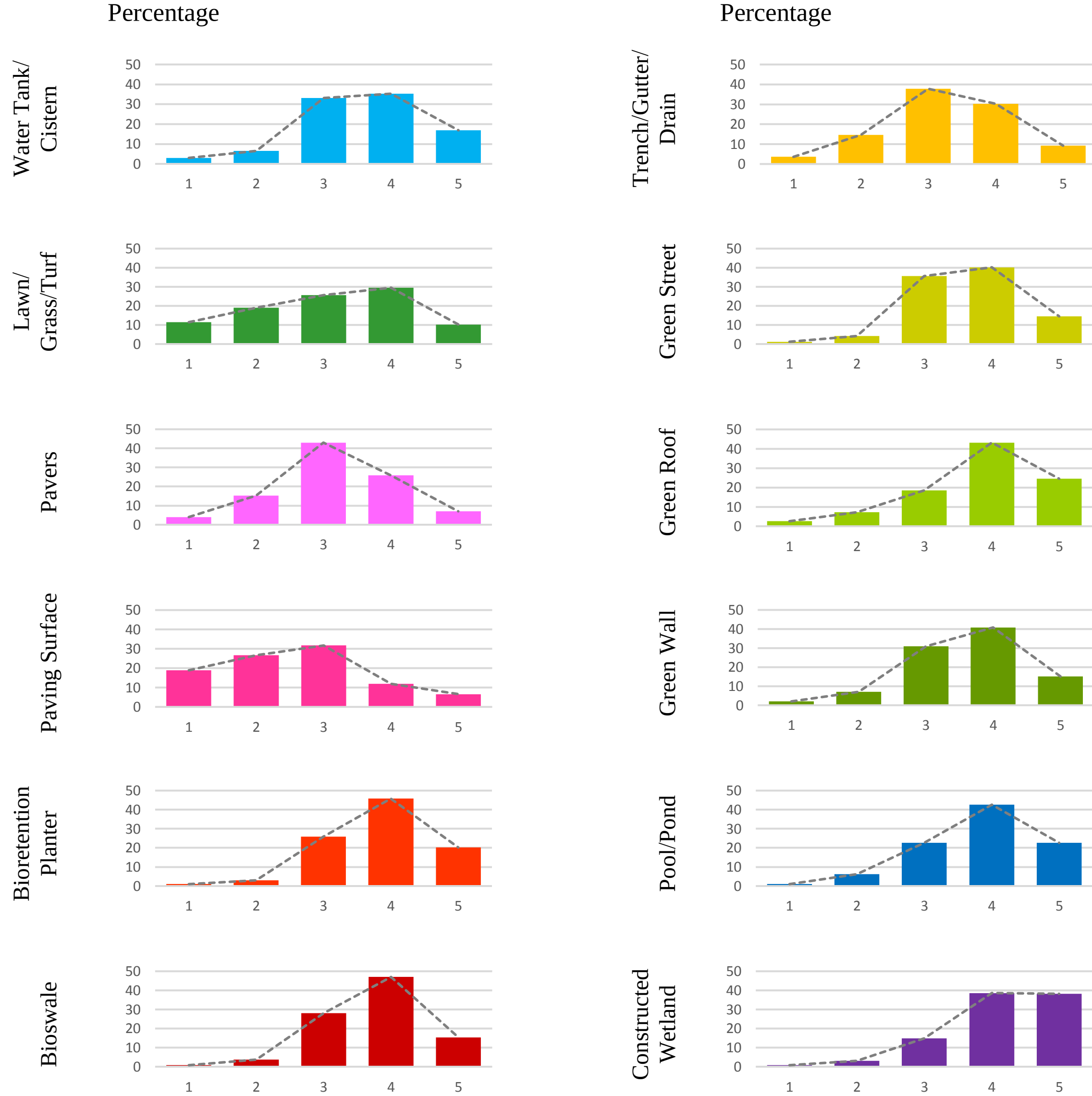
Landscape Elements	Distribution of Rating Scores for Sustainability					Missing	*N*
	1 (not sustainable)	2	3	4	5 (most sustainable)		
1. Water Tank/Cistern	5 (3.0%)	33 (6.6%)	166 (33.1%)	**177 (35.3%)**	85 (16.9%)	26 (5.2%)	476
2. Lawn/Grass/Turf	57 (11.4%)	96 (19.1%)	129 (25.7%)	**148 (29.5%)**	51 (10.2%)	2 (4.2%)	481
3. Pavers	20 (4.0%)	77 (15.3%)	**216 (43.0%)**	130 (25.9%)	35 (7.0%)	24 (4.8%)	478
4. Paving Surface	95 (18.9%)	134 (26.7%)	**159 (31.7%)**	60 (12.0%)	33 (6.6%)	21 (4.2%)	481
5. Bioretention Planter	5 (1.0%)	15 (3.0%)	130 (25.9%)	**230 (45.8%)**	102 (20.3%)	20 (4.0%)	482
6. Bioswale	4 (0.8%)	19 (3.8%)	141 (28.1%)	**236 (47.0%)**	77 (15.3%)	25 (5.0%)	477
7. Trench/Gutter/Drain	18 (3.6%)	74 (14.7%)	**190 (37.8%)**	152 (30.3%)	46 (9.2%)	22 (4.4%)	480
8. Green Street	6 (1.2%)	21 (4.2%)	179 (35.7%)	**202 (40.2%)**	73 (14.5%)	21 (4.2%)	481
9. Green Roof	13 (2.6%)	36 (7.2%)	93 (18.5%)	**217 (43.2%)**	123 (24.5%)	20 (4.0%)	482
10. Green Wall	10 (2.0%)	35 (7.0%)	155 (30.9%)	**205 (40.8%)**	76 (15.1%)	21 (4.2%)	481
11. Pool/Pond	5 (1.0%)	31 (6.2%)	114 (22.7%)	**214 (42.6%)**	114 (22.7%)	24 (4.8%)	478
12. Constructed Wetland	4 (0.8%)	15 (3.0%)	75 (14.9%)	**194 (38.6%)**	192 (38.2%)	22 (4.4%)	480

Table 10.1.6 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for sustainability of the landscape elements

Landscape Elements	*N*	Mean	Median	Mode	*SD*
1. Water Tank/Cistern	476	3.60	4.00	4	0.963
2. Lawn/Grass/Turf	481	3.08	3.00	4	1.184
3. Pavers	478	3.17	3.00	3	0.930
4. Paving Surface	481	**2.59**	3.00	3	1.141
5. Bioretention Planter	482	3.85	4.00	4	0.823
6. Bioswale	477	3.76	4.00	4	0.798
7. Trench/Gutter/Drain	480	3.28	3.00	3	0.963
8. Green Street	481	3.65	4.00	4	0.833
9. Green Roof	482	3.83	4.00	4	0.982
10. Green Wall	481	3.63	4.00	4	0.906
11. Pool/Pond	478	3.84	4.00	4	0.898
12. Constructed Wetland	480	**4.16**	4.00	4	0.856

For the rest 10 elements, they can be classified into two groups. The first group includes 8 elements—pool/ pond, bioretention planter, bioswale, green roof, green street, green wall, water tank/ cistern, and trench/ gutter/ storm drain—whose mean scores, both for effectiveness and sustainability, are between 3.20 and 4.00. Interestingly, it appears that the mean scores for sustainability of the LID elements—bioretention planter, bioswale, green roof, green street, green wall—are higher than those of the two conventional elements—water tank/ cistern and trench/ gutter/ storm drain. This result is different from the case of effectiveness rating in which these two conventional elements received a higher mean score than some of the LID elements in this groups. Another group includes 2 elements—pavers and lawn/ grass/ turf—whose mean scores, both for effectiveness and sustainability, are between 3.00 and 3.20. For this group, it appears that the order of the mean scores for effectiveness and sustainability of these two elements are different. In particular, while the mean score for effectiveness rating of pavers is lower than that of lawn/ grass/ turf, the mean score for sustainability rating of pavers is higher than that of lawn/ grass/ turf.

Figure 10.1.5 Bar graphs illustrating distributions of the rating scores for sustainability of the landscape elements (1=not sustainable, 5= sustainable)



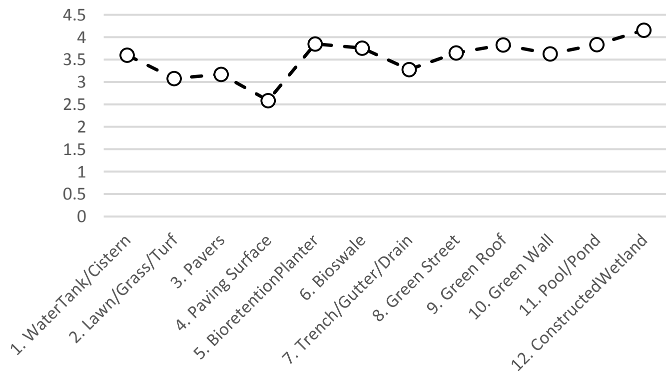


Figure 10.1.6 Line graph illustrating the means of the rating for sustainability in terms of stormwater management of the landscape elements

10.1.4 The rating for recognizability rating

In consideration of the rating scores for recognizability in terms of stormwater management of the landscape elements, the distributions of 10 out of 12 tested landscape elements skew to the positive side while the distribution of pavers resembles the normal curve and the distribution of paving surface skews to the negative side. Accordingly, pavers and paving surface received a quite low rating with regard to the recognizability in terms of stormwater management, compared to the other tested elements.

Table 10.1.7 Distribution of the rating scores for recognizability of the landscape elements (1=not recognizable, 5=most recognizable)

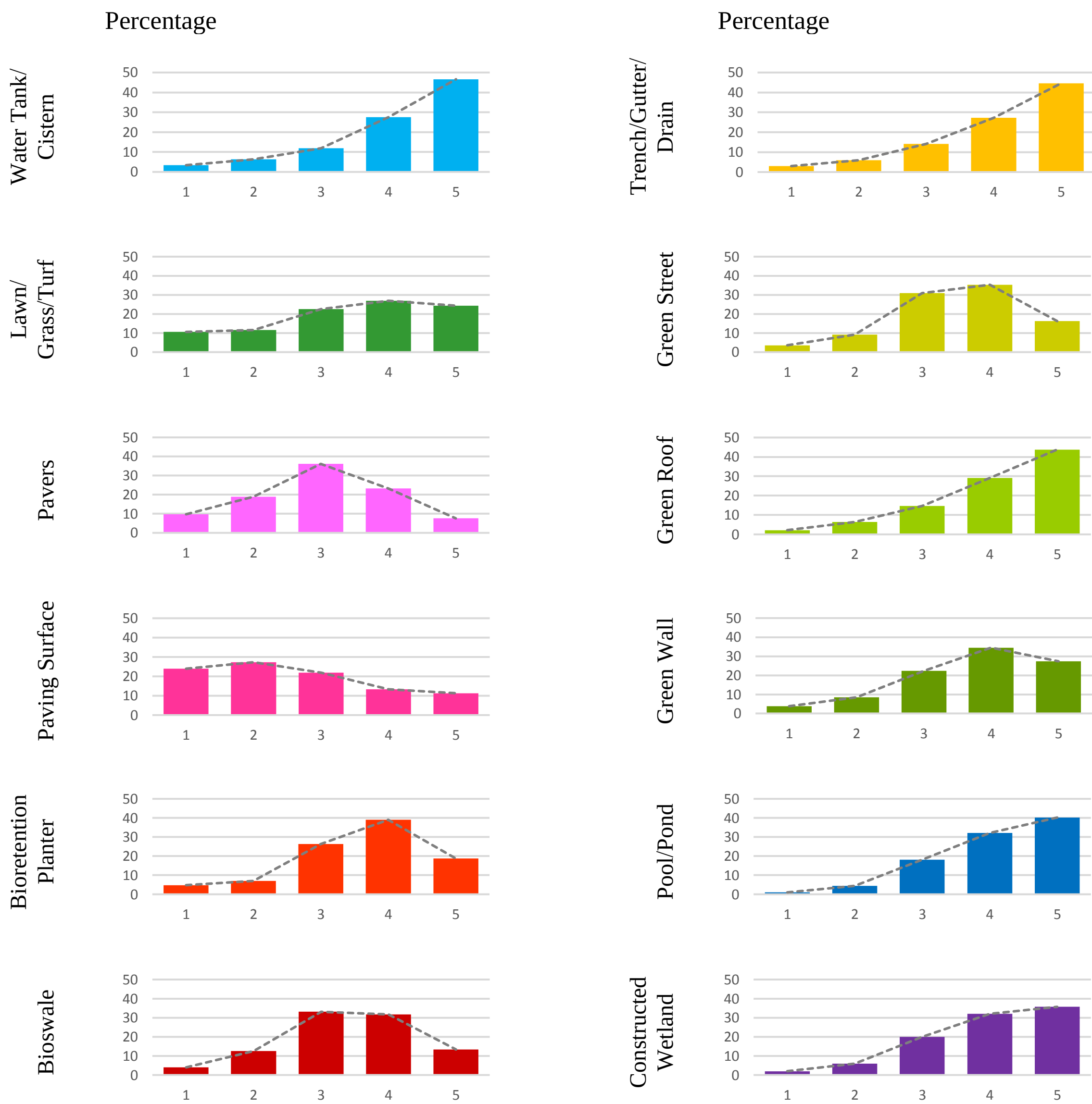
Landscape Elements	Distribution of Rating Scores for Recognizability					Missing	*N*
	1 (not recognizable)	2	3	4	5 (most recognizable)		
1. Water Tank/Cistern	17 (3.4%)	32 (6.4%)	60 (12.0%)	138 (27.5%)	**234 (46.6%)**	21 (4.2%)	481
2. Lawn/Grass/Turf	53 (10.6%)	58 (11.6%)	113 (22.5%)	**135 (26.9%)**	122 (24.3%)	21 (4.2%)	481
3. Pavers	49 (9.8%)	95 (18.9%)	**181 (36.1%)**	117 (23.3%)	38 (7.6%)	22 (4.4%)	480
4. Paving Surface	120 (23.9%)	**137 (27.3%)**	105 (21.9%)	64 (13.3%)	54 (11.3%)	22 (4.4%)	480
5. Bioretention Planter	21 (4.8%)	35 (7.0%)	132 (26.3%)	**196 (39.0%)**	94 (18.7%)	21 (4.2%)	481
6. Bioswale	20 (4.0%)	63 (12.5%)	**166 (33.1%)**	159 (31.7%)	67 (13.3%)	27 (5.4%)	475
7. Trench/Gutter/Drain	15 (3.0%)	32 (6.0%)	71 (14.1%)	137 (27.3%)	**224 (44.6%)**	23 (4.6%)	479
8. Green Street	18 (3.6%)	46 (9.2%)	155 (30.9%)	**177 (35.3%)**	82 (16.3%)	24 (4.8%)	478
9. Green Roof	11 (2.2%)	32 (6.4%)	74 (14.7%)	146 (29.1%)	**220 (43.8%)**	19 (3.8%)	483
10. Green Wall	19 (3.8%)	42 (8.4%)	112 (22.3%)	**173 (34.5%)**	137 (27.3%)	19 (3.8%)	483
11. Pool/Pond	5 (1.0%)	22 (4.4%)	91 (18.1%)	161 (32.1%)	**202 (40.2%)**	21 (4.2%)	481
12. Constructed Wetland	10 (2.0%)	30 (6.0%)	100 (19.9%)	161 (32.1%)	**179 (35.7%)**	22 (4.4%)	480

Table 10.1.8 Central tendencies (mean, median, mode, and standard deviation) of the rating scores for recognizability of the landscape elements

Landscape Elements	*N*	Mean	Median	Mode	*SD*
1. Water Tank/Cistern	481	**4.12**	4.00	5	1.088
2. Lawn/Grass/Turf	481	3.25	4.00	4	1.288
3. Pavers	480	3.00	3.00	3	1.081
4. Paving Surface	480	**2.57**	2.00	2	1.300
5. Bioretention Planter	481	3.63	4.00	4	1.035
6. Bioswale	475	3.40	3.00	3	1.021
7. Trench/Gutter/Drain	479	4.09	4.00	5	1.077
8. Green Street	478	3.54	4.00	4	1.006
9. Green Roof	483	4.10	4.00	5	1.035
10. Green Wall	483	3.76	4.00	4	1.078
11. Pool/Pond	481	4.11	4.00	5	0.936
12. Constructed Wetland	480	4.00	4.00	5	1.010

Considering the 10 elements which received a relatively positive rating, they can be classified into two groups. The first group include 5 elements in which their modes are 5 while their second, third, and forth most common scores are 4, 3, 2 and 1, respectively. Additionally, the mean scores of these 5 elements are also higher than 4.00. In view of these statistics, these 5 elements—which are water tank/ cistern, pool/ pond, green roof, trench/ gutter/ storm drain, and constructed wetland—were very recognizable regarding their stormwater management function. Interestingly, all except green roof are those that provide the presence of water. Perhaps it might be because green roof has been long, well promoted as an excellent stormwater management feature, making it was very well recognizable to the respondents. For the 5 elements in the second group, they are green wall, green street, bioretention planter, bioswale, and lawn/ grass/ turf. As their mean scores are between 3.20 and 4.00, they are also considered quite well recognizable as well. Remarkable enough, the 5 elements of this second group, along with green roof of the first group, are those that provide the presence of vegetation.

Figure 10.1.7 Bar graphs illustrating distributions of the rating scores for recognizability of the landscape elements (1=not recognizable, 5=most recognizable)



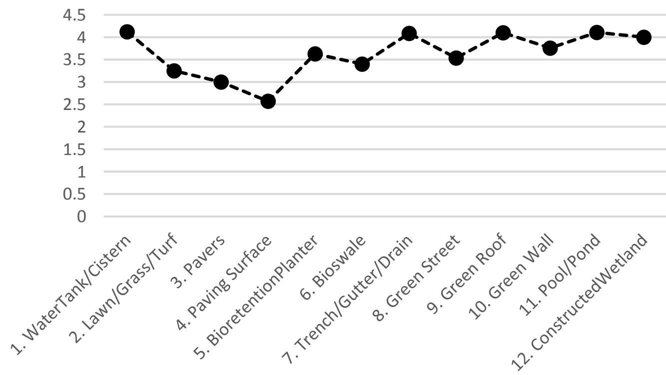


Figure 10.1.8 Line graph illustrating the means of the rating for recognizability in terms of stormwater management of the landscape elements

10.2 Difference between the ratings of each landscape element

In this section, the difference between the ratings for attractiveness, effectiveness, sustainability, and recognizability of each landscape elements are investigated. According to the line graphs presented in figure 10.2.1, the means of the ratings for these four qualities of some landscape elements are quite compatible with each other; in contrast, those of the others are not. In particular, it is obvious that the four means of constructed wetlands are very consistent, compared to those of the other elements. The case of water tank/ cistern is the most extreme one as its mean for attractiveness is dramatically low, contrasting with its other three means. Also, the case of trench/ gutter/ storm drain is intriguing as its four means are quite pole apart from each other. Bioretention planter, pavers, paving surface, and lawn/ grass/ turf hold a quite similar pattern—the mean for attractiveness is quite high compared to the other three means, which are very congruent to each other. The four means of green street, green roof, and green wall also share some similar aspects—the mean for attractiveness is approximately 4.00 and the other 3 means are around 3.50-4.00. For the case of pool/ pond, its means for attractiveness is the highest among the twelve tested element, and also higher than its 3 other means. Finally, the four means of bioswale can be divided into two pairs—the mean for attractiveness and the mean for recognizability are very similar to each other and obviously lower than the other two means, which are almost the same.

To further explore the differences between these four means of each landscape elements, the paired-samples *t* tests are performed. The *t* statistics, see table 10.3.1-10.3.12, demonstrate that the majority of the mean differences are statistically significant. According to these statistical results, it becomes fairly obvious that, based on respondents' opinions, the four qualities of each landscape element are distinctive to each other. In other words, it is found that most of the mean differences are statistically significant, implying that the respondents were quite sensitive and thoughtful with regard to the different qualities of each particular element. The prominent differences among the four qualities of each tested elements as perceived by the respondents are discussed as follows.

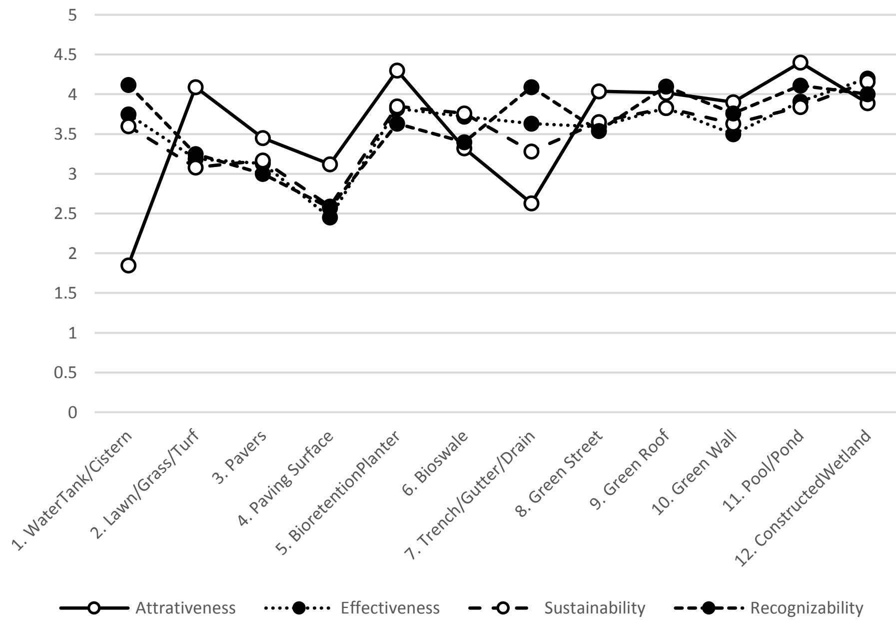


Figure 10.2.1 Line graphs illustrating mean scores for attractiveness along with effectiveness, sustainability, and recognizability in terms of stormwater management of the landscape elements

For water tank/ cistern, its mean for attractiveness is significantly lower than its other three means, which are exceptionally high. The effect sizes of these differences are very large. Remarkably, among the elements tested in this study, the mean for attractiveness of this element is the lowest while the mean for recognizability is the highest. Therefore, water tank/ cistern is considered awfully unappealing, but well recognized as an effective and sustainable stormwater management feature.

Table 10.2.1 Paired-samples *t* test elucidating the differences between the four means of water tank/ cistern

Paired-samples *t* test (ratings of water tank/ cistern)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	475	-1.878	-33.541	0.000*	-1.941; very large
Attractiveness *x* Sustainability	475	-1.721	-31.611	0.000*	-1.775; very large
Attractiveness *x* Recognizability	479	-2.256	-35.073	0.000*	-2.189; very large
Effectiveness *x* Sustainability	475	0.158	5.309	0.000*	0.157; small
Effectiveness *x* Recognizability	473	-0.373	-7.249	0.000*	-0.374; small-medium
Sustainability *x* Recognizability	473	-0.532	-10.209	0.000*	-0.529; medium

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Not surprisingly, lawn/ grass/ turf is a very attractive landscape element. The mean for attractiveness of this element is exceptionally high and significantly higher than those of the other three qualities. Even though lawns are not considered the LID elements, perhaps it might be because of their permeability that make them be recognized as a moderately effective and sustainable stormwater management feature.

Table 10.2.2 Paired-samples *t* test elucidating the differences between the four means of lawn/ grass/ turf

Paired-samples *t* test (ratings of lawn/ grass/ turf)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	478	0.875	18.208	0.000*	0.874; large
Attractiveness *x* Sustainability	478	0.990	19.220	0.000*	0.925; large
Attractiveness *x* Recognizability	478	0.628	9.655	0.000*	0.877; large
Effectiveness *x* Sustainability	479	0.110	2.670	0.008*	0.098; small
Effectiveness *x* Recognizability	476	-0.249	-4.138	0.000*	-0.211; small
Sustainability *x* Recognizability	477	-0.364	-5.317	0.000*	-0.291; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For the case of pavers, it appears that although all means of pavers are quite low compared to those of the other elements, pavers are considered somewhat attractive, as well as effective, sustainable, and recognizable, to the respondents because the four means of pavers are all in the positive side—more than 3.00. Considering the differences among the four qualities of pavers, the mean for attractiveness is significantly higher than the other three means while the mean for recognizability is significantly lower than the others. Note that only the difference between the mean for effectiveness and the mean for sustainability of pavers is not statistically significant.

Table 10.2.3 Paired-samples *t* test elucidating the differences between the four means of pavers

Paired-samples *t* test (pavers)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	478	0.330	7.392	0.000*	0.366; small
Attractiveness *x* Sustainability	476	0.279	5.849	0.000*	0.304; small
Attractiveness *x* Recognizability	478	0.455	8.371	0.000*	0.459; medium
Effectiveness *x* Sustainability	477	-0.044	-1.454	0.147	-0.044; very small
Effectiveness *x* Recognizability	476	0.132	2.712	0.007*	0.131; small
Sustainability *x* Recognizability	476	0.174	3.477	0.001*	0.169; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Considering the case of paving surface, even though its mean for attractiveness is quite low compared to the other elements, paving surface is considered somewhat attractive to the respondents because the mean for attractiveness of paving surface is not in the negative side, as that of water tank/ cistern and that of trench/ gutter/ storm drain. For the differences among the four qualities of paving surface, the mean for attractiveness is significantly higher than the other three means. Remarkably, among the tested elements, paving surface is the only one in which its mean for effectiveness, along with its mean for sustainability and for recognizability, is skewed toward the negative side—lower than 3.00. Moreover, each of which is also the lowest among the tested elements. Note that as paving surface is also the only one element tested in this study which is not a stormwater management measure, this result is considered a good sign as it implies that the majority of respondents understood the unrewarding functions of paving surface regarding stormwater management.

Table 10.2.4 Paired-samples *t* test elucidating the differences between the four means of paving surface

Paired-samples *t* test (paving surface)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	479	0.673	13.864	0.000*	0.639; medium
Attractiveness *x* Sustainability	479	0.529	9.776	0.000*	0.484; medium
Attractiveness *x* Recognizability	478	0.562	8.646	0.000*	0.476; medium
Effectiveness *x* Sustainability	479	-0.138	-3.423	0.001*	-0.126; small
Effectiveness *x* Recognizability	478	-0.115	-2.073	0.039*	-0.092; small
Sustainability *x* Recognizability	478	0.023	0.004	0.689	0.016; very small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Obviously, the four means of bioretention planter are very high. Considering the mean differences, it appears that the mean for attractiveness of bioretention planter is significant higher than the other means. Furthermore, its mean for effectiveness as well as its means for sustainability are also significant higher than its mean for recognizability. Note that its mean for effectiveness is lower than that of sustainability, but not statistically significant.

Table 10.2.5 Paired-samples *t* test elucidating the differences between the four means of bioretention planter

Paired-samples *t* test (ratings of bioretention planter)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	483	0.488	13.822	0.000*	0.602; medium
Attractiveness *x* Sustainability	481	0.454	13.229	0.000*	0.561; medium
Attractiveness *x* Recognizability	480	0.676	13.826	0.000*	0.730; medium-large
Effectiveness *x* Sustainability	481	-0.029	-1.159	0.247	-0.036; very small
Effectiveness *x* Recognizability	480	0.189	4.385	0.000*	0.191; small
Sustainability *x* Recognizability	479	0.225	5.205	0.000*	0.236; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Unlike the case of bioretention planter, the mean for attractiveness of bioswale is significant lower than the other means. However, the relationships among these other three means of bioswale are quite similar to the case of bioretention planter—the mean for effectiveness along with the mean for sustainability is significant higher than its mean for recognizability while the mean for effectiveness is not significantly lower than that of sustainability.

Table 10.2.6 Paired-samples *t* test elucidating the differences between the four means of bioswale

Paired-samples *t* test (ratings of bioswale)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	477	-0.391	-10.133	0.000*	-0.426; medium
Attractiveness *x* Sustainability	476	-0.432	-10.891	0.000*	-0.463; medium
Attractiveness *x* Recognizability	474	-0.074	-1.592	0.112	-0.068; very small
Effectiveness *x* Sustainability	475	-0.042	-1.912	0.056	-0.049; very small
Effectiveness *x* Recognizability	473	0.314	7.695	0.000*	0.335; small
Sustainability *x* Recognizability	474	0.358	9.221	0.000*	0.393; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

The case of trench/ gutter/ storm drain is considered quite similar to that of water tank/ cistern. More specifically, its mean for attractiveness is considered very low and also significantly lower than the other means; in contrast, its mean for recognizability is very high and also significantly higher than the other means. Considering the relationship between its mean for sustainability and its mean for effectiveness, the former one is significantly lower than the latter one.

Table 10.2.7 Paired-samples *t* test elucidating the differences between the four means of trench/ gutter/ drain

Paired-samples *t* test (ratings of trench/ gutter/ drain)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	480	-0.996	-18.827	0.000*	-1.002; very large
Attractiveness *x* Sustainability	479	-0.644	-12.559	0.000*	-0.637; medium
Attractiveness *x* Recognizability	478	-1.461	-21.714	0.000*	-1.375; very large
Effectiveness *x* Sustainability	479	0.354	8.043	0.000*	0.370; small
Effectiveness *x* Recognizability	476	-0.451	-9.141	0.000*	-0.448; medium
Sustainability *x* Recognizability	476	-0.813	-14.441	0.000*	-0.803; large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For green street, its mean for attractiveness is exceptionally high, higher than 4.00, and significantly higher than its other means. Considering its mean for sustainability, it is significantly higher than its mean for recognizability and its mean for effectiveness. Considering its mean for recognizability, it is significantly lower than its mean for sustainability, but not is significantly lower than its mean for effectiveness.

Evidently, the four means of green roof are remarkably high. However, the mean for recognizability is the highest—it is significantly higher than the mean for sustainability and the mean for effectiveness, but not significantly higher than the mean for attractiveness. The mean for attractiveness comes the second highest one as it is significantly higher than the mean for sustainability and the mean for effectiveness, in which their mean difference is not significant at all.

For green wall, its mean for attractiveness is also quite high and significantly higher than its other means. In this case, the mean for recognizability comes the second highest one and it is significantly higher than the mean for effectiveness and the mean for sustainability. Considering the relationship between its mean for sustainability and its mean for effectiveness, the former one is significantly higher than the latter one.

Table 10.2.8 Paired-samples *t* test elucidating the differences between the four means of green street

Paired-samples *t* test (ratings of green street)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	479	0.463	13.038	0.000*	0.485; medium
Attractiveness *x* Sustainability	479	0.402	11.971	0.000*	0.488; medium
Attractiveness *x* Recognizability	476	0.516	11.648	0.000*	0.560; medium
Effectiveness *x* Sustainability	478	-0.061	-2.610	0.009*	-0.083; very small
Effectiveness *x* Recognizability	474	0.057	1.514	0.131	0.065; very small
Sustainability *x* Recognizability	476	0.113	3.054	0.002*	0.103; very large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.2.9 Paired-samples *t* test elucidating the differences between the four means of green roof

Paired-samples *t* test (ratings of green roof)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	482	0.186	4.666	0.000*	0.187; small
Attractiveness *x* Sustainability	481	0.193	4.823	0.000*	0.184; small
Attractiveness *x* Recognizability	482	-0.077	-1.770	0.077	-0.075; very small
Effectiveness *x* Sustainability	481	0.002	0.082	0.934	0.000; very small
Effectiveness *x* Recognizability	479	-0.262	-6.271	0.000*	-0.263; small
Sustainability *x* Recognizability	479	-0.265	-6.413	0.000*	-0.268; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.2.10 Paired-samples *t* test elucidating the differences between the four means of green wall

Paired-samples *t* test (ratings of green wall)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	481	0.392	8.556	0.000*	0.407; medium
Attractiveness *x* Sustainability	480	0.268	5.843	0.000*	0.280; small
Attractiveness *x* Recognizability	482	0.143	2.859	0.004*	0.133; small
Effectiveness *x* Sustainability	480	-1.125	-4.342	0.000*	-0.145; small
Effectiveness *x* Recognizability	479	-0.256	-5.915	0.000*	-0.253; small
Sustainability *x* Recognizability	479	-0.131	-2.964	0.003*	-0.131; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

The means of pool/ pond are terrifically high—the one for attractiveness is the highest while the one for sustainability is the third and the other two are the second among those of the other elements. Considering the relationships among the means of pool/ pond, the mean for attractiveness is significantly higher than the other means while the mean for sustainability is significantly lower than the other means. Additionally, the mean for recognizability, which follows only that of attractiveness, is significantly higher than the mean for effectiveness and the mean for sustainability.

Table 10.2.11 Paired-samples *t* test elucidating the differences between the four means of pool/ pond

Paired-samples *t* test (ratings of pool/ pond)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	478	0.489	14.676	0.000*	0.611; medium
Attractiveness *x* Sustainability	477	0.561	14.743	0.000*	0.672; medium
Attractiveness *x* Recognizability	480	0.295	7.954	0.000*	0.340; small
Effectiveness *x* Sustainability	476	0.069	2.799	0.005*	0.081; very small
Effectiveness *x* Recognizability	475	-0.187	-5.329	0.000*	-0.214; small
Sustainability *x* Recognizability	475	-0.267	-7.410	0.000*	-0.294; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

For the case of constructed wetland, its four means are also outstandingly high. In consideration of the relationships among its means, the *t* statistics reveal that the mean for effectiveness is significantly higher than the other means while the mean for attractiveness is lower than the other means. For its mean for sustainability, is significantly higher than both its mean for recognizability and its mean for attractiveness.

Table 10.2.12 Paired-samples *t* test elucidating the differences between the four means of constructed wetland

Paired-samples *t* test (ratings of constructed wetland)	*df*	Mean Different	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Attractiveness *x* Effectiveness	480	-0.310	-7.568	0.000*	-0.322; small
Attractiveness *x* Sustainability	479	-0.271	-6.271	0.000*	-0.277; small
Attractiveness *x* Recognizability	478	-0.094	-1.919	0.056	-0.087; very small
Effectiveness *x* Sustainability	479	0.042	2.092	0.037*	0.047; very small
Effectiveness *x* Recognizability	477	0.218	5.724	0.000*	0.239; small
Sustainability *x* Recognizability	477	0.176	4.682	0.000*	0.193; small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

10.3 Correlation between the ratings for attractiveness, effectiveness, sustainability, and recognizability of the landscape elements

In consideration of the four ratings of each landscape element, the issue regarding if these ratings are correlated with each other is intriguing to explore. To investigate the correlations of these four ratings of each landscape element, the Pearson coefficients are calculated. Note that as the focus is on the correlations of the four ratings, there are six pairs of correlations to be examined for each of the landscape elements. As shown in table 10.3.1-10.3.12 and figure 10.3.1-10.3.12, it appears that the four ratings of all tested landscape elements are positively correlated with each other. In addition, almost all of the correlations are statistically significant. These results imply the situation in which the respondents who give high score on one quality of any particular element tended to give high score on its other three qualities and vice versa. Note that only the correlation between the rating for attractiveness and the rating for recognizability of two elements—water tank/ cistern and trench/ gutter/ storm drain—are not statistically significant. Doubtlessly, this is because these two elements received a very negative rating for their attractiveness, but a very positive rating for their recognizability.

As the Pearson coefficients revealed a lot of strong correlations among the four ratings of each tested landscape element, it seems as if each pair of correlation was influenced by the other two ratings. Aiming to examine this issue, the partial correlation analysis was performed. Based on the partial correlation coefficients, as also presented in table 10.3.1-10.3.12, the situation in which all of the correlations are weaker, but most of them are still fairly substantial, after subtracting the influence of the other two ratings is demonstrated. Seeing that, it seems that, for each element, most of the correlations between any two ratings are suspected as if they are influenced by the other two ratings.

Table 10.3.1 Pearson and partial correlation coefficients of the six pairs of the four ratings of water tank/ cistern

Correlation between the ratings of water tank/ cistern	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (r)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	474	0.196	0.000*	474	0.012	0.793
Attractiveness *x* Sustainability	474	0.249	0.000*	474	0.161	0.000*
Attractiveness *x* Recognizability	478	0.069	0.133	478	-0.036	0.441
Effectiveness *x* Sustainability	474	0.771	0.000*	474	0.719	0.000*
Effectiveness *x* Recognizability	474	0.392	0.000*	474	0.163	0.000*
Sustainability *x* Recognizability	472	0.385	0.000*	472	0.144	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.2 Pearson and partial correlation coefficients of the six pairs of the four ratings of lawn/ grass/ turf

Correlation between the ratings of lawn/ grass/ turf	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (r)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	477	0.458	0.000*	477	0.204	0.000*
Attractiveness *x* Sustainability	477	0.457	0.000*	477	0.215	0.000*
Attractiveness *x* Recognizability	477	0.214	0.000*	477	0.046	0.318
Effectiveness *x* Sustainability	478	0.681	0.000*	478	0.583	0.000*
Effectiveness *x* Recognizability	475	0.387	0.000*	475	0.266	0.000*
Sustainability *x* Recognizability	476	0.268	0.000*	476	0.003	0.955

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.3 Pearson and partial correlation coefficients of the six pairs of the four ratings of pavers

Correlation between the ratings of pavers	Pearson correlation			Partial correlation		
	df (N-1)	coefficient (r)	*p*-value (Sig.)	*df* (N-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	477	0.414	0.000*	477	0.211	0.000*
Attractiveness *x* Sustainability	475	0.362	0.000*	475	0.062	0.181
Attractiveness *x* Recognizability	477	0.300	0.000*	477	0.138	0.003*
Effectiveness *x* Sustainability	476	0.737	0.000*	476	0.655	0.000*
Effectiveness *x* Recognizability	475	0.429	0.000*	475	0.159	0.000*
Sustainability *x* Recognizability	475	0.417	0.000*	475	0.156	0.001*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.4 Pearson and partial correlation coefficients of the six pairs of the four ratings of paving surface

Correlation between the ratings of paving surface	Pearson correlation			Partial correlation		
	df (N-1)	coefficient (r)	*p*-value (Sig.)	*df* (N-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	478	0.501	0.000*	478	0.317	0.000*
Attractiveness *x* Sustainability	478	0.416	0.000*	478	0.099	0.031*
Attractiveness *x* Recognizability	477	0.276	0.000*	477	0.014	0.759
Effectiveness *x* Sustainability	478	0.688	0.000*	478	0.526	0.000*
Effectiveness *x* Recognizability	477	0.495	0.000*	477	0.242	0.000*
Sustainability *x* Recognizability	477	0.476	0.000*	477	0.218	0.001*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.5 Pearson and partial correlation coefficients of the six pairs of the four ratings of bioretention planter

Correlation between the ratings of bioretention planter	Pearson correlation			Partial correlation		
	df (N-1)	coefficient (r)	*p*-value (Sig.)	*df* (N-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	482	0.546	0.000*	482	0.185	0.000*
Attractiveness *x* Sustainability	480	0.559	0.000*	480	0.251	0.000*
Attractiveness *x* Recognizability	479	0.330	0.000*	479	0.026	0.572
Effectiveness *x* Sustainability	480	0.783	0.000*	480	0.643	0.000*
Effectiveness *x* Recognizability	479	0.508	0.000*	479	0.203	0.000*
Sustainability *x* Recognizability	478	0.499	0.000*	478	0.171	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.6 Pearson and partial correlation coefficients of the six pairs of the four ratings of bioswale

Correlation between the ratings of bioswale	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	476	0.612	0.000*	476	0.268	0.000*
Attractiveness *x* Sustainability	475	0.585	0.000*	475	0.095	0.039*
Attractiveness *x* Recognizability	473	0.523	0.000*	473	0.241	0.000*
Effectiveness *x* Sustainability	474	0.826	0.000*	474	0.688	0.000*
Effectiveness *x* Recognizability	472	0.552	0.000*	472	0.069	0.133
Sustainability *x* Recognizability	473	0.591	0.000*	473	0.251	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.7 Pearson and partial correlation coefficients of the six pairs of the four ratings of trench/ gutter/ drain

Correlation between the ratings of trench/ gutter/ drain	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	479	0.313	0.000*	479	0.194	0.000*
Attractiveness *x* Sustainability	478	0.377	0.000*	478	0.285	0.000*
Attractiveness *x* Recognizability	477	0.038	0.411	477	-0.136	0.003*
Effectiveness *x* Sustainability	478	0.481	0.000*	478	0.347	0.000*
Effectiveness *x* Recognizability	475	0.431	0.000*	475	0.369	0.000*
Sustainability *x* Recognizability	475	0.277	0.000*	475	0.118	0.010*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.8 Pearson and partial correlation coefficients of the six pairs of the four ratings of green street

Correlation between the ratings of green street	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	478	0.579	0.000*	478	0.127	0.006*
Attractiveness *x* Sustainability	478	0.616	0.000*	478	0.279	0.000*
Attractiveness *x* Recognizability	475	0.466	0.000*	475	0.094	0.040*
Effectiveness *x* Sustainability	477	0.818	0.000*	477	0.642	0.000*
Effectiveness *x* Recognizability	473	0.622	0.000*	473	0.227	0.000*
Sustainability *x* Recognizability	475	0.626	0.000*	475	0.218	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.9 Pearson and partial correlation coefficients of the six pairs of the four ratings of green roof

Correlation between the ratings of green roof	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	481	0.636	0.000*	481	0.192	0.000*
Attractiveness *x* Sustainability	480	0.643	0.000*	480	0.186	0.000*
Attractiveness *x* Recognizability	481	0.598	0.000*	481	0.321	0.000*
Effectiveness *x* Sustainability	480	0.835	0.000*	480	0.688	0.000*
Effectiveness *x* Recognizability	478	0.572	0.000*	478	0.089	0.052
Sustainability *x* Recognizability	478	0.599	0.000*	478	0.190	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.10 Pearson and partial correlation coefficients of the six pairs of the four ratings of green wall

Correlation between the ratings of green wall	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	480	0.453	0.000*	480	0.111	0.015*
Attractiveness *x* Sustainability	479	0.459	0.000*	479	0.152	0.001*
Attractiveness *x* Recognizability	481	0.453	0.000*	481	0.249	0.000*
Effectiveness *x* Sustainability	479	0.754	0.000*	479	0.621	0.000*
Effectiveness *x* Recognizability	478	0.549	0.000*	478	0.227	0.000*
Sustainability *x* Recognizability	478	0.534	0.000*	478	0.173	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.11 Pearson and partial correlation coefficients of the six pairs of the four ratings of pool/ pond

Correlation between the ratings of pool/ pond	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	477	0.591	0.000*	477	0.315	0.000*
Attractiveness *x* Sustainability	476	0.508	0.000*	476	-0.029	0.526
Attractiveness *x* Recognizability	479	0.556	0.000*	479	0.280	0.000*
Effectiveness *x* Sustainability	475	0.806	0.000*	475	0.657	0.000*
Effectiveness *x* Recognizability	474	0.632	0.000*	474	0.126	0.006*
Sustainability *x* Recognizability	474	0.635	0.000*	474	0.296	0.000*

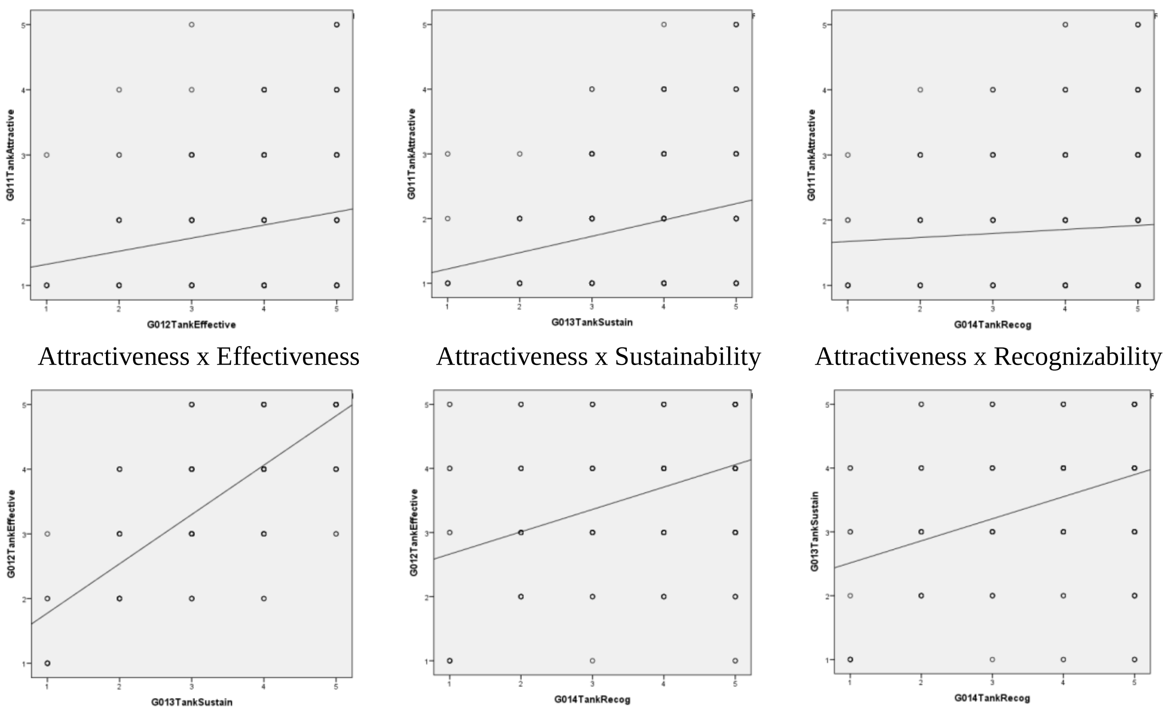
* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Table 10.3.12 Pearson and partial correlation coefficients of the six pairs of the four ratings of constructed wetland

Correlation between the ratings of constructed wetland	Pearson correlation			Partial correlation		
	df (*N*-1)	coefficient (*r*)	*p*-value (Sig.)	*df* (*N*-1)	coefficient (r_s)	*p*-value (Sig.)
Attractiveness *x* Effectiveness	479	0.586	0.000*	479	0.251	0.000*
Attractiveness *x* Sustainability	478	0.544	0.000*	478	0.046	0.320
Attractiveness *x* Recognizability	477	0.469	0.000*	477	0.163	0.000*
Effectiveness *x* Sustainability	478	0.866	0.000*	478	0.749	0.000*
Effectiveness *x* Recognizability	476	0.603	0.000*	476	0.118	0.010*
Sustainability *x* Recognizability	476	0.621	0.000*	476	0.236	0.000*

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

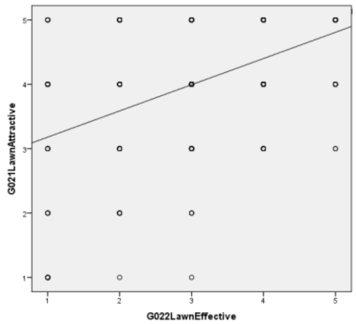
Figure 10.3.1 Scatterplots showing correlations of the four ratings of water tank/ cistern



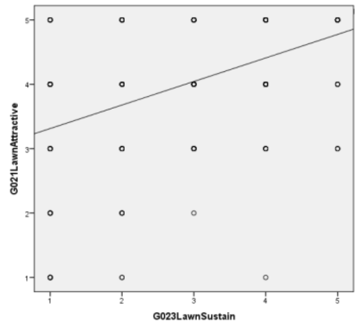
Attractiveness x Effectiveness | Attractiveness x Sustainability | Attractiveness x Recognizability

Effectiveness *x* Sustainability | Effectiveness *x* Recognizability | Sustainability *x* Recognizability

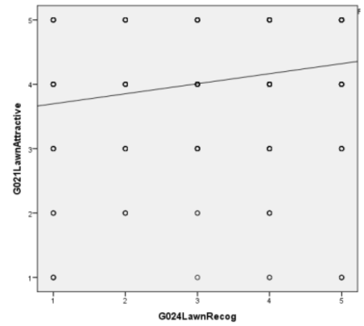
Figure 10.3.2 Scatterplots showing correlations of the four ratings of lawn/ grass/ turf



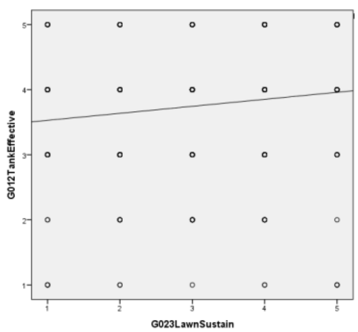
Attractiveness x Effectiveness



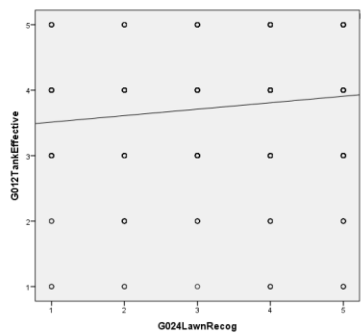
Attractiveness x Sustainability



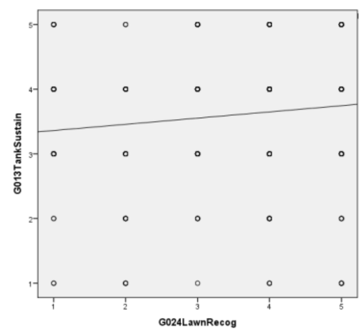
Attractiveness x Recognizability



Effectiveness *x* Sustainability

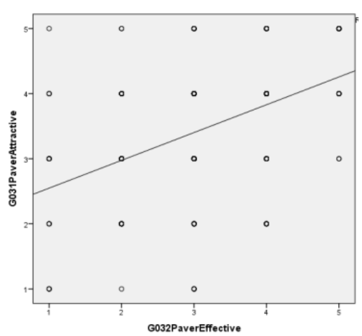


Effectiveness *x* Recognizability

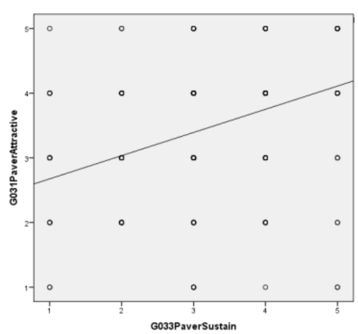


Sustainability *x* Recognizability

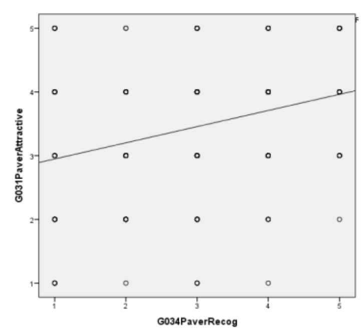
Figure 10.3.3 Scatterplots showing correlations of the four ratings of pavers



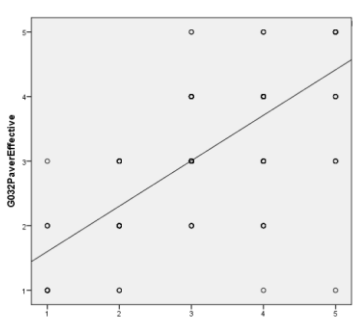
Attractiveness x Effectiveness



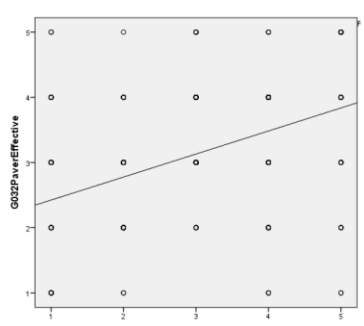
Attractiveness x Sustainability



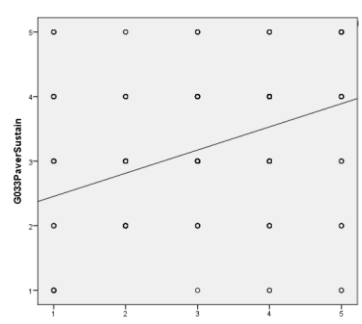
Attractiveness x Recognizability



Effectiveness *x* Sustainability



Effectiveness *x* Recognizability



Sustainability *x* Recognizability

Figure 10.3.4 Scatterplots showing correlations of the four ratings of paving surface

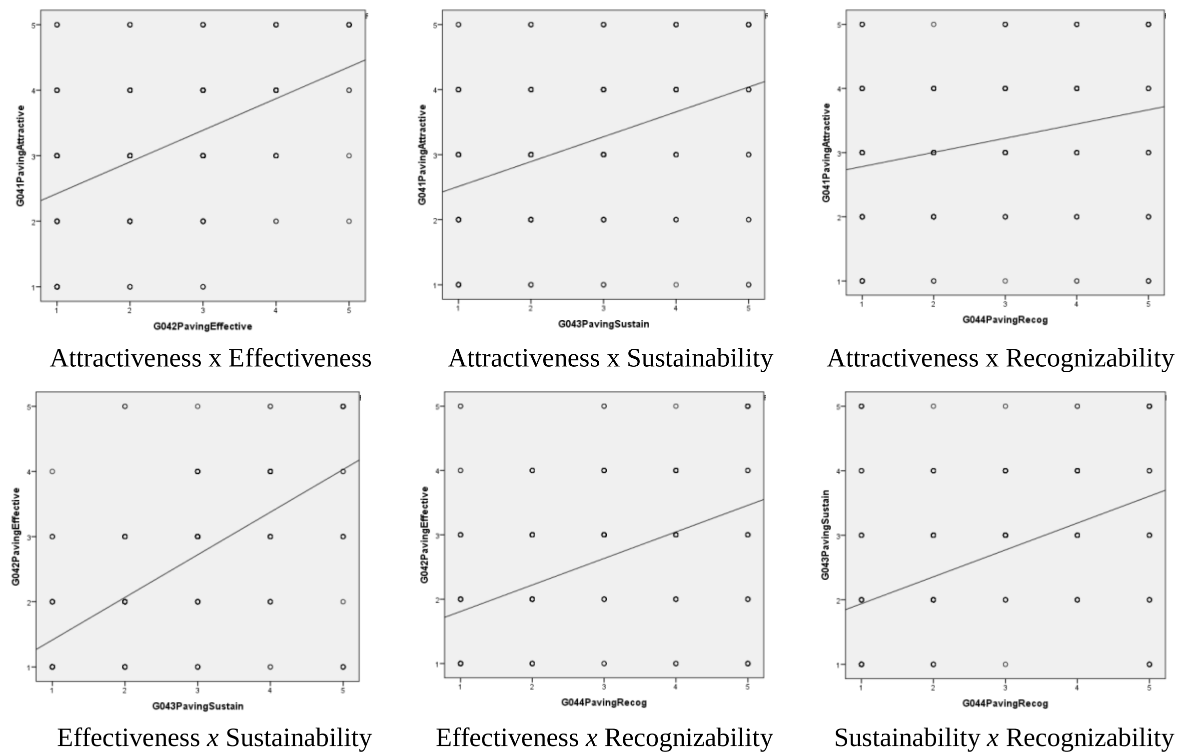


Figure 10.3.5 Scatterplots showing correlations of the four ratings of bioretention planter

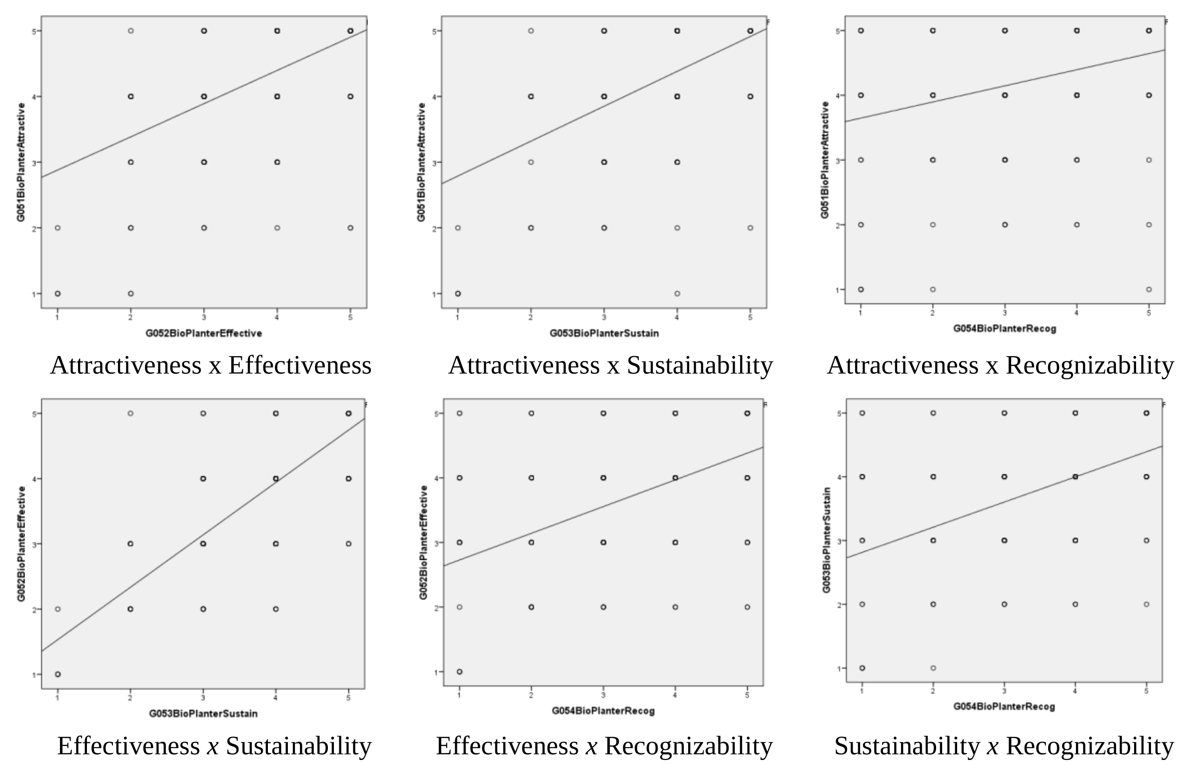
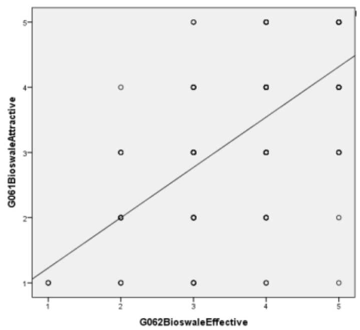
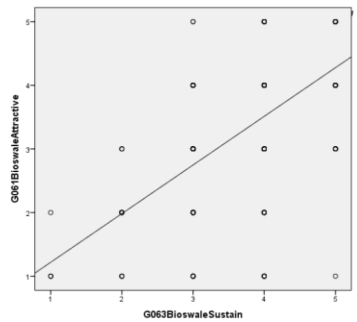


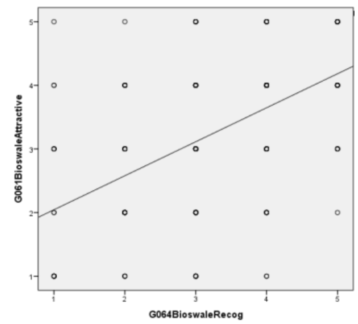
Figure 10.3.6 Scatterplots showing correlations of the four ratings of bioretention planter



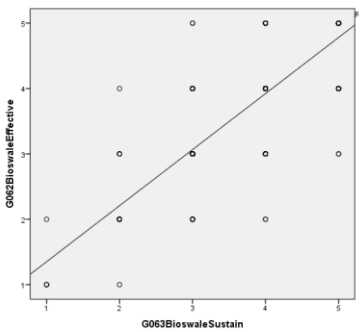
Attractiveness x Effectiveness



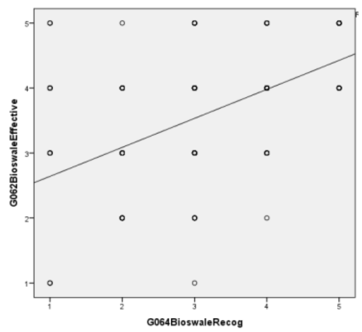
Attractiveness x Sustainability



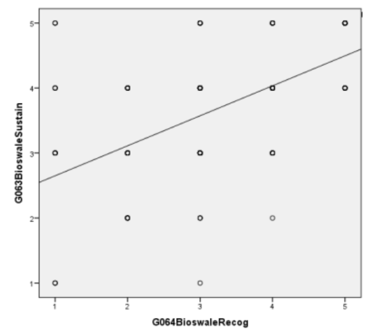
Attractiveness x Recognizability



Effectiveness *x* Sustainability

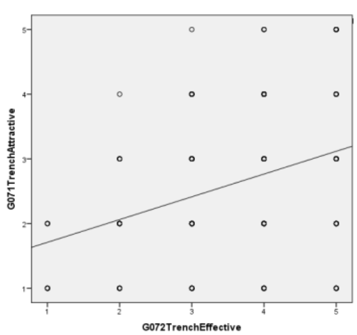


Effectiveness *x* Recognizability

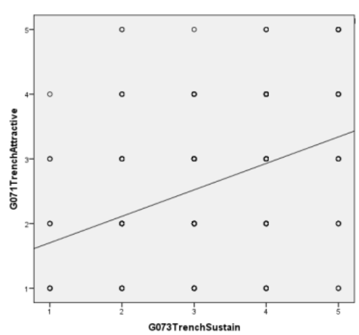


Sustainability *x* Recognizability

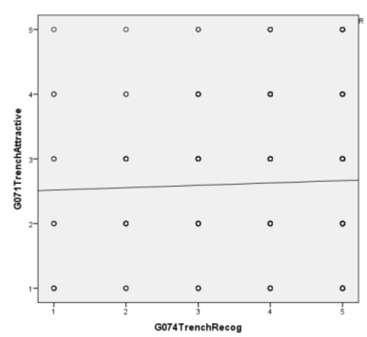
Figure 10.3.7 Scatterplots showing correlations of the four ratings of trench/ gutter/ drain



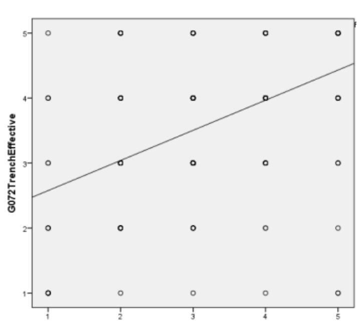
Attractiveness x Effectiveness



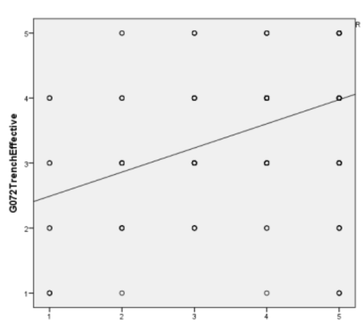
Attractiveness x Sustainability



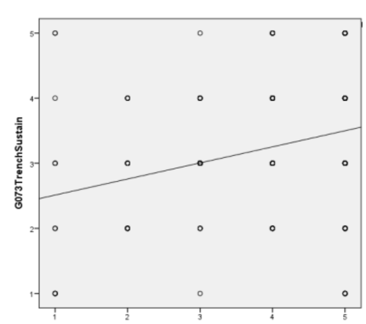
Attractiveness x Recognizability



Effectiveness *x* Sustainability

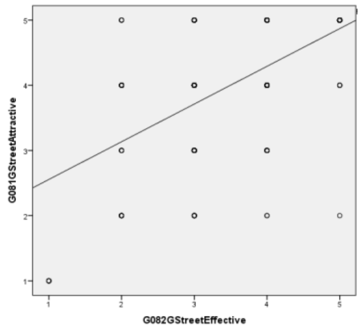


Effectiveness *x* Recognizability

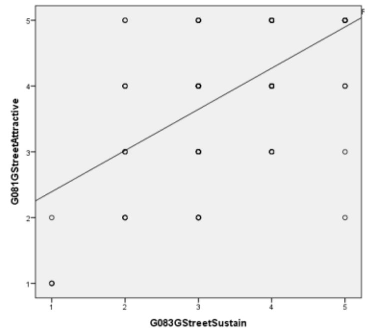


Sustainability *x* Recognizability

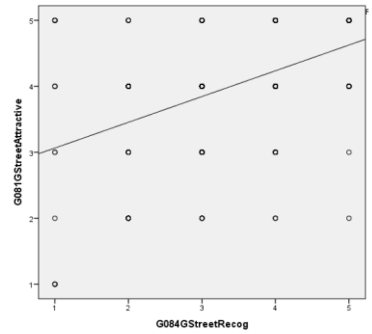
Figure 10.3.8 Scatterplots showing correlations of the four ratings of green street



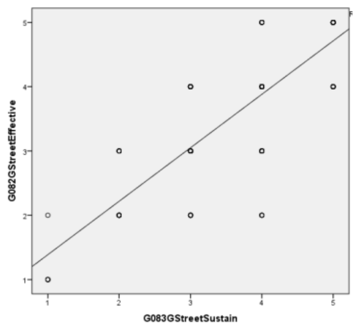
Attractiveness x Effectiveness



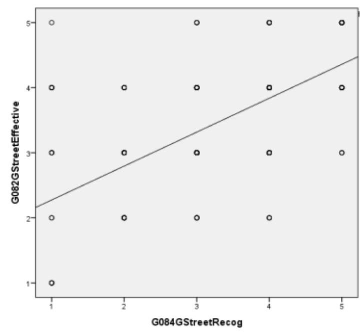
Attractiveness x Sustainability



Attractiveness x Recognizability



Effectiveness *x* Sustainability



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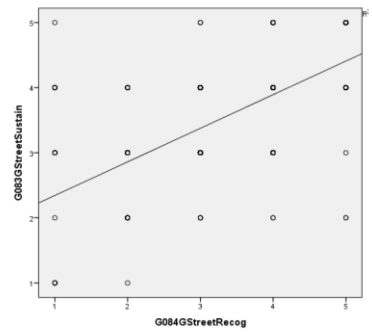
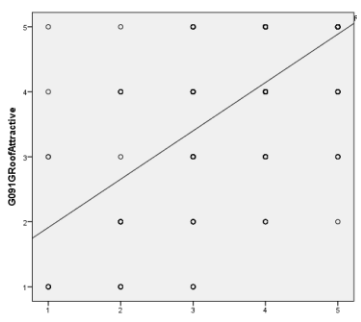


Sustainability *x* Recognizability

Figure 10.3.9 Scatterplots showing correlations of the four ratings of green roof



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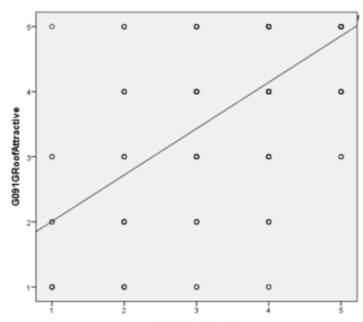

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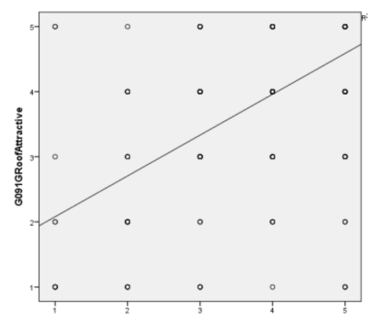
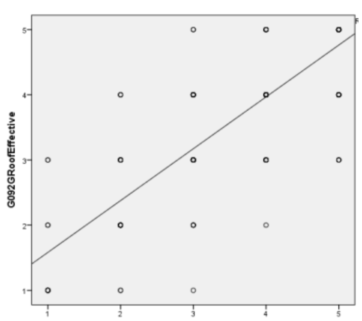
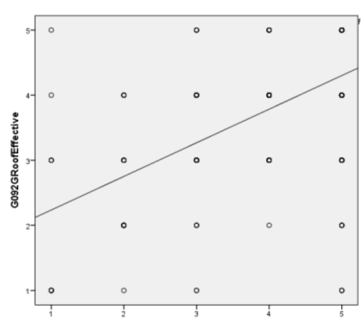


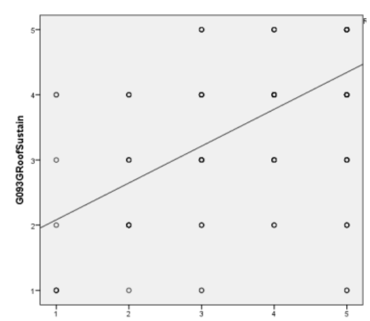
Attractiveness x Recognizability



Effectiveness *x* Sustainability

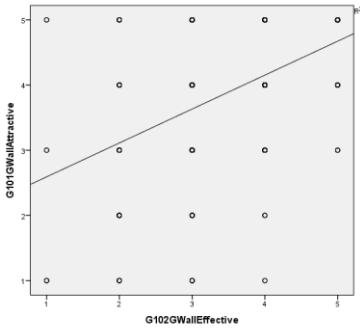


Effectiveness *x* Recognizability

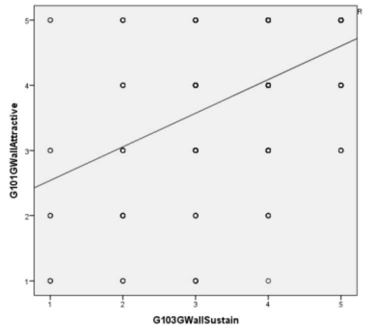


Sustainability *x* Recognizability

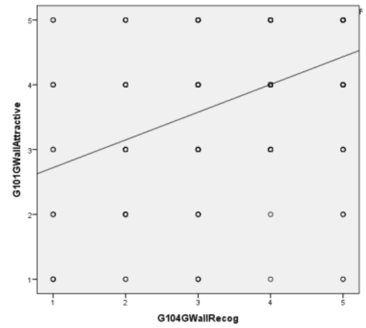
Figure 10.3.10 Scatterplots showing correlations of the four ratings of green wall



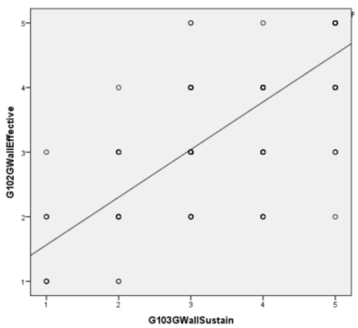
Attractiveness x Effectiveness



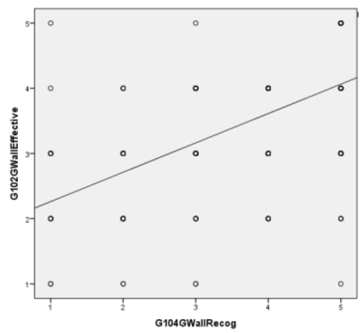
Attractiveness x Sustainability



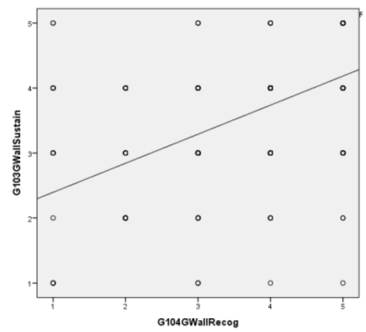
Attractiveness x Recognizability



Effectiveness *x* Sustainability

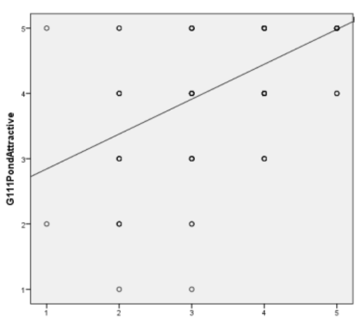


Effectiveness *x* Recognizability

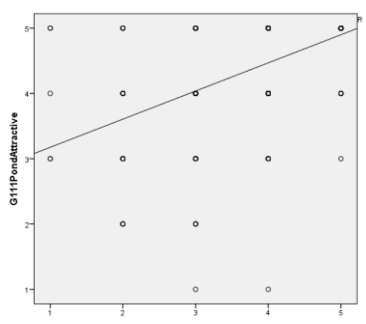


Sustainability *x* Recognizability

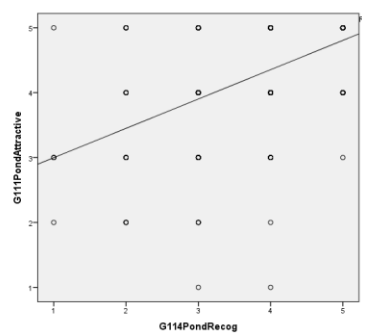
Figure 10.3.11 Scatterplots showing correlations of the four ratings of pool/ pond



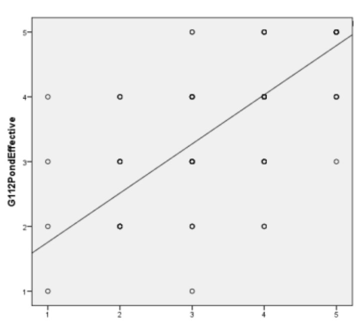
Attractiveness x Effectiveness



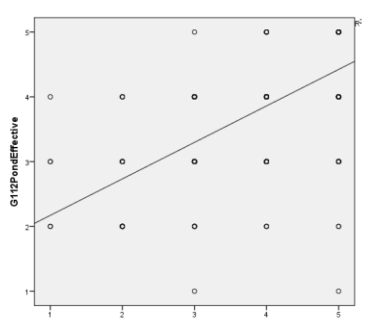
Attractiveness x Sustainability



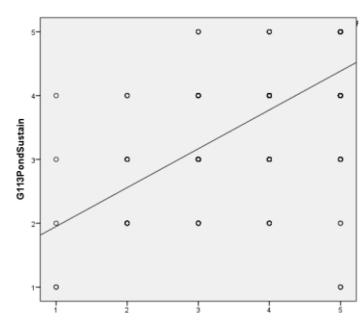
Attractiveness x Recognizability



Effectiveness *x* Sustainability

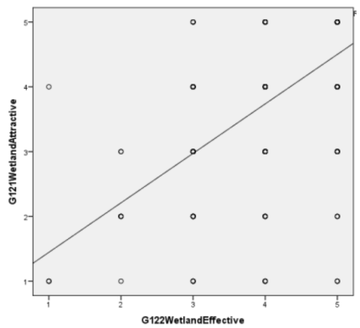


Effectiveness *x* Recognizability

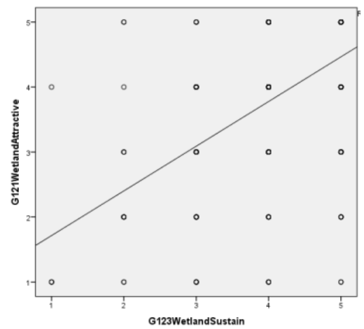


Sustainability *x* Recognizability

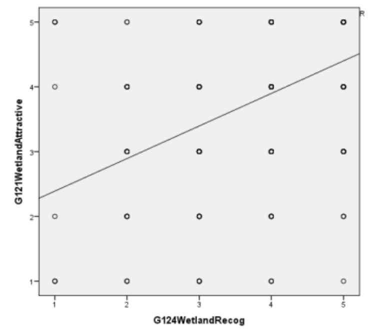
Figure 10.3.12 Scatterplots showing correlations of the four ratings of constructed wetland



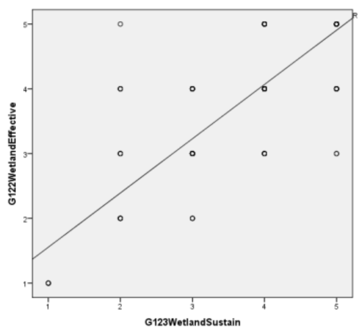
Attractiveness x Effectiveness



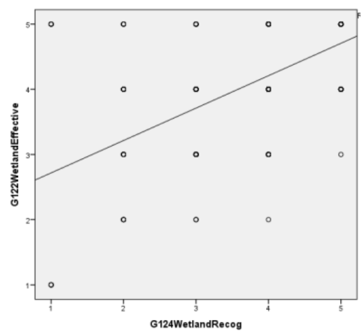
Attractiveness x Sustainability



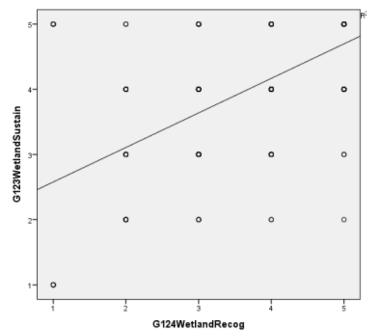
Attractiveness x Recognizability



Effectiveness *x* Sustainability



Effectiveness *x* Recognizability



Sustainability *x* Recognizability

10.4 Summary of results from the hypothesis tests (H-3.1-3.3)

Overall, the majority of the tested landscape elements received a quite high rating, whether for their attractiveness, effectiveness, sustainability, and recognizability. Only a few of them received a quite low rating for these four tested qualities.

Specifically, pool/ pond received the highest mean for attractiveness, constructed wetland received the highest mean for effectiveness as well as sustainability. For the recognizability, water tank/ cistern received the highest mean, closely followed by pool/ pond. Considering those with the low rating scores, water tank/ cistern received the lowest mean for attractiveness, paving surface received the lowest mean for effectiveness as well as sustainability and recognizability. It is important to note that some respondents also made note that paving surface implies impervious surface so that it is not recognized as an element which effectively and sustainably manage stormwater. This is very positive as it implies that these respondents were acquainted with the issue of pervious and impervious surfaces. Considering the differences between the ratings for attractiveness, effectiveness, sustainability, and recognizability of each landscape elements, most of the mean differences are statistically significant, implying that the respondents were quite sensitive and thoughtful with regard to the different qualities of each particular element. Regarding the correlations among the four ratings of each landscape element, it appears that all of the correlations are positively correlated and almost all of them are statistically significant. The only two correlations which are not statistically significant are the one between the attractiveness and recognizability of water tank/ cistern and the same one of trench/ gutter/ storm drain—it is obvious that their attractiveness is quite low while their recognizability is so high.

Table 10.4.1 Summary of results from the hypothesis tests (H-3.1-3.3)

Hypotheses	**Results from the hypothesis tests**
Question 3:	*How do people evaluate the landscape elements with regard to their attractiveness as well as their effectiveness, sustainability, and recognizability in terms of stormwater management?*
H-3.1	(1) Ten of the tested landscape elements received a quite high rating for their attractiveness; pool/ pond received the highest mean score, followed by bioretention planter, lawn/ grass/ turf, green street, green roof, green wall, and constructed wetland, and then by paving surface, pavers, and bioswale. Only two elements—water tank/ cistern and trench/ gutter/ storm drain—obviously received a quite low rating in this regard.
	(2) Paving surface received the lowest mean score for effectiveness rating and was the only one element which received a negative rating in this regard. For those with the positive effectiveness rating, constructed wetland received the highest mean score, followed by pool/ pond, green roof, bioretention planter, water tank/ cistern, bioswale, trench/ gutter/ storm drain, green street, green wall, lawn/ grass/ turf, and pavers.
	(3) Overall, the pattern of sustainability rating is comparable to that of the effectiveness rating—constructed wetland received the highest mean score while paving surface received the lowest. For the rest 10 elements, pool/ pond, bioretention planter, bioswale, green roof, green street, green wall, water tank/ cistern, and trench/ gutter/ storm drain are those whose mean scores fall between 3.20 and 4.00 while pavers and lawn/ grass/ turf are those whose mean scores fall between 3.00 and 3.20.
	(4) Water tank/ cistern, pool/ pond, trench/ gutter/ storm drain, and constructed wetland are the four types of elements which received a quite high rating for their recognizability while pavers and paving surface are the two elements which received a quite low rating in this regard. For the other 6 elements, they received a moderate rating—their mean scores is higher than 3.00 but lower than 4.00.
H-3.2	The majority of the differences among the four ratings—attractiveness rating, effectiveness rating, sustainability rating, and recognizability rating—within each landscape element are statistically significant. Accordingly, based on respondents' opinions, the four qualities of each landscape element are distinctive, yet correlated with each other.
H-3.3	The four ratings—attractiveness rating, effectiveness rating, sustainability rating, and recognizability rating—of the landscape elements are all positively correlated with each other. Almost all of these correlations are statistically significant.

Chapter 11

Conceptions and Knowledgeability about Sustainable Stormwater Management of the Respondents

This chapter aims to answer the fourth research question: *do people hold misconceptions and limited knowledge about urban stormwater problems and management efforts?* In particular, this chapter presents the analysis of the answers given to question 2.1-2.2, 3.1-3.3, and 5.3 of the questionnaire in order to investigate basic conceptions and knowledgeability regarding stormwater problems in San Francisco Bay Area of the respondents.

11.1 Concern about ecological problems in San Francisco Bay Area

Based on survey data, respondents expressed that they are very concerned about ecological problems in San Francisco Bay Area. As table 11.1.1 and figure 11.1.1 display, all the distributions of rating scores the respondents gave regarding their concern about ecological problems in San Francisco Bay Area skew to the right, the positive side.

Table 11.1.1 Distribution of rating scores the respondents gave regarding their concern about ecological problems in San Francisco Bay Area (1=least concerned, 5=most concerned)

Ecological Problems	Frequency Distribution of Rating Scores					Missing	*N*
	1 (least concerned)	2	3	4	5 (most concerned)		
- Water pollution/ shortage	5 (1.0%)	9 (1.8%)	57 (11.4%)	174 (34.7%)	**254 (50.6%)**	3 (0.6%)	502
- Global warming	13 (2.6%)	26 (5.2%)	99 (19.7%)	**185 (36.9%)**	176 (35.1%)	3 (0.6%)	502
- Air pollution	10 (2.0%)	41 8.2%)	118 (23.5%)	**211 42.0%)**	120 (23.9%)	2 (0.4%)	502
- Energy shortage	18 (3.6%)	49 (9.8%)	119 (23.7%)	**175 (34.9%)**	139 (27.7%)	2 (0.4%)	502
- Waste management	11 (2.2%)	47 (9.4%)	134 (26.7%)	**180 (35.9%)**	127 (25.3%)	3 (0.6%)	502
- Land degradation	11 (2.2%)	69 (13.7%)	**167 (33.3%)**	165 (32.9%)	88 (17.5%)	2 (0.4%)	502
- Wildlife habitat degradation	10 (2.0%)	54 (10.8%)	120 (23.9%)	**185 (36.9%)**	132 (26.3%)	1 (0.2%)	502

In addition, as table 11.1.2 and figure 11.1.2 reveal, all means of the rating scores are quite high; all of them are higher than 3.50. Importantly, it becomes obvious that the hypothesis—water crisis gets less concern from the public, compared to the other environmental problems including global warming, sea level rise, air pollution, energy shortage, waste management, soil contamination, and wildlife habitat degradation—is likely to be rejected. This is because, among the problems raised in the questionnaire, water crisis received the highest mean score. Moreover, this mean score is also the only one which is higher than 4.00. Additionally, water crisis in the Bay Area is the only one environmental problem in which its median and mode are 5, while those of the other problems are mostly 4.

Table 11.1.2 Central tendencies (mean, median, mode, and standard deviation) of rating scores for concern about ecological problems in San Francisco Bay Area

Ecological Problems	*n*	Mean	Median	Mode	SD
- Water pollution/ shortage	499	**4.33**	5.00	5	0.824
- Global warming	499	3.97	4.00	4	0.998
- Air pollution	500	3.78	4.00	4	0.968
- Energy shortage	500	3.74	4.00	4	1.079
- Waste management	499	3.73	4.00	4	1.014
- Land degradation	500	**3.50**	4.00	3	1.006
- Wildlife habitat degradation	501	3.75	4.00	4	1.026

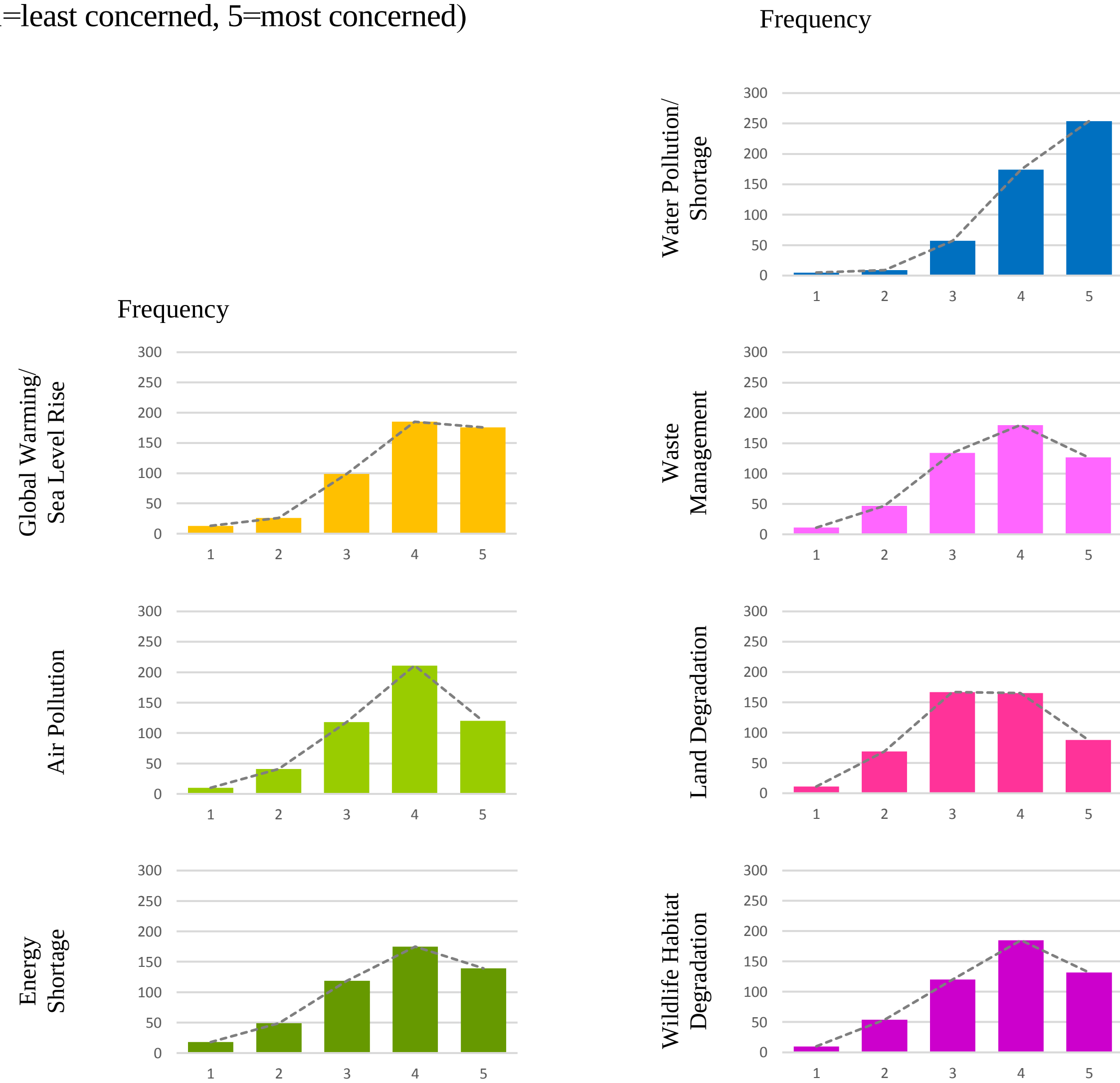
In order to test if the differences between the mean for respondents' concern about water crisis in the Bay Area and the other means are statistically significant, the paired-sample *t* tests were conducted. As shown in table 11.1.3, the results of these tests demonstrate that respondents' concern about water crisis in the Bay Area is significantly higher than their concern about the other six environmental issues.

Table 11.1.3 Paired-samples *t* test elucidating the differences between the mean of concern about water pollution/ shortage and the other means

Paired-samples *t* test	*df*	Mean Difference	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
- Global warming	497	0.355	9.070	**0.000***	0.393; small-medium
- Air pollution	498	0.551	14.371	**0.000***	0.612; medium
- Energy shortage	498	0.593	13.380	**0.000***	0.614; medium
- Waste management	497	0.596	13.630	**0.000***	0.649; medium
- Land degradation	498	0.830	18.340	**0.000***	0.902; large
- Wildlife habitat degradation	498	0.577	13.135	**0.000***	0.623; medium

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Figure 11.1.1 Bar graphs illustrating distributions of rating scores the respondents gave regarding their concern about ecological problems in San Francisco Bay Area
(1=least concerned, 5=most concerned)



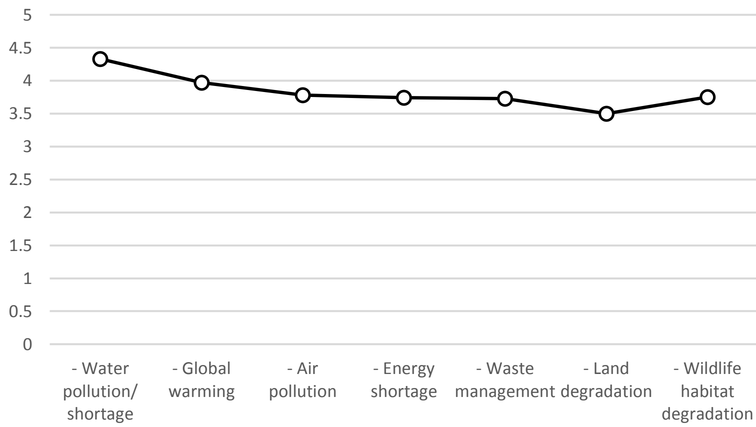


Figure 11.1.2 Line graph illustrating the mean scores of the concern about ecological problems in San Francisco Bay Area

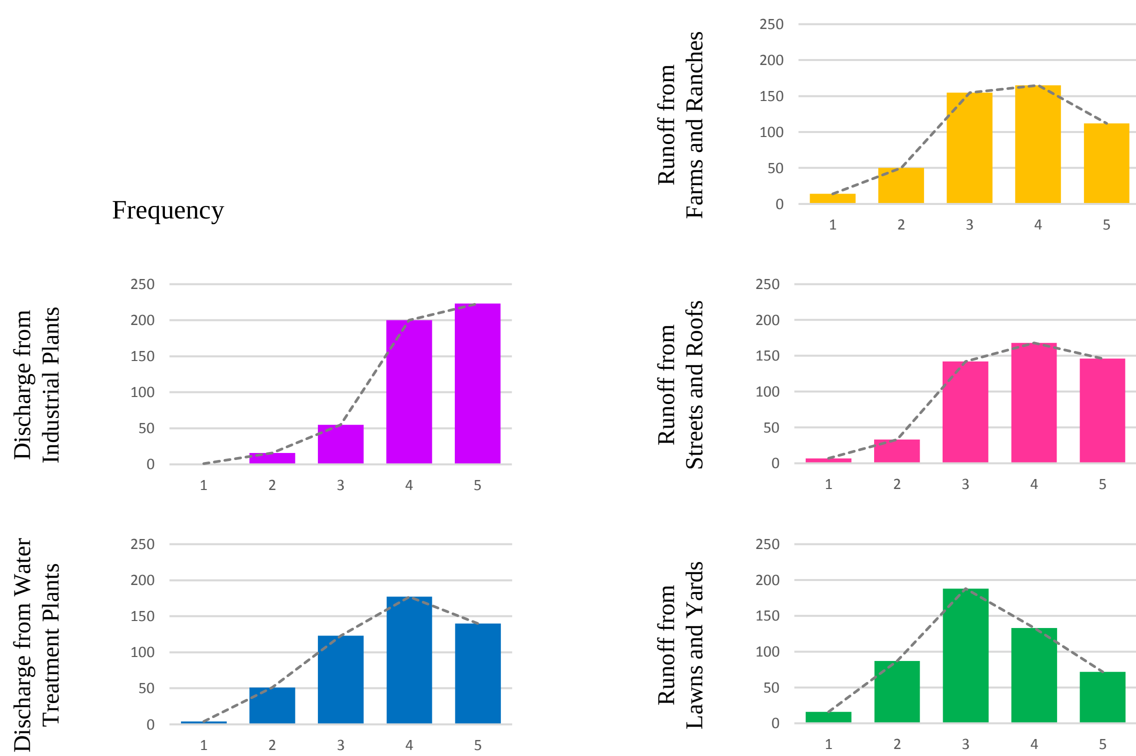
11.2 Significant sources of water pollution in San Francisco Bay Area

In view of the statistics of this part, it seems that what US EPA notes—"The benefits of public education efforts cannot be understated, especially on topics such as "nonpoint source" or "stormwater" pollution. A 2005 report, Environmental Literacy in America by the National Environmental Education & Training Foundation (NEETF) found that 78 percent of the American public does not understand that runoff from agricultural land, roads, and lawns, is now the most common source of water pollution; and nearly half of Americans (47 percent) believes industry still accounts for most water pollution" (US EPA 2014)—is reaffirmed. As table 11.2.1 and figure 11.2.1 along with table 11.2.2 and figure 11.2.2 show, the highest rating regarding the extent of its impact on water quality in San Francisco Bay Area goes to the discharge from industrial plants (Mean=4.27).

Table 11.2.1 Distribution of rating scores for the perceived sources of impact on water quality in San Francisco Bay Area (1=no impact, 5=significant impact)

Sources of water pollution	Frequency Distribution of Rating Scores					Missing	*N*
	1 (least impact)	2	3	4	5 (most impact)		
- Discharge from industrial plants	1 (0.2%)	16 (3.2%)	55 (11.0%)	200 (39.8%)	**223 (44.4%)**	7 (1.4%)	502
- Discharge from treatment plants	4 (0.8%)	51 (10.2%)	123 (24.5%)	**177 (35.3%)**	140 (27.9%)	7 (1.4%)	502
- Runoff from farms and ranches	14 (2.8%)	50 (10.0%)	155 (30.9%)	**165 (32.9%)**	112 (22.3%)	6 (1.2%)	502
- Runoff from streets and roofs	7 (1.4%)	33 (6.6%)	142 (28.3%)	**168 (33.5%)**	146 (29.1%)	6 1.2%)	502
- Runoff from lawns and yards	16 (3.2%0	87 (17.2%)	**188 (37.5%)**	133 (26.5%)	72 (14.3%)	6 1.2%)	502

Figure 11.2.1 Bar graphs illustrating distributions of rating scores for the perceived sources in impact on water quality of San Francisco Bay Area
(1=no impact, 5=significant impact)



Considering the distributions and central tendencies of the five key sources listed, the discharge from industrial plants is the only one whose mean is higher than 4.00 and whose mode is 5, while runoff from lawns and yards is the only one whose mean is lower than 3.50 and whose mode is 3. For the rest three sources, their means fall between 3.50 and 4.00 while their medians and modes are 4.

Table 11.2.2 Central tendencies (mean, median, mode, and standard deviation) of rating scores for the perceived sources of impact on water quality in San Francisco Bay Area

Ecological Problems	*N*	Mean	Median	Mode	SD
- Discharge from industrial plants	495	**4.27**	4.00	5	0.799
- Discharge from treatment plants	495	3.80	4.00	4	0.990
- Runoff from farms and ranches	496	3.63	4.00	4	1.029
- Runoff from streets and roofs	496	3.83	4.00	4	0.973
- Runoff from lawns and yards	496	**3.32**	3.00	3	1.027

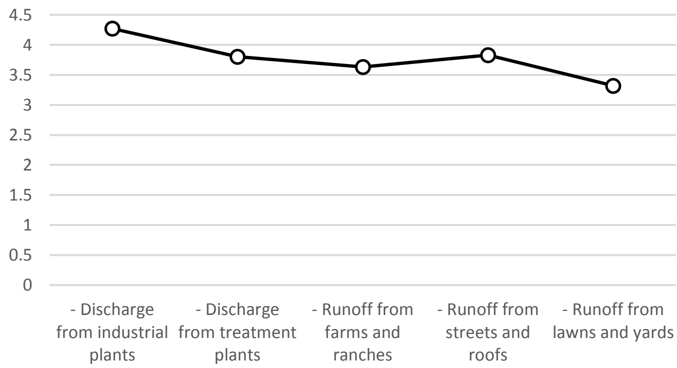


Figure 11.2.2 Line graph illustrating the mean scores for the perceived impact of sources of water pollution in San Francisco Bay Area

Table 11.2.3 Paired-samples *t* test elucidating the differences between the mean of the perceived impact of discharge from industrial plants and the other means

Paired-samples *t* test	*df*	Mean Difference	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
- Discharge from treatment plants	494	0.465	11.588	**0.000***	0.522; medium
- Runoff from farms and ranches	494	0.642	13.882	**0.000***	0.694; medium
- Runoff from streets and roofs	494	0.436	8.946	**0.000***	0.494; medium
- Runoff from lawns and yards	494	0.949	17.750	**0.000***	1.032; very large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

Regarding the differences between the perceived extent of impact of discharge from industrial plants and those the other sources, the results of paired-sample *t* tests reveal that the mean for the impact of discharge from industrial plants is significantly higher than that of discharge from treatment plants, runoff from farms and ranches, runoff from streets and roofs, and also runoff from lawns and yards.

11.3 Notions of sustainable ways to manage urban stormwater

In this part, the notions of sustainable ways to manage urban stormwater the respondents hold are investigated by analyzing answers given to question 3.3 of the questionnaire. Of 502 respondents, 487 (97.01%) of them did answer this question while 15 (2.99%) of them did not. Note that almost all of those who did not answer this question did leave the messages that they had no idea on this topic so that they could not answer this question.

The results from descriptive statistics (frequencies), see table 11.3.1 and figure 11.3.1, reveal that to collect it for future uses received the highest counts (296, 60.8%). This outcome implies that a considerable number of respondents thought that stormwater is a valuable resource so that to collect it for future uses is the sustainable way to manage it. Nonetheless, it seems like not a few respondents also thought that stormwater is dirty so that we should treat it before discharging, drain it to sewer treatment plants, and not drain it to nearby waterbodies. For the other two options listed—allowing it to infiltrate into the ground and holding it in ponds or lakes, approximately one third of the respondents chose them as sustainable ways to manage urban stormwater. In consideration of these results, it seems like respondents still held misconception or had limited ideas about stormwater and the sustainable ways to manage it.

Table 11.3.1 Frequencies and percentages of respondents selecting each measure as a sustainable way to manage urban stormwater

Sustainable ways to manage urban stormwater	Frequency (n = 487)	Percentage
- Drain it to sewer treatment plants	227	46.61
- Drain it to nearby waterbodies	63	12.94
- Treat it before discharging	269	55.24
- Allow it to infiltrate into the ground	183	37.58
- Hold it in ponds or lakes	135	27.72
- Collect it for future uses	296	60.78

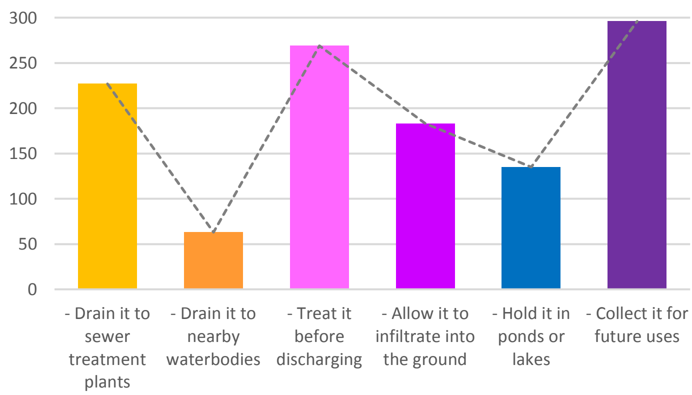


Figure 11.3.1 Bar graphs illustrating frequencies (counts) of respondents selecting each measure as a sustainable way to manage urban stormwater

11.4 Places with ecological benefits

The results from descriptive statistics reveal that the majority of respondents did not have any place with ecological benefits in their mind. In particular, of 502 respondents, 342 (68.1%) of them indicated that they do not know any place possessing ecological benefits while 121 (24.1%) of them indicated that they did know of such a place and 39 (7.8%) did not answer this question. Figure 11.4.1 illustrates proportion of respondents who indicated that they know and do not know any place possessing ecological benefits. Of 121 respondents, 106 of them specified the places while 15 of them did not.

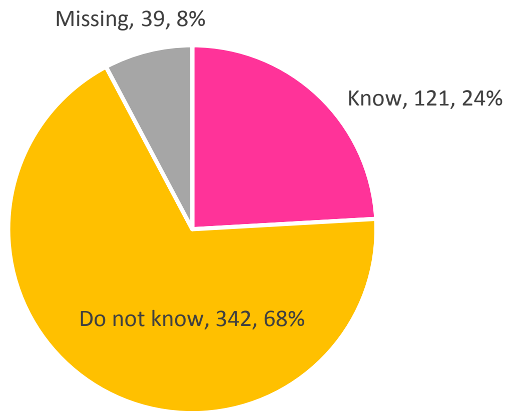


Figure 11.4.1 Pie chart illustrating proportion of respondents indicating that they know and do not know any place possessing ecological benefits

Table 11.4.1 Places respondents mentioned that they have ecological benefits

Ecological places	Frequency
Wilderness and Natural Areas : Forests (6), Amazon Rainforest (2), Grasslands (1), Wetlands (2), Marshes (2), SF Bay (2)	15
National Parks, Nature Preserves, and Ecological Restoration Projects : National Parks (5), State Parks (3), Nature Preserves (3), Coastal Preservation Areas (2), Wildlife Refuges (1), Ecological restoration projects (1), SF Natural Recreation Area (2), East Bay Regional Parks (2), Denali National Park (1), Yosemite National Park (1), Muir Woods (2), Point Reyes (1), Presidio (1), Ocean Beach, SF (1), Crissy Field (4), Heron's Head Park (2), Arastradero Preserve (1), Point Isabel Regional Shoreline, Richmond, CA (1), Don Edwards SF Bay National Wildlife Refuge (1), Yolo Bypass Wildlife Area (1), Channel Islands National Marine Sanctuary (1), Point Pinole Regional Shoreline (1), Oakland Shoreline (1), Daylighting Strawberry Creek (1)	40
Urban Parks, City Parks, and Gardens : Parks (7), Green Spaces (5), Zoos (1), Central Park, NY (1), Golden Gate Park, SF (7), Dolores Park, SF (1), Lake Merritt, Oakland (2), Berkeley Marina, Berkeley (1), Remillard Park, Berkeley (1), Cordonices Park, Berkeley (1), Cesar Chavez Park, Berkeley (1), Blake Garden, Kensington (1), VanDuden Botanical Garden, Vancouver (1)	30
Stormwater Management or Low Impact Development (LID) Projects : Stormwater Management Projects (1), Castaic Lake Water Treatment Plant (1), Mint Plaza (3), Brisbane City Hall (1), El Cerrito City Hall (2), Bioswales in Seattle (1)	9
Green or Sustainable Buildings and Design Projects : Green Buildings (1), Green roofs (1), Academy of Science (15), Exploratorium (1), SF Federal Building (1), El Cerrito Recycling Center (3), Daily City Public Library (1), SFO Terminal 2 (1), SF Pier 27 Cruise Terminal (1), Disney World (1), The Sea Ranch, Sonoma, CA (1), University of Buffalo's Solar Stands (1)	28
Cities and Countries : Seattle, WA (2), Portland, OR (1), Coos Bay, OR (1), San Francisco, CA (1), San Jose, CA (1), Vancouver, Canada (1), The Netherlands (1), Sweden (1), Iceland (1), Puerto Rico (1), Costa Rica (1), Bhutan (1)	13

Remark: The number in parentheses behind each item indicates the total frequency the item was raised.

Considering what the respondents specified, 135 results in total can be classified into 6 categories—(1) wilderness and natural areas, (2) national parks, nature preserves, and ecological restoration projects, (3) urban parks, city parks, and gardens, (4) stormwater management or low impact development (LID) projects, (5) green or sustainable buildings and design projects, and (6) cities and countries, see table 11.4.1. The majority of the places the respondents specified fall into the national parks, nature reserves, and ecological restoration projects category. Only a small number of stormwater management or low impact development (LID) projects were mentioned. Interestingly, among LID projects, California Academy of Science received the highest counts (15).

11.5 Places with sustainable stormwater management benefits

Like the previous section, results from analysis of 502 respondents indicate that the majority of respondents did not know the places which implemented sustainable stormwater management measures. Specifically, 387 (76.7 %) of them indicated that they do not know while 95 (18.9%) of them indicated that they know and 22 (4.4%) of them did not answer this question, see figure 11.5.1. Note that, of 95 respondents who indicated that they know, 82 of them specified the places while 13 of them did not.

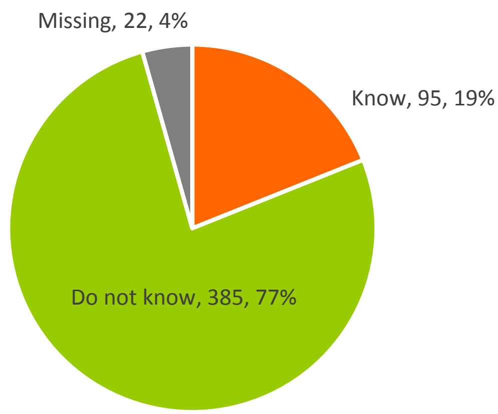


Figure 11.5.1 Pie chart illustrating proportion of respondents indicating that they know and do not know any place which implemented sustainable stormwater management measures

Considering what the respondents specified, 84 results in total can be classified into 6 categories—(1) waterbodies and wetlands, (2) general Stormwater management measures and practices, (3) specific stormwater management projects, (4) green or sustainable buildings and design projects, (5) cities and countries, (6) other specific places, and (7) other general places, see table 11.5.1. The majority of the places the respondents specified fall into the specific stormwater management projects.

It is also interesting to note that very few respondents from the eight LID test sites mentioned the site each of them were in as a sustainable stormwater management site. More specifically, only 13 of 82 respondents specified the places mentioned the site at which they were surveyed as the sustainable stormwater management place. These 13 respondents include 1 respondent from Mint Plaza, 2 respondents from Lower Sproul Plaza, 5 respondents from Brisbane City Hall, and 5 respondents from El Cerrito City Hall. For the other four sites—Davis Court, Fox Square, Cesar Chavez Street, and San Pablo Green Street in El Cerrito—no respondent in these sites mentioned them as the sustainable stormwater management place. Accordingly, these results suggest that these LID sites seem to fall short of achieving public recognition of their sustainable stormwater management benefits.

Table 11.5.1 Places respondents mentioned that they implemented sustainable stormwater management measures

Sustainable stormwater management places	Frequency
Waterbodies and Wetlands : Reservoirs (1), Marshlands (1), Lake Merritt, CA (1), Lake Tahoe, CA (1), Hoover Dam, Las Vegas, NV (1)	5
General Stormwater Management Measures and Practices : Green Roofs (1), Permeable Pavement (1), Residential Rainwater Collection (3)	5
Specific Stormwater Management Projects : Stormwater management project in Los Angeles, CA (1), Stormwater management project of Caltrans (1), Bioswales in Seattle (1), Green Streets in Portland, OR (1), San Pablo Green Street (6), El Cerrito City Hall (5), Brisbane City Hall (5), Mint Plaza (3), New Sproul Plaza (2), Water gardens in Twin Cities, MN (1), Emeryville Greenway (1), Monkey Cheek projects, Thailand (1)	28
Green or Sustainable Buildings and Design Projects : Green Buildings (2), Academy of Science (1), El Cerrito Recycling Center (4), SFPUC Building (2), SF Pier 27 Cruise Terminal (1), Hello Gray Institute, CA (1), Sacramento Library, CA (1), Heifer International Headquarters, AR (1), Earthship Biotecture, NM (1), Rackspace, San Antonio, TX (1)	15
Cities and Countries : Seattle, WA (2), Olympia, WA (1), Portland, OR (6), De Pere, WI (1), El Cerrito, CA (1), Berkeley, CA (1), Dali City, CA (1), San Jose, CA (1), Huntington Beach, CA (1), Stockholm (1), Sweden (1), The Netherlands (1), Mexico (1), India (1), Singapore (1)	21
Other Specific Places : Golden Gate Park (1), Crissy field (1), UC Berkeley Campus (4), A winery in Napa, CA (1),	7
Other General Places : Some parking lots (1), Some golf courses (1), Some botanical gardens (1)	3

Remark: The number in parentheses behind each item indicates the total frequency the item was raised.

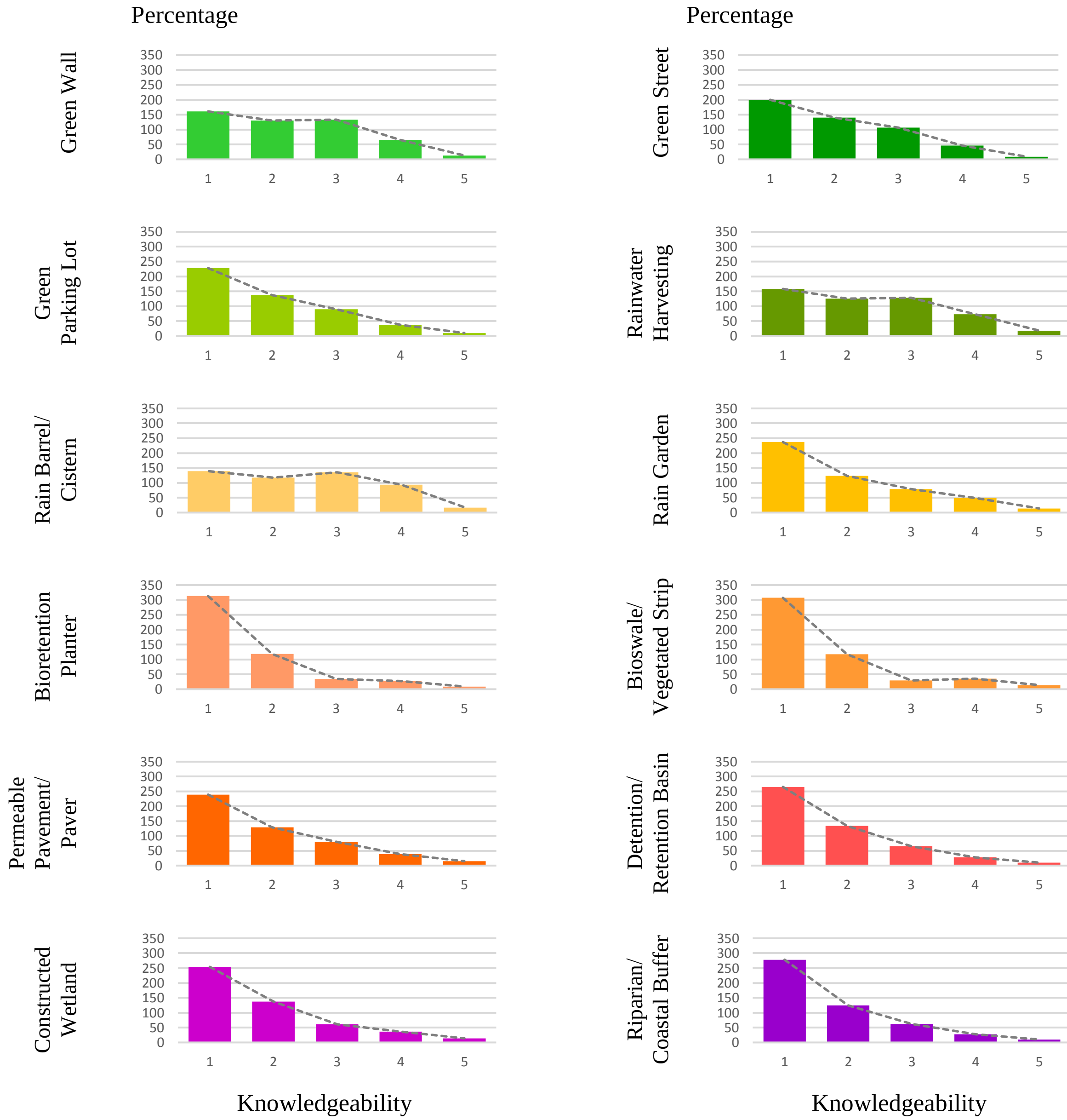
11.6 Knowledgeability about sustainable stormwater management topics

This part aims to explore the extent to which people think they are knowledgeable about the 25 sustainable stormwater management concepts and measures.

Table 11.6.1 Distribution of rating scores for knowledgeability of sustainable stormwater management concepts and measures (1=not knowledgeable, 5=very knowledgeable)

Sustainable Stormwater Management Concepts and Measures	Distribution of Rating Scores					Missing	*N*
	1 (not knowledgeable)	2	3	4	5 (very knowledgeable)		
- Sustainable Stormwater Mgmt.	**229 (45.6%)**	153 (30.5%)	86 (17.1%)	29 (5.8%)	4 (0.8%)	1 (0.2%)	502
- Low Impact Development (LID)	**263 (52.4%)**	154 (30.7%)	54 (10.8%)	26 (5.2%)	5 (1.0%)	0	502
- Best Mgnt. Practices (BMPs)	**311 (62.0%)**	94 (18.7%)	62 (12.4%)	28 (5.6%)	7 (1.4%)	0	502
- Nonpoint Source Pollution	**314 (62.5%)**	112 (22.3%)	47 (9.4%)	21 (4.2%)	6 (1.2%)	2 (0.4%)	502
- Combined Sewer Overflows	**321 (63.9%)**	117 (23.3%)	43 (8.6%)	16 (3.2%)	4 (0.8%)	1 (0.2%)	502
- Stormwater Runoff	**180 (35.9%)**	119 (23.7%)	127 (25.3%)	62 (12.4%)	14 (2.8%)	0	502
- Stormwater Interception	**302 (60.2%)**	117 (23.3%)	53 (10.6%)	23 (4.6%)	7 (1.4%)	0	502
- Stormwater Infiltration	**286 (57.0%)**	121 (24.1%)	58 (11.6%)	28 (5.6%)	9 (1.8%)	0	502
- Stormwater Filtration	**290 (57.8%)**	117 (23.3%)	56 (11.2%)	31 (6.2%)	8 (1.6%)	0	502
- Stormwater detention/ Retention	**245 (48.8%)**	140 (27.9%)	75 (14.9%)	31 (6.2%)	10 (2.0%)	1 (0.2%)	502
- Storm Drain	**172 (34.3%)**	117 (23.3%)	142 (28.3%)	58 (11.6%)	13 (2.6%)	0	502
- Green Infrastructure	**156 (31.1%)**	131 (26.1%)	145 (28.9%)	57 (11.4%)	11 (2.2%)	2 (0.4%)	502
- Green Roof	121 (24.1%)	116 (23.1%)	**164 (32.7%)**	83 (16.5%)	17 (3.4%)	1 (0.2%)	502
- Green Wall	**161 (32.1%)**	130 (25.9%)	133 (26.5%)	65 (12.9%)	13 (2.6%)	0	502
- Green Street	**200 (39.8%)**	140 (27.9%)	107 (21.3%)	46 (9.2%)	9 (1.8%)	0	502
- Green Parking Lot	**228 (45.4%)**	137 (27.3%)	90 (17.9%)	37 (7.4%)	10 (2.0%)	0	502
- Rainwater Harvesting	**158 (31.5%)**	125 (24.9%)	128 (25.5%)	73 (14.5%)	18 (3.6%)	0	502
- Rain Barrel/ Cistern	**139 (27.7%)**	117 (23.3%)	135 (26.9%)	94 (18.7%)	17 (3.4%)	0	502
- Rain Garden	**237 (47.2%)**	123 (24.5%)	79 (15.7%)	49 (9.8%)	14 (2.8%)	0	502
- Bioretention Planter	**313 (62.4%)**	118 (23.5%)	34 (6.8%)	27 (5.4%)	9 (1.8%)	1 (0.2%)	502
- Bioswale/ Vegetated Strip	**307 (61.2%)**	117 (23.3%)	29 (5.8%)	35 (7.0%)	14 (2.8%)	0	502
- Permeable Pavement/ Paver	**239 (47.6%)**	129 (25.7%)	80 (15.9%)	39 (7.8%)	15 (3.0%)	0	502
- Detention/ Retention Basin	**265 (52.8%)**	134 (26.7%)	65 (12.9%)	28 (5.6%)	10 (2.0%)	0	502
- Constructed Wetland	**254 (50.6%)**	137 (27.3%)	61 (12.2%)	36 (7.2%)	14 (2.8%)	0	502
- Riparian/ Coastal Buffer	**278 (55.4%)**	124 (24.7%)	62 (12.4%)	27 (5.4%)	10 (2.0%)	1 (0.2%)	502

Figure 11.6.1 Bar graphs illustrating distributions of rating scores for knowledgeability of sustainable stormwater management concepts and measures
(1=not knowledgeable, 5=very knowledgeable)



The results from statistical analysis reveal that the majority of respondents reported that they were not knowledgeable about sustainable stormwater management concepts and measures. As table 11.6.1 and figure 11.6.1 show, all of the distributions of rating scores obviously skew to left, the negative side. Moreover, as table 11.6.2 displays, the modes of 24 out of 25 topics are 1; green roof is the only one topic in which its mode is 3. Considering the mean scores, see table 11.6.2 and figure 11.6.2, green roof is also the only one topic in which its mean is more than 2.50. Accordingly, among the 25 topics, green roof is the topic about which the respondents reported that they were most knowledgeable. For the other 24 topics, the mean scores of 7 of them—rain barrel or cistern, rainwater harvesting, green wall, green infrastructure, storm drain, and stormwater runoff—fall between 2.00-2.50, while the mean scores of the rest 17 topics are lower than 2.00. The topic which received the lowest mean scores is combined sewer overflows; thus, among the 25 topics, the respondents reported that they were least knowledgeable about this topic.

Table 11.6.2 Central tendencies (mean, median, mode, and standard deviation) of rating scores for attractiveness of the landscape elements

Topics	*n*	Mean	Median	Mode	*SD*
- Sustainable Stormwater Management	501	1.85	2.00	1	0.955
- Low Impact Development (LID)	502	1.72	1.00	1	0.922
- Best Mgnt. Practices (BMPs)	502	1.66	1.00	1	0.988
- Nonpoint Source Pollution	500	1.59	1.00	1	0.910
- Combined Sewer Overflows	501	**1.53**	1.00	1	0.842
- Stormwater Runoff	502	2.23	2.00	1	1.144
- Stormwater Interception	502	1.64	1.00	1	0.941
- Stormwater Infiltration	502	1.71	1.00	1	0.994
- Stormwater Filtration	502	1.71	1.00	1	0.997
- Stormwater detention/ Retention	501	1.84	2.00	1	1.022
- Storm Drain	502	2.25	2.00	1	1.123
- Green Infrastructure	500	2.27	2.00	1	1.088
- Green Roof	501	**2.52**	3.00	3	1.127
- Green Wall	502	2.28	2.00	1	1.123
- Green Street	502	2.05	2.00	1	1.067
- Green Parking Lot	502	1.93	2.00	1	1.051
- Rainwater Harvesting	502	2.34	2.00	1	1.167
- Rain Barrel/ Cistern	502	2.47	2.00	1	1.176
- Rain Garden	502	1.96	2.00	1	1.128
- Bioretention Planter	501	1.60	1.00	1	1.045
- Bioswale/ Vegetated Strip	502	1.67	1.00	1	1.045
- Permeable Pavement/ Paver	502	1.93	2.00	1	1.101
- Detention/ Retention Basin	502	1.77	1.00	1	1.005
- Constructed Wetland	502	1.84	1.00	1	1.069
- Riparian/ Coastal Buffer	501	1.74	1.00	1	1.003

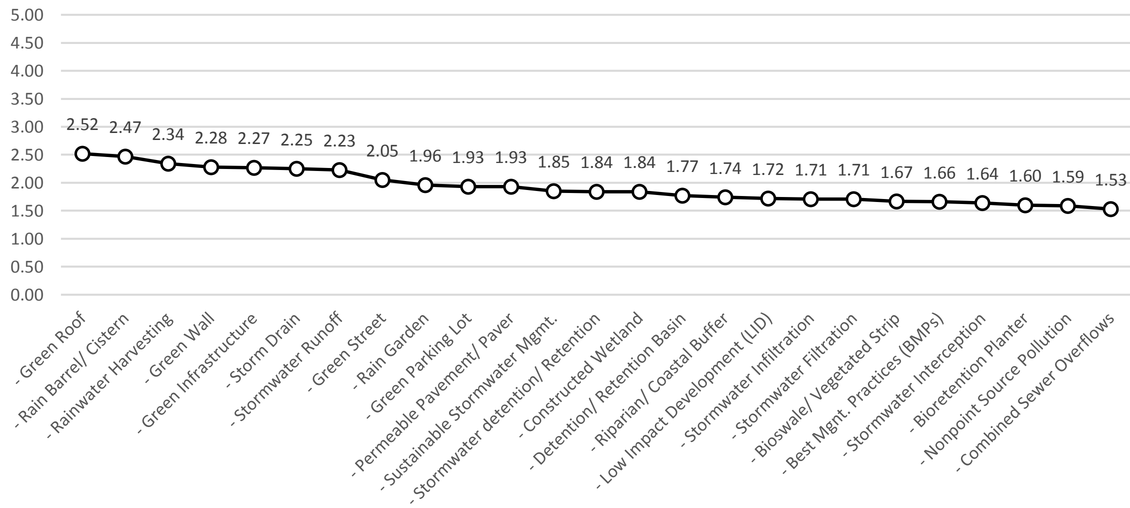


Figure 11.6.2 Line graph illustrating mean scores (from the largest to the smallest) for knowledgeability of sustainable stormwater management concepts and measures

11.7 Summary of results from the hypothesis tests (H-4.1-4.6)

According to the study, it appears that water crisis in San Francisco Bay Area is the ecological issue the respondents were most concerned, compared to other issues including global warming, sea level rise, air pollution, energy shortage, waste management, soil contamination, and wildlife habitat degradation. Not surprisingly, discharge from industrial plants was perceived as having a higher impact on a water quality of the Bay Area than stormwater runoff. Regarding concepts of sustainable stormwater management, collecting it for future uses received the highest scores followed by treating it before discharging, draining it to sewer treatment plants, then allowing it to infiltrate into the ground, and holding it in ponds or lakes. Draining it to nearby waterbodies received the lowest scores in this regard. When asked to identify places which contain ecological benefits, the majority of respondents reported that they do not know such places. Likewise, the majority of respondents also reported that they do not know places which contain sustainable stormwater management benefits. In addition, it appears that people tend to not mention LID facilities as places of ecological benefit. Importantly, very few respondents of the eight LID test sites mentioned the site each of them visiting as a sustainable stormwater management site. The majority of respondents reported that they were not knowledgeable about sustainable stormwater management concepts and measures. Among the 25 topics, green roof is the topic about which the respondents reported that they were most knowledgeable while combined sewer overflows is the topic about which the respondents reported that they were least knowledgeable.

Table 11.7.1 Summary of results from the hypothesis tests (H-4.1-4.6)

Hypotheses	**Results from the hypothesis tests**
Question 4:	*Do people hold misconceptions and limited knowledge about urban stormwater problems and management efforts?*
H-4.1	The extent to which the respondents' concern about water crisis in San Francisco Bay Area is significantly higher than those about the other environmental issues.
H-4.2	Runoff is perceived that it has less impact on a water pollution and degradation problem of San Francisco Bay Area than discharge from industrial plants.
H-4-3	Collecting stormwater for future uses received the highest scores as the sustainable way to manage it, followed by treating it before discharging, draining it to sewer treatment plants, then allowing it to infiltrate into the ground, and holding it in ponds or lakes. Draining it to nearby waterbodies received the lowest scores in this regard.
H-4.4	Only a small number of stormwater management or low impact development (LID) projects were mentioned as places holding ecological benefits. The places that the respondents mostly specified are those the national parks, nature reserves, and ecological restoration projects.
H-4.5	The majority of the respondents were not able to identify places with sustainable stormwater management benefits. In addition, very few respondents of the eight LID test sites mentioned the site each of them were at as the sustainable stormwater management site.
H-4.6	The majority of respondents reported that they were not knowledgeable about sustainable stormwater management concepts and measures. Green roof received the highest mean score while combined sewer overflows received the lowest mean scores in this regard.

Chapter 12

Interest in Learning about Sustainable Stormwater Management of the Respondents

This chapter aims to answer the fifth research question: *do people hold limited learning experiences and lack of interest in learning more about sustainable stormwater management?* Particularly, in this chapter the answers to question 5.1-5.2 and 6.1-6.2 of the questionnaire are statistically analyzed in order to investigate experiences and interests regarding learning about sustainable stormwater management of the respondents.

12.1 Learning experience about sustainable stormwater management

Based on the information collected from survey, the majority of the respondents had no learning experiences about sustainable stormwater management. More specifically, of 502 respondents, only 76 (15.14%) of them reported that they had ever learned or received any information about sustainable stormwater management while 424 (84.46%) of them reported that they had never and 2 (0.40%) of them did not answer this question, see figure 12.1.1.

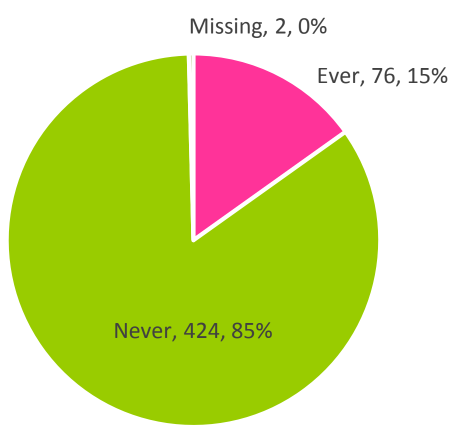


Figure 12.1.1 Pie chart illustrating proportion of respondents reporting whether they had ever or never learned about sustainable stormwater management

For those who had ever learned or received any information about this issue, most of them are those working for cities who had learned and received the information from the cities, or related organizations and institutions, as part of their work and those studying at UC Berkeley, both current students and alumni, who had learned and received the information from their classes. Only few respondents reported that they had learned and received the information in this regard from other sources such as websites, newspapers, and site visits. Table 12.1.2 provides more detail information regarding sources of information from which the respondents had ever learned about sustainable stormwater management.

Table 12.1.1 Sources of information from which the respondents had ever learned about sustainable stormwater management

Ecological place	Frequency
Cities Programs and Presentations : San Mateo County Stormwater Program (3), Contra Costa County (3), SF State (1), City Meetings (3), Presentation of El Cerrito City (1), SFPUC Presentation (1), Working at El Cerrito Recycle Center (1), Working on Development/ Stormwater Projects (2), NPDES (1), Employment Training Programs (1), City Standard (1), City of Richmond (1), City of San Jose (1), DWWR booklets (1)	21
University Classes : Classes at UC Berkeley (3), CED Classes (3), Matt Kondolf's class (1), Kristina Hill's class (1), Joe McBride's Class (1), LA130 Class (6), LA222 Class (2), LAEP Colloquium (1), Classes at UCLA (1), Classes at UCSC (1), University Classes (3)	23
Site Visit ***:*** San Pablo Ave Rain Garden Project in El Cerrito (1), Hoover Dam, Colorado River (1), SFPUC Building (1)	3
Others : Research Papers (1), Working on Research Projects (2), Sweden (1), Websites (4), Water and Sewage Bills (1), News report (1), Newspaper/ Magazine articles (2), Monkey Cheek Project in Thailand (1), Permaculture Principle (1), SF Earth Day Event (1), Urban Farmer Program (1)	16

Remark: The number in parentheses behind each item indicates the total frequency the item was raised.

12.2 Participation experience in sustainable stormwater management programs

Similar to learning experience, the result from survey show that the majority of the respondents had no participation experience in sustainable stormwater management programs. In particular, of 502 respondents, only 34 (6.77%) of them reported that they had ever participated the programs related to sustainable stormwater management while 466 (92.83%) of them reported that they had never and 2 (0.40%) of them did not answer this question, see figure 12.2.1.

Of the respondents who reported that they had ever participated, most of stormwater management programs were provided by the cities and some by academic institutions and other organizations. All the programs the respondents mentioned in the survey are presented in table 12.2.1.

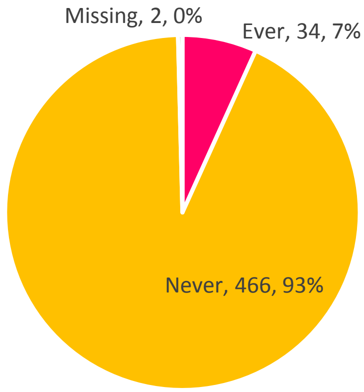


Figure 12.2.1 Pie chart illustrating proportion of respondents reporting whether they had ever or never participated sustainable stormwater management programs

Table 12.2.1 Programs about sustainable stormwater management in which the respondents had ever participated

Ecological place	Frequency
Cities Programs : San Mateo County Stormwater Program (2), Contra Costa County Programs/ Workshops (3), Albany Program (1), Emeryville Program (1), Brisbane City Meeting (1), City Presentation (1)	9
Academic Programs : Landscape Conference (2), UC Berkeley Conference (1)	3
Other Programs ***:*** NPDES Program (1), Clean Water Program (1), EPA Competition (1), California Water Tour (1), Bay Affairs (1)	5
Others : Installing Sustainable Stormwater Management at home (1), Working with DPW in LA (1)	2

Remark: The number in parentheses behind each item indicates the total frequency the item was raised.

12.3 Interest in learning more about sustainable stormwater management

12.3.1 Degree of interest

Overall, the respondents reported that they are moderately interested in learning more about sustainable stormwater management. As table 12.3.1 and figure 12.3.1 show, the distribution of the rating scores looks quite normal, yet slightly skews to the positive side. In addition, as table 12.3.2 displays, both median and mode of the data are 3.00 while the mean is 3.20, a little bit more than 3.00.

Table 12.3.1 Distribution of rating scores for interest in learning more about sustainable stormwater management (1=not interested in, 5=very interested in)

Interest in learning more about sustainable stormwater management	Frequency Distribution of Rating Scores					Missing	*N*
	1 (not interested in)	2	3	4	5 (very interested in)		
	35 (7.0%)	84 (16.7%)	**180 (35.9.4%)**	136 (27.1%)	58 (11.6%)	9 (1.8%)	502

Table 12.3.2 Central tendencies (mean, median, mode, and standard deviation) of rating scores for interest in learning more about sustainable stormwater management

Interest in learning more about sustainable stormwater management	*N*	Mean	Median	Mode	SD
	493	3.20	3.00	3	1.079

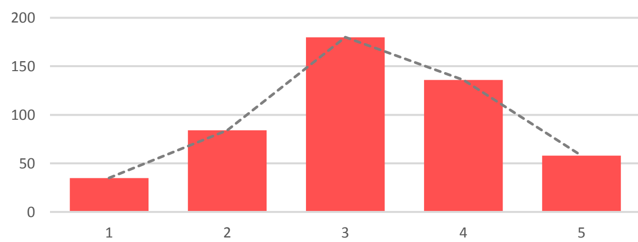


Figure 12.3.1 Bar graphs illustrating distributions of rating scores for interest in learning more about sustainable stormwater management

To explore if the respondents of the test sites and control sites reported different level of interest in learning more about sustainable stormwater management, the independent-sample *t* test is conducted. The result (see table 12.3.3) reveals that the respondents of the test sites reported a slightly lower level of interest in learning more about sustainable stormwater management than the respondents of the control sites. However, this difference is very small and not statistically significant, $t(491) = -0.308$ $p < 0.05$, Cohen's d = -0.758 (very small effect size).

Table 12.3.3 Independent-samples *t* test elucidating if the respondents of the test sites and control sites reported different level of interest in learning more about sustainable stormwater management

Independent-samples *t* test	*df*	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
Test (LID) sites *x* Control (non-LID) sites	491	-0.308	0.758	-0.028; very small

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

In addition to the independent-sample *t* test, a one-way between-groups ANOVA test was also conducted in order to explore if the respondents of the different study sites reported different level of interest in learning more about sustainable stormwater management. As shown in table 12.3.4, the outputs of the ANOVA test suggested that there is at least one significant difference in rating scores by study sites with a medium effect size because the *F* statistic is beyond the critical value; $F(15) = 2.235$, $p < 0.05$. Note that this test violates the homogeneity assumption.

Table 12.3.4 One-way between-groups ANOVA test elucidating if the respondents of the different study sites reported different level of interest in learning more about sustainable stormwater management

One-way between-groups ANOVA	*df*	*F*	*p*-value (Sig.)	Effect Size (Eta Squared)	Homogeneity Test (Sig.)
All 16 study sites	15	2.235	0.005*	0.066; medium	0.007*

* $p < 0.05$; F-value is significant at the 0.05 level.

In view of the significant *F* statistic, post-hoc tests, Tukey HSD tests, were performed to determine where the statistically significant differences really are. The results from Tukey HSD tests revealed that there are only four statistically significant differences between means in this ANOVA test, see table 12.3.5.

Interestingly, all of these four differences are those of Upper Sproul Plaza. More specifically, the respondents of Upper Sproul Plaza reported a higher level of interest in learning more about sustainable stormwater management than those of the other four study sites, including Davis Court ($p = 0.023$), Brisbane City Hall ($p = 0.035$), Daly City Civic Center ($p = 0.007$), and S.D. Bechtel Plaza ($p = 0.000$). As one plausible presumption, as the majority of respondents of Upper Sproul Plaza were UC Berkeley students, they reported a high level of interest in learning more about sustainable stormwater management, compared to the lay public.

Table 12.3.5 Tukey HSD tests (post-hoc tests) showing statistically significant differences of mean scores for interest in learning more about sustainable stormwater management between each pair of the study sites

p-value (Sig.)	Mint Plaza	Davis Court	Fox Square	Brisbane City	El Cerrito	New Sproul	Cesar Chavez	(El)San Pablo	Jessie Square	Justin Herma	S.D. Bechtel	Yerba Buena	Daly City	Upper Sproul	Valenci a Street	(Al)San Pablo
Mint Plaza		0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.726	1.000	0.987	0.395	1.000	1.000
Davis Court	0.999		0.983	1.000	1.000	0.999	0.886	1.000	0.979	1.000	0.999	0.998	1.000	**0.023***	0.979	1.000
Fox Square	1.000	0.983		0.992	1.000	1.000	1.000	1.000	1.000	1.000	0.431	1.000	0.892	0.741	1.000	1.000
Brisbane City	1.000	1.000	0.992		1.000	1.000	0.930	1.000	0.990	1.000	0.998	0.999	1.000	**0.035***	0.990	1.000
El Cerrito	1.000	1.000	1.000	1.000		1.000	1.000	1.000	1.000	1.000	0.749	1.000	0.991	0.282	1.000	1.000
New Sproul	1.000	0.999	1.000	1.000	1.000		1.000	1.000	1.000	1.000	0.719	1.000	0.985	0.429	1.000	1.000
Cesar Chavez	1.000	0.886	1.000	0.930	1.000	1.000		0.999	1.000	1.000	0.202	1.000	0.674	0.929	1.000	1.000
(El)San Pablo	1.000	1.000	1.000	1.000	1.000	1.000	0.999		1.000	1.000	0.871	1.000	0.998	0.189	1.000	1.000
Jessie Square	1.000	0.979	1.000	0.990	1.000	1.000	1.000	1.000		1.000	0.389	1.000	0.874	0.703	1.000	1.000
Justin Herman	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		0.862	1.000	0.997	0.297	1.000	1.000
S.D. Bechtel	0.726	0.999	0.431	0.998	0.749	0.719	0.202	0.871	0.389	0.862		0.630	1.000	**0.000***	0.389	0.864
Yerba Buena	1.000	0.998	1.000	0.999	1.000	1.000	1.000	1.000	1.000	1.000	0.630		0.969	0.520	1.000	1.000
Daly City	0.987	1.000	0.892	1.000	0.991	0.985	0.674	0.998	0.874	0.997	1.000	0.969		**0.007***	0.874	0.998
Upper Sproul	0.395	**0.023***	0.741	**0.035***	0.282	0.429	0.929	0.189	0.703	0.297	**0.000***	0.520	**0.007***		0.703	0.270
Valenci a Street	1.000	0.979	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000	0.389	1.000	0.874	0.703		1.000
(Al)San Pablo	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.864	1.000	0.998	0.270	1.000	

* $p < 0.05$; HSD is significant at the 0.05 level (2-tailed).

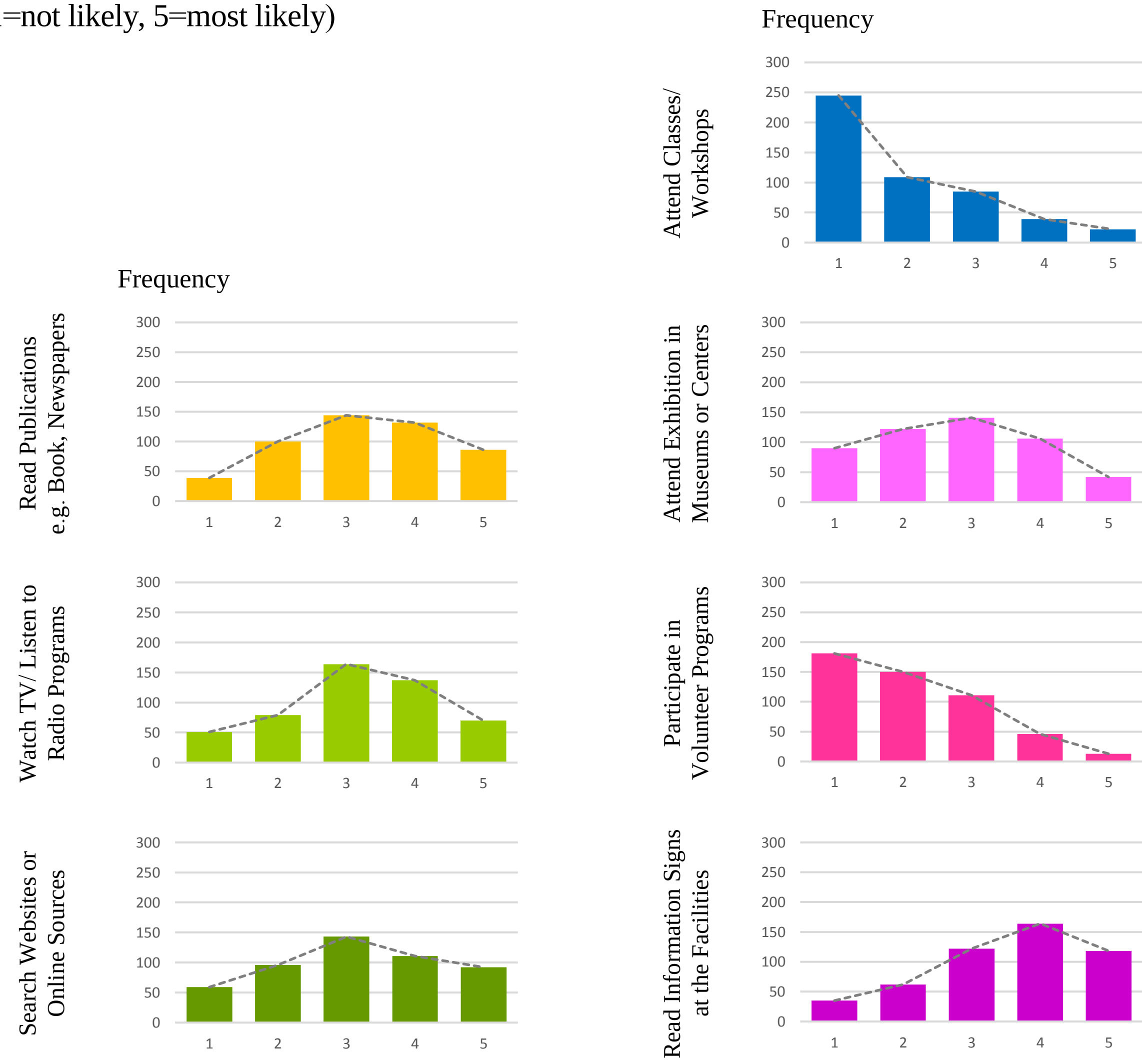
12.3.2 Preferable learning options

Based on the statistical results, the options for learning more about sustainable stormwater management can be classified into three groups. The first group contains only one option—reading signs at the facilities, which is the option respondents reported that they are more likely to do than the others. As table 12.3.6 and figure 12.3.2 show, this option is the only one in which its mean and mode are 4.00, making its distribution obviously skews to the positive side. Most importantly, it also received the higher mean score than the others, see table 12.3.7 and figure 12.3.3. The second group includes four options in which their mean and mode are 3.00, making their distributions resemble a normal distribution and their means fall between 2.50 and 3.50. These four options are reading publications (book, newspaper, etc.), watching TV or listening to radio programs, searching websites or online sources, and attending exhibitions in museum or learning centers. In the last group, there are two options including attending classes or workshops and participating in volunteer programs. These two options are those the respondents reported they are not likely to do, compared to the other options. As shown in table 12.3.5 and figure 12.3.2, the distributions of these two options obviously skews to the negative side, as their medians are 2.00 and their modes are 1. Considering the mean scores, these two options also received the lower means than the others. Note that, among the 7 options, attending classes or workshops seems to be the least desirable learning option because it received the lowest mean, which is also the only one that is lower than 2.00.

Table 12.3.6 Distribution of rating scores for the extent to which the respondents are likely to do any of the options in order to learn more about sustainable stormwater management (1=not likely, 5=most likely)

Options of Learning	Frequency Distribution of Rating Scores					Missing	*N*
	1 (not likely)	2	3	4	5 (most likely)		
- Attend classes/ workshops	**245 (48.8%)**	109 (21.7%)	85 (16.9%)	39 (7.8%)	22 (4.4%)	2 (0.4%)	502
- Read publications	39 (7.8%)	100 (19.9%)	**144 (28.7%)**	132 (26.3%)	86 (17.1%)	1 (0.2%)	502
- Watch TV/ listen to radio	51 (10.2%)	79 (15.7%)	**164 (32.7%)**	137 (27.3%)	70 (13.9%)	1 (0.2%)	502
- Search websites	59 (11.8%)	96 (19.1%)	**143 (28.5%)**	111 (22.1%)	92 (18.3%)	1 (0.2%)	502
- Attend exhibitions	90 (17.9%)	122 (24.3%)	**141 (28.1%)**	106 (21.1%)	42 (8.4%)	1 (0.2%)	502
- Participate volunteer programs	**181 (36.1%)**	150 (29.9%)	111 (22.1%)	46 (9.2%)	13 (2.6%)	1 (0.2%)	502
- Read signs at the facilities	35 (7.0%)	62 (12.4%)	122 (24.3%)	**164 (32.7%)**	118 (23.5%)	1 (0.2%)	502

Figure 12.3.2 Bar graphs illustrating distributions of rating scores the respondents gave regarding the extent to which they are likely to do any of the options in order to learn more about sustainable stormwater management
(1=not likely, 5=most likely)



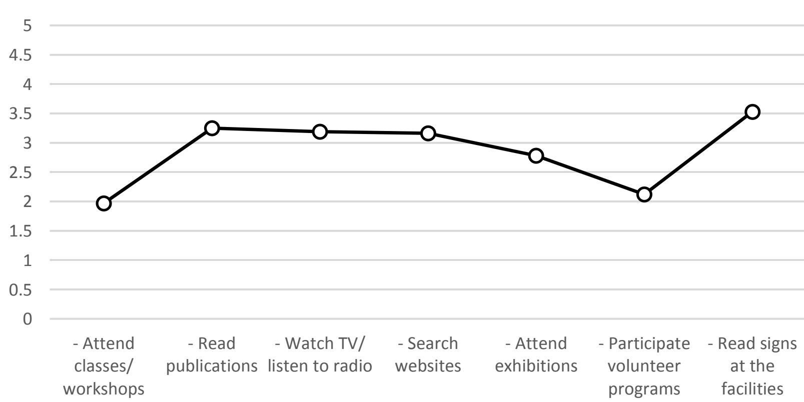


Figure 12.3.3 Line graph illustrating distributions of rating scores the respondents gave regarding the extent to which they are likely to do any of the options in order to learn more about sustainable stormwater management

Table 12.3.7 Central tendencies (mean, median, mode, and standard deviation) of rating scores for the extent to which the respondents are likely to do any of the options in order to learn more about sustainable stormwater management

Ecological Problems	*N*	Mean	Median	Mode	SD
- Attend classes/ workshops	500	**1.97**	2.00	1	1.170
- Read publications	501	3.25	3.00	3	1.183
- Watch TV/ listen to radio	501	3.19	3.00	3	1.168
- Search websites	501	3.16	3.00	3	1.263
- Attend exhibitions	501	2.78	3.00	3	1.209
- Participate volunteer programs	501	2.12	2.00	1	1.082
- Read signs at the facilities	501	**3.53**	4.00	4	1.179

In order to test the hypothesis that if learning from the interpretive signs at the LID sites is more preferable compared to the other options, the paired-samples *t* tests are performed. As shown in table 12.3.8, the results of these tests demonstrate that the extent to which the respondents are likely to read signs at the facilities in order to learn more about sustainable stormwater management is significantly higher than those of the other learning options.

Table 12.3.8 Paired-samples *t* test elucidating the differences between the mean of reading signs at the facilities and the other means

Paired-samples *t* test	*df*	Mean Difference	*t*-value	*p*-value (Sig.)	Effect Size (Cohen's *d*)
- Attend classes/ workshops	499	1.564	25.045	**0.000***	1.329; very large
- Read publications	500	0.283	5.181	**0.000***	0.237; small
- Watch TV/ listen to radio	500	0.343	6.064	**0.000***	0.290; small
- Search websites	500	0.373	6.175	**0.000***	0.303; small
- Attend exhibitions	500	0.758	13.995	**0.000***	0.628; medium
- Participate volunteer programs	500	1.413	23.402	**0.000***	1.246; very large

* $p < 0.05$; *t*-value is significant at the 0.05 level (2-tailed).

12.4 Summary of results from the hypothesis tests (H-5.1-5.3)

As hypothesized, the greater part of the respondents had no learning as well as participation experience about sustainable stormwater management. However, they reported that they are quite interested in learning more about this subject. Neither do gender, age, nor education attainment generate significantly different levels of interest in this regard. Nonetheless, the statistical analysis demonstrates that the respondents of Upper Sproul Plaza reported a significantly higher level of interest than the respondents of the other four study sites, including Davis Court, Brisbane City Hall, Daly City Civic Center, and S.D. Bechtel

Plaza. Perhaps, as most of the respondents of Upper Sproul Plaza were students, they were more enthusiastic about learning than the lay public. Reading interpretive signs at the facilities was reported as the most preferable option, followed by reading publications, watching TV and listening to radio, and searching websites and online sources. The options that the respondent reported that they were least likely to do is attending classes and workshops, followed by attending exhibitions and then participating in volunteer programs. Remarkably, reading interpretive signs at the facilities received significantly higher ratings, on average, than the other learning options.

Table 12.4.1 Summary of results from the hypothesis tests (H-5.1-5.3)

Hypotheses	**Results from the hypothesis tests**
Question 5:	*Do people hold limited learning experiences and lack of interest in learning more about sustainable stormwater management?*
H-5.1	The majority of respondents have never learned or received information about sustainable stormwater management.
H-5.2	The majority of people have never participated in sustainable stormwater management programs.
H-5.3	(1) People are moderately interested in learning more about sustainable stormwater management.
	(2) Learning from the interpretive signs at the LID sites is quite preferable, compared to the other options.

Chapter 13

Landscape Design for Public Appreciation and Education of Sustainable Stormwater Management

As the survey reveals that some LID facilities and features were still unlikely to receive positive public responses and are unable to achieve public satisfaction and recognition, making better sustainable stormwater designs certainly needs to be emphasized. Design has long been considered a mechanism for communicating landscape qualities especially through aesthetic appeal. Furthermore, a number of landscape scholars (e.g. Nassauer 1992, 2012; Nassauer and Opdam 2008; Hough 1995; Mozingo 1997; France 2002; Echols and Pennypacker 2008a, 2008b; Pennypacker and Echols 2008; Spirn 2012) have also mentioned that design can enhance both ecological and pedagogical performances of landscapes, thereby helping establish the desirable relationships between aesthetics and ecology and reconnect people and ecosystems. Accordingly, the central idea of this chapter is based on the tenet that good landscape designs can empower people and our society toward sustainable future. By all means, realizing that urban landscapes implementing LID design principles possess terrific aesthetic as well as educational potentials, LID design must be done in a manner that provides and enhances them. This chapter, thus, proposes the design criteria and guidelines for creating urban LID landscapes that can effectively provide desirable aspects to enhance user satisfaction together with legible clues to raise public stormwater literacy.

13.1 Design criteria for sustainable stormwater management landscapes

In landscape design, the design criteria are generally set as the explicit goals that a project should accomplish. These criteria can also be used as a tool for evaluating the potential for success of a project or a design. Based on the review of design strategies proposed in relevant literatures and used in existing projects along with the insights derived from the survey results, the following is an innovative set of design criteria to assist designers and related professions in creating successful LID facilities which will increase public satisfaction and literacy regarding sustainable stormwater management practices. The following discussions explain the ideas and examples corroborating and elucidating each of the design criteria.

13.1.1 Visibility and legibility

It is evident that, as Backhaus and Fryd (2013: 52) precisely note, "stormwater management is weak as a main design feature." In point of fact, it is widely recognized that ecological landscapes, which include sustainable stormwater management facilities, often hold an awfully diffuse visual aspect as they often blend with their contexts or surroundings (Lyle 1994: 284-285). As a result, the designed landscapes which hold ecological benefits are illegible or indistinguishable so that they are not easily recognized by the public. As Nassauer (1995: 161) notes, "Ecological function is not readily recognizable to those who are not educated to look for it... Even to an educated eye, ecological function is sometimes invisible." In view of this problematic issue, Mozingo (1997: 51) suggests that "To promote ecological design, making it a perceivably visible landscape experience is all important." Strictly speaking, designers as well as those responsible for the implementation of LID projects must pay attention to the creation of visible and legible stormwater management system which can eventually become a major feature in the landscapes.

Figure 13.1 The physical appearance of Mint Plaza in which its stormwater management efforts look invisible and illegible

As contrast is considered fundamental to visibility and legibility, the designs should be done in a manner that the LID landscapes contrast with or can be distinguished from their urban settings. Mint Plaza located near downtown San Francisco, CA is one of numerous design efforts which apparently fall short of mediating their sustainable stormwater management functions, as the results of the pilot study presented in chapter 6 and the results of the questionnaire survey presented in chapter 8-9 reveal. This is because the physical appearance of Mint Plaza bears a resemblance to the typical urban landscape designs (see figure 13.1). Specifically, the two rain gardens do not look different from planters in conventional-designed urban spaces. In addition, most of the excellent rainwater management systems are invisible as they are located underground. The plaza of Stephen Epler Hall at Portland State University, Oregon demonstrate how design can make sustainable stormwater management functions visible and legible. The landscape elements for treating and harvesting rainwater were deliberately designed in order to make them spectacular so that they can catch visitors' attention and offer education about stormwater management efforts (see figure 13.2-13.3). As Pennypacker and Echols (2008: 30-31) explain,

> "First rain descends from the roof of Epler Hall via downspouts that follow three of the building columns. At the bottom of each downspout the rain disappears into a raised concrete basin filled with river rock. Observant visitors will realize that the water seeps down through the river rock then flows out small scuppers at the bottom of each basin. From this point, the rainwater runs straight across the plaza in three runnels… Each runnel leads to a sunken basin filled with plants (these were dubbed 'biopaddies' by the designers), and a gap in the raised concrete edge surrounding each basin allows the runnel to extend all the way to the sunken planter's edge. Curious visitors will realize that this gap lets rainwater fall from the runnel directly into the biopaddy. Visitor

knowledgeable about riparian plants and stormwater management will notice that the sunken planters are filled with sedge, which serves as a biofilter for the rainwater."

Owing to this design, the stormwater management efforts become visible, legible, understandable, and, ultimately, become the main design features of the plaza. In addition to the plaza of Stephen Epler Hall, the courtyard of Maple Valley Library in King Country, Washington is also exemplary. At the center of this courtyard, a circle-shaped, gravel-filled infiltration basin is placed to receive rainwater drained from the building's roof. This infiltration basin also functions as a prominent aesthetic landmark which provides clues about the stormwater management efforts of the site (see figure 13.4-13.5).

Figure 13.2-13.3 The stormwater management features at the plaza of Stephen Epler Hall

Figure 13.4-13.5 The infiltration basin at the courtyard of Maple Valley Library

Apart from the manifest elements, the meaningful sites can also enhance the visibility and legibility of stormwater management efforts. The sites considered meaningful are those which have relationship with the historical stories or hold geographical or hydrological significance. This kind of site can accentuate the stormwater management efforts of the designs, such as Canal Park in Washington, DC. This three-acre site was once a part of Washington City canal, a man-made waterway that linked Potomac River to the branch of

Anacostia River. This canal was used for transportation from 1815 until the late 1840s when modern streets and railroads became popular so that the canal was abandoned, and some portions were filled.[1] In the late 1870s the canal was converted to an open storm sewer and in the early 1900s Canal Street is built over this canal.[2] In order to revitalize the area, the city hosted a design competition for Canal Park in 2004 and after a subsequent redesign, construction of the park was completed in 2012. The stormwater management system is one of the most important sustainable design strategies incorporated into the design of the park (see figure 13.6-13.7). The linear rain garden along with the underground cistern help capture and filter almost all stormwater runoff generated by the park, thereby minimizing the impacts on the city's drainage system. Interestingly, this linear rain garden was also designed to recall the old Washington City Canal and the three pavilions recall floating barges that were once common in the canal.[3] The design evokes the site's history, possibly making the stormwater management intent more remarkable and graspable to the public, especially the locals.

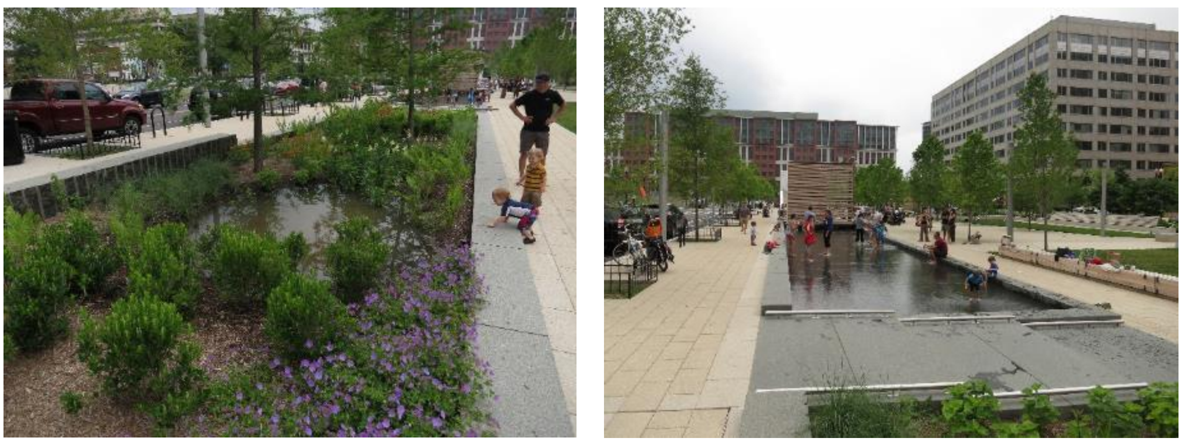


Figure 13.6-13.7 The linear rain garden designed to reminisce about
the history of the site of Canal Park

13.1.2 Accessibility

As several scholars (e.g. Laurie 1989; Nassauer 1995; Mozingo 1997; Orr 2002; Echols and Pennypacker 2008a) have corroborated, direct experience with the ecological designs has been considered beneficial to the development of appreciation and education of the ecological landscapes. The LID designs, therefore, should be accessible in order to offer people opportunities to have direct experience with the facilities and advance their understanding about stormwater management practices. If a design cannot be accessed or experienced, it is just like a flower that blooms deep in a forest with nobody to see its beauty or appreciate its value. In addition, the provision of public access to the stormwater management facilities also help avoid "museumification" in the word of Gobster (2007: 95-

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[1] The information from the informative sign at the site, visited in June 2013.
[2] The information from the Canal Park website, http://www.canalparkdc.org, retrieved January 16, 2016.
[3] The information from the website of Olin, http://www.theolinstudio.com, retrieved January 16, 2016.

114), which refers to the phenomenon in which everyday places are transformed to untouchable objects as those in the museum.

In the light of the issues mentioned above, first, the LID facilities should be sited in the accessible areas, at or near where most people are living or doing their everyday activities, so that they are easy to visit. Next, the designs should be done in the ways that provide and enhance accessibility of the sites. The entrance plaza of El Cerrito City Hall seemingly falls short of achieving this criterion. Despite the fact that the plaza is located adjacent to the pedestrian walkways and leads to the main entrance of the building, very few people use or pass through this space because most of the employees and visitors of the city hall usually come by car so that they use the rear entrance which flanking the parking lot to enter the building (see figure 13.8). Some visitors stated that even though they had visited the city hall a number of times, they had never visited the entrance plaza. Accordingly, it is really a pity that the majority of people do not have chance to experience this well-designed stormwater control feature. In contrast to the situation of El Cerrito City Hall, the entrance plaza of Brisbane City Hall is located between the parking area and the building. Thus, people always pass through this plaza to get to the main entrance and have chance to experience the stormwater management facilities at the plaza before entering the building (see figure 13.9).

Figure 13.8 The entrance plaza of El Cerrito City Hall where stormwater control features are rarely experienced by people (Picture Source: http://www.carducciassociates.com/projects/civic/el_cerrito_city_hall/el_cerrito_city_hall.php, retrieved January 22, 2016)

Figure 13.9 The entrance plaza of Brisbane City Hall where stormwater control features are often experienced by people (Picture Source: http://nevuengan .com/green-infrastructure/brisbane-city-hall-rain-garden, retrieved January 22, 2016)

For the sites where public access needs to be restricted, such as those located in the courtyards or on the rooftops of the buildings, the provision of site visit programs or tours is valuable for those who are interested in experiencing and learning about the landscapes and stormwater management practices. The ASLA Headquarters Green Roof in Washington, DC is one place where the site visit tours are available to the public (see figure 13.10). Perspective visitors, whether groups or individuals, can schedule for the tours in order to explore or learn about the design alternatives and ecological benefits of this green roof.

Figure 13.10 The ASLA Headquarters Green Roof where site visit tours are available to the public (Picture Source: http://landscapeperformance.org/case-study-briefs/asla-headquarters-green-roof, retrieved January 22, 2016)

13.1.3 Functionality

The functionality is also the pivotal issue. In order to establish positive attitude toward the LID facilities, at first the facilities themselves must not be designed in the ways that impede the functionality of the urban spaces where they are situated. The case of rain gardens at the sidewalk of San Pablo Avenue in El Cerrito is one example in which the LID facilities frustrated the function of the sidewalk (see figure 13.11). Passersby stated that these rain gardens blocked the way to the sidewalk from the street. They also mentioned about the safety issues: rain gardens are too deep so that they are risky to children and elderly people to fall into and the weedy planting in the rain gardens increase the chance of being habitats of snakes or other pests. These comments illustrate the barriers to understanding this set of ecologically beneficial elements.

Figure 13.11 The rain gardens at the sidewalk of San Pablo Avenue that users find impede the functionality of the sidewalk (Picture Source: http://blue greenbldg.org/bioretention/el-cerrito-sidewalk-rain-gardens/, retrieved January 22, 2016)

The designs of stormwater management facilities, furthermore, should be done in the ways that offer opportunities for people to use the spaces, providing appropriate activities to serve their users. Like other ecological projects, stormwater management landscapes should be integrated into urban fabric and designed to function as site or even urban amenities, as places where people can come for a variety of recreational and educational purposes. Stormwater management facility can become a classroom, a park, a playground, a plaza, a square, a street, a sidewalk, and so on, where people can carry on everyday activities. The plaza of Stephen Epler Hall at Portland State University can serve as an example in this regard (see figure 13.2-13.3). As Pennypacker and Echols (2008: 34) describe, "a plaza [was] designed not only for looking or passing through but also for lingering and living, people by university faculty and students who have both the intellectual inclination and the opportunity to take some time here, observe, deduce, and be both delighted and enlightened." The new Uptown Circle in Normal, Illinios is also exemplary. This streetscape redevelopment design aimed to incorporate stormwater management and public recreation so as to create a vibrant urban amenity for people (see figure 13.12). According to Hoerr Schaudt (2016), "This creative storm water system returns the cleansed water to the site in the form of a fountain, and recycles water into an irrigation system for the adjacent streetscapes. The Circle is that rarest of public amenities—a water feature that can safely be enjoyed physically as well as visually and aurally." In addition that stormwater management facilities can serve people's everyday recreational activities, they can also function as learning or educational facilities. The Living Roof at the California Academy of Science in San Francisco, California is an excellent case in point. This green roof serves as an outdoor classroom where a variety of educational programs and activities take place (see figure 13.13). These programs and activities provide participants opportunities to learn about not only stormwater management, but also other issues related to natural sciences.

Figure 13.12 The new Uptown Circle which also functions as a public recreational space (Picture Source: http://www.hoerrschaudt.com/project/uptown-normal/?parent=90, retrieved January 22, 2016)

Figure 13.13 The Living Roof at the California Academy of Science which also functions as an outdoor classroom for a variety of learning activities (Picture Source: http://www.asla.org/sustainablelandscapes/cas.html, retrieved January 22, 2016)

13.1.4 Attractiveness and interest

Attractiveness and interest are pivotal to public appreciation of landscape designs. In addition, based on the idea of "artful rainwater design" developed by Echols and Pennypacker (2008a), attractive and interesting stormwater designs can also call attention to stormwater management practices and ultimately motivate those who visit them to learn about stormwater ecology and management.

Figure 13.14-13.15 The sculptural artworks, Water Glass and Water Table, at the plaza of Ellington Condominium (Picture Source: http://www.bustersimpson.net/watertable-waterglass/, retrieved January 22, 2016)

Creating the eye-catching feature is the simplest way to make stormwater design attractive and interesting. Stormwater features that become a sculptural artwork or an artistic element that celebrates or manifests the temporal dynamics of rainwater or rain event are especially effective. Water Glass and Water Table at the plaza of Ellington Condominium in Seattle, Washington are superior examples of this (see figure 13.14-13.15). These two elements call the attention of residents and passersby to rainwater. According to Buster Simpson (2016a), "As sculpture, Water Table/ Water Glass provide a domestic tableau. As metaphor, Water Table/ Water Glass are two elements, which create utilitarian fountains; the glass becomes a vessel, a cistern, and a detention tank; the table expresses the philosophical approach for the plaza's landscape irrigation water table system as well as a usable table when dry. Both sculptures join to nurture the wetlands landscape."

In addition to eye-catching features, some creative designs also provide emotion-arousing or thought-provoking experiences, such as the Rain Drums at Cedar River Watershed Education Center in North Bend, Washington (see figure 13.16-13.17). According to Dan Corson (2016), "The space between 3 buildings houses a wild overgrown forest floor with a slow moving stream and a canopy of tall, thin and lacy vine maples. Interspersed between the trees are 17 "rain drums" that play the raindrops as they fall from the sky and drip from the branches. When the sky is dry, there is a set of computer controlled water drippers that create a set of changing rhythms." This display of moving rainwater becomes an entertaining and interesting show for visitors of the center.

Figure 13.16-13.17: The Rain Drums at Cedar River Watershed Education Center (Picture source: http://dancorson.com/rain-drum-courtyard, retrieved January 22, 2016)

Figure 13.18-13.19: The Watershed Map of Ridge and Valley Sculpture at the Penn State Arboretum (Picture source: http://artfulrainwaterdesign.psu.edu/project/ridge-and-valley-penn-state-arboretum, retrieved January 22, 2016)

Similarly, the Watershed Map makes the stormwater design of Ridge and Valley Sculpture at the Penn State Arboretum in University Park, Pennsylvania attractive and interesting to people (see figure 13.18-13.19). According to PennState (2016b), "During small rain events, rain drips from the scupper onto river pebbles, then flows to the bluestone map; in large events, rain arcs from the scupper to fall directly onto the map, where all rivers and streams in the watershed are incised, each as a ¼-inch-deep runnel, transforming the map during small rain events into the watershed in miniature. The whole terrace is gently sloped to make the rain follow the watershed's configuration." In the words of the artist, Stacy Levy, "This project gives a role to the rain: to activate the watershed map and make the terrace an interesting place" (PennState 2016b).

13.1.5 Cultural aesthetics

People are entrenched in the cultural concepts of landscape beauty. First, people tend to prefer natural to built environments (Cronon 1996; Owens and McKinnon 2009). Because the interpretation of nature is through a cultural lense, what people perceive as nature is usually their accepted concept of nature which might sometimes hide its unnaturalness behind a delightfully natural look, rather than the real nature which could sometimes hold a less pleasing visual appearance (Cronon 1996). This cultural concept of nature was developed from the need to survive or to maintain our species. As we need environment that is suitable for survival—the one that supports our lives, we prefer the fertile and productive landscape with access to fresh water and opportunity to find and produce food. This is the reason why we love green, and why we appreciate the landscape with the presence of water as well as a mass and variety of vegetation. In addition, according to Appleton (1975: 66), the human ideal landscape arose from the need to survive in the midst of danger in African savanna. In other words, besides the fact that we do not want to be hungry, we also do not want to be hunted. For that reason, humans also prefer landscapes that provide secure and comfortable feeling, particularly those that provide the condition of "seeing without being seen." Appleton described this of landscape preference as the prospect-refuge theory—landscapes that provide vantage points along with opportunities to hide or escape, such as the Dell at the University of Virginia. There the meandering creek and the wet detention pond, along with the mixture of wetland and riparian vegetation form an idealized naturalistic expression of the landscape (see figure 13.20-13.21).

Figure 13.20-13.21: The Dell at the University of Virginia (Picture source: http://artfulrainwaterdesign.psu.edu/project/dell-university-virginia, retrieved January 22, 2016)

The appreciation for the unnatural nature is complicated by the fact that majority of people also do not directly appreciate ecological quality. According to Nassauer (1995: 161), "We know how to see ecological quality only through our cultural lenses… More significantly, picturesque conventions have become so integral to landscape perception…" In view of that fact, the ecological designs which also offer picturesque views are likely to be aesthetically appreciated by the public, such as the Dell at the University of Virginia. This complex stormwater management system features several picturesque scenes, as shown in figure 13.20 and 13.21.

Nassauer also contends that people perceive that the messy look of ecological landscapes diminishes their beauty or aesthetic quality as it apparently violates the cultural or normative expectation of landscapes aesthetics, especially picturesque conventions and neat landscape appearance. Based on the results of a number of empirical studies, Nassauer proposed the idea of "cues to care" to cope with this problem, to meet aesthetic expectation of the public. As she writes, "Landscape language that communicates human intention, particularly intention to care for the landscape, offers a powerful vocabulary for design to improve ecological quality" (Nassauer 1995: 161). At Queens Botanical Garden in New York (see figure 13.22-13.23), the combination of green lawn, water features, and also vegetation creates a neat, picturesque landscape that fulfills cultural aesthetic expectation of people. Furthermore, the stormwater pond at this botanical garden also offers an appealing naturalistic landscape. Visitors, thus, are invited to enjoy and learn about a variety of stormwater management strategies through their experience with this well-designed and well-maintained naturalistic, park-like landscape.

Figure 13.22 The combination of green lawn, water features, and vegetation creating an attractive park-like landscape at Queens Botanical Garden (Picture Source: http:// www.bkskarch.com/work/queens-botanical-garden-visitor-administra tion-center/, retrieved January 22, 2016)

Figure 13.23 The stormwater pond offering an appealing naturalistic landscape at Queens Botanical Garden (Picture Source: http://artfulrainwaterdesign.psu.edu/project/queens-botanical-garden, retrieved January 22, 2016)

In addition to the "cues to care" idea, Nassauer also suggests that ecological landscape "requires designing orderly frames for messy ecosystems" (Nassauer 1995:161). The Outwash Basin at the Ray and Maria Stata Center on the MIT campus in Cambridge, Massachusetts (see figure 13.24-13.25) is located in a rectangular, sunken basin. The stepped gabion retaining wall certainly help frame the facility to look orderly and well organized.

Moreover, according to Echols and Pennypacker (2006: 29), "Many of the plantings are arranged in strong geometric patterns, contrasting with the naturalistic jumble of boulders and clarifying that this is a human-contrived landscape."

Figure 13.24-13.25 The Outwash Basin at the MIT campus (Picture Source: http://artfulrainwaterdesign.psu.edu/project/outwash-basin-mit, retrieved January 22, 2016)

13.1.6 Ecological revelation

As the study in this dissertation made clear, ecological processes and the benefits of stormwater management facilities or LID designs are not easily noticed by the public. However, the hydrological cycles and management systems of stormwater, actually, can be highlighted, whether for aesthetic or instructional purposes. Eco-revelatory design refers to a novel design strategy that attempts to engage and delight people by revealing the ecological phenomena of the landscape. According to the words of Lyle (1994: 45), "if we can manifest the inherent elegance of ecological processes in visible forms, those forms will become symbols for the times. Even the wind generators that many find objectionable can be seen as an evocative kind of kinetic sculpture—unfamiliar perhaps and certainly not natural, but meaningful, even beautiful, in terms of process and context." Thus, this design strategy can bring eye-catching, emotion-arousing, thought-provoking aspects to stormwater facilities which help enhance the attractiveness and interestingness of the landscapes. This design strategy, furthermore, can also enhance educational potential of the ecological landscapes. As Brown, Harkness, and Johnston (1998: x) explain: "It can result in works that are multifaceted, four-dimensional benchmarks, reference sites for what we understand about our environment and its workings. Works can convey knowledge through direct experiences as well as by interpretation."

The straightforward way to reveal the ecological essence of the stormwater facilities is to display the hydrological cycles and processes of stormwater management or to provide opportunities for people to directly experience the working of stormwater management systems, such as the design for the 21st Street in Paso Robles, California (see figure 13.26). The median of this street was designed to function as a stormwater channel where runoff is conveyed, treated, and infiltrated. This open channel provides significant opportunities for residents to witness the flow and cycle of rainwater in their community. The stormwater and wastewater management design at Sidwell Friends Middle School in Washington, DC also achieves this eco-revelatory quality (see figure 13.27). The green roof along with the rain gardens, vegetated swales, constructed wetlands, and habitat pond located at the sunken courtyard in front of the school building magnificently exhibit the processes of stormwater and wastewater management. These features in the landscape also function as outdoor living laboratories and classrooms where students can learn about ecological sciences as well as stormwater and wastewater management practices.

Figure 13.26 The stormwater channel at the median of 21st Street (Picture source: http://landarchs.com/ award-winning-21st-street-turns-roadway-into-green-and-complete-street/, retrieved January 22, 2016)

Figure 13.27 The stormwater wetland and pond at Sidwell Friends Middle School (Picture source: http://landscapeperformance.org/case-study-briefs/sidwell-friends-middle-school, retrieved January 22, 2016)

Figure 13.28-13.29 The steel sculpture at New Seasons Market's Arbor Lodge which represents the situation when salmon battle their way upstream (Picture source: http://www.architectureweek.com/2005/1130/environment_1-1.html, retrieved January 22, 2016)

Figure 13.30-13.31 The scupper and channel at Oregon Convention Center which allow visitors to witness the story of the water's journey from rooftop to river (Picture source: https://www.asla.org/portland/site.aspx?id=43983, retrieved January 22, 2016)

Sometimes the ecological systems and structures of the designed landscapes can also be exaggerated or metaphorized in order to make them become more prominent or more powerful experiences. At New Seasons Market (Arbor Lodge) in Portland, Oregon (see figure 13.28-13.29), the striking stainless steel sculpture spectacularly celebrates the rain events and also illuminates the story about the relationship between rainwater and salmon. In particular, as the stainless steel tendrils and stainless steel salmon silhouettes are attached to the scuppers, salmon silhouettes appear to be facing cascading water when rainwater pours from the scupper, whether during or after storm events. This spectacle certainly makes people witness the rain events in a playful way. Moreover, it also excites and enlightens spectators as it manifests the situation when the salmon battle their way upstream to the spawning areas. Another similar example is the rain garden at the Oregon Convention Center in Portland, Orego which metaphorically represents the journey of rainwater (see figure 13.30-13.31). According to Echols and Pennypacker (2008a: 275), "Four huge scuppers protrude from the convention center building and convey rain water from its five-acre roof into a detention and biofiltration system designed as an urbane abstraction of a regional river… The design tells the story of the water's journey from rooftop to river."

13.1.7 Interactive activities

Throughout history, humans have lived in intimate contact with nature. However, as a result of rapid-paced urbanization, humans are increasingly removed from nature, estranged from nature and ecosystems. Within the past decades, empirical studies assert that interacting with nature is important to people's quality of life, whether in terms of physical or psychological health (Keniger, Gaston, Irvine, and Fuller 2013). These studies emphasize the idea that interacting with nature is essential to foster positive relationships between people and nature, make people connect to and take care of the environment around them, and, ultimately, help people develop their ecological literacy and ethics. Considering this, LID facilities should be designed in a manner that provide opportunities for people to have a vibrant interaction or touch with rainwater, not just only to have a visual and aural experience, in order to help people relate to and understand stormwater ecosystems and management practices.

People can interact with rainwater through their daily recreational activities. In Malmö, Sweden, residents, especially children, of Ekostaden Augustenborg can touch or even play with rainwater flowing through the runnels or filling in the ponds and wetlands (see figure 13.32). In Normal, Illinois, both adults and children also enjoy the touch of flowing water at the traffic circle which was redesigned by integrating stormwater management into a vibrant recreational space for the public (see figure 13.33). Since ecological learning can happen during serendipitous interactions with surrounding environments, designs which provide opportunities for people to interact with rainwater can also offer educational benefits. The rainwater harvesting system at Chartwell School in Monterey, California functions as an educational interpretive stormwater feature as it offers opportunities for the students to enjoy touching rainwater which flows through the overflow channel while leaning about effective and sustainable ways to manage stormwater (see figure 13.34).

Figure 13.32 A little girl enjoying the touch of rainwater flowing through a runnel in Ekostaden Augustenborg (Picture source: https://www.pinterest.com/pin/9499849189142066/, retrieved January 22, 2016)

Figure 13.33 A variety of people enjoying the touch of flowing recycled rainwater at the traffic circle in Normal (Picture source: https://www.pinterest.com/pin/347692033705869982/, retrieved January 22, 2016)

Figure 13.34 The students enjoying the touch of water at the rainwater channel while leaning about stormwater management at Chartwell School (Picture source: http://www.sherwoodengineers.com/projects/campus-education/chart well-school/, retrieved January 22, 2016)

Figure 13.35 The roof garden at California Academy of Science (Picture Source: http://www.pacifichorticulture.org/articles/an-evolving-land scape/, retrieved January 22, 2016)

Figure 13.36 The roof garden at Gary Comer Youth Center (Picture Source: http://land scapeperformance.org/case-study-briefs/ gary-comer-youth-center, retrieved January 22, 2016)

In addition to designs that provide direct interactions with stormwater, other design strategies enhance appreciation and education of stormwater systems. The LID facilities that provide opportunities for people to have interactive activities with other elements in the landscape, especially plants and animals (fishes, birds, butterflies, etc.), or even the landscape as a whole can also be advantageous as well. The roof gardens at California Academy of Science in San Francisco, California (see figure 13.35) as well as at Gary Comer Youth Center in Chicago, Illinois (see figure 13.36) superbly offer such opportunities. Apart from helping absorb rainwater and reduce the amount of runoff, these gardens serve as outdoor classrooms that supports a variety of educational programs. At these roof gardens, visitors, especially children, can have direct interactions with several kinds of plants while learning about urban agriculture, horticulture, and other environmental related issues.

13.1.8 Interpretive signage

Knowledge about ecology and environment is a key to the development of landscape appreciation and environmental ethics of the public (Carroll 1993; Matthews 2002; Carlson 2012; Orr 1992; Stone and Barlow 2005). Within recent decades, many studies have reiterated the idea that the landscape designs in which ecologically sustainable practices are implemented, which include the stormwater management or LID facilities, can provide such knowledge for the public (Laurie 1989: 50; Nassauer 1997: 8; Gobster, Nassauer, Daniel, and Fry 2007: 957-972; Nassauer and Opdam 2008: 633; Hester 2010: 327; Nassauer 2012: 221-229; France 2002: 245; Echols 2007: 6; Echols and Pennypacker 2008a: 24; Pennypacker and Echols 2008: 28-39). Apparently, the provision of the interpretive signage is the simplest or most straightforward way to provide useful knowledge for users or visitors of the ecological sites.

Figure 13.37 The interpretive sign at Pierce County Environmental Services

Figure 13.38 The interpretive sign at Center for Urban Water in Takoma

Figure 13.39 The interpretive sign at Thornton Place

Figure 13.40 The interpretive sign at Cromwell Park

According to Pennypacker and Echols (2008: 38), the interpretive signage system provided at Pierce County Environmental Services which is located in Chambers Creek Regional Park, University Place, Washington is a particularly good example (see figure 13.37). As they state, "signs in this landscape ensure that visitors will not only notice, but will leave the site with real "lessons learned." First, the signs each offer a small, easily digested tidbit of information about the design strategy, materials, and plants that can be read at a glance. Second, the signs are strategically located along major pedestrian routes so that visitors can't traverse the site without encountering these engaging info bites. And third, the signs are bright yellow in color, making them highly visible in the landscape."

Besides Pierce County Environmental Services, a number of other stormwater management sites provide interpretive signs to supply their visitors with information about stormwater ecosystems and management strategies. These interesting cases include: Center for Urban Water in Takoma, Washington; Thornton Place in Seattle, Washington; Cromwell Park in Shoreline, Washington; Canal Park in Washington, DC; The Edge Park in Brooklyn, New York; San Pablo Rain Gardens in El Cerrito, California; Brisbane City Hall in Brisbane, California; SW 12th Avenue Green Street in Portland, Oregon; Oregon Museum of Science and Industry (OMSI) in Portland, Oregon; Water Pollution Control Laboratory of the Bureau of Environmental Services (BES) in Portland, Oregon; and Portland Community College (PCC) Stormwater Education Plaza in Portland, Oregon (see figure 13.38-13.42).

Figure 13.41 The interpretive sign at Canal Park

Figure 13.42 The interpretive sign at Brisbane City Hall

13.1.9 Water features

As an essential resource for humans to survive and sustain life, water is, undoubtedly, one of the most attractive elements in the landscape. The research literature reiterates that water is aesthetically pleasing and the presence of water can enhance preferences for one landscape over another (e.g. Shafer, Hamilton, and Schmidt 1969; Zube, Sell, and Taylor 1982; Kaplan and Kaplan 1989; Yang and Brown 1992). Given these findings, including a water feature in the LID design can make the LID landscape more special, creating visual attractiveness, moderating urban noise, and offering interactive experience with water. Furthermore, it can also constitute a bridge between human and water ecosystems as well as rainwater cycles particularly a stormwater management feature designed in a manner that it becomes a prominent water feature in the landscape. This stormwater feature can help make the implementation of stormwater management stand out, thereby helping people sense or recognize the sustainable stormwater management intent and practice in the landscape design.

There are indeed various forms of water features, whether pools, ponds, channels, or fountains, which can be included in LID designs. And also, there are definitely a number of excellent designs which successfully make stormwater management elements become the prominent water features of the landscapes. Worth noting that while several of them provide the perennial presence of water, some of them provide the presence of water only during and after rain events.

Figure 13.43 The water garden at Water Pollution Control Laboratory (Picture source: http://www.arton file.com/images/UEI-01-06-05.jpg, retrieved January 22, 2016)

Figure 13.44 The courtyard pool at the Avenue in Washington, DC (Picture source: http://landscapeper formance.org/case-study-briefs/ the-avenue, retrieved January 22, 2016)

Figure 13.45 The roundabout fountain in Normal (Picture source: http:// landscapeperformance. org/case-study-briefs/uptown-normal-circle-and-streetscape, retrieved January 22, 2016)

Figure 13.46 The stepped runnel at Nueva School (Picture source: https: //www.asla.org/2010awards/050.htm l, retrieved January 22, 2016)

Figure 13.47 The runoff cascade in Gondrecourt-le-Chateau (Picture source: http://www.urcaue-lorraine. com/espace.php?id=23, retrieved January 22, 2016)

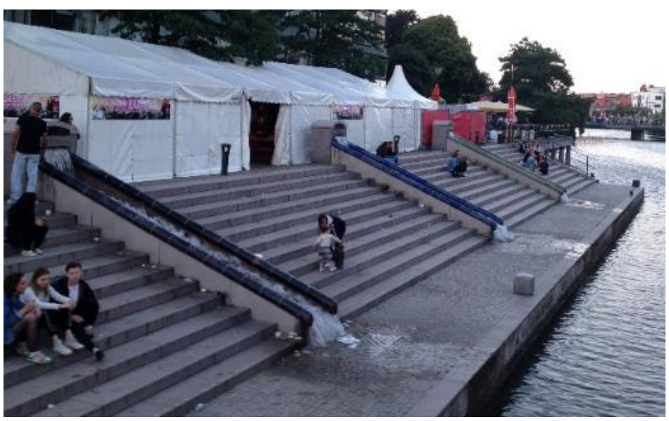

Figure 6.48 The stairway fountain at the promenade in Malmö

The water garden at Water Pollution Control Laboratory in Portland, OR; the courtyard pool at the Avenue, a mix-used complex, in downtown Washington, DC; and the roundabout fountain in Normal, IL are excellent cases which most of the time provide the presence of water (see figure 13.43-13.45). The stepped runnel at Nueva School in Hillsborough, CA; the runoff cascade in Gondrecourt-le-Chatea, France; and the stairway fountain at the promenade in Malmö, Sweden are excellent cases which allow people to witness the flow of rainwater or runoff during and after rainstorms (see figure 13.46-13.48).

13.1.10 Application and replication

The widespread application and replication of the LID designs is also crucial to the enhancing appreciation and education of such ecological design practices. People will better understand urban LID features by seeing them more in their daily city life. In addition, the widespread application and replication of the LID designs is also important in terms of the generation of the cumulative benefits to the environment. Only one or a few projects cannot dramatically change or improve the quality of the ecosystems, but many of them can. When people notice the changes and become familiar with LID designs in the urban landscape, they will realize and appreciate these ecological practices. Through replication, both special and typical designs can produce good results.

The persuasive power of special designs is one way to promote the application and replication of LID strategies. In particular, the projects which are considered outstanding, whether in terms of visual appearance or ecological performance, are most influential. Such projects attract public attention, stimulate interest in learning about ecological strategies, and then increase the support of further application and replication. The famous Living Roof of California Academy of Science is a prime case in point (see figure 5.4, 13.13, 13.35). The seven grassy hills located at the rooftop of the building not only make this design look exceptionally distinctive, but also essential to the building's LEED Platinum rating. This roof garden, thus, became renowned as a prominent and excellent example of green roof design promoting the ecological benefits and the further implementation of green roof.

Figure 13.49 The Viewlands Cascade project in Seattle

Figure 13.50 The 2nd Avenue NW project in Seattle

The experimental, demonstration, or pilot projects can also be valuable to the promotion of LID designs as well. Many ecologically designed landscapes which include LID features began as experimental projects which showcasing innovative, creative ecological design strategies. These projects garner public attention and serve as references for future expansions. In particular, pilot projects which proved satisfying to the public for both their aesthetic and functional characteristics can significantly enhance widespread public support for replication. The classic examples of this are the Viewlands Cascade and the 2nd Avenue NW projects in Seattle, Washington (see figure 13.49-13.50). These two projects served as important experimental, pilot projects of Seattle Public Utilities (SPU). The SPU monitored the hydrological performance of these projects and found that they could significantly reduce runoff volume and pollution. In consequence, SPU developed the Natural Drainage System (NDS) strategy and Street Edge Alternatives (SEA) Street project which eventually resulted in the implementation of a number of projects throughout the city. The prominent succeeding cases include the Broadview Green Grid project and the Growing Vine Street project (see figure 13.51-13.52).

Figure 13.51 The Broadview Green Grid project in Seattle (Picture source: http://www.seattle.gov/util/EnvironmentConservation/Projects/GreenStormwaterInfrastructure/CompletedGSIProjects/BroadviewGreenGrid/index.htm, retrieved January 22, 2016)

Figure 13.52 The Growing Vine Street project in Seattle (Picture source: https://www.flickr.com/photos/justsmartdesign/3078795372, retrieved January 22, 2016)

Apart from making distinctive designs, developing typical designs is also vital. Special projects can be very expensive to construct or maintain and also hard to apply in different contexts. Moreover, it is unnecessary as well to have so many of them. Therefore, the practices of stormwater management should step beyond distinctive or experimental sites and move toward broad implementations (Hill 2009; Felson 2013). Furthermore, they should also be well integrated into urban contexts to become a part of people's everyday lives. Thus, another approach to achieve the goal of promoting application and replication of LID is to develop typical designs. These designs must be cost-effective, both in terms of construction and maintenance, and can be integrated into a wide range of contexts. The national, if not international, leader in the broad implementation of LID is Portland's Green Streets Program which retrofits streets manage stormwater runoff as well as to create vibrant spaces for pedestrians. The well-known examples of Portland's green streets include the SW 12th Avenue Green Street project and the NE Siskiyou Green Street Project (See figure 13.53-13.54). As the designs of these projects are certainly simple, cost-effective, yet aesthetically pleasing and ecologically beneficial, they are easy to replicate and can be applied to various contexts. According to Roth (2009), "Without question, Portland's Greenstreets program is the benchmark for American cities seeking to manage storm water and runoff from the street level before it enters the sanitation system pipes." San Francisco's Better Street Plan is a successor of Portland's Green Streets Program. The Leland Avenue and Newcomb Avenue streetscape improvement projects are the two pioneering projects of San Francisco's Better Street Plan (See figure 5.10-5.11).

Figure 13.53 The SW 12th Avenue Green Street in Portland (Picture source: https://www.asla.org/awards/2006/06winners/341.html, retrieved January 22, 2016)

Figure 13.54 The NE Siskiyou Green Street in Portland (Picture source: http://artfulrainwaterdesign.psu.edu/project/ne-siskiyou-green-street, retrieved January 22, 2016)

13.2 Design guidelines for sustainable stormwater management features

Stormwater management features hold different attributes and appearances and, importantly, as the survey results reveal, people hold varying attitudes toward each of them. Accordingly, their designs should be done in a manner that enhance their pros and diminish their cons. The sections below discuss design guidelines for creating the stormwater management features that are attractive, recognizable, and also beneficial for educational purposes. Several excellent cases are also exemplified.

13.2.1 Water tank/ cistern

The survey made clear that water tanks or cisterns are not appealing to the eyes of many people. However, they are very effective and sustainable stormwater management features. Attention to the visual appearance of water tanks or cisterns can make them more striking and intriguing. In addition, water tanks or cisterns are the elements that easily lends themselves to being sculptural artworks that celebrate the dynamics of rainwater.

The blue cistern at Growing Vine Street (See figure 13.55) and the Water Glass at the plaza of Ellington Condominium in Seattle, Washington (See figure 13.14) are superior cases in point. The musical cistern at Mills College in Oakland, California is also a remarkable example of rethinking the form of a cistern (See figure 13.56). The name of this cistern comes from the music that the rainwater creates when it bounces off a series of angled flat metal shingles before falling into the cistern. Additionally, the cistern at Eco Modern Flat in

Fayetteville, Arkansas is noteworthy as well because it is outstanding at the same time as blending with the overall architectural and landscape designs (See figure 13.57).

Figure 13.55 The blue water tank at Growing Vine Street project

Figure 13.56 The musical cistern at Mills College (Picture Source: http://www.sfwater.org/Modules/ShowDocument. aspx?documentID=2779, retrieved January 22, 2016)

Figure 13.57 The Eco Modern Flat in Fayetteville (Picture Source: http://inhabitat.com/eco-modern-flats-renovation-is-the-first-multifamily-leed-platinum-project-in-arkansas/eco-modern-flats-modus-studios-1/, retrieved January 22, 2016)

The typical, standard metal tanks can also look good if they are well placed. One example in this regard can be found at the Center for Urban Water in Takoma, Washington. As the water tanks here are well positioned, they look as if they are parts of the building design (See figure 13.58).

Figure 13.58 The water tank at the Center for Urban Water in Takoma

13.2.2 Street gutter/ drainage channel/ storm drain

Similar to the case of water tanks, whether street gutters, drainage channel, or storm drains often look unappealing in the eyes of the public, even though they are well recognized as the effective and sustainable stormwater management features. Therefore, appearance of these elements must be of concern to designers. The elaborate design of their cover grates is a simple, yet effective means to make them more attractive. Figure 13.59-13.61 provides some examples of elaborate-designed grates. In Mumbai, India, the storm drain grate is also an abacus allowing every child in the neighborhood able to count (see figure 13.62).

Figure 13.59-13.61 Examples of elaborate design of the covering grates (Picture source: https://www.pinterest.com/ezraremy/rills-and-runnels/, retrieved January 22, 2016)

Figure 13.62 The storm drain grate transformed into an abacus in Mumbai (Picture source: http://adsoftheworld.com/media/ambient/aseema_charitable_trust_abacus, retrieved January 22, 2016)

Figure 13.63 The open gutter at Scharnhorst-Ost neighborhood (Picture source: Backhaus and Fryd 2013: 55)

Figure 13.64 The drainage rill in Aix-en-Provence (Picture source: https://www.pinterest.com/slowottawa/urban-hydrology/, retrieved January 22, 2016)

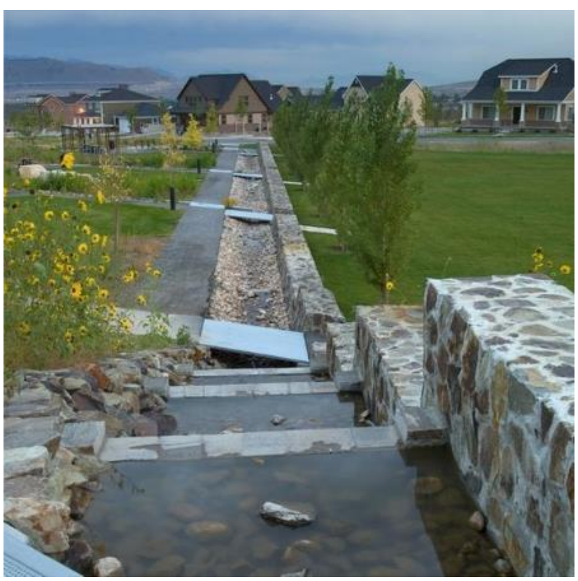

Figure 13.65 The stormwater canals at Daybreak Community (Picture source: http://landscapeperfor mance.org/case-study-briefs/daybreak-community, retrieved January 22, 2016)

Figure 13.66 The channel at Park Killesberg (Picture source: https://www.pinterest.com/slowottawa/urban-hydrology/, retrieved January 22, 2016)

Figure 13.67 The channel in Schwäbisch Gmünd (Picture source: https://www.pinterest.com/slowottawa/urban-hydrology/, retrieved January 22, 2016)

Figure 13.68 The river stone-lined drainage channel at the Historic Fourth Ward Park (Picture source: http://artfulrainwaterdesign.psu.edu/project/historic-fourth-ward-park, retrieved January 22, 2016)

Open street gutters or drainage channels are also the elements that easily lends themselves to the revelation of rain events and rainwater management. The open gutter located in Scharnhorst-Ost neighborhood of Dortmund, Germany which conveys runoff to the infiltration basin (see figure 13.63) and the drainage rill in Aix-en-Provence, a university city in southern France (see figure 13.64) are good cases in point. The stormwater canals at Daybreak Community in South Jordan, Utah offer opportunities for residents to witness rainwater flowing to a series of constructed treatment wetlands (see figure 13.65). The open channels allow people to not only see the rainwater, but also to touch or even to play with rainwater, such as the drainage runnel at Ekostaden Augustenborg in Malmö, Sweden (see figure 13.32). The open channels at Park Killesberg and Schwäbisch Gmünd in Germany allow people to interact with water (see figure 13.66-13.67). The fancy-shaped channels can also be very intriguing, such as the river stone-lined drainage channel at the Historic Fourth Ward Park in Atlanta, Georgia (see figure 13.68). Some more examples of fancy-shaped channels are presented in figure 13.69-13.72.

Figure 13.69-13.72 Some more examples in fancy-shaped channels (Picture source: https://www.pinterest.com/ezraremy/rills-and-runnels/, retrieved January 22, 2016)

Figure 13.73 The storm drain markers of the City of Philadelphia (Picture source: http://www.phillywatersheds.org/what_were_doing/community_partnerships/programs/storm-drain-marking, retrieved January 22, 2016)

Figure 13.74 The girl marking the stormwater drain with a marker (Picture source: http://www.phillywatersheds.org/category/blog-tags/ttf, retrieved January 22, 2016)

Apart from working on making creative designs, placing interpretive markers on storm drain inlets are also another means to interest and inform people about the function of storm drains and their relationships with the health of local water quality. Typically, these markers say such thing like “No Dumping, Drains to River” or “Keep It Clean, Drains to Creek,” and can be coordinated with volunteer events such as the Storm Drain Marking Program of the City of Philadelphia that has placed markers throughout the city (see figure 13.73-13.74).

13.2.3 Pavers/ permeable and impermeable pavement

As the survey made clear, people perceive pavers as not quite attractive and they do not recognize them as stormwater management means, compared to some other stormwater management features. Happily enough, the survey results also revealed that the attractiveness along with the effectiveness, sustainability, and recognizability regards to stormwater management of pavers are all higher than those of the conventional, impervious surfaces. Because pavers are more appreciated, both in terms of their aesthetic and ecological performances, the design of hard surfaces can maximize the use of pavers, as well as permeable pavement, while minimizing impermeable pavement.

Figure 13.75 The use of pavers to create interesting pavement pattern at Erie Street Plaza (Picture source: http://www.archdaily.com/155956/erie-street-plaza-stosslu, retrieved January 22, 2016)

Figure 13.76 The previous concrete pavement at the Edgewater Park (Picture source: http://www.cemstone.com/contractors-project-gallery-edgewater-park.cfm, retrieved January 22, 2016)

Realizing that pavement is the element in the landscape enables acess, making attractive pavement can effectively draw people into open spaces. At Erie Street Plaza in Milwaukee, Wisconsin, the pavers create a striking pattern (see figure 13.75). The pattern on the porous concrete pavement at the Edgewater Park in Minneapolis, Minnesota (see figure 13.76) "features integral blue color to symbolize the rivers of the Twin Cities, proving that pervious can be both decorative and sustainable" Cemstone (2016).

Figure 13.77 The sign informing about the porous pavement at Walden Pond (Picture source: http://www.millermicro. com/porpave.html, retrieved January 22, 2016)

Figure 13.78 The sign informing about the porous pavement at High Point Residential Development (Picture source: Echols 2007: 15)

People may find it difficult to differentiate pervious from impervious pavement and therefore may not recognize the environmental benefits of pavers and pervious pavement. The use of interpretive signage is a straightforward way to help people understand this point. The use of signage to inform people about the advantage of porous pavement can be found at the parking area of Walden Pond in Concord, Massachusetts and the sidewalk of High Point Residential Development in Seattle, Washington (see figure 13.77-13.78).

Figure 13.79 The permeable paving artwork at Dutch Kills Green (Picture source: http://landscapeperformance.org/case-study-briefs/dutch-kills-green, retrieved January 22, 2016)

Figure 13.80 The grated channel at the courtyard of Cedar River Watershed Education Center (Picture source: https://www.asla.org/ awards/2004/04winners/entry441.html, retrieved January 22, 2016)

Figure 13.81 The pavement transformed into a water channel in Gondrecourt-le-Chatea (Picture source: https://www.pinterest.com/ezraremy/rills-and-runnels/, retrieved January 22, 2016)

The designs of pavement that combine with drainage features can be an effective way to provide clues of stormwater management, such as the permeable paving artwork at Dutch Kills Green in New York which channels stormwater into infiltration areas (see figure 13.79). At Cedar River Watershed Education Center in North Bend, Washington, the grated channel crosses the pavement of the courtyard (see figure 13.80). In Gondrecourt-le-Chateau, France, the pavement is designed to transform into an open water channel (see figure 13.81). At these three places, visitors can witness the flow of rainwater, making them aware of the stormwater management of the places. Stepped runnels can also help accentuate the flow of water in the landscape. Figure 13.82 illustrates an example of a runnel incorporated into a stairway, creating a stairway fountain as does the stepped runnel at the Urban Plaza of Portland State University in Oregon (see figure 13.83).

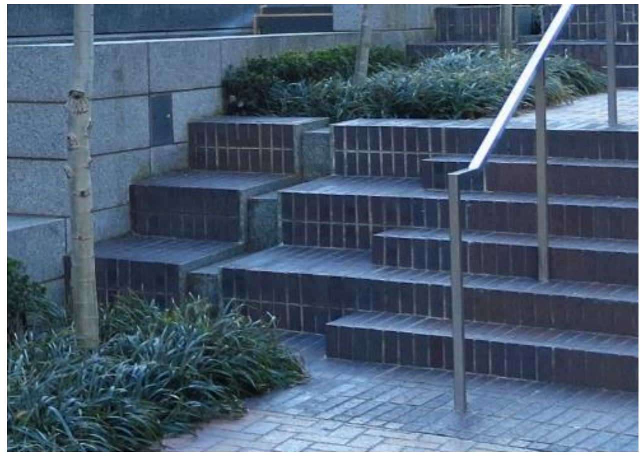

Figure 13.83 The stepped runnel at the Urban Plaza of Portland State University

Figure 13.82 An example of a stepped runnel creating a stairway fountain (Picture source: https://www.pinterest.com/ezraremy/rills-and-runnels/, retrieved January 22, 2016)

Figure 13.84 The creek name placed on the pathway of Lake Merritt

Figure 13.85 The street art created as a part of the City of Philadelphia Mural Arts Program (Picture source: https://www.pinterest.com/carolynubi/storm-water-management/, retrieved January 22, 2016)

Pavement can also be used to hint or inform people about the underground movement or system of stormwater. At Lake Merritt in Oakland, California, the creek names are placed on the pathway to let people know that there are creeks flowing underground (see figure 13.84). The street art created as a part of the City of Philadelphia Mural Arts Program aims to raise awareness of people about urban water system and stormwater runoff released into the city's waterways. The mass of blue dots represents rainwater moving into the inlets and flowing under the street in order to help people visualize the path water below the ground (see figure 13.85).

13.2.4 Lawn/ grass/ turf

Lawn has long maintained its popularity as an attractive landscape element, especially in North America. Even though lawn creates increasingly recognized ecological and economic drawbacks, its visual quality still attracts people. So, not surprisingly, the survey results revealed that attractiveness rating of lawn is exceptionally high. Notably, lawn is not actually considered one of the LID elements, but perhaps it might be because of its permeability that makes many people think that it can effectively and sustainably help manage stormwater.

As lawn is attractive to people's eye, yet not quite environmentally and economically beneficial, the use of lawn in this era of sustainable development should be minimized. Yet only a small patch of lawn can impress people if it is creatively designed. In addition, lawns which are not only for visual appreciation, but allow people to use them are desirable. Some good cases in point can be found at Randall Children's Hospital in Portland, Oregon, San Girolamo Urban Garden in Bari, Italy, Endeavour Primary School in Hampshire, United Kingdom, and Park Fiction in Hamburg, Germany, for example (see figure 13.86-13.89). Due to their artistic shape and form along with three-dimensional aspect, these lawns are very pleasing and playful.

Figure 13.86 The lawn at Randall Children's Hospital (Picture source: http://landscape performance.org/case-study-briefs/randall-childrens-hospital, retrieved January 22, 2016)

Figure 13.87 The lawn at San Girolamo Urban Garden (Picture source: http://www.archilovers.com/projects/46982/san-girolamo-urban-garden.html#images, retrieved January 22, 2016)

Figure 13.88 The lawn at Endeavour Primary School (Picture source: https://www.pinterest.com/gloviak/ landschaft/, retrieved January 22, 2016)

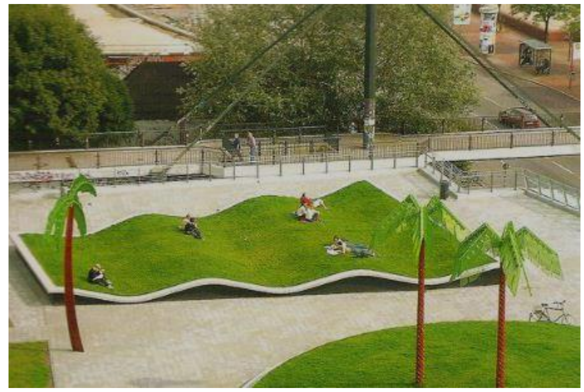

Figure 13.89 The lawn at Park Fiction (Picture source: https:// www.pinterest. com/peinrin77/l-lawn/, retrieved January 22, 2016)

Figure 13.90 The Levinson Plaza (Picture source: http://www.archdaily.com/174300 /levinson-plaza-mission-park-mik young-kim-design, retrieved January 22, 2016)

Figure 13.91 The Deichmann Plaza at Ben-Gurion University (Picture source: http:// www.bguf.org.uk/ news/deichmann-plaza-ben-gurion-university/, retrieved January 22, 2016)

Designs that incorporating lawn into hardscape create an interesting pattern and reduce impervious surfaces. At Levinson Plaza in Boston, Massachusetts and the Deichmann Plaza at Ben-Gurion University in Beer-Sheva, Israel, the combination of grass and pavers produce elegant patterns (see figure 13.90-13.91). The good examples in point can be found at the New High School Campus for the Cultural Institute in Mexico as well as at Sala Phuket in Thailand (see figure 13.92-13.93). The use of turf blocks or grasscretes can also create an attractive permeable pavement, such as the design for St. Mikes School in Santa Fe, New Mexico (see figure 13.94).

Figure 13.92 The use of grass and pavers at the New High School Campus for the Cultural Institute (Picture source: https:// www.pinterest.com/patriciat montei/urban-drainage, retrieved January 22, 2016)

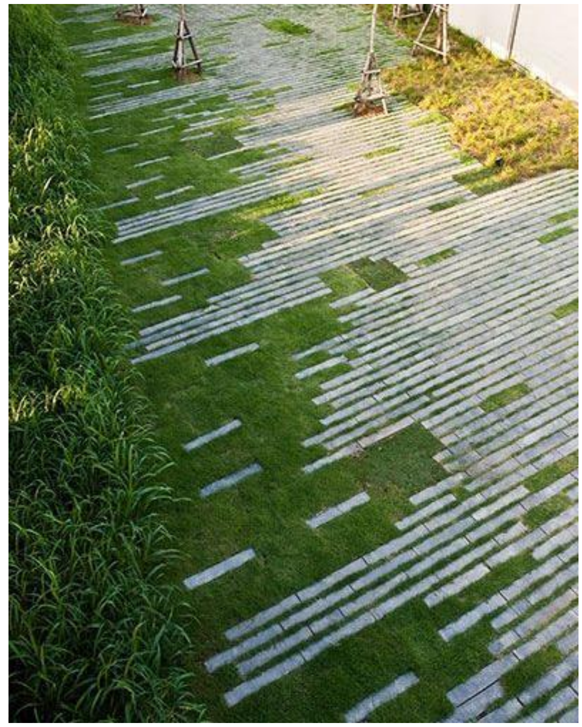

Figure 13.93 The use of grass and pavers at Sala Phuket (Picture source: http://www. departmentofarchitecture.co.th/?page_id=345, retrieved January 22, 2016)

Figure 13.94 The use of grasscrete at St. Mikes School (Picture source: https:// spsgrasscrete.wordpress. com/, retrieved January 22, 2016)

Nevertheless, the disadvantages of lawn is not widely recognized and the need to emphasize ecologically appropriate ways to care for lawns cannot be understated. The interventions other than design such as the use of interpretive signage, incentive programs, and interactive activities can inform people and raise their awareness about the environmental and economic disadvantages of lawns, such as those at Royal Botanic Garden in Sydney, Australia (see figure 13.95).

Figure 13.95 The interpretive sign about lawn care at the Royal Botanic Garden (Picture source: https://www.flickr.com/photos/rosrusspix/16551474439, retrieved January 22, 2016)

13.2.5 Rain garden/ bioretention planter/ bioswale

Based on the survey results, bioretention planters are very visually appealing to people. Perhaps the reason is that they look orderly, and sometimes also help make the landscapes around them look orderly, as they have rigid frames or boundaries. In addition, most of bioretention planters are often well-designed and some of them are designed to have unique shapes and forms, making them look special and even more attractive. Bioretention planters, furthermore, are also well recognized as the as effective and sustainable stormwater management features. Again, this might be the result of elaborate designs that make them look distinctive or even give some cues about their stormwater management functions. The void at the planter curb is considered the most important clue that make bioretention planters different from the typical ones. People can guess that these voids are designed to allow stormwater runoff to flow into the planters, thereby helping people recognize the stormwater management utility of the bioretention planters. There are abundance of excellent bioretention planter designs. At the plaza of Stephen Epler Hall in Portland State University, the bioretention planters are designed to have an outstanding appearance along with perceptible relationship with other stormwater management, particularly downspouts and runnels. These bioretention planters are not only attractive, but also recognizable as stormwater management features (see figure 6.2-6.3). The bioretention planters at 100 Taylor Avenue North and at Maynard Green Street in Seattle, Washington are also excellent in this way (see figure 13.96-13.98). Benches can be integrated into the design in order to help connect people with bioretention planters, such as the design of bioretention planters in NoMa (North of Massachusetts Avenue) neighborhood of Washington, DC (see figure 13.99). To be sure it may not always be easy for the public to recognize and appreciate the bioretention planters, interpretive signage can be very helpful, such as interpretive signs at the bioretention planters of San Pablo Avenue in El Cerrito, California (see figure 5.36).

 

Figure 13.96-13.97 The bioretention planters at 100 Taylor Avenue North

Figure 13.98 The bioretention planters at Maynard Green Street (Picture source: https://www.flickr.com/photos/rosrusspix/16551474439, retrieved January 22, 2016)

Figure 13.99 The design of bioretention planters at NoMa neighborhood (Picture source: http://parkerrodriguez.com/const2.html, retrieved January 22, 2016)

Bioswales along with bioretention basins, also known as rain gardens, often look messier than bioretention planters because they are generally bigger and not rigidly framed. This might be the reason why, as the survey reveals, the attractiveness of bioswales is obviously lower than that of bioretention planters. Since the effectiveness, sustainability, and recognizability in regard to stormwater management of bioswales are also lower than those of bioretention planters, Nassauer's idea of orderly framing (Nassauer 1995) may be essential to making bioswales more accepted. Designs that provide clues that bioswales are intentionally designed and carefully maintained can be seen at Fox Square in Oakland, California (see figure 5.25-5.26), Brisbane City Hall in Brisbane, California (see figure 5.27), Edinburgh Gardens in Melbourne, Australia (see figure 13.100-13.102), High Point development in Seattle, Washington (see figure 13.103).

Figure 13.100-13.102 The rain garden of Edinburgh Gardens (Picture source: https://urbanfloranl.wordpress.com/2012/10/31/the-edinburgh-gardens-rain-garden-in-melbourne/, retrieved January 22, 2016)

Figure 13.103 The bioswale at the High Point development (Picture source: https://www.pinterest.com/slowottawa/urban-hydrology/, retrieved January 22, 2016)

Planting is also pivotal to the appearance of bioretention cells. The weedy, messy look of planting can reduce the attractiveness of these elements. As mentioned above, orderly frames can play a role in making weedy planting looks more visually tidy. However, planting can also help enrich the attractiveness of the designs, such as the green and colorful plants used at 12th Avenue in Portland, Oregon and at High Point development in Seattle, Washington (see figure 13.104-13.105).

Figure 13.104 The use of green planting at 12th Avenue (Picture source: https://www.pinterest.com/apatton 12345/stormwater/, retrieved January 22, 2016)

Figure 13.105 The use of colorful planting at High Point development (Picture source: https://www.pinterest.com/carolynubi/storm-water-management/, retrieved January 22, 2016)

Figure 13.106 The bioswale at Sherbourne Common (Picture source: https://www.asla.org/ContentDetail. aspx?id=31738, retrieved January 22, 2016)

Figure 13.107 The rain garden at Shoemaker Green (Picture source: http://artfulrainwaterdesign.psu.edu/project/shoemaker-green-university-pennsylvania, retrieved January 22, 2016)

A bioretention facility sometimes can also be combined with a pool or channel, for example to create an attractive, artful water feature, such as the bioswale at Sherbourne Common in Toronto, Canada (see figure 13.106). Designs that allow people to get into and explore the bioretention facilities are very advantageous as they can enhance people-ecology relationship and also facilitate hands-on learning. One prime case in point can be seen at Shoemaker Green at the University of Pennsylvania (see figure 13.107).

13.2.6 Stormwater pond/ constructed wetland

As views of water are exceptionally appealing, pools, ponds, and wetlands which provide the presence of water are undoubtedly considered attractive elements in landscapes. In addition, as these water features are often easily perceived as effective and sustainable stormwater management features, the existence of these elements is also beneficial to the recognition of the stormwater management benefits of the landscapes. The wetland at Lowland Park, the second phase of Milliken State Park, in Detroit, Michigan and the stormwater pond at Durham College in Oshawa, Canada are the excellent examples of stormwater wetlands and ponds that help make the landscape more alluring to people (see figure 13.108-13.109). Besides, a stormwater pond or a treatment basin can also be designed as a water feature serving as a focal point or place landmark. The treatment basin at Yale University in New Haven, Connecticut serves as not only a focal point, but also a gathering space and a learning amenity (see figure 13.110-13.112). Oftentimes, the stormwater ponds and wetlands can look unkempt and then unappealing, in which the weedy plants are regarded as the key cause of this problem. To cope with this issue, the idea of "orderly frames" and "cues to care" Nassauer (1995) advocates can be helpful to enhance their attractiveness and recognizability. As one example, the geometric-formed steps and boardwalk at Tanner Spring Park in Portland, Oregon really help make the wetland pond look neat and nice to the eyes of the visitors (see figure 13.113). Similarly effective are the design of the walkway through the reed beds at Tianjin Qiaoyuan Wetland Park in Tianjin City, China and the design of a series of gabion structures at the constructed wetland of Renaissance Park in Chattanooga, Tennessee (see figure 13.114-13.115).

Figure 13.108 The wetland at Lowland Park (Picture source: http://landscapeperformance.org/case-study-briefs/ milliken-state-park-lowland-park, retrieved January 22, 2016)

Figure 13.109 The stormwater pond at Durham College (Picture source: https://www.pinterest.com/ slowottawa/urban-hydrology/, retrieved January 22, 2016)

Figure 13.110-13.112 The treatment basin at Yale University (Picture source: http:// landscapeperformance.org/case-study-briefs/kroon-hall-yale, retrieved January 22, 2016)

Figure 13.113 The wetland pond at Tanner Spring Park (Picture source: http://www.museumofthecity.org/ project/portlands-fountains-as-park-spaces/, retrieved January 22, 2016)

Figure 13.114 The walkway at Tianjin Qiaoyuan Wetland Park (Picture source: https://www. pinterest.com/ShirokayaV/lnd/, retrieved January 22, 2016)

Figure 13.115 The gabion structures at Renaissance Park (Picture source: https://www.pinterest.com/yalan_12935/landscape-design-detail/, retrieved January 22, 2016)

Figure 13.116 The walkway at Qunli Stormwater Park (Picture source: http://www.archdaily.com/446025/qunli-stormwater-wetland-park-turenscape, retrieved January 22, 2016)

Figure 13.117 The walkway at Minghu Wetland Park (Picture source: http://www.archdaily.com/590066/minghu-wetland-park-turenscape, retrieved January 22, 2016)

Stormwater ponds and wetlands can also be very valuable for both recreational and educational uses. The opportunity to get into and explore these landscape features is exceptionally useful and beneficial to the development of good relationship between people and water resource and the sound understanding of stormwater ecosystems and management measures. At Qunli Stormwater Park and Minghu Wetland Park in China, walkways encourage people to enjoy exploring the wetland ecosystems (see figure 13.116-13.117). At

Lowland Park in Detroit, Michigan, walkways and also interpretive signs are provided to support both recreational and educational opportunities (see figure 13.118-13.119).


Figure 13.118-13.119 The walkways and interpretive signs provided to support recreational and educational opportunities at Lowland Park (Picture source: http://landscape performance.org/case-study-briefs/milliken-state-park-lowland-park, retrieved January 22, 2016)

13.2.7 Green street/ green parking lot

Green streets combine a number of bioretention facilities, including bioretention planters, bioretention basins or rain gardens, and bioswales, along a significant length of the roadway. Obviously, green streets are appealing and often appear to be more attractive than the typical, standard streets. The plausible rationale is that the design of green streets makes them more beautiful and special. The physical aspects of these elements play a vital role in making people recognize the stormwater management intent of the designs. In particular, the gaps between the curbs of the bioretention facilities along with the weedy plants species are considered the important clues that help people recognize the stormwater management goal of the street designs.

Portland's Green Street Program is regarded as the pioneer and prototype of the design and implementation of green street idea. For decades, the city has developed and implemented design guidelines and standards for green streets. Following Portland's lead, today there are a large number of green streets throughout the United States. The SW 12th Avenue Green Street and the NE Siskiyou Green Street in Portland, Oregon (see figure 13.53-13.54) as well as the Cesar Chavez Green Street in San Francisco, California (see figure 5.33-5.34) illustrate the typical appearance of green streets. The increasing prevalence of green streets in cities and neighborhoods helps people become more familiar with green streets, thereby making green streets well recognized and appreciated. Nonetheless, interpretive signs can be helpful to inform passersby about the intent and goal of the green street designs. These signs are provided at several green streets projects such as San Pablo Green Street in El Cerrito, California (see figure 5.36), SW 12th Avenue Green Street in Portland, Oregon (see figure 13.120) and NE Siskiyou Green Street in Portland, Oregon (see figure 13.121).

Figure 13.120 The interpretive sign at SW 12th Avenue Green Street (Picture source: https://www.asla.org/awards/2006/06winners/341.html, retrieved January 22, 2016)

Figure 13.121 The interpretive sign at NE Siskiyou Green Street (Picture source: http://artfulrainwaterdesign.psu.edu/project/ne-siskiyou-green-street, retrieved January 22, 2016)

In transforming the entire length of streets, the stormwater management elements and functions must not impede, but improve the functionality as well as safety of the streets and sidewalks. The streetscape redesign along 1st Street NE between M Street and N Street in NoMa neighborhood of Washington, DC introduced a series of bioretention planters at the sidewalk which certainly helps improve not only water quality, but also the walking experience and the image of the neighborhood (see figure 13.122-13.123).

Figure 13.122 The bioretention planters along 1st Street NE in NoMa neighborhood (Picture source: http://www.nature.org/connectthedrops/protecting-the-potomac.xml, retrieved January 22, 2016)

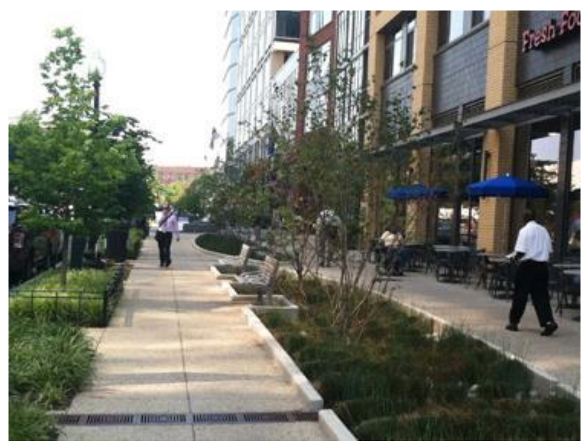

Figure 13.123 The bioretention planters along 1st Street NE in NoMa neighborhood (Picture source: https://asla.org/guide/site.aspx?id=35752, retrieved January 22, 2016)

Figure 13.124 The parking area at OMSI (Picture source: http://www.estuarypartnership.org/sites/default/files/fieldguide/examples/swale.htm, retrieved January 22, 2016)

Figure 13.125 The information signage at the parking area at OMSI

Figure 13.126 The parking area at CSUF (Picture source: https://www. pinterest. com/5marchitects/parking-lots/, retrieved January 22, 2016)

Similarly, the features of green parking lots often make them look more attractive and special than the conventional parking lots. Bioretention cells, especially bioswales, as well as permeable pavements are the key elements used in the design of green parking lots. In the parking area of Oregon Museum of Science and Industry (OMSI), bioswales replace conventional raised medians in order to function as wetlands that help convey, infiltrate, and filter stormwater runoff (see figure 13.124). Additionally, the design provides information signage to inform visitors of OMSI about the stormwater management functions of the bioswales in this parking area (see figure 13.125). At the novel parking area at California State University Fullerton (CSUF) in Fullerton, California, the bioswale not only helps improve the quality of stormwater runoff, but also helps improve the parking lot's aesthetic quality (see figure 13.126). Other examples of green parking lots can also be found at the Center for Urban Water in Takoma, Washington (see figure 13.127) and at El Cerrito City Hall in El Cerrito, California (see figure 13.128).

Figure 13.127 The parking area at the Center for Urban Water in Takoma

Figure 13.128 The parking area at El Cerrito City Hall

13.2.8 Green roof

As certainly confirmed by the survey, generally people seem to hold positive attitudes toward green roofs, known also as ecoroofs or vegetated roof systems. The replacement of dreary conventional roof materials with green or colorful certainly helps make green roofs look attractive and preferable to people. As Chicago City Hall Green Roof well demonstrates, a green roof can make not only the building on which it is installed, but seemingly also the city in which it is located more beautiful and appealing (see figure 13.129-13.130).

The ecological benefits of green roofs have been widely promoted for many years and by now green roofs are quite well recognized and appreciated by the public. The City of Portland, Oregon is one city trying to promote the use of green roofs and the Ecoroof Program is one of its pioneering efforts. According to Environmental Services, City of Portland (2009: 4): "Portland's Ecoroof Program is a cooperative effort of the Bureau of Environmental Services, Bureau of Planning and Sustainability, Bureau of Development Services and other bureaus that own facilities with roofs. The program promotes ecoroofs by researching ecoroof technologies and providing information and technical assistance to the public." The ecoroof of Hamilton West Apartments, implemented in 1999, is regarded as the first demonstration and test project of the City of Portland (see figure 13.131). As stated in Environmental Services, City of Portland (2005: 1), "Hamilton and other ecoroofs represent an important sustainable stormwater (low impact development) strategy. They manage stormwater at the source, using natural systems that have positive impacts for stormwater runoff volume and quality. Associated benefits such as energy cost reduction, air pollution and heat reduction, bird and insect habitat, extended roof lifespan, and urban beautification, make ecoroofs a valuable urban asset."

Figure 13.129 The Chicago City Hall before installing green roof (Picture source: https: //www.asla.org/meetings/awards/awds02/chicagocityhall.html, retrieved January 22, 2016)

Figure 13.130 The Chicago City Hall after installing green roof (Picture source: https: //www.asla.org/meetings/awards/awds02/chicagocityhall.html, retrieved January 22, 2016)

Figure 13.131 The ecoroof at Hamilton West Apartments (Picture source: Environmental Services, City of Portland 2009)

Besides the Ecoroof Program, there are also several other programs launched in the City of Portland with the aim of promoting the idea of green roofs. The Ecoroof Incentive offered five dollars per square foot of built ecoroof. This incentive program, which began in 2008 and ended in 2013, significantly increase the area of ecoroofs within the City. According to Cunningham (2014): “Since the late 1990s, over 560 extensive and intensive greenroofs have been installed in Portland, totaling more than 38 acres. The development of supporting policies like the ecoroof Floor Area Ratio Bonus, the Stormwater Management Manual, the City Green Building Policy and the Ecoroof Incentive helped build the momentum that led to a record-breaking 2013.” The chart presented in figure 13.132 illustrates the number and square footage of ecoroofs installed in the City of Portland from 1999 to 2013. The notable ecoroofs projects in Portland include the Performing Arts Building at Reed College (see figure 13.133), the Columbia Boulevard Wastewater Treatment Plant (see figure 13.134), the Emery Apartments in the South Waterfront district (see figure 13.135), and the new Walmart Portland Supercenter in Delta Park Center (see figure 13.136).

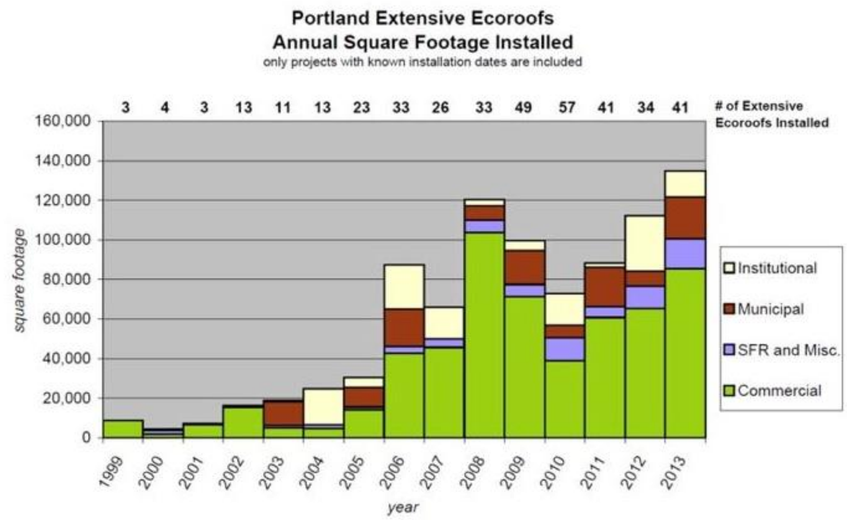

Figure 13.132 The chart illustrating the number and square footage of ecoroofs installed in the City of Portland from 1999 to 2013 (Picture source: Cunningham 2014)

Figure 13.133 The ecoroof at the Performing Arts Building at Reed College (Picture source: Cunningham 2014)

Figure 13.134 The ecoroof at the Columbia Boulevard Wastewater Treatment Plant (Picture source: Cunningham 2014)

Figure 13.135 The ecoroof at the Emery Apartments in the South Waterfront district (Picture source: Cunningham 2014)

Figure 13.136 The ecoroof at the new Walmart Portland Supercenter (Picture source: Cunningham 2014)

Apart from those of the City of Portland, there are also a number of programs launched by other cities throughout the United States. Philadelphia's Green Roof Tax Credit program provides owners or developers of green roofs constructed in the city a tax rebate for 50% of the construction costs up to $100,000 (Philadelphia Water n.d.). The ecoroofs projects in Philadelphia include the Law School of the University of Pennsylvania (see figure 13.137) and the PECO building (see figure 13.138). These programs, along with other plans and policies established to promote and support the implementation of green roofs, significantly increased the interest in implementing more green roofs, thereby helping increase the number of green roofs in the United States. The increasing number of green roofs, in turn, substantially help people recognize and appreciate them more.

Figure 13.137 The green roof at the Law School of the University of Pennsylvania (Picture source: Philadelphia Water n.d.)

Figure 13.138 The green roof at the PECO building (Picture source: Philadelphia Water n.d.)

Green roofs present considerable opportunities for broad implementation. Therefore, developing prototypical designs is certainly useful to the extensive reproduction of green roofs and many green roof design manuals, standards, and guidelines exist. These documents facilitate green roof implementation by making it easier, practical, and more common, thereby resulting in the increase of installed green roof projects. The *Ecoroof Handbook* (2009) and the *Ecoroof Guide* (2010) developed by the Environmental Services of the City of Portland are particularly good resources for the development and implementation of green roofs. While prototypical design can accelerate broad implementation of green roofs, outstanding designs can promote the idea of green roofs. Such designs can effectively catch public attention and promote replication of green roofs. As mentioned earlier, the Living Roof of California Academy of Science is an excellent case in point.

The fact that many green roofs are not publicly accessible is a key limitation that impedes the possibility for the public to experience, enjoy, and learn about green roofs. This can be mitigated by designs that can offer or support site visit programs, such as the tours offered at ASLA Headquarters Green Roof. Designs can provide appropriate spaces for recreational and educational activities, such as the aforementioned California Academy of Science and Gary Comer Youth Center. Notable visual access alone can also advance public recognition, appreciation, and education of green roofs. As noted by ASLA (2016), whereas the green roof of Chicago City Hall "is not normally accessible to the public, it is visually accessible from 33 taller buildings in the area. The design form is intended to be read from these various vantage points."

13.2.9 Green wall

As the survey elucidated, people also hold positive attitudes toward green walls, though green walls are slightly less recognizable compared to green roofs. This might be because green walls have been less promoted and implemented than green roofs, making them less prevalent and popular than green roofs. An increase in the interest and implementation of green walls would require policies, programs, and incentives as well as design and construction guidelines that support their installation.

Creating the demonstration projects is one effective way to promote the benefits of green walls. The green walls installed on the southeast side of Gould Hall at the University of Washington (UW) in Seattle, Washington is one key demonstration project aiming to promote the benefits of green walls (see figure 13.139). As Nancy Rottle, the director of the UW Green Futures Lab, said, "We want to use the project as a billboard for new sustainable practices, and to discover to what extent green walls and screens can help promote biodiversity, produce food and reduce energy use. By harvesting water to irrigate the green wall, the project will reduce potable consumption and may lessen storm water impacts" (quoted in Kelley 2012).

Figure 13.139 The green wall project of the University of Washington (Picture source: https://green.uw.edu/gsf/ project/2032, retrieved January 22, 2016)

Due to the fact that green walls, like green roofs, lend themselves to being replicated, the development of prototypical designs is helpful to the extensive implementation green walls. Today, there are a number of innovative green wall products and technologies as well as companies and contractors that design and install green walls, making the implementation of green walls is much more pragmatic and feasible. Notably, most of green walls are installed with the aim of creating visual aesthetics, improving air quality, reducing energy consumption, mitigating urban heat island effects, and increasing urban biodiversity rather than managing stormwater. The stormwater management functions of green walls, thus, need to be highlighted. The City of Portland, again, has realized the importance of this issue. According to Buranen (2015: 28): “Portland… has several exterior green walls, including those at the Modera Hotel, the Oregon Museum of Science and Industry, the Federal Building, the parking garage at the airport, and various apartment buildings. None of these walls were designed to manage stormwater. Using green walls to manage stormwater is still a new concept. But, because Portland is often on the cutting edge in trying new types of green infrastructure, it’s not surprising that the city is now involved with green walls built for that purpose.” The green wall at the Portland Expo Center is the first stormwater green wall in Portland. The native plants used in this green wall help filter and absorb rainwater drained from the building roof (see figure 13.140-13.141).

Figure 13.140-13.141 The green wall at the Portland Expo Center (Picture source: https://www.portlandoregon.gov/bes/article/505020, retrieved January 22, 2016)

Figure 13.142-13.143 The Watershed Consciousness at the welcome court of the Evergreen Brick Works (Picture source: http://inhabitat.com/ferruccio-sardellas-flourishing-green-watershed-wall-is-a-living-map-of-torontos-waterways/ferrucio-green-wall-lead/, retrieved January 22, 2016)

Like many other stormwater management elements, the creation of arty green wall projects is very powerful attention-getter. The Living Water Map, also named as Watershed Consciousness, is a vertical living sculpture installed on the building wall at the welcome court of the Evergreen Brick Works in Toronto, Canada (see figure 13.142-13.143). For this sculpture, rainwater plays a vital maintenance role in feeding its plants. This green wall also represents the watershed network of Toronto. According to Ferruccio Sardella, the artist who created this project: "The whole purpose of the artwork is to re-connect us to the watersheds that sustain us—to look at a map of Toronto from a different perspective and raise our water consciousness" (Boyer 2012).

13.2.10 Scupper/ downspout

The last but not least key stormwater management features are scuppers and downspouts. Even though insights regarding people's attitudes toward them are not explicit as they were not included in the dissertation survey, extrapolating from the reactions to the elements that were part of the survey is possible. Likely scuppers and downspouts would be recognized as effective and sustainable stormwater management features, yet not the attractive or intriguing ones. Accordingly, making them prominent in stormwater management designs is one way to highlight their existence. The scuppers of the Swenson Civil Engineering Building at the University of Minnesota in Duluth, Minnesota are oversized and create not only a stunning visual imagery of the building, but an enlightening stormwater management showcase as well (see figure 13.144-13.145). The simple, yet remarkable design of the scuppers of the International Student Center (ISC) at Kansas State University in Manhattan, Kansas manifestly release runoff from the roof of the building into the rain gardens, celebrating the rain events and also inform spectators about rainwater management measures (see figure 13.146).

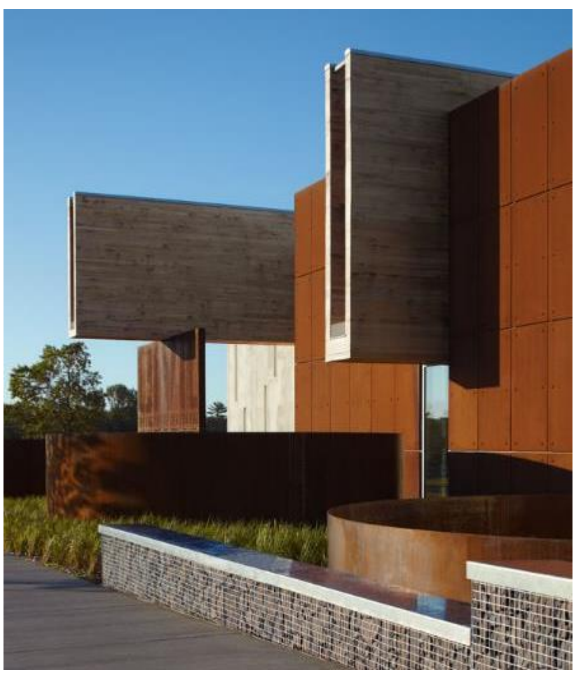

Figure 13.144-13.145 The scuppers of the Swenson Civil Engineering Building at the University of Minnesota Duluth (Picture source: http://americanbuilders quarterly. com/2012/swenson-civil-engineering-building/, retrieved January 22, 2016)

Figure 13.146 The scuppers of the International Student Center at Kansas State University (Picture source: http://artfulrain waterdesign.psu.edu/project/kan sas-state-interna tional-student-center-rain-garden, retrieved January 22, 2016)

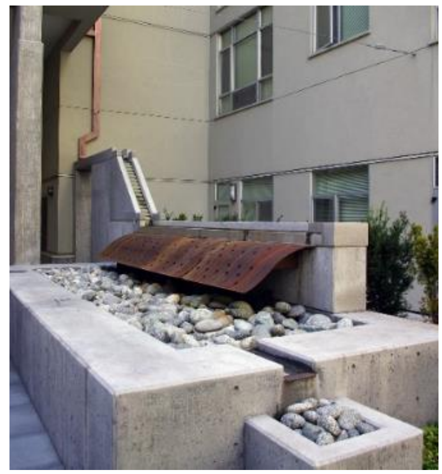

Figure 13.147-13.149 The copper downspouts at the courtyard of 10th@Hoyt Apartment (Picture source: http://artfulrainwaterdesign. psu.edu/project/10thhoyt, retrieved January 22, 2016)

Creating the designs that relate downspouts to water features can significantly clue in people that the water they are seeing comes from rain. One vivid example is the downspout to the Water Glass, designed to look like a straw in a glass, at the plaza of Ellington Condominium in Seattle, Washington (see figure 13.14). The three copper downspouts at the courtyard of 10th@Hoyt Apartment in Portland, Oregon which convey roof runoff down to stepped runnels and then sculptural fountains also help make spectators realize that these water features are parts of the rainwater system (see figure 13.147-13.149). At Grant Park Village in Portland, Oregon, the downspout pours rainwater to the spiral-shaped, gravel-filled runnel and then into the bio-retention planter, creating a striking set of interconnected stormwater features (see figure 13.150).

Figure 13.150 The downspout at Grant Park Village (Picture source: http://walshconstructionco.com/our-work/ grant-park-village/, retrieved January 22, 2016)

Making scuppers and downspouts into elements or artworks which are eye-catching and thought-provoking also helps highlight the existence of these elements, such as the downspouts at several locations of the New Seasons Market, a local grocery chain in the Portland region. One of them is the metal sculpture of a shopper standing under a storm cloud located at the Seven Corners location which, when raining, looks like water is falling from the cloud onto the shopper and then into the bioswale (see figure 13.151). Likewise, during raining, the steel watering can figures attached to a downspout of the Cedar Hills location appear like they pour rainwater onto the bioswale (see figure 13.152). At the same location, a steel salmon silhouette attached to a downspout represents a salmon swimming up the river (see figure 13.153). The idea of attaching salmon figures to a downspout or a scupper to create a striking artwork that celebrate rainwater can also be found at the Arbor Lodge location (see figure 13.28-13.29), the Hawthorne Hostel, as well as at an insurance company in Portland, Oregon (see figure 13.154-13.155). Figure 13.156-13.169 illustrate other examples of arty scupper and downspout designs.

Figure 13.151 The sculptural downspout at New Seasons Market’s Severn Corners (Picture source: http://ivanmclean.com/ 2011/02/, retrieved January 22, 2016)

Figure 13.153 The steel salmon downspout at New Seasons Market's Cedar Hills (Picture source: http://www.harvestingrainwater.com/imagesvideoaudio/image-gallery/contempora ry-water-harvesting-art/, retrieved January 22, 2016)

Figure 13.152 The downspout watering cans at New Seasons Market's Cedar Hills (Picture source: http://www.harvestingrainwater.com/imagesvideoaudio/image-gallery/contempora ry-water-harvesting-art/, retrieved January 22, 2016)

Figure 13.154 The downspout at Hawthorne Hostel (Picture source: http://www.harvesting rainwater.com/imagesvideoaudio/image-gallery/contempora ry-water-harvesting-art/, retrieved January 22, 2016)

Figure 13.155 The downspout at an insurance company in Portland (Picture source: http://www.harvestingrainwater.com/imagesvideoaudio/image-gallery/contemporary-water-harvesting-art/, retrieved January 22, 2016)

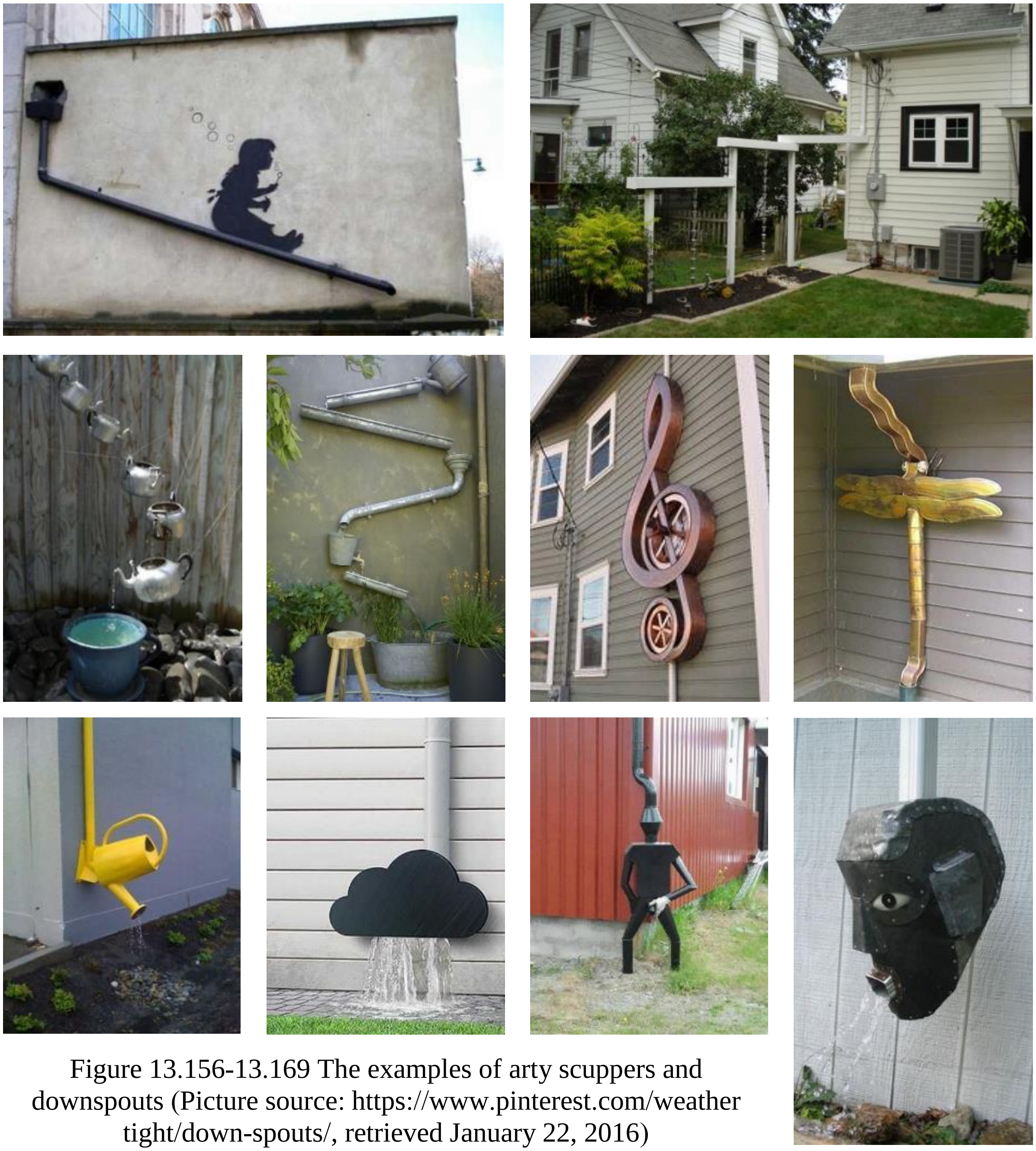

Figure 13.156-13.169 The examples of arty scuppers and downspouts (Picture source: https://www.pinterest.com/weathertight/down-spouts/, retrieved January 22, 2016)

Chapter 14
Conclusion

This dissertation provides information and insight relevant to public appreciation of and education about sustainable stormwater management in San Francisco Bay Area, but hopefully this knowledge can be useful in other geographical areas and, ultimately, to the field of landscape architecture and environmental planning—especially, the practice of ecological design. This last chapter, therefore, provides conclusions regarding the key implications and contributions of this dissertation which are twofold. One is the considerations pertinent to the achievement of sustainable stormwater management and the other is the considerations regarding the theories and methods applicable to the study of attitudes toward ecological design.

14.1 Considerations for achieving sustainable stormwater management

This research proposes that apart from considering ecological function as the fundamental, those who are responsible for the application of sustainable stormwater management should consider aesthetic expectation as the requisite, stormwater education as the opportunity, ecological literacy as the goal, and landscape design as the means for the success of the projects. This paradigm, however, can be adopted and applied to the other types of ecological landscape design as well.

14.1.1 Aesthetic expectation as the requisite

Based on the survey results discussed in chapter 8, 9, and 10, it is evident that the urban LID cases were, for the most part, aesthetically appreciated by the public, thereby suggesting that these projects can serve as good models for the ensuing projects. Moreover, this discovery also implies that the implementation of LID design can definitely be continued within urban contexts without serious concern about public resistance of its aesthetic quality.[1] Nonetheless, as many landscape scholars have raised, the application of LID facilities should not take aesthetic considerations for granted.

LID facilities, although accomplishing ecological goals, have long been criticized for their visual quality which seems unable to fulfill aesthetic expectation of the public. According to Echols (2007: 2), "stormwater facilities are often engineered simply to solve excess runoff problems with no concern for aesthetic or other qualities." In consequence, these facilities continually appear to be illegible and unable to draw public interest. Furthermore, these facilities also typically possess messy or unkempt looks which defy the conventional ideal of scenic beauty, especially the "picturesque," which glorifies neat and

[1] It is important to note that even though this finding seems able to be applied to other geographical areas of the country, the application must be carefully done with regard to the different geographical, social, and other contexts. In some cases, thus, the studies specific to the areas may be in need in order to provide more and certain insight.

orderly appearance. As discussed in chapter 2, this kind of problem can also be found within a whole range of ecological landscape design and restoration projects. According to Mozingo (1997: 58), “The lack of aesthetic value of most ecological designs lends it a ploddingness that is neither appealing to us as designers, nor as humans. It creates a kind of landscape hair shirt that may make some feel holy but sends too many of us running to the nearest Italian garden.” For that reason, in the words of David Orr (2002: 180), “The standard for ecological designers is to cause no ugliness, human or ecological, somewhere else and at some later time.”

In this present time, as stormwater management facilities are a growing part of urban landscapes, their aesthetic quality is crucial (National Research Council of the National Academies 2008: 373). Specifically, the aesthetic appeal of such facilities has a tremendous effect on not only the beauty of the cities, but also public acceptance and support which is vital to their success and sustainability. The tenet that aesthetic pleasure of the public plays a significantly part in supporting ecological landscape designs has been advocated by many scholars and practitioners, whether in landscape design, planning, and management, or in other related fields. As Gobster, Nassauer, Daniel, and Fry (2007: 969) argue, “a key societal pathway to addressing ecological goals is through aesthetic experiences.” According to Mozingo (1997: 46), “The positive aesthetic experience of “in the ground” built projects which encompass new ideas of good landscape form can positively promote change. It can impel support of the radical alteration in environmental priorities that ecological design implies.” On top of that, Nassauer (1997: 81) also points out that “In the twenty-first century, landscape ecology must be supported by cultural sustainability. Landscapes that evoke the sustained attention of people—that compel aesthetic experience—are more likely to be ecologically maintained in a world dominated by humans.”

Within the past decades, furthermore, the “ecological aesthetic” was initiated and promoted as a new aesthetic paradigm, as also discussed in chapter 2. In brief, as Gobster, Nassauer, Daniel, and Fry (2007: 962) clearly explain, “An ecological aesthetic is, by definition, normative in that it asserts that it is desirable for humans to take aesthetic pleasure from landscape that embody beneficial ecological functions. In this way, aesthetic experiences can promote and sustain healthier ecosystems, and thus indirectly promote human health and welfare.” Accordingly, as Spirn (1984: 37) notes, “It is time to expand what has been a romantic attachment to the ornaments of nature into a commitment to reshape the city in harmony with the workings of nature.”

Aesthetics, both conventional and ecological, hence, must be considered and encompassed in order to ensure appreciation and support of sustainable stormwater management projects from the public and, ultimately, promote and sustain healthy stormwater ecosystems of the cities.

What is more is that, by applying what Nassauer (1993: 60) said—“One way that people will learn how to appreciate biological diversity and rich landscape structure is by seeing it in suburbs that encourage people to begin to innovate”—to urban areas and sustainable stormwater issues, it seems plausible that to implement more LID projects in cities is also very advantageous to the boost of the appreciation of sustainable stormwater facilities. In other words, realizing that familiarity also plays a significant role in landscape preference

(Kaplan 1977: 235-250), to make people more and more familiar with LID projects by implementing more and more such projects can also beneficial in this regard.

14.1.2 Stormwater education as the opportunity

Considering the survey results discussed in chapter 11 and chapter 12, the statistics manifest that people thought they were not quite knowledgeable about sustainable stormwater management, yet they were also quite open to information and knowledge, especially through reading the interpretive signs at the LID sites. Thus, the fact that urban LID facilities can be utilized as public outreach or on-site demonstrations for educational purposes should not be understated. Instead, these facilities should be certainly considered a means for teaching or transferring stormwater knowledge to urban society and then establishing desirable relationships between aesthetics and ecology. As Pennypacker and Echols (2008: 28) clearly state, “An on-site stormwater management system can be an engaging opportunity to educate people about rainwater issues from promoting awareness of stormwater best management practices strategies to the site’s historical water condition.”

After the mid-twentieth century, the idea that aesthetic appreciation of nature is a matter of knowledge has been extensively reiterated, as discussed in chapter 2. According to this tenet, appreciation of landscape—in the same way as appreciation of arts such as drawings, paintings, music, and poetry—could be enriched by knowledge (Rolston 1995: 377; Matthews 2002: 37). Especially for this age of environmental crisis, people do need knowledge to help them understand how nature appears as what they see and how it is important to their lives (Rolston 1995: 377). Furthermore, knowledge can also release people from mistakenly experiencing ecologically destructive phenomena as scenic landscapes (Nassauer 1997: 8), thereby attenuating the power of the picturesque paradigm in landscape appreciation (Carlson 2012). As we know, it took centuries to promote a picturesque paradigm until it eventually became the epitome of landscape aesthetics. Thus, we do need time to educate people to appreciate the beauty of sustainable or ecological landscapes, including urban LID facilities. But this will not take too long because our exceedingly serious environmental crisis is currently accelerating the implementation and appreciation of ecologically sustainable projects. As Nassauer (1993: 60) writes, “What looks weedy to most people today may look beautifully diverse as people learn more about the function and sustainability of ecologically designed landscapes.” Apart from that, environmental consciousness and stewardship of the public can be enhanced by ecological knowledge and literacy (Stapp et al. 1969; Orr 1992).

Education, thus, is a pivotal means to bring aesthetic and ecological values of landscapes into closer alignment, and, ultimately, promote and sustain healthy ecosystems. For example, as Gobster, Nassauer, Daniel, and Fry (2007: 962) exemplify, “by learning about the important ecological functions of bogs and swamps, and perhaps by gaining experience and appreciation of some of their ecological features, people might come to have more positive experiences in them, or at least be willing to accept their ecological benefits as a fair trade for their aesthetic shortcoming. Knowledge interventions can also aim at teaching people about the negative impacts of some environmental conditions or practices so that they might be less likely to engage in them. For example, by learning about the invasive tendencies of some visually attractive plants, people might come to see them as undesirable and refrain from planting them in residential gardens where they could escape into the wild.” In addition, Gobster, Nassauer, Daniel, and Fry (2007: 970) state that: "Knowledge interventions relevant to landscape aesthetics come in many forms, from information provided by agencies and through the media, to on-site signage, guided and self-guided tours, and more extended experiential activities such as involvement in ecological restoration programs."

Driven by laws and regulations, stormwater education has become widespread and the provision of ecological and environmental knowledge to the public has notably increased. As reviewed in chapter 3, the US EPA issued the Phase II of the NPDES program in 1999. According to this federal mandate, Public Education and Outreach—which refers to the effort to educate citizens about the impacts of polluted stormwater runoff—is required to be implemented by certain municipalities (US EPA 2005a). This regulatory requirement can be fulfilled by providing educational materials (especially brochures, fact sheets, posters, bumper stickers, or websites), learning activities, and volunteer opportunities, for example, for citizens, both kids and adults (US EPA 2005b). Ultimately, the implementation of Public Education and Outreach has been mandated with the goal of establishing informed and knowledgeable communities, stimulating citizens to change their attitudes and behaviors toward sustainable stormwater management as well as to appreciate and advocate LID initiatives and projects, all crucial to the achievement of stormwater management programs (US EPA 2005c).

Within recent years, many stormwater management facilities—such as Canal Park in Washington D.C., Thornton Creek Water Quality Channel in Seattle, Cedar River Watershed Education Center in North Bend, Abbotsford Wetland Park in British Columbia, San Pablo Rain Gardens in El Cerrito, Brisbane City Hall in Brisbane, and several Green Street projects in Portland—have intended to offer the public several opportunities meant for stormwater education. Nonetheless, as Gobster, Nassauer, Daniel, and Fry (2007: 970) mention: "The efficacy of knowledge interventions in different landscape and situational contexts is a subject worthy of further research effort."

14.1.3 Ecological literacy as the goal

According to the results of the survey discussed in chapter 11, the issue regarding water pollution and water shortage was not subtle to the public. Rather, among the seven environmental problems raised in this study, water pollution and water shortage appeared to be the one about which the respondents were most concerned. Given that, it seems as if they were quite thoughtful about water crisis. However, the study demonstrates that a multitude of the respondents still held some misconceptions and limited ideas about stormwater ecosystems and problems. They were unlikely to be literate enough regarding this subject, even though they expressed appreciation of the LID landscapes. This suggests the pivotal role that sustainable stormwater management or LID design projects implemented in cities could play in advancing the inhabitants' ecological literacy, especially the literacy in terms of sustainable stormwater ecology and management.

In this environmentally conscious time, people are the real actors in achieving future sustainability, and their ecological literacy is necessary in this acheivement, as discussed in chapter 2. In particular, ecological literacy significantly help people profoundly understand environmental problems and effectively advocate rationally environmental policies and practices. Furthermore, their ecological literacy also significantly helps them recognize the ideas regarding ecological ethics and aesthetics, thereby motivating them to properly develop pro-environmental attitudes and behaviors. Realizing that sound knowledge is the basis of ecological literacy, education, particularly environmental education, has been extensively highlighted as the means to provide scientific knowledge about the environment and, ultimately, to establish ecologically literate citizens. Undeniably, advancement of people's ecological literacy is not an easy task.

Within recent decades, however, scholars and designers have advocated the tenet that the ecological literacy can be developed by not only environmental education, but also empirical experience within their everyday urban landscapes. As Spirn (1984: 274) argues, "Although some are more adept than others, every citizen is well versed in reading the urban ecosystem. Small children are taught to read history of a tree's growth in its branching pattern and twigs and to diagnose a tree's health from its appearance." Mozingo (1997: 57) also articulates that "the next generation will be more ecologically literate, but they will be literate about ecology in a very unprecedented way. The children in these environmental education programs dwell in cities. Their ecological literacy generates from their everyday urban context, rather than from a rural or wilderness context typical of the environmental education of previous generation. This is a much more socially and culturally inclusive concept of environmental learning which draws upon the vestiges of ecological systems that exist in all part of the urban landscapes… The ecosystems with in the city cannot expect to have the ecological value and caliber of those ecosystem within the ecological domain, but they have much more power to change culture in their immediacy and proximity." Accordingly, the application of landscape design, especially ecological design, in cities should consider and include ecological literacy as a potential, reasonable goal.

The applicable way to address ecological literacy as the goal of LID design is the provision of educational opportunities in order to advance visitors' knowledge necessary to the understanding of sustainable stormwater ecology and management. As discussed in chapter 3 and in the previous section, the potential of utilizing urban LID facilities as public outreach or on-site demonstrations for stormwater education has been widely underlined and manifested across the country. Adopting what Mozingo (1997: 57) elucidates in the excerpt presented above, another effective way that people will be more literate about sustainable stormwater ecology and management is by seeing and experiencing its vestiges in their daily urban life. Therefore, providing more evidences or indications of sustainable stormwater ecology and management by implementing more LID projects in cities could result in increasing the chance to reach the goal of raising people's stormwater literacy.

14.1.4 Landscape design as the means

In considering of the survey results discussed in chapters 8 and 9, landscape design did play a role in making people appreciate the LID sites. Nonetheless, because some LID facilities and features were still unable to achieve public satisfaction and recognition, making attractive and legible designs must be the emphasis.

Throughout history, design proved to be an effective means for creating and communicating landscape qualities, especially aesthetic appeal. Design can be a powerful tool to align aesthetic and ecological values of landscapes. As Gobster, Nassauer, Daniel, and Fry (2007: 969) argue, "landscape design and related planning, policy, and management activities may be used to intervene to bring aesthetic and ecological goals into closer alignment." In addition, Gobster, Nassauer, Daniel, and Fry (2007: 972) also state that "Landscape planning, design, and management that address the aesthetics of future landscape patterns, then, can be powerful ways to protect and enhance ecological goals." As they clarify, "design that aims to meet ecological goals should also strive to deliver positive aesthetic experiences, consistent with public aesthetic expectation for a particular landscape context. Landscapes that produce important ecological benefits are unlikely to last in human dominated landscapes if they are undistinguished or aesthetically unattractive. Appropriate design, planning, policy, and management can create aesthetically attractive landscapes, achieving ecologically beneficial landscapes that are also culturally sustainable" (Gobster, Nassauer, Daniel, and Fry 2007: 970). During recent decades, as discussed in chapter 2, several landscape scholars have developed and proposed myriad of design principles and recommendations for enhancing the aesthetic qualities of ecological landscapes, which can be adopted and applied to LID design. Prominent among them include "cues to care" (Nassauer 1995), "impelling forms" (Hester 1995), "visibility, temporality, reiterated forms, expression, metaphor" (Mozingo 1997), "hypernature" (Mayer 2008), and "eco-scape" (Reimer 2010). In addition, the concept of "artful rainwater design" intends specifically to guide the design of sustainable stormwater management facilities, emphasizing the use of "rainwater to create amenities that enhance a site's attractiveness or value" (Echols and Pennypacker 2008a: 268).

Apart from granting aesthetic pleasure, landscape design can also enrich educational opportunities. As scientific knowledge is fundamental to ecological design, many scholars aver that design could and should be used to transfer knowledge to society. Specifically, because ecological landscapes hold educational potential for urban dwellers, the design of such landscapes can significantly play a role in enhancing these opportunities. According to Orr (2002: 31), "ecological design must become a kind of public pedagogy built into the structure of daily life." The typical method used in this regard is the use of well-designed interpretive signage system. In many national parks, nature reserves, wildlife preserves, ecological restoration projects, and also stormwater management facilities, accordingly, the series of interpretive stands and signs are provided to serve their visitors with relevant information and knowledge, as discussed in chapter 2. In addition to this straightforward technique, Pennypacker and Echols (2008: 28) also proposed, based on the idea of "artful rainwater design," that stormwater education can be addressed in the landscapes through another technique, which is the "thought-provoking design." As discussed in chapter 3, this technique refers to the creation of stunning elements in order to call public attention to stormwater management efforts.

Based on the design strategies gleaned from various literature along with the information derived from the survey, this dissertation develops an innovative set of design criteria, as presented in chapter 13. Specifically, this dissertation proposes that for the sustainable stormwater management landscapes to fulfill public aesthetic expectation and stormwater education, they should possess 1) visibility and legibility, 2) accessibility, 3) functionality, 4) attractiveness and interestingness, 5) cultural aesthetics, 6) ecological revelation, 7) interactive activities, 8) interpretive signage, 9) water features, and 10) application and replication. Even though this set of design criteria intends to guide the design of sustainable stormwater management facilities in San Francisco Bay Area, it can also be applied to other types of ecological design and other geographical areas. In addition to the design criteria, chapter 13 presents design guidelines for specific sustainable stormwater management elements using examples from all over the world including: 1) water tank/ cistern, 2) street gutter/ storm drain/runnel, 3) pavers/ permeable pavement, 4) lawn/ grass/ turf, 5) rain garden/ bioretention planter/ bioswale, 6) stormwater pond/ constructed wetland, 7) green street/ green parking lot, 8) green roof, 9) green wall, and 10) scupper/ downspout.

Above all else, the results of this study underscore the centrality of design to sustainable stormwater management efforts as well as other ecological landscape projects. In particular, given the idea that good landscape designs can empower people and move our society toward sustainable future, it is crucial to emphasize the role of design in creating powerful ecological landscapes. In other words, design should be considered as an effective means for making the landscapes which not only effectively sustain ecological functions, but also properly offer aesthetic aspects to enhance user satisfaction together with educational opportunities to raise public ecological knowledge and literacy.

14.2 Considerations for studying attitudes toward ecological design

Realizing that the achievement of sustainable stormwater management along with other ecological design efforts needs public support, understanding public attitudes toward such landscape design is vital. Accordingly, research that can provide this insight is also vital. This dissertation found that landscape aesthetics and behavioral sciences, among others, serve as foundations of this sort of research. As discussed below, those who aim to study attitudes toward ecological design should consider landscape aesthetics as theoretical bases and consider methods in behavioral sciences as methodological bases.

14.2.1 Landscape aesthetics as theoretical bases

This research highlighted the importance of relationships between beauty and ecology in landscape design. As Gobster, Nassauer, Daniel, and Fry (2007: 961) state, “attention to ecological quality can be influenced by the perceived aesthetic value of landscapes.” To explore attitudes toward ecological landscapes, landscape aesthetics is a key theoretical basis study.

Aesthetics has been one of the principal theories in landscape perception and design throughout history. The word “aesthetics” has its root from the Greek, aisthetikos, which means “things apprehended by the senses” (Hyman and Stiftel 1988: 115). Although “Beauty is in the eye of the beholder”—which literally means that the perception of beauty is subjective or different people have different ideas about what is beautiful—has come to be a renowned statement, many philosophers have believed in the existence of shared patterns on the subject of human aesthetic judgment. As Immanuel Kant claimed in his classic philosophical work, *The Critique of Judgment* (1790), aesthetic judgment is differentiated into two fundamentals, subjectivity and universality (Zangwill 2010). What this means is that while aesthetics is evaluated based on human senses or feelings of pleasure, the nature of aesthetic judgment also possesses universal validity (Atalay 2007: 44-45). This is because, all people are humans so that they tend to share some same basic instincts and needs, including those of aesthetic judgment.

Irrefutably, aesthetic conventions grounding for landscape preference have evolved over time as a result of cultural, social, political, and economic contexts. Arguably, the eighteenth century's picturesque ideal of landscape beauty prevails in current landscape aesthetics (Hunt 1992: 285). The term "picturesque," which literally means "picture-like," refers to aesthetic appreciation of nature which is considered as art-like scenes—especially those of landscape paintings (Carlson 2012). Over centuries, the picturesque has maintained its popularity as the prominent convention of scenic landscapes throughout Europe and North America. For the reason that neat and orderly appearance is one key fundamental of such paramount landscape beauty on which people have long been entrenched (Nassauer 1995: 163), a great number of ecological landscape design and restoration projects, including LID facilities, are unlikely to fulfill this aesthetic expectation of the public due to their unsightly or unusual visual aspects.

Because the disjuncture between aesthetics and ecology of landscapes has an immense effect on future sustainability of landscapes, a range of ideas and theories relevant to the interactions between aesthetics and ecology in landscape perception have emerged. In particular, realizing that ecological landscapes have often fallen short of achieving public appreciation and support, scholars and practitioners in the fields of landscape design and planning as well as those in the field of ecology, psychology, sociology, and so on, have developed and proposed several ideas and theories to rationally explain the causes of this conflict and suggest the ways to cope with it. In brief, landscapes which hold ecological benefits often have an unkempt or untidy appearance which rebels against the conventional, cultural ideal of landscape aesthetics, especially the "picturesque," resulting in the lack of public appreciation and support of these ecological landscapes. In order to tackle this onerous problem, thus, the interventions which aim at or result in the modification of aesthetic perception and preference of the public are imperative. More specifically, the interventions through landscape design and environmental education are suggested as two effective means that, according to Gobster, Nassauer, Daniel, and Fry (2007: 959), "might establish desirable relationship between aesthetics and ecology," thereby helping sustain ecological landscapes.

14.2.2 Behavioral sciences as methodological bases

This dissertation, like many studies in landscape and environmental design field—such as those done by Kevin Lynch, Clare Cooper, Rachael Kaplan, Joan Nassauer, just to name a few—employed methods in behavioral sciences to study attitudes of the public toward landscapes and landscape designs. These behavioral science methods, have distrinct value in exploring attitudes toward ecological landscapes.

Since the mid-twentieth century, the relationship between humans and their environment had emerged as a major concern (Moore and Golledge 1976: xi), thereby resulting in the increase of interest in human-environment research based on behavioral science, the scientific study of human attitudes and behaviors. In the context of human-environment research, specifically, behavioral science investigates issues regarding the development of the understanding of human activities and attitudes associated with a physical environment, particularly the built environment. In order to thoroughly study such issues, the field also involves anthropology, sociology, psychology, geography, economics, and politics.

Behavioral research has been more central to everyday life than most people realize. Sommer and Sommer (2002: 1) note that: “The lives of all of us have been touched, directly or in directly, by the procedures and results of behavioral research.” Over the last half century in the design and planning disciplines, the partnership with behavioral sciences has grown extensively. According to Gutman (1972: 337): “This development shows up in the extensive care that many architects now give to determining user needs before beginning to work on designs, in the effort to include sociologists and psychologists as members of design-building team, and in growing tendency, both in America and in England, to allow building forms to express behavioral science concepts about the nature of man and society.” Design professionals often really want the information behavioral scientists to guide their design practice. Unfortunately, as Lang (1987: 22) points out: “One of the problems has been that much of the recent research by both behavioral scientists and designers, presented at conferences such as those of the Environmental Design Research Association (EDRA), is not focused on issues of direct concern to designers. This has led to much discussion of the ‘utility gap’ between research findings and professional practice…” Lang stated this almost three decades ago and since then behavioral science has increasingly and significantly produced empirical facts useful for the design and planning disciplines, including those related to issues of aesthetics and ecology. The research precedents provided in chapter 4 are some examples of research that supplies designers insights about human behaviors and attitudes toward their surrounding ecosystems that can be applied to design practice.

Behavioral science uses the scientific method or “as close an approximation of it as possible” (Lang 1987: 22) and its results are considered more trustworthy than casual observations or subjective, normative ideals of the designers. Aside from its findings, the important contribution of behavioral science is its research methods that useful and powerful for gathering data or extracting information from individuals.

In this dissertation, the classic, paper questionnaire survey was selected as data collection method and several statistical tools were employed to analyze the collected data and to test research hypotheses, as discussed in chapter 4 and chapter 7. This set of data collection and analysis methods proved to be very effective in generating insights about public appreciation and education of sustainable stormwater management for this dissertation. Therefore, those who intend to study issues of a kind can consider applying this set of methods to their work. Nonetheless, one important lesson arose from the use of take-home-questionnaire survey. The key limitation of this method is that the researchers could not propel the respondents to complete every single question so that respondents left blank answers. The good design of questions can reduce this problem. In particular, respondents tended to answer close-ended questions more consistently than open-ended questions. Another way to address this is to increase the sample size. As this study found that the missing answers can reach up to 30% for open-ended questions, the target respondent sample size should be 40, instead of 30, in order to make sure that the answers for each question will be more than 30, enough to produce sound statistics.

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Appendix A: Notice of approval for human research

UNIVERSITY OF CALIFORNIA AT BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO   SAN FRANCISCO • SANTA BARBARA • SANTA CRUZ

COMMITTEE FOR PROTECTION OF HUMAN SUBJECTS
OFFICE FOR THE PROTECTION OF HUMAN SUBJECTS
University of California, Berkeley
2150 Shattuck Avenue, Suite 313
Berkeley, CA 94704 -5940

(510) 642-7461
Fax: (510) 643-6272
Website: http://cphs.berkeley.edu
FWA#00006252

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE:	*June 03, 2014*
TO:	*Louise A. MOZINGO, Lands Arch* *Wilasinee Suksawang, Lands Arch*
CPHS PROTOCOL NUMBER:	*2014-04-6197*
CPHS PROTOCOL TITLE:	*Towards Ecological Literacy: Design for Sustainable Stormwater Management Appreciation and Education in Urban Landscapes of San Francisco, California.*
FUNDING SOURCE(S):	*NONE*

A(n) *new* application was submitted for the above-referenced protocol. Your submission has been reviewed by the Office for the Protection of Human Subjects (OPHS) and granted exemption, as it satisfies the Committee's requirements under category *2* of the federal regulations.

Effective Date: *June 03, 2014*

Amendments/Modifications: Any change in the design, conduct, or key personnel of this research must be approved by the OPHS ***prior*** to implementation. For more information, see Amend/Modify an Approved Protocol.

Please note that although your research has been deemed exempt from full committee and subcommittee review, you still have a responsibility to protect your subjects, and the research should be conducted in accordance with the principles of the Belmont Report. Download the Belmont Report at this link: www.hhs.gov/ohrp/humansubjects/guidance/belmont.html.

This approval is issued under University of California, Berkeley Federalwide Assurance #00006252.

If you have any questions about this matter, please contact the OPHS staff at 642-7461; fax 643-6272; or email ophs@berkeley.edu .

Sincerely,

Rebecca ARMSTRONG
Committee for Protection of Human Subjects

Page: 1

Appendix B: Survey instrument of this dissertation

College of Environmental Design
Landscape Architecture & Environmental Planning
University of California, Berkeley
202 Wurster Hall #2000 Berkeley, CA 94720-2000
Tel. (510) 642-2962 Fax. (510) 643-6166

Survey on Urban Landscape Design of Mint Plaza, San Francisco, CA

This research aims to study public responses to the design of urban landscapes. The ultimate goal is to develop design guidance for creating better urban landscapes for the City of San Francisco and its vicinity.
This survey consists of 4 pages. The total time to complete the survey is approximately 5-10 minutes. When finished, please mail it by using the provided stamped envelope by **February 15, 2015**.
Your participation in this study is voluntary. No personal information will be asked. Everything collected through this survey will be kept confidential. For more information about the research and survey, please contact the researcher, Wilasinee Suksawang, at (510) 703-2251 or <wilasinee@berkeley.edu>.

1.1 How long have you known Mint Plaza?
☐ First visit ☐ Less than a month ☐ Less than a year ☐ More than a year

1.2 How often do you visit Mint Plaza?
☐ Daily ☐ Weekly ☐ Few times a month ☐ Rarely

1.3 What do you usually do when you visit Mint Plaza? (Please select all that apply.)
☐ Pass by ☐ Rest/ Relax ☐ Eat/ Drink ☐ Meet friends
☐ Join events ☐ Other (please specify) ______

1.4 To what extent do you like each of the following aspects of the landscape design of Mint Plaza?
(For each aspect, please select a number that applies.)

	Not at all				Very much
- Aesthetic attractiveness	1	2	3	4	5
- Functional adequacy and efficiency	1	2	3	4	5
- Ecological performance	1	2	3	4	5
- Other (please specify) ______	1	2	3	4	5
- ______	1	2	3	4	5

2.1 How concerned are you with each of the following ecological problems in the San Francisco Bay Area?

	Not concerned				Most concerned
- Global warming/sea level rise	1	2	3	4	5
- Air pollution	1	2	3	4	5
- Water pollution/shortage	1	2	3	4	5
- Energy shortage	1	2	3	4	5
- Waste management	1	2	3	4	5
- Land degradation/soil contamination	1	2	3	4	5
- Wildlife habitat degradation	1	2	3	4	5
- Other (please specify) ______	1	2	3	4	5
- ______	1	2	3	4	5

2.2 Do you know any place that you have visited or heard of that has ecological benefits?
☐ No. ☐ Yes. Please specify the place(s) ______

3.1 To what extent do you think each of the following possible sources has impact on water pollution in the Bay Area?

	No impact				Significant impact
- Discharge from industrial uses	1	2	3	4	5
- Discharge from waste treatment plants	1	2	3	4	5
- Runoff from farms and ranches	1	2	3	4	5
- Runoff from streets and roofs	1	2	3	4	5
- Runoff from lawns and yards	1	2	3	4	5
- Other (please specify) ______	1	2	3	4	5
- ______	1	2	3	4	5

1/4

3.2 In your opinion, what are sustainable ways to manage urban stormwater? (Please select all that apply.)

- ☐ Drain it to sewer treatment plant
- ☐ Treat it before discharging
- ☐ Hold it in ponds or lakes
- ☐ Drain it to nearby waterbodies
- ☐ Allow it to infiltrate into the ground
- ☐ Collect it for future uses
- ☐ Other (please specify) ____________

3.3 Do you know any place that you have visited or heard of that implemented sustainable stormwater management?

☐ No. ☐ Yes. Please specify place(s)____________

4.1 To what extent the landscape design of Mint Plaza is sustainable in terms of stormwater management?

1	2	3	4	5
Not sustainable				Very sustainable

4.2 Which landscape features in Mint Plaza help to manage urban stormwater in a sustainable way? (Please select all that apply.)

- ☐ Planting
- ☐ Paving
- ☐ Trenches/pipes
- ☐ Cistern
- ☐ Planters
- ☐ Pavers
- ☐ Lawn/grass
- ☐ Pool/pond/fountain
- ☐ Other (please specify)____________

5.1 Have you ever learned or received any information about sustainable stormwater management?

☐ No. ☐ Yes. Please specify the source(s) of information ____________

5.2 Have you ever participated any programs about sustainable stormwater management?

☐ No. ☐ Yes. Please specify the program(s) you paticipated ____________

5.3 To what extent do you think that you are knowledgeable about each of the following topics?

	Not knowledgeable				Very knowledgeable
- Sustainable Stormwater Management	1	2	3	4	5
- Low impact development (LID)	1	2	3	4	5
- Best Management Practices (BMPs)	1	2	3	4	5
- Nonpoint Source (NPS) Pollution	1	2	3	4	5
- Combined Sewer Overflows (CSOs)	1	2	3	4	5
- Stormwater Runoff	1	2	3	4	5
- Stormwater Interception	1	2	3	4	5
- Stormwater Infiltration	1	2	3	4	5
- Stormwater Filtration	1	2	3	4	5
- Stormwater Detention/ Retention	1	2	3	4	5
- Stormwater Drain	1	2	3	4	5
- Green Infrastructure	1	2	3	4	5
- Green Roof	1	2	3	4	5
- Green Wall	1	2	3	4	5
- Green Street	1	2	3	4	5
- Green Parking Lot	1	2	3	4	5
- Rainwater Harvesting	1	2	3	4	5
- Rain Barrel/ Cistern	1	2	3	4	5
- Rain Garden	1	2	3	4	5
- Bioretention Planter	1	2	3	4	5
- Bioswale/Vegetated Strip	1	2	3	4	5
- Permeable Pavement/Paver	1	2	3	4	5
- Detention/ Retention Basin	1	2	3	4	5
- Constructed Wetland	1	2	3	4	5
- Riparian/ Coastal Buffer	1	2	3	4	5

6.1 To what extent are you interested in learning more about stormwater management?

1	2	3	4	5
Not interested in				Very interested in

2/4

6.2 Below are some learning options. To what extent are you likely to do any of these options in order to learn more about sustainable stormwater management?

	Not likely				Most likely
- Attend classes/workshops	1	2	3	4	5
- Read publications (book, newspaper, etc.)	1	2	3	4	5
- Watch TV/ listen to radio programs	1	2	3	4	5
- Search websites or online sources	1	2	3	4	5
- Attend exhibitions in museums or centers	1	2	3	4	5
- Participate in volunteer programs	1	2	3	4	5
- Read informative signs at the facilities	1	2	3	4	5
- Other (please specify) ______________	1	2	3	4	5
- ______________	1	2	3	4	5

7.0 Below are twelve landscape elements. Please rate each of them regarding the following four issues:

- Attractiveness (to what extent you think that the element is aesthetically attractive)
- Effectiveness (to what extent you think that the element is effective in terms of stormwater management)
- Sustainability (to what extent you think that the element is sustainable in terms of stormwater management)
- Recognizability (to what extent you recognize the stormwater management function of the element)

(For each issue, select a number that applies. For each element, make sure to give a rating for all four issues.)

7.1) Water Tank/Cistern

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.2) Lawn/Grass/Turf

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.3) Pavers

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.4) Paving

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.5) Bioretention Planter/Rain Garden

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.6) Bioswale/Vegetated Swale

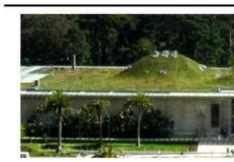
Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.7) Trench/Gutter/Strom Drain

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.8) Green Street

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable



7.9) Green Roof

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.10) Green Wall

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.11) Pool/Pond

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

7.12) Constructed Wetland

Not Attractive	1	2	3	4	5	Most Attractive
Not Effective	1	2	3	4	5	Most Effective
Not Sustainable	1	2	3	4	5	Most Sustainable
Not Recognizable	1	2	3	4	5	Most Recognizable

8.1	Gender	☐ Male	☐ Female	
8.2	Age	☐ Less than 20	☐ 21-30 years old	☐ 31-40 years old
		☐ 41-50 years old	☐ 51-60 years old	☐ More than 60 years old
8.3	Education	☐ High school or lower	☐ Undergraduate or college degree	☐ Master degree
		☐ Doctoral degree	☐ Other (please specify) ________	
8.4	Study Field	☐ Please specify ________		
8.5	Occupation	☐ Please specify ________		

Thank you very much for your participation.

4/4

Appendix C: Survey instrument of the first pilot study

College of Environmental Design
CITY AND REGIONAL PLANNING
University of California, Berkeley
228 Wurster Hall #1850
Berkeley, California 94720-1850
phone 510.642.3256
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San Francisco Small Urban Open Spaces Survey

Researchers in the College of Environmental Design at University of California, Berkeley are studying the small urban open spaces in San Francisco to improve the design of these spaces. The survey will take about 5 minutes to complete. When finished, please send it by using the provided stamped envelope by **November 17, 2012**. No personal information will be asked. Everything collected through this survey will be kept confidential. If you have any questions, please contact Wilasinee Suksawang (wilasinee@berkeley.edu) or Amna Alruheili (alruheili@berkeley.edu).

1. How do you like Mint Plaza?

-3	-2	-1	0	+1	+2	+3
Strongly dislike			Neutral			Strongly like

2. How long have you known Mint Plaza?
   - [ ] First visit
   - [ ] Less than a month
   - [ ] Less than a year
   - [ ] More than a year

3 How often do you visit this place?
   - [ ] Daily
   - [ ] Weekly
   - [ ] Few times a month
   - [ ] Rarely

4. How long do you usually stay in this place?
   - [ ] Less than half an hour
   - [ ] Less than 1 hour
   - [ ] More than 1 hour
   - [ ] Rarely stay

5. What do you usually do when you visit here? (Please select one or more)
   - [ ] Have lunch
   - [ ] Drink coffee
   - [ ] Sit
   - [ ] Talk
   - [ ] Read
   - [ ] Watch people
   - [ ] Join special events
   - [ ] Walk dog
   - [ ] Other. Please specify ______________________

6. What is one thing you <u>most</u> like about this place?

   ____

7. What is one thing you <u>least</u> like about this place?

   ____

8. Which other urban plazas in Downtown San Francisco do you usually go to?

   ____
   ____

9. Why do you like to go to these places?

   ____
   ____

10. What did you think about Mint Plaza when you saw it for the first time? ______________________________

    ____
    ____
    ____

11. What do you think this place is used for? ___________

    ____
    ____
    ____

12. Have you ever been here after a heavy rain?
    - [ ] Yes
    - [ ] No

13. What do you think happens here after a heavy rain , and why? ________________________________

    ____
    ____
    ____

14. Which features of this place do you think will function well in dealing with heavy rain, and why?

    ____
    ____
    ____
    ____

Please move to the next page

15. Below are some examples of storm water control measures that can be applied in Mint Plaza. Based on your preference, please rate their desirability and effectiveness.

A) Tank

-2	-1	0	1	2
Very undesirable		Neutral		Very desirable

-2	-1	0	1	2
Very ineffective		Neutral		Very effective

B) Grass

-2	-1	0	1	2
Very undesirable		Neutral		Very desirable

-2	-1	0	1	2
Very ineffective		Neutral		Very effective

C) Pavers with Grass

-2	-1	0	1	2
Very undesirable		Neutral		Very desirable

-2	-1	0	1	2
Very ineffective		Neutral		Very effective

D) Trench/ Gutter

-2	-1	0	1	2
Very undesirable		Neutral		Very desirable

-2	-1	0	1	2
Very ineffective		Neutral		Very effective

E) Planter

-2	-1	0	1	2
Very undesirable		Neutral		Very desirable

-2	-1	0	1	2
Very ineffective		Neutral		Very effective

F) Pond

-2	-1	0	1	2
Very undesirable		Neutral		Very desirable

-2	-1	0	1	2
Very ineffective		Neutral		Very effective

16. Gender [ ] Male [ ] Female

17. Age [ ] Less than 20 [ ] 20-40 years old [ ] 40-60 years old [ ] More than 60 years old

18. Field of study ______________________ 19. Occupation ______________________

Thank you very much for your time

Appendix D: Survey instrument of the second pilot study

[ ] LA 130 [ ] PSY 101

Survey on Knowledge and Perception of Sustainable Urban Stormwater Management in Urban Landscape Design

This survey is a part an exploratory study in PSY 101 Research and Data Analysis in Psychology. No personal information will be asked. Everything collected will be kept confidential.

Part I: Personal Backgrounds

1.1	Gender	[ ] Male	[ ] Female		
1.2	Age	[ ] Less than 20	[ ] 20-30 years old	[ ] 30-40 years old	[ ] More than 40 years old
1.3	Status	[ ] UCB Student	[ ] Visiting Student		
1.4	Study Level	[ ] Undergraduate	[ ] Graduate		
1.5	Field of study	Please specify ……………………………………………………………………………………			
1.6	Nationality	Please specify ……………………………………………………………………………………			

Part II: Knowledge of Sustainable Urban Stormwater Management in Urban Landscape Design

2.1 Do you think that you have any knowledge about the following topics?

- Sustainable urban stormwater management	[ ] Yes	[ ] No
- Low impact development (LID) design	[ ] Yes	[ ] No
- Runoff	[ ] Yes	[ ] No
- Nonpoint source (NPS) pollution	[ ] Yes	[ ] No
- Rainwater harvesting	[ ] Yes	[ ] No
- Rain garden	[ ] Yes	[ ] No
- Permeable pavement	[ ] Yes	[ ] No
- Bioretention basin	[ ] Yes	[ ] No
- Vegetated swale	[ ] Yes	[ ] No
- Constructed wetland	[ ] Yes	[ ] No
- Detention pond	[ ] Yes	[ ] No
- Dry well	[ ] Yes	[ ] No
- Wet pond	[ ] Yes	[ ] No
- Green roof	[ ] Yes	[ ] No

2.2 How have you learned about sustainable stormwater management?

[ ] Never Learned	[ ] Classroom	[ ] Internet	[ ] Television programs
[ ] Books	[ ] Museum Exhibitions	[ ] Site Visits	[ ] Volunteer Programs
[ ] Contact with Experts	[ ] Others. Please specify ………………………………………………………		

Part III: Perception of Sustainable Urban Stormwater Management in Urban Landscape Design

In the next page, eight examples of urban stormwater management design elements are presented.
Please rate them, based on your opinion, regarding the following three issues.

- Appreciation (to what extent you think that the element is aesthetically attractive)
- Sustainability (to what extent you think that the element is sustainable in term of stormwater management)
- Recognizability (to what extent you recognize the stormwater management function of the element)

Please cross the dot of the score you want to choose – for example, X.
Make sure to choose three scores for each element, one for each issue.

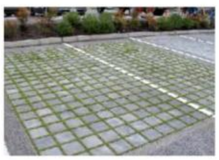
Page 1 of 2

3.1 Water Tank/ Cistern

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

3.2 Lawn/ Grass

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable



3.3 Pavers

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

3.4 Planter

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

3.5 Pool/ Pond

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

3.6 Swale

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

3.7 Paving

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

3.8 Trench/ Gutter

	1	2	3	4	5	6	7	
Least Attractive								Most Attractive
Least Sustainable								Most Sustainable
Least Recognizable								Most Recognizable

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