ASSESSING KNOWLEDGE ABOUT HYDROLOGY AMONG LANDSCAPE ARCHITECTS IN NORTH TEXAS

by

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Abstract

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The purpose of this study is to determine the level of knowledge in hydrology a landscape architect needs in professional practice versus the hydrological knowledge, and resulting skill, gained from education. The research also explores the knowledge and skill of other professionals practicing hydrology and determines the amount of knowledge gained by education and practical experience. Finally, the research compares any overlap of knowledge and skill between the professions of landscape architecture and hydrology.

Water is a central resource for all economic, social and environmental activities. Hydrology and topics such as water supply, demand and quality are affected by various methods used by landscape architects and engineers to deal with water, including Low Impact Development (LID) and other strategies (ASLA, 2013c; Green, 2012; WWAP, 2012). The Texas Water Development

Board (TWDB) predicts an 82 percent increase in population from 2010 to 2060 and a 22 percent increase in water demand. Large urban areas, such as North Texas, are expected to see larger increases in population than the state average and, therefore, larger increases in demand (TWDB, 2012). The projected outpacing of water demand over supply necessitates a greater understanding of hydrology among landscape architects.

The American Society of Landscape Architects (ASLA) includes language about water in its definition of the practice of landscape architecture. Moreover, it is argued that landscape architects are prepared with the knowledge needed to offer services pertaining to water and the hydrological function of land (Adsit, 2012; ASLA, 2003; O'Rourke, 2008; Marsh, 1983). However, little research has been uncovered on the topic of hydrology as a function of the landscape architecture discipline and area of practice.

This research followed qualitative methods of inquiry and used informant interviews to collect data (Taylor & Bogdan, 1998) on professionals' experiences with hydrology in education and practice. Professionals in landscape architecture and hydrology in North Texas were asked identical sets of open-ended questions. The responses were analyzed by retrieving keywords and major concepts from which patterns and themes could be identified to inform the findings of this research (Taylor & Bogdan, 1998; Glaser & Strauss, 1967).

Data indicated a knowledge gap between education and professional practice in landscape architecture as well as between the professions of landscape architecture and hydrology. Data also showed varying perceptions of overlap of services between the professions. It was concluded that the key area of knowledge needed for landscape architects concerning hydrology is stormwater management, and the landscape architects interviewed received minimal educational training on the topic.

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Chapter 1
Introduction
1.1 Background

Since Roman times builders such as Marcus Vitruvius stressed the importance of hydrology when planning new settlements. Frederick Law Olmstead considered ecological issues, including hydrology, in his approach to planning park systems in the early 20th century. Later, Ian McHarg reintroduced Warren Manning's concept of overlay analysis, emphasizing the conservation and protection of natural processes (O'Rourke, 2008). William Marsh described water issues and their role in landscape planning and design. He suggested a methodology for dealing with groundwater, watershed/floodplain management, pollution, and other water issues (Marsh, 2005).

In its definition of landscape architectural practice, the American Society of Landscape Architects (ASLA) describes the role of water in the profession. Landscape architectural services include studies of water resources, as well as technical written and graphical communication, to aid in the planning and design of landscapes that affect water supply and quality (ASLA, 2003).

Several agencies and organizations report on water supply, demand, use, and quality. The United States Geological Survey (USGS), the Texas Water Development Board (TWDB), the North Central Texas Council of Governments (NCTCOG) and others report statistics on water data. The reports illustrate the effect of increasing human population as well as physiological and climate factors that affect water. For example, a USGS estimate in 2000 indicated that Americans withdrew 408 billion gallons of water each day for all uses (USGS, 2013). TWDB describes data pertinent to this research, including a 50-year water plan that contains projections for water usage, supply, and demand (TWDB, 2012).

Human use is not the only factor that affects hydrology and its relationship to land. Extreme climate, notably severe droughts, shrinks surface and ground water supplies. In 1997, after nearly five decades of moderate-to-severe drought, Texas lawmakers decided that decreasing water supplies threatened the state's future and as a result passed Senate Bill 1. This legislation directed that the state be divided into sixteen regional water-planning districts and that the TWDB publish a state water plan every five years. Data from the most recent (2012) water plan were used in this study (TWDB, 2012).

The emphasis on planning in the state's approach to handling water issues relates to the field of landscape architecture. By definition, landscape architecture involves the planning of water and land resources (ASLA, 2003), so landscape architects delve into hydrology as part of their job description (and as part of the reason for professional licensure). The broader literature reviewed in the following chapter further outlines ways that landscape architects deal with hydrology, including stormwater and water quality. It also discusses the traditional roles of landscape architects in education and professional practice.

It is implicit in the current scholarship, education and practice of landscape architecture that exposure to hydrology and other water issues in the academic setting should prepare professionals to perform services pertaining to hydrology. This applies to both landscape architecture and engineering. However, little research was uncovered on the topic of hydrology as a function of landscape architecture discipline and area of practice. Study is needed to determine the role of hydrology and water in landscape architecture and whether there are similarities with professions in hydrology. There is no previous research on hydrology as an area of specialization or concentration within landscape architecture, but landscape architects are expected to perform some of the duties of hydrologists. The level of hydrological knowledge among landscape architects is at the core of this research.

1.2 Purpose of Research

The purpose of this research is to determine the level of knowledge in hydrology that landscape architects need in professional practice, compared to that which they acquire in their education. It similarly explores the hydrological knowledge of other professionals practicing hydrology, and determines the amount of each that was gained from education and from practical experience.

Other explorations in this research involve the overlap of knowledge among landscape architects and hydrologists. Identifying the level of knowledge of hydrology of professionals in each field aids in delineating the similarities and differences of their roles in hydrology. Differences in knowledge within each profession are also discovered and attributed to pertinent factors, which include the amount of time practicing and the academic program the professional completed.

1.3 Research Questions

The principal questions posed in this research are:

What is the level of competency in hydrology needed by a landscape architect in routine professional practice?

What knowledge about hydrology is acquired in landscape architecture education?

Is there an overlap of services between landscape architects and other professionals who practice hydrology?

1.4 Definition of Terms

The following list contains some terms used frequently in this thesis. Definitions and acronyms (when applicable) are applied in relation to the subject of this research.

American Society of Landscape Architecture (ASLA): A professional society that represents landscape architects in the United States and Canada and seeks to better the practice and understanding of landscape architecture through education, research, state registration and other programs (ASLA, 2002).

Best management practice (BMP): A low impact control that is the most effective and practicable means of controlling point or nonpoint source pollutants at levels compatible with environmental quality goals (PGC, 1999).

Built environment: The man-made creation of or alterations to a specific area, including its natural resources. This is in contrast to the natural environment (ASLA, 2002).

Design: The creative illustration, planning and specification of space for the greatest possible amount of harmony, utility, value and beauty (ASLA, 2002).

Ecology: A branch of biology dealing with the relationship between living things and their environment (ASLA, 2002).

Grade: The slope of a plot of land. Grading is the mechanical process of moving earth changing the degree of rise or descent of the land in order to establish good drainage and otherwise suit the intent of a landscape design (ASLA, 2002).

Ground water: Rain and snow water accumulated in the earth's porous rock (ASLA, 2002).

Hydrologist: A professional who applies scientific and mathematical principles to solve water-related problems in society (USGS, 2013).

Hydrology: The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground (ASCE, 1999).

Integrated management practice (IMP): A group of low impact best management practices controls placed strategically across a site to interact with and treat stormwater at its source (PGC, 1999).

Impervious surface: A hard surface that prevents or retards the movement of water down into the soil and creates runoff potential (PGC, 1999).

Infiltration: The downward movement of water from earth's surface into the soil (PGC, 1999).

Landscape architect (LA): A professional who designs, plans and manages outdoor spaces ranging from entire ecosystems to residential sites, and whose media include natural and built elements; also referred to as a designer, planner, consultant, not to be confused with landscapers, landscape contractors or nurserymen (ASLA, 2002).

Landscape architecture: The science and art of design, planning, management and stewardship of the land. Landscape architecture involves natural and built elements, cultural and scientific knowledge, and concern for resource conservation to the end that the resulting environment serves a useful and enjoyable purpose. Successful landscape architecture maximizes use of the land, adds value to a project and minimizes costs, all with minimum disruption to nature (ASLA, 2002).

Low impact development (LID): The integration of ecological and environmental goals for a site into all phases of urban planning and design (PGC, 1999).

Planning: The illustration and description of problem statements and large-scale design solutions that affect extensive areas of land; the anticipation of problems to be encountered as human use and development of land continue (ASLA, 2002).

1.5 Methodology

Qualitative research methods were used in this study to determine the characteristics of hydrological knowledge and skill in landscape architecture and hydrology (Taylor & Bogdan, 1998). An interview protocol was created and interviews with key informants from the fields of landscape architecture and hydrology were performed in North Texas. Selection for the informant pool was based on previous acquaintances between the researcher and practicing professionals, then by using the snowball technique to gather more interviewees (Taylor & Bogdan, 1998; Deming & Swaffield, 2011). Interviews were recorded via smart phone device, transcribed, and the transcripts were analyzed.

The analysis of professionals' attitudes towards hydrological knowledge and skill in landscape architecture consisted of searching for a list of key words and phrases developed by the researcher during literature review. These key words and phrases made the identification of themes possible among the numerous informant responses. These themes assisted the researcher in making generalizations and conclusions about the overall role of hydrological knowledge in landscape architectural practice and education (Glaser & Strauss, 1967).

1.6 Significance and Limitations

There is limited research on the topic of hydrology as an area of specialization in landscape architecture or its relevance in the profession. Students at The University of Texas at Arlington have explored some topics in water issues, such as Low Impact Development (LID) and other stormwater management methodologies, as well as research into the use of hydrological modeling software by landscape architects (Holmes, 2012; Parker, 2010). This research explores knowledge and services pertaining to the topic of hydrology and other water issues in landscape architecture academia and professional practice. It seeks to provide a basis for other studies on the topic as it explores hydrology knowledge at a basic level. Qualitative data from this research describe the perception of professionals in North Texas pertaining to the knowledge and skills gained in educational settings. They also explain whether the knowledge and skills gained are sufficient for everyday practice in landscape architecture in North Texas.

This research may inform academia, if respondents indicate that topics are missing from curricula in landscape architecture. It may also more clearly delineate the roles of both landscape architects and hydrologists in the professional setting. Expanding knowledge on either of these topics benefits landscape architecture and refines the educational and professional processes in the field.

A limitation to this research is that curricula in landscape architecture vary and some students may be exposed to hydrology more than others, depending on the location of their educational training. A delimiting factor of the study is that informants are from the North Texas region. Many professionals practicing in North Texas have also been educated in Texas or surrounding states.

While this research concerns the hydrological knowledge in landscape architecture, it seeks to determine generally whether professional education programs have prepared designers to deal with issues pertaining to water and more specifically hydrology. This research does not specifically concentrate on missing elements in hydrology in landscape architecture curricula, and it does not suggest changes to these curricula. The research does provide a basis for further study pertaining to hydrology in landscape architecture, and the researcher suggests topics for such studies.

1.7 Chapter Summary

This thesis documents the research pertaining to water knowledge needs in the education and practice of landscape architecture. Chapter 1 outlines the purpose and general background of the study and poses the principle research questions. Chapter 2 explores existing literature that relates to water, specifically hydrology, and its role in landscape architecture, as well as the backgrounds of landscape architecture and hydrology/engineering education and practice. The third chapter provides details on the research methodologies used in this study.

The final two chapters of this thesis deal with findings and conclusions. Chapter 4 contains analysis of all data collected. Themes derived from data acquired in research inform the conclusions in Chapter 5. This final chapter also contains discussion of the topic and suggestions for future research, for which this study is a foundation.

Chapter 2

Literature Review

2.1 Introduction

The review of literature for this research begins with an exploration of the importance of water by reviewing existing literature and information available. These water data include supply, demand, usage and quality, with some discussion on climate effects on water. Next, the science of hydrology and hydraulics are explored, followed by discussion of a connection between hydrology and other water issues. The concluding sections of this literature review explore the traditional roles of landscape architects and hydrologists in education and practice, as well as emerging roles for both fields concerning water availability and quality and hydrology. There is special discussion on policies created by the American Society of Landscape Architects (ASLA) concerning water issues, as well as the landscape architect's role in minimizing negative effects of hydromodifications. These final review topics emphasize the purpose and hint toward possible outcomes of this research.

2.2 Importance of Water

The earth has a lot of water - about 1.4 billion cubic kilometers, or 370 quintillion (billion billion) gallons, of which only about 2.5 percent exists as freshwater (WWAP, 2012). Only about 0.3 percent, of freshwater stores are available for human use (due to its location in underground aquifers and its physical states in ice and snow). According to the United Nations' World Water Development Report (WWDR), water is a central natural resource and all social and economic activities and environmental functions depend on it. Moreover, water supports life and the livelihoods of individuals. Safe water is needed for domestic uses like drinking and hygiene, but more so for food and energy production (WWAP, 2012).

Water in the unbuilt environment supports various ecosystems, upon which human economic and cultural activities like fishing, hunting, and recreation rely (WWAP, 2012). Ismail Serageldin, former head of World Bank, underscores the importance of water, its movement, and its quality with a bold statement: In 1995, while discussing water rights and politics of various regions, he posits, "Many of the wars of the 20^{th} Century were about oil, but wars of the 21^{st} Century will be over water, unless we change the way we manage water." (Serageldin, 2009, p. 163)

According to ASLA, a key component of the licensure of landscape architects is protecting the health of the public (ASLA, 2013). A landscape architect's designs may influence water and its quality. These could be designs for public squares, campuses for industrial, military, or educational use, or even the selection of land for agricultural uses or the layout of a water treatment facility (BLS, 2013).

The WWDR reports that in developing nations up to 90 percent of wastewater is dumped into rivers, lakes, and productive coastal zones. About 70 percent of industrial waste is also dumped untreated in developing nations. This situation is exacerbated by the outsourcing of heavily polluting industries in developed nations to developing nations, where regulations have not kept pace with change (WWAP, 2012). Landscape architects are working in these areas with other professionals (hydrologists, ecologists, sociologists) to improve the health of the public and the environment. For example, Hu Jie, ASLA, designed China's 680-hectare Beijing Olympic Forest Park with more than 200 other professionals from various disciplines. Knowledge in hydrology was needed to design and build specific elements. A four-acre treatment wetland cleanses all greywater of the site and its surroundings, then drains to a new 20-hectare lake that stores the treated water for reuse (Green, 2012).

The Beijing Olympic Forest Park is an example of how landscape architects employ collaboration and knowledge in hydrology to solve problems worldwide. This research pertains to the practice of landscape architecture in North Texas, so discussion in the following sections contains topics in hydrology in the United States and Texas.

This section discussed water supply, demand, and quality issues that affect the world. Landscape architects, by the nature of their profession (balancing the built and unbuilt), may impact these issues in the future as greater care is taken to deal with stormwater and water quality issues using knowledge of hydrology. Next, the discussion continues on the national scale.

2.2.1 Water in the United States

The United States Environmental Protection Agency (EPA) oversees provisions in several statutes that deal with water. Executive orders and legislation by Congress define the mission and operations of the EPA's Office of Water. Notable laws include the Rivers and Harbors Act of 1899 and the Clean Water Act (CWA) of 1972 (Kalnins, 2013). The latter is the result of amendments to the Water Pollution Control Act. Other legislation that deals with water include the Endangered Species Act (ESA) of 1973, The Marine Protection Research and Sanctuaries Act (MPRSA aka Ocean Dumping Act) of 1972, and the Safe Drinking Water Act (SDWA) of 1974 (EPA, 2012). The CWA deals primarily with the protection of surface water quality in the United States. It uses regulatory and non-regulatory means of reducing pollutant discharges into waterways and deals with the financing of municipal wastewater treatment facilities and pollution from runoff. The tools used in each of these areas serve to restore and maintain the chemical, physical and biological health of the waters of the U.S. (EPA, 2012).

Of the legislation mentioned above, the CWA has had the biggest influence on the field of landscape architecture. It created the United States Army Corps of Engineers (USACOE), which oversees provisions of Section 404 of the

CWA and Section 10 of the Rivers and Harbors Act. The USACOE governs all navigable waterways of the United States as well as any waters that have a physical, chemical, or biological connection to navigable waterways (Kalnins, 2013). As discussed in subsequent sections, landscape architects design projects that concern navigable waterways like rivers, lakes, and wetlands. ASLA recognizes the role of landscape architecture in these environments and has developed policies pertaining to each (ASLA, 2007-2007d).

The legislation discussed above deals with water quality. While water supply and quantity is generally left to individual states, there are agencies at the federal level that report on water supply and demand. The United States Geological Survey (USGS) reports on water usage in the United States every five years. In their report, *Estimated water use in the United States in [year]* they discuss changes in water supply due to factors like demographics, economic trends, legal decisions, and fluctuations of the climate (see USGS, 2005). These factors have been reported on since 1950 and the latest data available comes from the 2005 report. The USGS reports that in these 55 years the population of the United States doubled, but their data show that the rate of water withdrawals has not increased as much as water use (USGS, 2005).

Since the 1950s periodic droughts have spurred the introduction of more efficient irrigation practices, as well as technologies for water reuse and more efficient use of water in industrial processes. Areas in the United States hit particularly hard by drought have implemented water use restrictions as well, and because of all these factors water withdrawals have not surpassed the highest rates of the 1980s (USGS, 2005). Landscape architects play vital roles mitigating drought and climate change. ASLA indicates that landscape architects are central to the development of water-efficient green infrastructures that provide green space and minimize water use. Landscape architectural elements that achieve this strategy include parks, bioswales, treatment wetlands (Green, 2012) and green rooftops. These elements have roles in water recycling and reuse, and address concerns of drought and climate change (ASLA, 2013c) at planning and design levels.

In 2005 water use in the United States required about 410 billion gallons of water per day to be withdrawn from water stores. Of this, 328 billion gallons were from surface water sources and 82.6 billion gallons came from aquifers (see Figure 2.1). Figure 2.2 describes the various uses for water withdrawals and the quantities of water they require.

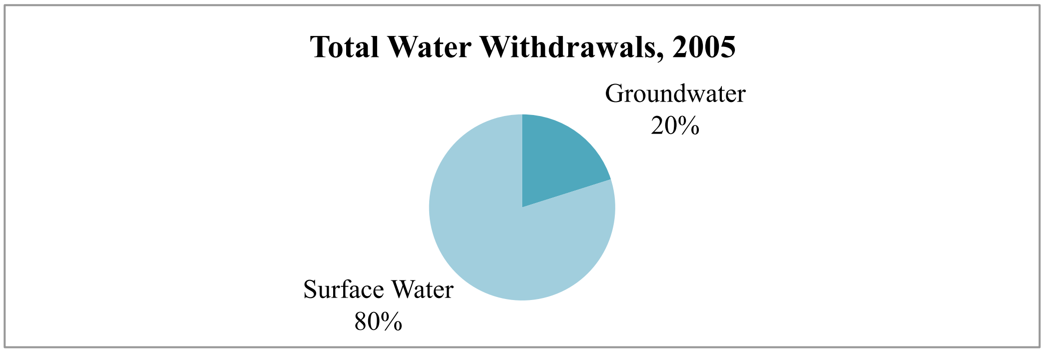

Figure 2.1: Water withdrawals, 2005.

Data Source: USGS, 2005

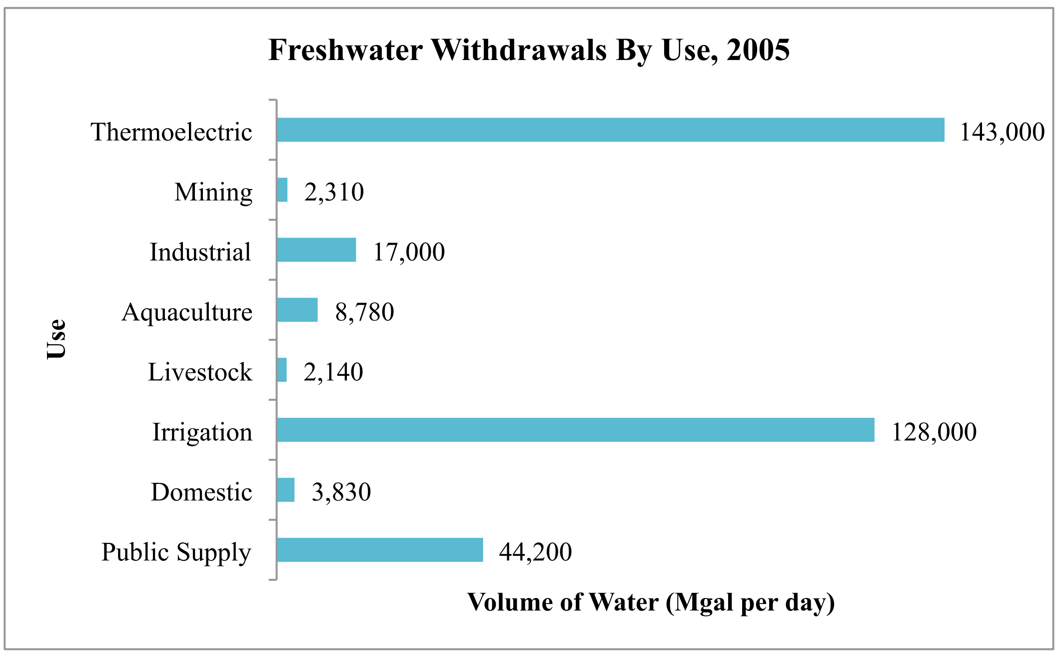

Figure 2.2: Freshwater withdrawals by use, 2005

Data Source: (USGS, 2005)

This brief look at water use data illustrates that much of the water withdrawn in the United States is for uses that do not pertain to landscape architecture (use for thermoelectric power generation and agricultural irrigation), but there are uses that concern the profession, including public supply and domestic use. The use of treatment wetlands, as in the Beijing Olympic Forest Park, improve water quality, make more water available for use (domestic irrigation), and remove some strain on municipal supplies (Green, 2012).

As previously noted, the EPA oversees water quality legislation and works with states to protect water supplies by preserving water quality. In 2004 the EPA compiled data collected by states and reported to Congress on the quality of water in the United States. Studies by states covered less than 30 percent of all U.S. waters, but of these waters, 44 percent of stream miles, 64 percent of lake acres, and 30 percent of bay and estuarine square miles were too polluted to support uses like fishing and swimming. Waters assessed included 563,955 miles of streams, 16.2 million acres of lakes, and 25,399 square miles of bays and estuaries in the United States. Figure 2.3 describes the percentages of surveyed waters in “good”, “good, but threatened”, and “impaired” statuses (EPA, 2009).

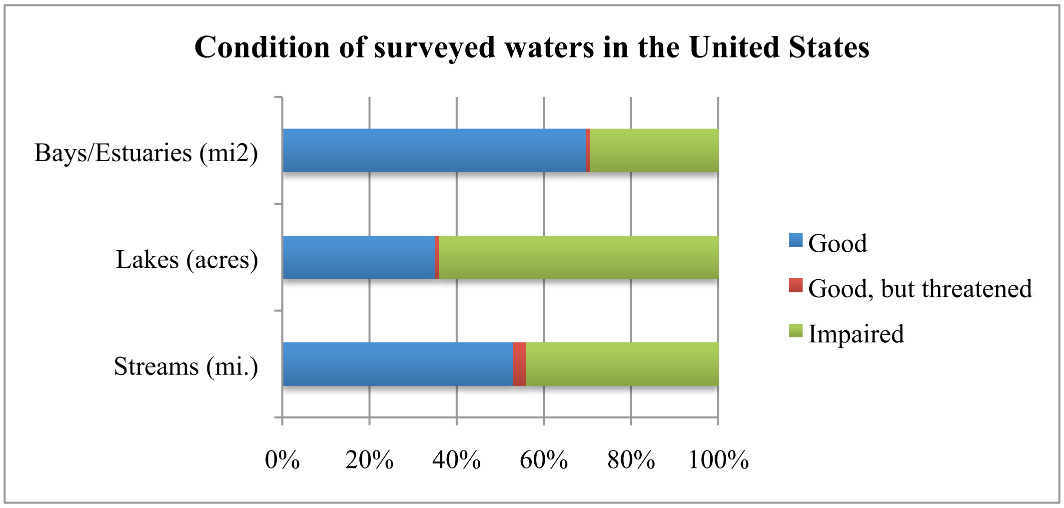

Figure 2.3: Condition of surveyed waters in the United States
Data Source: (EPA, 2009)

The EPA reported that the leading causes of impaired water quality were due to pathogens, mercury, nutrients, and organic enrichment or low dissolved oxygen. The sources of these were from atmospheric deposition, agriculture, hydrologic modifications, or unspecified sources (EPA, 2009). The EPA also described how treatment wetlands mitigate these effects, provide for reuse, reduce costs for treatment for municipalities, and provide habitats for wildlife (EPA, 2004). They reported that in 2004 more than 1,000 treatment wetlands were operational in the United States. As previously mentioned, wetlands are a type of Best Management Practice (BMP) that landscape architects employ to improve water quality and provide a means for reuse (Green, 2012).

We have seen that the United States is not immune to water supply, demand, and quality issues. As most landscape architects who live in the United

States also practice in the United States, these professionals have greater opportunity for applying knowledge in hydrology to solve some of the current and forecasted water issues in the country. Their knowledge and expertise are valuable in thinking critically about these problems, designing appropriate solutions, and working with regulatory authorities throughout the process.

2.2.3 Water in Texas

Water in Texas has a long history of regulation. The first legislation was the First Irrigation Act in 1886 (LRL, 2013) and rules and regulations have multiplied since. It was in the 1950s that Texas began heavily regulating water due to a severe drought that is considered the drought of record, which necessitated the creation of the Texas Water Development Board (TWDB) in 1957. The TWDB is the state's primary water supply, planning, and financing agency. The first Texas Water Plan was drafted in 1961 when there were less than 10 million Texans, most of whom lived in rural areas and used well water. The 1990s saw the creation of another agency that, like the TWDB, has powers in the regulation of water. Several agencies were consolidated in 1992 to form the Texas Commission on Environmental Quality (TCEQ), which deals with water quantity and quality (TWDB, 2012).

Texas has many lakes and rivers, which are sources of freshwater for public use. There are 15 major river basins and 8 coastal basins. Within these basins are 191,000 miles of rivers and streams, 7 major estuaries, and 5 minor estuaries. Descriptions of the major river basins can be found in the 2007 State Water Plan, and they include data on location, reservoir capacity and yield, surface water rights, and supply (TWDB, 2012).

The TWDB describes existing water supply as "…the amount of water that can be produced with current permits, current contracts, and existing infrastructure during droughts." (TWDB, 2012, p. xii)

As of 2010 the water supply in Texas is 17 million acre-feet and this number is expected to decrease almost 10 percent to just over 15 million acre-feet in the next 50 years. These data include surface and groundwater supplies through 2060, but supplies from reuse are discussed separately (TWDB, 2012).

Water reuse has gained popularity over the last 20 years. From 1990 to 2010 the number of organizations receiving permits from the TCEQ for direct, non-potable water reuse increased from 1 to 187. This number is projected to continue increasing over the next 50 years. The Texas Water Code describes reused, reclaimed, or recycled water as "…domestic or municipal water that has been treated to a quality suitable for beneficial use." (TWDB, 2012, p. 170). As previously discussed, treatment wetlands are BMPs employed by landscape architects to collect water and treat it near its source allowing for reuse, whether in a natural or municipal application (Green, 2013; EPA, 2004).

Water supply is projected to decrease over the next 50 years. Inversely, demand is expected to increase, although not as quickly as the population of

Texas. Population is expected to increase 82 percent from over 25 million residents to over 46 million residents. However, water use is projected to increase only 22 percent to about 22 million acre-feet per year. Demand for residential use is projected to increase about 58 percent, while agricultural use is projected to decrease about 16 percent due to more efficient means of irrigating crops. Figure 2.6 combines this discussion of supply and demand and describes the correlation between the two (TWDB, 2012).

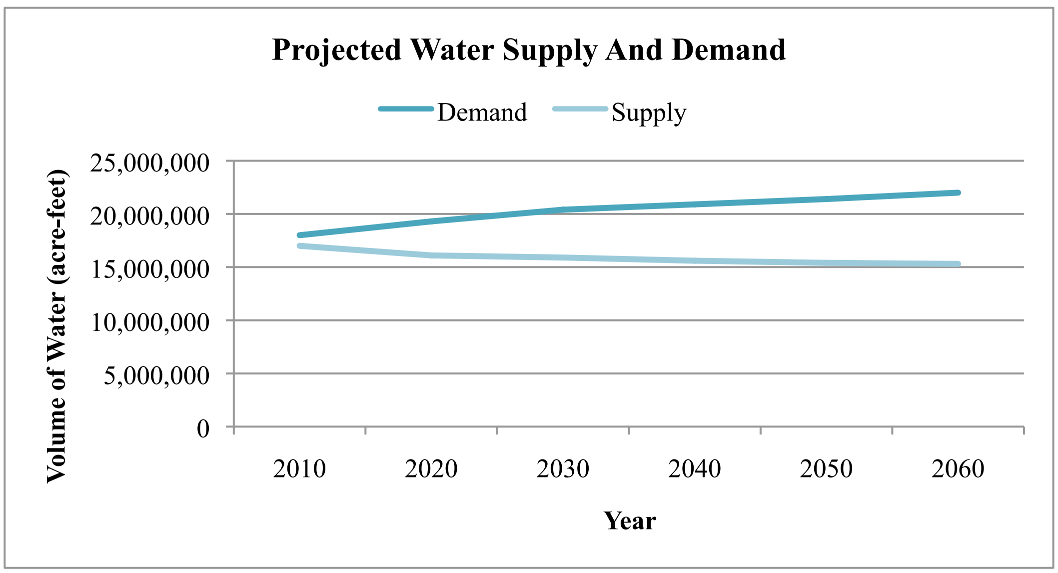

Figure 2.4: Projected water supply and demand

Data Source: TWDB, 2012

What these data may not be able to accurately take into account is the drought condition over the next 50 years, although the TWDB has projected increased use due to drought. In more arid climates, vast amounts of water are required for irrigation purposes. In fact, Texas' main uses of freshwater are for thermoelectric power generation and irrigation. Together, Texas, California, Idaho, and Florida used more than one fourth of all the water withdrawn in the United States in 2005 (USGS, 2005). These are all places with expansive agricultural industry, and California and Texas are typically very arid.

In May 1999 then Governor George W. Bush signed legislation that created the Drought Preparedness Council (DPC). It created or included agencies to support management efforts and increase drought monitoring, assessment, preparedness, mitigation, and assistance (DPC, 2006). The DPC created the State Drought Preparedness Plan that complements the State Water Plan and Drought Contingency Plan. The State Drought Preparedness Plan studies the impacts of drought and includes topics of supply, demand, and usage. It notes that human and natural resources that depend on rainfall are the most harmed from drought, where aquatic, riparian, and wetland systems and human recreation are injured slightly less (DPC, 2006).

The Drought Contingency Plan provides guidelines for all public water systems, as well as wholesale and retail suppliers, when devising their own plans for dealing with drought. One such guideline from a Drought Contingency Plan was the creation and implementation of water use restrictions (TCEQ, 2013). Professionals who do planting designs that require irrigation are familiar with these municipal restrictions. The restrictions vary among municipalities in North Texas and limit the number of days that may be used for landscape irrigation. It is up to water providers, municipalities, and designers to educate the public on drought and water use restrictions.

Pollution is another factor that landscape architects must consider, especially when designing urban areas. The Texas Water Quality Management Plan (WQMP) is a document the state uses to achieve its water quality goals and it is updated regularly to follow standards of the Clean Water Act (CWA). Elements in the WQMP include limits of effluent from wastewater facilities, total maximum daily loads (TMDLs), management controls for nonpoint source pollution, and protecting source waters (TCEQ, 2013). Water quality topics relate to hydrology because the movement of water affects its quality. For example, first flushes of rain events transport surface pollution to water sources. There is an entire field of practice and study that deals with this movement of water and its quality.

2.3 The Science of Hydrology

This section explores the definition and science of hydrology. The American Society of Civil Engineers (ASCE) defines hydrology as "the science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground" (ASCE, 1999).

Hydrology concerns the study of the occurrence, distribution, movement, and properties of water in each phase of its hydrologic cycle. In the hydrologic cycle water is purified by evaporation from sources on the surface of the earth into the atmosphere and precipitate back to the surface. Water takes a variety of routes in completing this cycle. It falls directly into the oceans or into rivers that eventually reach the oceans. Water in the form of snow settles on mountaintops and later melts into rivers. It can also soak directly into the ground into aquifers, or be trapped in polar ice caps, where it can remain for millions of years (USGS, 2013).

Humans are a part of this hydrological cycle. Humans use water from the surface or from underground aquifers and once they are done with it they discharge it back into a river or another part of the hydrological cycle. This is where water quality plans, as discussed previously, are necessary because the many uses humans have for water introduce pollutants of various physical, chemical, and biological forms (USGS, 2013).

A landscape architect is concerned mostly with the surface of the earth. Design implications on the surface affect underground water supplies due to the permeability of soils and the impermeability of many hardscape elements. Additionally, water in the atmosphere is captured or manipulated by landscapes and structures on the surface. Therefore, a landscape architect may influence a site's hydrology at various stages of the water cycle.

2.3.1 Water and the Science of Hydrology

As mentioned earlier, water is a central natural resource, on which most human social and economic activities and environmental functions depend

(WWAP, 2012). Hydrology is the science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground (ASCE, 1999). Although hydrology is a discipline and area of practice, the term is often used interchangeably with water, water quality, quantity and supply.

Hydrology is the science that engages various concerns of water, including water quality, water supply, and ecosystem health. In an article titled "Hydrology," the Sustainable Sites Initiative (SITES) immediately shifts the conversation of hydrology to stormwater management and other water topics. Their interpretation of the term "hydrology" includes discussion on water quality, supply, and use. For instance, by managing stormwater effectively water can be collected and cleaned onsite and subsequently used for irrigation purposes. (SITES, 2013).

SITES stresses that by applying hydrological knowledge landscape architects can affect water quality and supply. Knowledge of the movement of water informs a designer how to do such things as direct runoff from pervious surfaces to soils or plantings, which, in turn, improves water quality (SITES, 2013). This, in turn, affects water supply by making more clean water available for human use. There is also brief discussion on preserving and restoring natural hydrological function of sites and using hydrological knowledge to deal with issues of flooding (SITES, 2013).

Phillips (et al.), in their presentation at ASLA's annual expo in 2012, presented a concept called hydromodification, or hydromod. In their discussion, hydromodification was described as the change to a watershed's hydrology due to urbanization (Phillips, et al., 2012). Because landscape architects build cities, and due to increasing stress on water supplies, this was a thoughtful topic for discussion with peers.

Urbanization impacts to surface hydrology include increases in runoff volume, peak flow rate, and flow frequency. Increases in flow rate cause decreases in concentration time of water for infiltration into groundwater stores. Changes in sediment sources and supply also affect hydrology by altering stream flow. Increased imperviousness of the ground contributes to all of the above topics, as well as water quality (Phillips, et al. 2012).

Increased imperviousness affects water quality by increasing non-point source pollution. The number one source of water pollution affecting 40 percent of U.S. water bodies is stormwater runoff. The initial flush of rainfall (1/2 inch or 15 minutes) in a storm event washes 85 percent of pollutants off of impervious surfaces and into water bodies (Phillips, et al). Legislation exists that attempts to control this and other problems with modified hydrological functions (see 2.2.1 and 2.2.2). Landscape architects and their practice are under the scrutiny of such legislation and regulation.

This section served to illustrate how hydrology and topics such as water quality, quantity, and flow are typically argued and reviewed as one. As discussed in subsequent chapters of this research, the knowledge needs in one of the areas typically invoke discussions of the others. The following section focuses on the traditional and contemporary roles of landscape architects and further elaborates on landscape architects' involvement with hydrology and water.

2.4 The Traditional Roles of Landscape Architects

Landscape architects seek a balance of built and unbuilt environments. They plan and design spaces in residential, commercial, and industrial areas that involve nearly everything outdoors. These include parks, plazas, roads and highways, airports, housing developments, and many more (ASLA, 2013a; BLS 2013; NBM, 2013). Landscape architecture is a licensing profession and landscape architects must protect the public's health, safety, and welfare in whatever they do (See TOC, 2003 for additional information on licensure).

The following lists typical skills needed in landscape architecture. Section 2.5.3.2 discusses instances of hydrological and water related skills in the landscape architecture profession. The list below pertains more to the intellectual qualities a person needs to become a landscape architect.

First, analytical skills are important for issues in landscape architecture. These skills are not only needed for technical issues, like grading a site, but also to ensure the design emanates an understanding of the arts and humanity of design. Oral and written communication skills are also necessary for landscape architects to share their ideas, get points across, and gain business contracts. As landscape architecture is a design profession, creativity is needed to make products that are both functional and aesthetically pleasing. Landscape architects need critical thinking skills to deal with unanticipated changes or problems in design and they also need technical skills, such as computer drafting, modeling, and rendering. Finally, landscape architects need to be able to visualize a design without seeing it first. All these skills and topics of knowledge aid landscape architects in practice (ASLA 2013a; BLS, 2013).

2.4.1 ASLA Policies on Water Issues

The American Society of Landscape Architects (ASLA) has developed policies on several different topics that are relevant, directly or indirectly, to water and hydrology. These include policies on environmental sustainability, water quality and conservation, waterways, wetlands, and coastal zones. Their policy on environmental sustainability mentions minimizing environmental degradation and this includes water issues (ASLA, 2007). The statement on water quality and conservation concerns water supply, allocation of water resources, quality, and ecosystems (ASLA, 2007a). ASLA's discussion about waterways, wetlands, and coastal zones deals with suitable uses, sustainability, and conservation (ASLA, 2007b; ASLA, 2007c; ASLA, 2007d). See Appendix B for complete quotes on ASLA's public policies.

The fact that the ASLA creates policy statements on the above water topics shows that they acknowledge the importance of water in the profession and education. The involvement of landscape architects in the protection of waterways, wetlands, and coastal areas puts the field at the forefront of water issues in design. It is important to know if professionals in North Texas have a knowledge base, whether from education or practice, to deal with issues in hydrology that affects these topics.

2.4.2 Education

To become a landscape architect one needs a college degree and training for licensure. A bachelor's or master's degree from an accredited university is required for an aspiring professional to become a licensed practitioner or academic practitioner. As of 2011, 68 schools offer accredited programs in landscape architecture (ASLA, 2013a; BLS 2013).

There are two types of undergraduate degrees in landscape architecture - a Bachelor of Landscape Architecture (BLA) and a Bachelor of Science in Landscape Architecture (BSLA); each takes four to five years to complete. A Master of Landscape Architecture (MLA) program is open to anyone with an undergraduate degree and takes three years of full-time study. Students with a BLA or BSLA can finish in about two years, but without an undergraduate degree in landscape architecture, study time for an MLA can exceed three years. Finally, some institutions offer Master of Arts (MA) or Master of Science (MS) in landscape architecture. This degree is solely for those who wish to pursue a career in landscape architectural research, but not for those who wish to become a licensed practitioner (ASLA, 2013; BLS 2013).

A quick review of the top ranked (DFC, 2011) graduate (MLA) and undergraduate (BLA) landscape architecture programs (by DesignIntelligence) suggests that hydrology and water related issues are not typically covered as separate courses in their curricula. However, it is suggested that the material is covered in the content of various courses. Figures 2.5 and 2.6 summarize the review of top ranked academic programs and the hydrology content of courses offered. These data provide a background on possible knowledge gained by landscape architects nationwide. Data acquired from interviews may be compared to this review, but findings from interviews are the principle data used by the researcher to make conclusions on topics pertaining to the knowledge gained in education by professionals in North Texas.

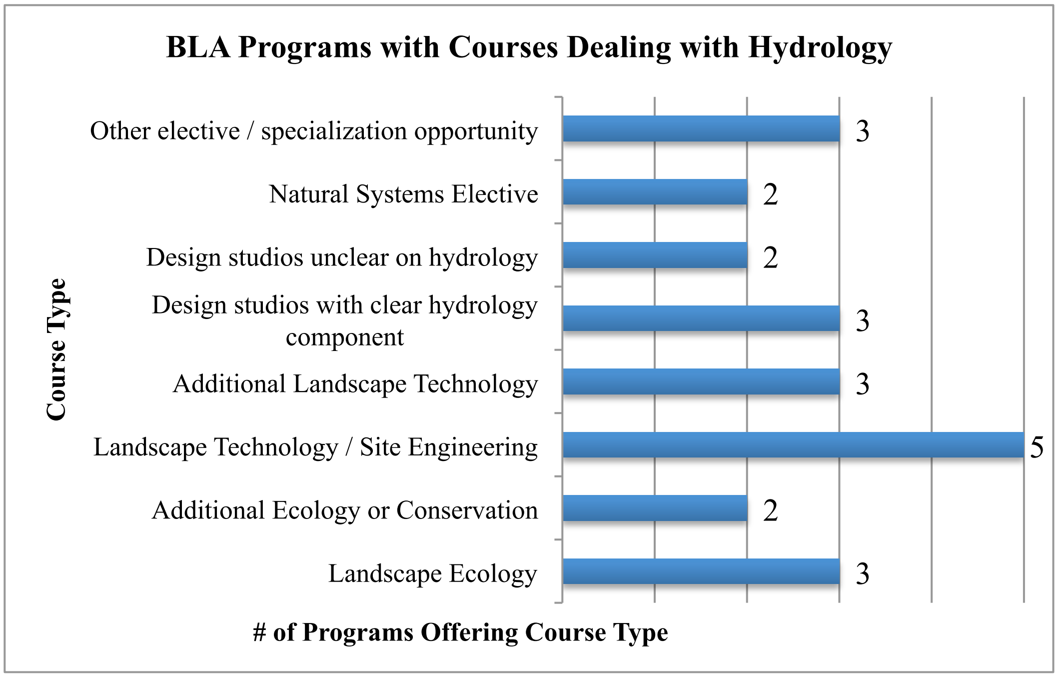

Figure 2.5: Five BLA Programs with courses dealing with hydrology. Courses whose descriptions indicate a hydrology component include landscape ecology, landscape technology (or site engineering), design studios, and electives. Data Source: (LSU 2013; PSU 2011; Cal Poly 2013; Purdue 2012; A & M 2013)

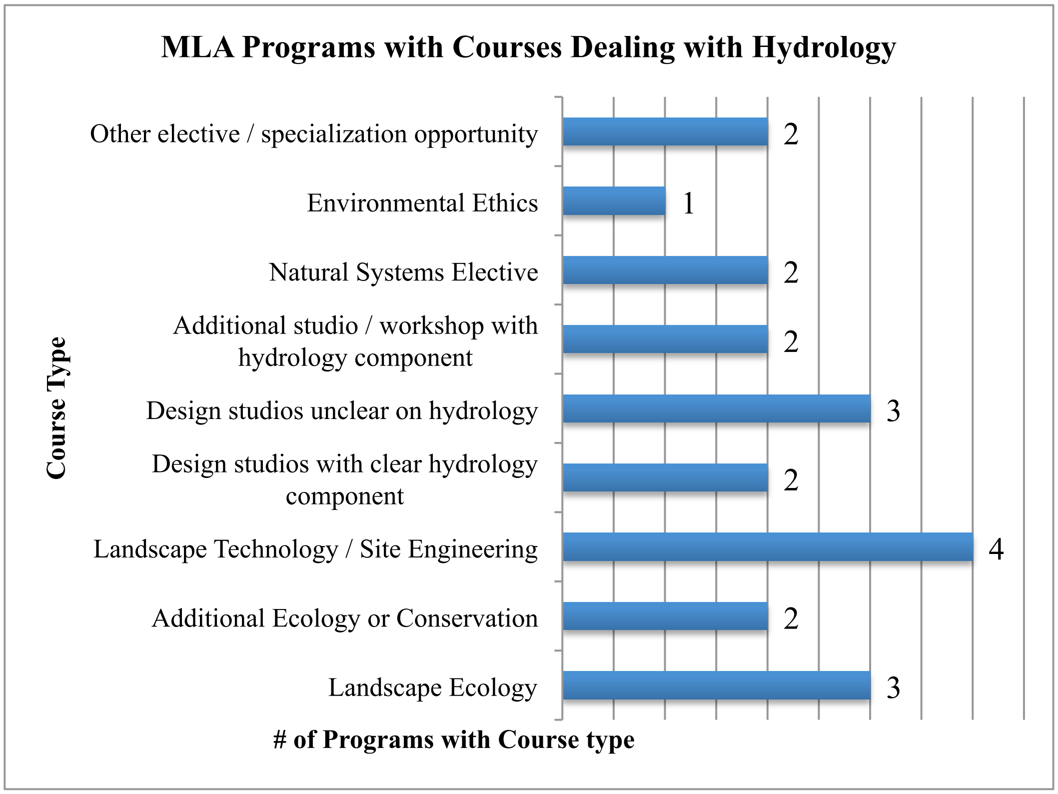

Figure 2.6: Four MLA Programs with courses dealing with hydrology. Courses whose descriptions indicate a hydrology component include landscape ecology, landscape technology (or site engineering), design studios, electives, and environmental ethics.

Data Source: (Harvard 2013; LSU 2013a; KSU 2013; U Penn. 2013)

2.4.3 Professional Practice

2.4.3.1 General Practice Statistics

Nearly a quarter of professionals practicing landscape architecture are self-employed. Most of the typical workday for a landscape architect is spent indoors making plans, models, and designs. They also research their projects and meet with clients and other professionals who are involved in the projects. These professionals include engineers, architects, general contractors, and government agencies. Some of their time is spent on job sites. Landscape architects typically work over 50 hours per week, including nights and weekends, to meet deadlines (BLS, 2013; TPR, 2013).

Job outlook and growth in landscape architecture is expected to grow similarly to all other occupations by 2020, at about 16 percent. Cost of land and development is increasing and the public's desire for beautiful spaces follows. Another factor driving growth of the profession is the recent emphasis on sustainability and environmental concerns (BLS, 2013).

Although it is an average job outlook, it is lower than the norm for the field of landscape architecture. A 2011 ASLA poll of 300 landscape architecture firms indicates that the economy is of great concern to those in a position to hire. In fact, 95 percent of respondents said they were "very concerned" (ASLA, 2013b, p. 1) about the economy. One respondent indicated that in this economy engineers are performing the services typically suited to landscape architects. (ASLA, 2013b). This statement relates directly to one portion of this study discussed in future chapters – an overlap of professional services among landscape architects and engineers/hydrologists. We now look at the traditional and contemporary roles of landscape architects as they pertain to water and hydrology.

2.4.3.2 Landscape Architecture and Water

As previously mentioned, landscape architects possess tools to ease the effects of hydromodification. Throughout history designers have modified the landscape and its hydrology. In the second millennium BC, the Mesopotamian Empire used stormwater management and other techniques to control flooding, convey waste, and collect stormwater for domestic and irrigation purposes (NRC, 2005). Minoan Crete (*ca.* 3200-1100 BC) had water collection and conveyance systems, utilizing cisterns and aqueducts. Rural areas in the same location still use the practice today (Angelakis, et al, 2013). More recently, design strategies like Low Impact Development (LID) have been developed to deal with stormwater (PGC, 1999).

Prince George's County, Maryland developed LID in the late 1990s (PGC, 1999). It was founded on principles from Ian McHarg and associates several decades earlier and its goal was to allow for development of a site while preserving its pre-development hydrology. Professionals do this by using various techniques to treat stormwater close to the source (NRC, 2005). More recently, the Sustainable Sites Initiative (SITES) was introduced. ASLA, the United States Green Building Council (USGBC), and the Ladybird Johnson Wildflower Center initiated the development of SITES in 2005. SITES promotes sustainable development, and one reason for this necessity of sustainability directly relates to this research: resource depletion (SITES, 2013). The water-wise methodologies that SITES promotes certainly influence water supply.

The ASLA recently assisted the U.S. Environmental Protection Agency (EPA) in acquiring case study data on 479 projects that deal with stormwater management by implementing green infrastructure and LID techniques (ASLA, 2013). The techniques included bioswales, rain gardens, bioretention facilities, permeable paving, curb cuts, cisterns, removal of downspouts, green rooftops, and rain barrels. A majority of these cases were retro fittings of existing properties and almost half decreased operating and water costs for the property owner (ASLA, 2013). Figure 2.7 summarizes the amount of use of these BMPs in the EPA/ASLA case studies.

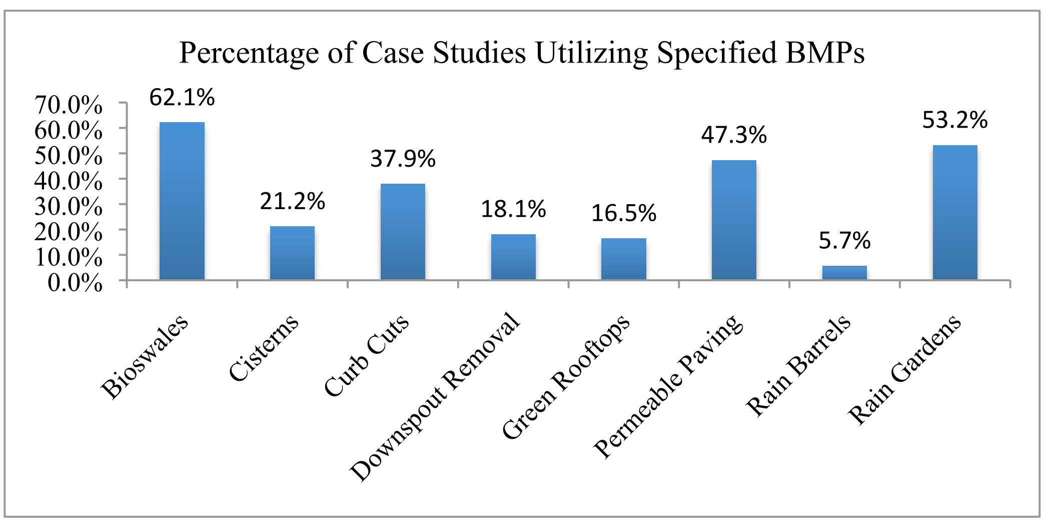

Figure 2.7: Percentage of ASLA/EPA cases studies utilizing specified BMPs
Data Source: (ASLA, 2013)

2.5 The Traditional Role of Hydrologists

Hydrologists study water and its movement, distribution, and other properties in its cycle. Then, they determine how the above influence the environment. For instance, a hydrologist may be involved in finding water resources, controlling floods and erosion, or preventing and mitigating pollution in public and natural water supplies. Hydrologists work with other engineers, scientists, and public officials to develop conservation plans and other practices. Most hydrologists specialize in a certain niche of hydrology, including groundwater hydrology, hydrometeorology, and surface water hydrology (BLS, 2013a; USGS, 2013).

Knowledge and skill in hydrology and other water issues serve hydrologists in solving problems such as water quality and availability. The skills required to be a hydrologist include analytical skills, critical thinking skills, communication skills in writing and speaking, and physical stamina (field work). Analytical and critical thinking skills help hydrologists understand the relationship between land use and water supply. Communication skills serve hydrologists in dealing with other professionals and government entities, which are routine in practice (AIH, 2011; BLS, 2013a). Technical or scientific knowledge needed in the profession includes proficiency in geology, physics, chemistry, mathematics, and life sciences (USGS, 2013).

Although there is an educational component in becoming a hydrologist, the degrees they receive are not as specific as those of landscape architects. Some of their services are similar to those landscape architects perform, but certainly differ, focusing on water, not aesthetics or other facets of landscape architecture (BLS, 2013a). Like landscape architecture, the field of hydrology has a governing organization that oversees the certification of professionals. The American Institute of Hydrology (AIH) was formed in 1981 to promote the science and practice of hydrology. Like ASLA, AIH connects the academic and professional sectors of the field. It also relates these sectors to government regulation by working to develop and maintain both educational and professional standards (AIH, 2011).

2.5.1 Education

Most hydrologists need at least a master's degree to practice hydrology, and many must be licensed, depending on their state of residence. Few schools offer degrees specifically in hydrology, so many educational backgrounds of hydrologists are in natural sciences and engineering. Hydrology concentrations are offered in many programs in geosciences, environmental science, and engineering. Students of hydrology, or any of the previously mentioned curricula, need strong skills in math, statistics, physical science, computer technology, and life sciences. Additionally, students need experience with computer modeling and digital mapping, and they often use tools like geographic information systems (GIS) and global positioning systems (GPS) (BLS, 2013a).

Regardless of which type of degree a student earns, for registration purposes the student must have more than 45 semester hours of general and advanced courses in hydrology (AIH, 2011a). This far exceeds any exposure to water or hydrology in landscape architecture education. The stringent requirements for coursework in hydrology provide the knowledge necessary for a student to pass the certification examination. This examination consists of two parts – Hydrology Fundamentals and Specific Discipline – Practical. Paired with work experience, knowledge gained from education and proven in examination paves the way for a student to become a hydrologist (AIH, 2011a).

2.5.2 Professional Practice

Professionals practicing hydrology are certified as either hydrologists or hydrologic technicians. A hydrologic technician has some educational background and work experience, but has not taken the full examination for certification. There are three levels for a hydrologic technician, membership to which has increasing levels of educational knowledge and professional skill. The certification for an individual to practice as a hydrologist (not a hydrologic technician) requires a degree, as discussed previously. Then, varied amounts of experience are required, depending on the degree earned (five, four, or three years for a bachelor's, master's, or doctorate degree, respectively) (AIH, 2011a). Professional experience requires the following knowledge and skill.

Some typical duties of hydrologists include measuring properties of water, such as stream flow and volume, collecting water and soil samples to test various properties, and research better means of water conservation. Additionally, more than 100 station-years of stream flow are available for comparative study and their data are used often. With these and other data, hydrologists use computer models to forecast future water supplies, pollution, and other aspects of hydrology. They use data acquired to write reports that can influence regulation to minimize environmental impacts of human activities (BLS, 2013a; Langbein & Isiri, 1995).

The growth rate for jobs in hydrology is slightly higher than for landscape architecture - at 18 percent. More hydrologists are needed because climate change and population growth place a greater strain on the nation's water resources. As in landscape architecture, growing development requires professional knowledge and skill in determining risks to water supply, flooding, and water quality. Of the jobs held by hydrologists in 2010, 30 percent work for the federal government. Approximately 25 percent of hydrologists work in engineering and architecture firms, while one-fifth work in management and scientific consulting services. The remaining professionals work for state and local governments (BLS, 2013a).

Most hydrologists work in the field, in offices, and in laboratories. In the field they do basic sampling, test water quality, and direct field crews. In the office or lab they use computers to analyze and model their data. Much of this work relies on computers. They usually work full time and the length of each daily shift depends on whether they are working in the field or in an office or lab. Finally, hydrologists often travel and visit sites away from their office or lab (AIH, 2011; BLS, 2013a; USGS, 2013).

The review of the hydrology profession in this study shows similarities and differences with that of landscape architecture, and suggests that in both professions one needs an understanding of hydrology and the hydrologic cycle. As indicated, the educational requirements and knowledge needs differ, but a definite connection of needs exists between landscape architects and hydrologists. This is explored further in subsequent chapters of this research.

2.7 Chapter Summary

This chapter underscores the importance of water in relation to the science of hydrology, as well as to landscape architecture and hydrology as disciplines and areas of practice. The importance of water and hydrology worldwide, and their relevance to landscape architecture, was presented by citing instances of water or hydrology in landscape architecture practice and governance. Providing a brief background on water supply, demand, usage, and quality (current and future projections), also illustrates the importance of water in landscape architecture, as landscape architects shape the future landscape and influence the use of land and treatment of water and hydrological function.

Research into the education and professions of landscape architecture and hydrology is done to determine any similarities or differences among them. Both professions have educational requirements to be satisfied before examination and registration can occur (ASLA, 2013a; AIH, 2011a). Requirements for education and work experience differ among the fields, but the licensing regime has similarities. They are similar in that the federal government governs neither field. In each instance, licensing is left to states and overseen by a national membership organization (AIH, 2011a; ASLA, 2013a).

As landscape architecture and hydrology are different professions, knowledge needs in education and practice differ. This chapter gives a background on knowledge needs, but further study is needed. The following chapter details the methodologies used to produce findings on such knowledge needs.

Chapter 3
Research Methods
3.1 Introduction

This chapter describes the methodology used in this research. The study uses qualitative research methods as described by Taylor and Bogdan (1998) and data analysis techniques from both Taylor and Bogdan and Glaser and Strauss (1967). The questions posed in this research require qualitative research methods that suggest in-depth inquiry of the phenomena explored. The methods outlined in this chapter are informed by existing literature and knowledge gained in research methods courses, and they cover research design and data collection techniques.

A qualitative study best suits this topic because the exact relationship between hydrology and landscape architecture, both in landscape architecture education and professional practice, has received little attention with in-depth studies and scholarly literature. The data collected may yield knowledge not considered when setting up the study, so flexibility is required.

3.2 The Qualitative Approach

A benefit of qualitative inquiry is that it allows for flexible research design. The design may even change, depending on the data collected because data collection and analysis are done simultaneously (Glaser & Strauss, 1967). It is suggested in literature that qualitative researchers are mostly concerned with meanings people attach to their lives, and how such people think and act in their everyday lives. It is also suggested that that qualitative researchers emphasize the meaningfulness of their research, while quantitative researchers emphasize the reliability and reproducibility of their research. (Taylor & Bogdan, 1998).

Qualitative inquiry employs inductive reasoning. With this type of reasoning a researcher looks at patterns in the data collected to develop concepts and to gain understanding and insight. Conversely, a quantitative inquiry looks for data to support a preconceived notion or hypothesis (Taylor & Bogdan, 1998).

3.3 Research Design

This study utilizes informant interviews as a means of data collection (see Figure 3.1). Qualitative interviewing can be unstructured, non-standardized, and open ended. This type of interviewing is found to be an appropriate method of data collection for a study such as this, in which the researcher has a solid idea of his interests and the kinds of questions needed to acquire sufficient data on the topic (Taylor & Bogdan, 1998). Because human subjects are used in this study, an approval process through the Institutional Review Board (IRB) at the University of Texas at Arlington was needed. A protocol containing the research design, along with all documentation that would be used on informants, was presented to the IRB for approval prior to starting discourse with any informants. Appendix A contains IRB documentation.

A specific set of interview questions was presented to informants in the fields of landscape architecture and hydrology. These questions were descriptive and open-ended, allowing informants to discuss subjects that are important to them, as well as the meanings they hold on these subjects (Taylor & Bogdan, 1998). The interviews were conducted in person and over the telephone.

Literature has shown that an important part of qualitative interviewing is probing. The open-ended questions were used to start discussion on a topic and the researcher probed informants for more details. This method creates a clearer picture of the meanings attached to informant responses and it is the principal way of obtaining extra data that has the potential to illuminate topics not initially considered by the interviewer (Taylor & Bogdan, 1998).

Data derived from informant interviews were used to determine the levels of knowledge of hydrology among landscape architects and hydrologists in common design settings in North Texas. The data differentiated between knowledge gained from education and knowledge gained in practice. Finally, the interview questions were also meant to explore the attitudes landscape architects and hydrologists have towards each other, including the perceived roles of each.

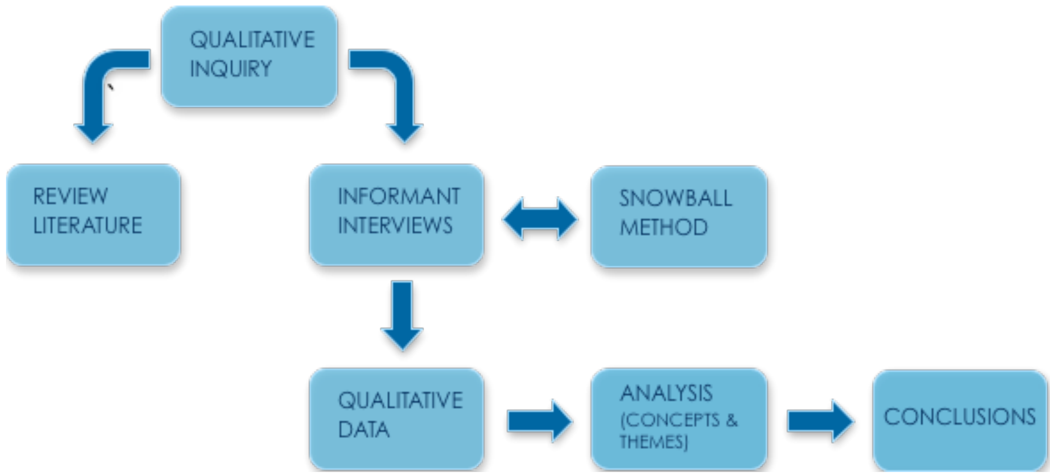

Figure 3.1: Research design flow chart

3.3.1 Study Population

Informant selection for qualitative interviewing yields the same flexibility as other aspects of qualitative inquiry, in that the number and types of informants do not have to be immediately revealed. Instead, the researcher has a general idea of the types of informants and how to recruit them. The sample size of an interviewing study is determined after some research has been done, rather than in the beginning, and the number of informants is somewhat unimportant. The importance in an interviewing study lies within the potential of each informant to help the researcher develop theories into the area being studied (Taylor & Bogdan, 1998). In the case of this study, any information regarding knowledge of water is useful for theorizing.

All informants in this research were practicing in the North Texas region at the time of study, and they were either practicing landscape architecture or hydrology. The initial means of informant recruitment were based on the researcher's acquaintance with professionals in each field. Next, the snowball method (Taylor & Bogdan, 1998; Deming & Swaffield, 2011) of recruitment was utilized to gain a larger pool of informants.

This snowball method consists of connecting with new informants by networking through previous ones (Taylor & Bogdan, 1998). At the end of an interview, the researcher asked the informant to provide names and contact information of other professionals who were similarly suited to provide insight on the topic. In the event that too few informants were available, or data acquired were not sufficient, the researcher reserved the ability to contact local firms to invite non-acquainted professionals to participate in the study. This would be done by contacting corporate contacts or principals at firms and asking to speak with them and/or some of their employees.

3.3.2 Interview Protocol

As previously mentioned, all interviews were conducted face-to-face or on the telephone. Interviews were recorded via smart phone device with the consent of the informant. Some notes were also taken during the time of the interviews to remind the researcher to ask for clarification or elaboration on certain topics. The interviews were later transcribed via word processor by a third party and returned to the researcher in Microsoft Word Document format. It was from these transcripts that the researcher developed themes and general conclusions.

3.3.2.1 Interview Questions

Interview questions used to gather data that answer the main questions of this research:

1. What is the level of competency in hydrology needed by a landscape architect in routine professional practice?
2. What knowledge about hydrology is acquired in landscape architecture education?
3. Is there an overlap of services provided by landscape architects and other professionals practicing hydrology?

A similar set of interview questions was derived for informants in each field. Interview questions were set up in three parts: respondent profiles; in-depth questions regarding knowledge, education, and practice; and follow-up questions. The researcher used profile questions to discover the educational and professional background of the informant. The principal in-depth interview questions inquired about the extent of knowledge in hydrology the professional had gained from education and professional practice. Finally, follow-up questions were added for use in the event the researcher believed more data were needed.

Landscape architects

Profile Questions:

1. How long have you been practicing landscape architecture?
2. What type of firm do you work in?

3. Where did you complete your academic program in landscape architecture?
    a. What degree or degrees do you hold?

In-depth Questions:

1. What knowledge about hydrology did you acquire in landscape architecture education?
2. What knowledge about hydrology is needed to perform typical services in landscape architecture?
3. Is there an overlap of services provided by landscape architects and other professionals practicing hydrology?

Follow up Questions:

1. What tools do you use to perform services pertaining to hydrology? For example, low impact development, modeling software, and other tools.
2. What percent of your weekly professional activities requires knowledge and skill in hydrology?

Other Professionals Practicing Hydrology

Profile Questions:

1. How long have you been practicing hydrology?
2. What type of firm do you work in (size, disciplines, public or private)?
3. At what school(s) did you complete your education?
    a. What degree or degrees do you hold?

In-depth Questions:

1. What knowledge about hydrology did you acquire from your education?
2. What are the key topics in hydrology needed to perform typical services in your field?
3. Is there an overlap of services provided by landscape architects and other professionals practicing hydrology?

Follow up Questions (if needed)

1. What tools do you use to perform services pertaining to hydrology? For example, low impact development, modeling software, and other tools.
2. What percentage of your weekly professional activities requires knowledge and skill in hydrology?

3.3.3 Data Analysis

According to Glaser and Strauss (1967), in a qualitative study the researcher must be concerned with forming social theories and concepts. Their "grounded theory" approach is a method for using data to form theories, concepts, hypotheses, and propositions, rather than basing the above off assumptions, other research, or existing theory. Of two principal strategies for developing grounded theory, the constant comparative method is deemed most appropriate for this research. In the constant comparative method the researcher continually codes and analyzes the data to develop concepts. This constant comparing of specific incidents in data helps the researcher refine concepts and identify their properties.

Then, the relationship of these incidents to one another is explored and integrated into one coherent theory. These methods are not used to prove a specific theory, but to show plausible support for it (Glaser & Strauss, 1967).

The data analysis portion of this research involved the studying of interview transcripts and searching for themes in the data. These themes assisted the researcher in forming concepts and theoretical propositions. Additionally, concepts were abstracted from interview data.

First, the researcher looked at words and phrases from the informants, and themes began to emerge. When a theme was noted, the specific statements were compared to see if there were any concepts that unite them. Different themes were then compared to find any underlying similarities (Taylor & Bogdan, 1998). It should be noted that hunches or ideas the researcher formed during the interview process were noted and used to aid in analyzing the data acquired. This was in line with the flexible nature of qualitative interviewing and qualitative studies altogether (Taylor & Bogdan, 1998).

3.4 Methodological Limitations and Delimitations

A limitation of the methods used in this research is the qualitative nature of inquiry itself. In this methodology, the researcher has complete control over the research design (Taylor & Bogdan, 1998), which makes the research susceptible to human bias and error. Another limitation to this research is time.

As this is an academic endeavor, the research was bound by the amount of time and resources available to the researcher.

There are also delimiting factors to this methodology. One such factor is the laboratory of study. All research and interviewing is done in North Texas, and all informants currently practice in the region. This was a consideration by the researcher, so that he would have better access to informants. Moreover, this allowed the researcher to make contact with a more homogenous population in North Texas. The duration of the informants' practice in North Texas is not a topic of this study. However, bias could exist in the population, based on where the informants studied and where they have practiced. Therefore, the researcher emphasizes the laboratory of study, North Texas, throughout this research.

The means of recruitment also possibly add bias. Recruitment started with acquaintances of the researcher and continued with the snowball technique of being introduced to their acquaintances and colleagues for interview purposes. This method may diminish the diversity of the population and, therefore, add bias to the data. One way the researcher mitigates this possible delimitation is by recruiting professionals in different sectors of landscape architecture practice to ensure a balanced look at practice in North Texas.

3.5 Chapter Summary

The qualitative research methods for this research provided flexibility for the researcher in research design (Taylor & Bogdan, 1998). Informant interviews were utilized to provide qualitative data, from which themes and concepts were derived. These open-ended interviews with professionals in North Texas encouraged discussion of the topics the researcher deemed necessary to help answer the main questions of this research.

The research population, or informant pool, as well as the methods of recruitment (snowball method) were also discussed (Taylor & Bogdan, 1998). Finally, data analysis techniques (discussed in Chapter 4) were introduced, and the researcher identified limitations and delimitations of the study and presented them in the final sections. The next chapter focuses on interview data and analysis and findings.

Chapter 4

Analysis and Findings

4.1 Introduction

This chapter presents the data collected in interviews and analyzes them for discussion in the concluding chapter. The informant pool for this study consisted of landscape architects and hydrologists in North Texas with varied educational and professional backgrounds. Emphasis was placed on the education and practice of professionals in landscape architecture. However, four engineers who deal with hydrology were also interviewed to acquire greater understanding of the professional domains in hydrology.

Following the research design outlined in the methodology section, the researcher analyzed the interview transcripts to acquire data. Key points and themes were identified following methods suggested by Taylor and Bogdan (1998) and Glaser and Strauss (1947), as discussed earlier. Thematic elements in the data derived from the interview questions are initially discussed separately for each profession. Then, general themes among the professions are explored.

4.2 Interview Responses

This section contains responses to interview questions. Throughout this study of water knowledge in landscape architecture, the researcher contacted many professionals for interview. Fifteen of these professionals responded and completed interviews. Eleven of those respondents were practicing landscape architects and four of them were practicing hydrologists in North Texas.

Interview results were first analyzed separately per profession, as well as by the type of question. Interviews were set up to have three parts: the profile questions, the in-depth (main) questions, and the follow up questions. These are reported in the same fashion in the following section. Overall findings from interviews are summarized at the end of the section.

4.2.1 Responses to Profile Questions

The profile portion of the interview questions was designed to provide basic background data on the educational and professional experiences of informants of both professions. They also established information regarding the setting in which the informants practiced at the time of the study. Data from these questions illuminated connections between educational and practical knowledge.

4.2.1.1 Landscape Architects

Of those professionals in landscape architecture interviewed, three have been practicing for 0-5 years; two have practiced 5-10 years; two have practiced 10-15 years; and four have practiced for over 20 years (see Figure 4.1). The types of firms in which these professionals practice were also varied. Three were working in government offices; two of these were federal offices and one was for a municipality. Two informants worked in multi-disciplinary firms with architecture, engineering, and landscape architecture. Likewise, a residential design-build firm employed two informants and two worked in engineering firms. Finally, one informant worked in an architectural firm and one was self-employed doing residential and commercial planting designs (see Figure 4.2).

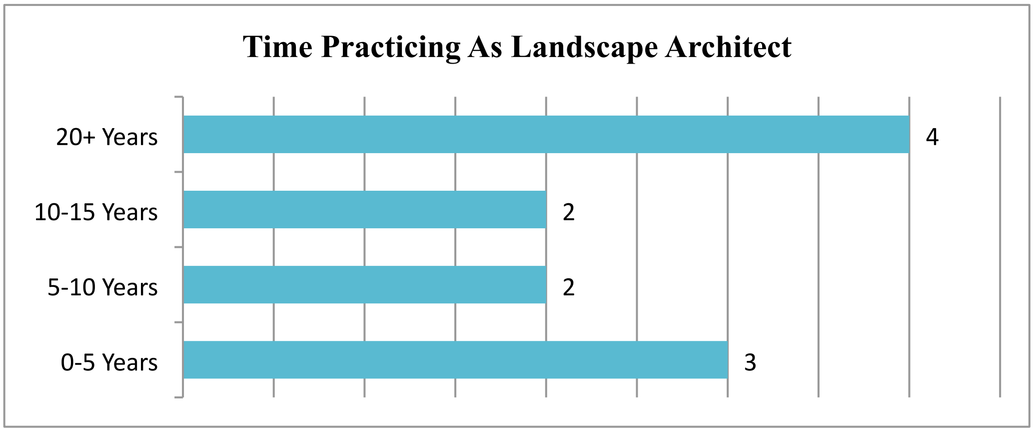

Figure 4.1: Time practicing as landscape architect

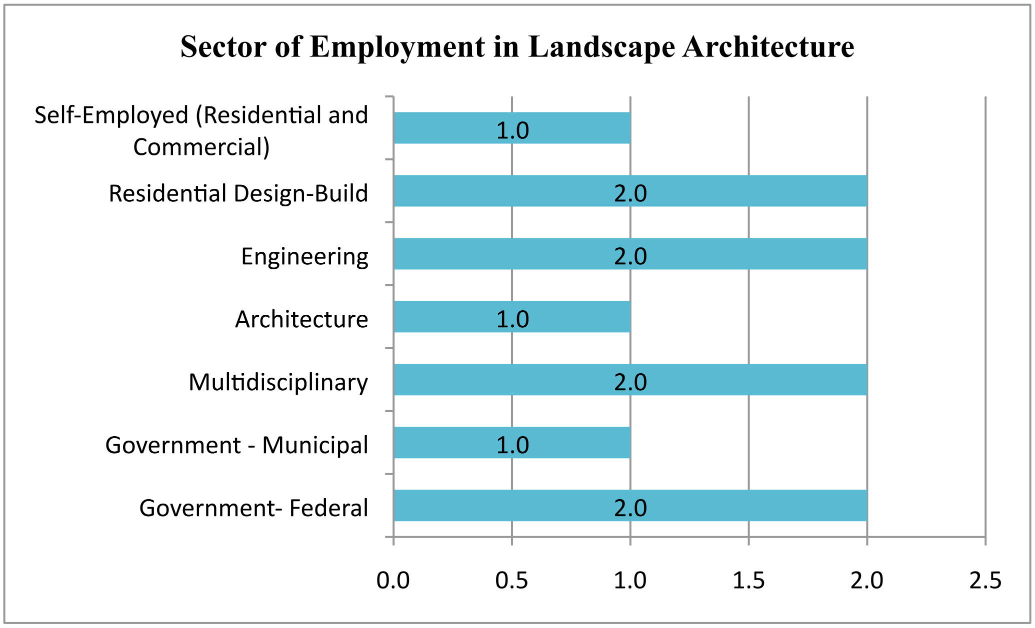

Figure 4.2: Sector of employment in landscape architecture

All informants in landscape architecture had degrees in landscape architecture. Figure 4.3 shows that eight of these informants had dual degrees, with MLAs at the graduate level. Of these, three had both undergraduate and graduate degrees in landscape architecture. The other five informants with graduate-level training had undergraduate degrees in horticulture, biology, business management, fine arts, and geology. Of those informants with no graduate level education, two had BLAs and one had a BSLA.

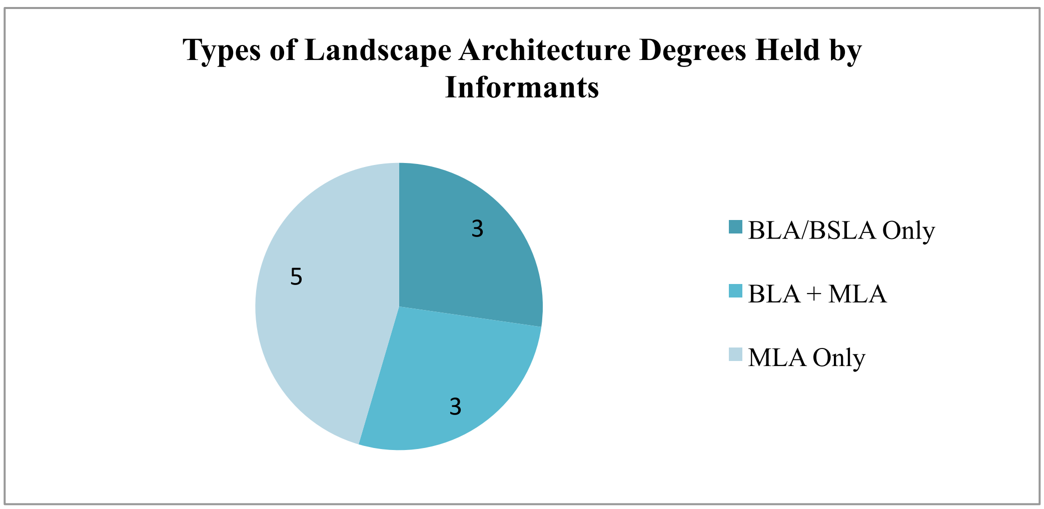

Figure 4.3: Types of landscape architecture degrees held by informants

The informants who held undergraduate degrees in landscape architecture earned them at Rhode Island School of Design, Texas A & M University, Texas Tech University, Arizona State University (BSLA), Oklahoma State University, and Pretoria University. All informants who hold MLAs in this research, except one, earned the degree in Texas from the University of Texas at Arlington or Texas Tech University. The exception was with one professional who studied at Harvard University School of Design. All of the undergraduate degrees outside landscape architecture were earned in Texas at Texas Tech University, Dallas Baptist University, Northwood University, Steven F Austin University, and Texas A & M University.

4.2.1.2 Hydrologists

Of the four hydrologists interviewed, each had between 10 and 20 years of experience in the field. Two worked at multi-disciplinary engineering consulting firms and had bachelor's degrees from schools in Texas. One of these informants earned a bachelor's degree in agricultural engineering from Texas A & M University. The other studied at the University of Texas at Austin and earned a degree in civil engineering. One informant worked at an engineering consulting firm and holds a BS in agricultural engineering. This informant completed some coursework in environmental engineering at the master's level at The University of Texas at Arlington, but did not earn a degree. The remaining informant had a much higher education level and works in an academic setting. The educational background of this respondent consisted of undergraduate and graduate degrees. The first was a BS in agricultural studies, then a master's in irrigation from the same university. This respondent was also the only one with a doctorate degree, which was in the field of biological and agricultural engineering.

4.2.2 Responses to In-Depth Questions

The in-depth interview questions were meant to answer the research questions in this study. These research questions explore what knowledge in hydrology is acquired in education. Similarly, they inquire about this level of knowledge as it pertains to the professional practice in landscape architecture. Finally, the main research questions also seek knowledge in order for the researcher to form an opinion on whether an overlap of services exists among the professions of hydrology and landscape architecture. The responses acquired had as many similarities and differences as responses to profile questions. As with responses to the profile questions, these responses were separated by profession and analyzed separately in preparation for discussion as a whole.

One issue must be noted here. In regards to the term hydrology, previous review shows that topics in hydrology tend to include more than just the movement of water. At the very least, hydrology by its definition, influences other topics in water, including quality and quantity (supply). Although questions are framed with the word hydrology, many of the respondents use this and the term water interchangeably. If not just a syntax issue, respondents went on to highlight water-related issues as major discussion pieces in this research, so their frame of mind indicates interchangeability. Reporting of the findings below reflects this issue in its content.

4.2.2.1 Landscape Architects

The first in-depth interview question delved into the academic past of the respondents and sought to describe the level of knowledge in hydrology that each informant gained in education. Although graduation dates were not included in interview questions, the amount of time the informants in landscape architecture have practiced indicate most informants completed their education more than five years ago (and about half more than fifteen years ago: See figure 4.1). All interviewees in landscape architecture responded to this first question similarly. Basic site grading and drainage was the principal topic concerning knowledge of hydrology gained in education. For example, one informant indicated that a landscape technology class he attended dealt with the topic of grading and drainage, and all designs and calculations were done with computer software such as LandCAD.

Across the board, each professional was exposed to the subject of stormwater management as a student in landscape architecture. In fact, half of the informants indicated this was the only exposure to hydrology and water-related issues covered in their education. Two reported that they had studied some stormwater management, one studied wetlands, and two had more extensive study in watershed management. However, it was not determined whether these were separate watershed management courses or topics of other courses.

The second question, similar to the first, was postured to discover what knowledge about hydrology and water is needed in the routine practice of landscape architecture. A majority of responses to this question included site grading and drainage, but they also included responses not covered in question one. Seven professionals suggested that in their practice they need to know stormwater management skills. Two of these informants went further and indicated a need for knowledge on soils and their properties of filtration and infiltration. Only one respondent described the need for knowledge in hydraulics and floodplain management. Similarly, one respondent reported that mitigation of water use was necessary to know. One informant, who specialized in creek side management, gave the most extensive list of knowledge required for practice. This professional added wetland function, stream bank stability and restoration, and creek corridors to the list of knowledge in hydrology that was needed for practice. All three informants who work mostly in residential design said that the need for knowledge in hydrology was very minimal, but that they occasionally need to know about drainage of existing sites. They elaborated that when doing a residential design it is important not to block drainage swales with plants or structures. These swales typically run along the back and/or sides of the property.

The final question of the in-depth set was designed to provide an understanding of the perception of service overlap among the professions. Only one informant indicated a difference in services and did not describe any similarities between the professions as overlap. The three informants in residential design could only speculate on whether an overlap of services exists between the professions of landscape architecture and hydrology. Their response was affirmative, but they had no practical experience working with hydrologists. Based on the questions raised, two of the informants agreed that some overlap exists, but pointed out some issues that distinguish the two fields.

For instance, respondents indicated that landscape architects should educate engineers on green infrastructure, including plants and human recreational spaces (such as walking/biking paths, water features, open green spaces, and wooded areas). One respondent pointed out that engineers usually do not use a watershed approach. Rather, they usually only look at the sites they are developing. Landscape architects also viewed engineers to be more concerned with hydraulics and moving water away than with other hydrology and water issues such as retention and treatment for reuse. Engineers were said to be the ones who deal with modeling site hydrology, while landscape architects use the models (such as hydrographs and simulations) to design.

Four landscape architecture interviewees gave absolutely affirmative answers that overlap exists. One of these, a government employee, explained that whichever field/office received the funding was the entity that did the design. The professional who deals with creek side restoration gave the other absolutely affirmative response, and this informant specified that the overlap exists with hydrology and hydraulics (H & H) engineers, civil engineers, and ecologists. Figure 4.4 describes the responses to this question graphically.

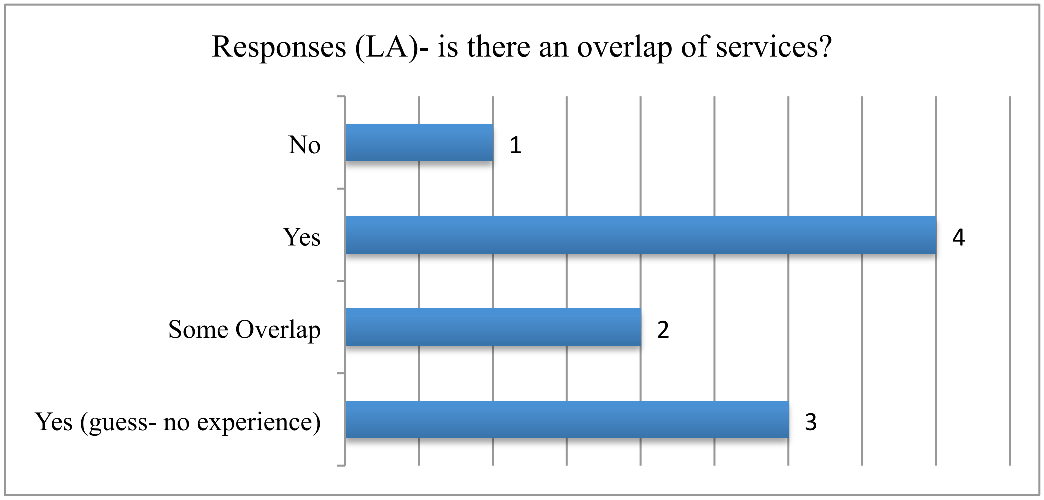

Figure 4.4: Responses by LAs on overlap of services

4.2.2.2 Hydrologists

Posing similar questions to hydrologists, data were uncovered regarding the same topics, although with different outlooks. The first question dealing with knowledge acquired in education yielded data that indicated that the hydrology or water components of the engineers' education were far more extensive than those of the landscape architects. Each informant had general hydrology and hydraulics courses, but also had more specialized training. One informant indicated specific studies on water quality and design methodologies. One informant had extensive study in irrigation because he specialized in the subject to earn a degree. Other topics this informant studied included watershed hydrology, hydrology for landscape design, hydraulic structures, groundwater hydrology, and water resources engineering. The informants with only undergraduate level education were not exposed to as many topics in water and each had similar educational backgrounds. The knowledge gained by these informants in education included hydraulics (both sheet flow, or surface, and concentrated hydraulics) and fluid dynamics.

The professional knowledge requirements of hydrology for all hydrologists interviewed were more extensive than those for landscape architects. However, there was consensus among the professions regarding stormwater management skills being required in practice. Each informant in hydrology was largely concerned with the hydrology of stormwater management, but also with the hydraulics (sizing pipes, drains, retention/detention features). The topic of stormwater management routinely included water quality topics, as well. Another commonly reported knowledge need was the need to understand historical rain events and to be able to quantify the impacts on hydrology by pinnacle storm events, such as 5-year and 100-year storms. So, knowledge of surface hydrology was necessary for each informant to possess for professional practice. One informant emphasized the need to know groundwater hydrology more than others, and they pointed out that surface hydrology and groundwater hydrology are two separate topics. Finally, only one informant acknowledged the need to know about government regulation and laws. This was not a topic considered by the researcher for interview purposes, but some information on regulation and laws was uncovered in the literature review of this research (Chapter 2). This may be a topic that many professionals are concerned with, but due to the wording of research questions, other informants did not consider such responses.

The perception of professional overlap varied among the hydrologists. One informant agreed that there is an overlap of services, but only in the form of designing with Low Impact Development (LID) Best Management Practices (BMPs). This informant indicated that he has worked in firms where landscape architects would do all site grading and other engineering-type services. The engineers and hydrologists would then study their plans to confirm their function. The other informants did not see an overlap. One informant agreed that there is collaboration among the professionals. The other informant suggested that landscape architects and hydrologists often try to perform each other's services, and very poorly at that. This informant suggested that landscape architects should concern themselves with the aesthetics of a site and minimal hydraulics like sizing of drains or rain gardens. However, these services would still need to be checked by an engineer. A final response to the question of service overlap brings the term hydrology back on topic. This interviewee's response was negative, based on the interviewee's understanding of hydrology as defined by the engineering profession.

4.2.3 Responses to Follow-Up Questions

The follow-up questions formulated for this research were designed to further inform the researcher in the event it was felt not enough data were being collected. The first interviews conducted seemed short. As the researcher familiarized himself with the interview process, he decided he should pose the follow-up questions in each interview. Their responses are organized similarly to the profile and in-depth question sets.

4.2.3.1 Landscape Architects

The tools that the informing professionals use to deal with water were not tools but, rather, methodologies for dealing with stormwater. Half of all respondents described Low Impact Development (LID) Best Management Practices (BMPs) as the principal way they deal with hydrology or water. Three professionals did not indicate a need to use any tools or methods for dealing with hydrology in professional practice, and two expanded on the tools they do use. These included hydrographs and models, which were provided by engineers. In fact, one informant said he uses hydraulic models (provided by engineers) to study historical storm events (100-year, 20-year floods) and make predictions for the future.

Other schools of thought or methodologies similar to LID were also described as methods for dealing with hydrology. Integrated Stormwater Management (iSWM) includes several BMPs comparable to LID. As previously mentioned, some governments and government planning organizations have promoted the use of iSWM in building their cities or regions. One informant described another methodology for dealing with stormwater: the Institute of Sustainable Infrastructure (ISI) Vision. The informant explained that the ISI had developed this methodology, similar to LID, for engineers.

The amount of time spent each week with hydrological issues in standard practice was also explored. Four respondents reported that they spend less than 5 percent of their weekly professional activities dealing with water and hydrology. Two informants agreed on a figure of 10 percent, one spends a quarter of his time on water issues, and three spend between 40 and 50 percent. One respondent had a different answer. This respondent said it usually depends on the project type. He indicated that he typically spends about half his time on water issues, but that his current project demanded 90 percent of his professional energy be focused on hydrology or water issues (see figure 4.5)

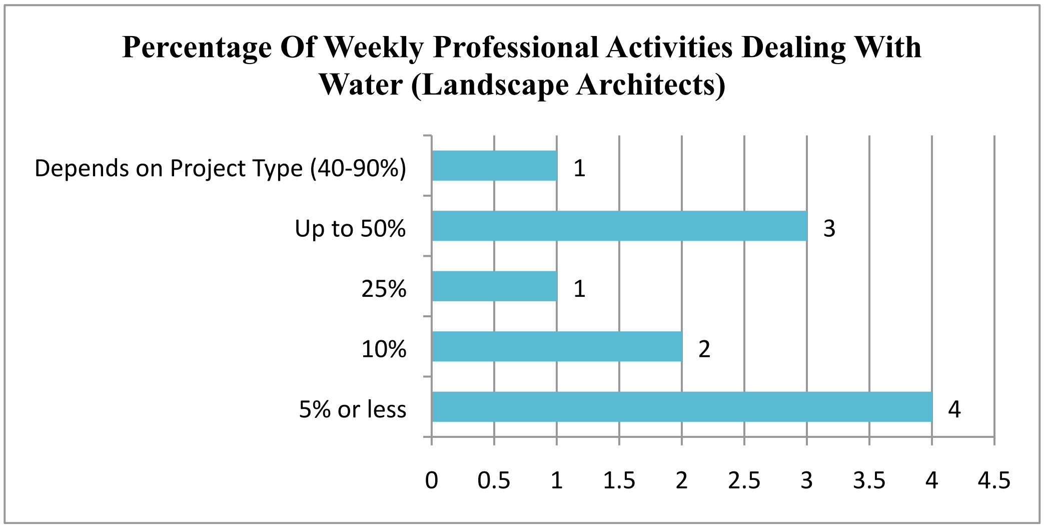

Figure 4.5: Percentage of weekly professional activities dealing with water (landscape architects)

4.2.3.2 Hydrologists

Responses to the first follow-up question described the tools used to perform services pertaining to hydrology and water. The hydrologists provided more extensive data in interviews than did landscape architects. The hydrologists use a variety of computing tools to perform their services. The tools they used were not design methodologies, as many landscape architects reported (like LID), rather, they were physical tools. Computer modeling tools included Geographical Information Systems (GIS), HEC-RAS, HEC-HMS, Stormwater Assessment Tools (SWAT), Civil3D, and SCS methodologies. Only one informant indicated that he uses tools in a field setting outdoors (stream gauges). The use of these tools does allow for remote use, as with computer modeling software.

Regarding the final question on the amount of time each week spent dealing with hydrology and water issues, one informant reported a need for knowledge in hydrology 100 percent of the time. Another informant reported that most of his time each week was spent dealing with hydrology, and his answer was 90 percent of the workweek. The other informants agreed that, initially, their knowledge requirements were higher, but that over the course of their careers and carrying different job titles the demand has decreased. These informants both answered that at least 90 percent of their work week was focused on hydrology in the beginning, but that those numbers shrunk to 25 percent and 50 percent over time (see figure 4.6).

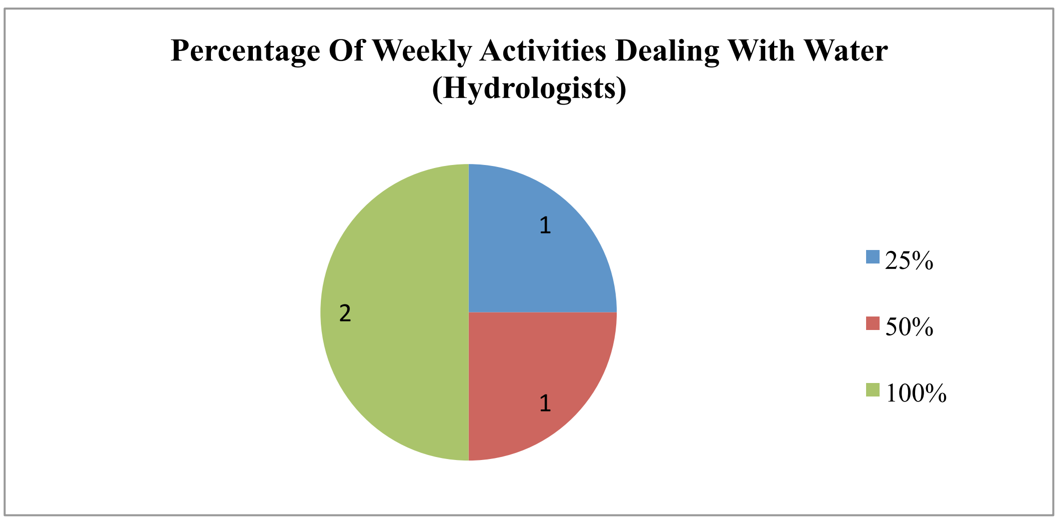

Figure 4.6: Percentage of weekly activities dealing with water (hydrologists)

4.3 Themes Retrieved from Findings

4.3.1 General Themes

There were some overarching themes in the discussions with landscape architects. In analyzing the amount of knowledge gained from education, the theme was a basic exposure to water issues in the form of grading and drainage instruction as part of formal course structure and/or curricula. Professional practice caused these professionals to have to expand their knowledge in hydrology and water. Depending on the project and type of routine work, knowledge needs increased upon entry into the profession. LID design, in particular, was a skill learned in practice for some of the informants who completed their education before it became a hot topic since its inception by Prince George's County, Maryland in 1999 (PGC, 1999).

The educational theme for hydrologists was dissimilar of that for landscape architects. As expected, not only did they gain a greater amount of knowledge from education than landscape architects, it was more generalized and encompassed several different topics in hydrology and hydraulics. Depending on the type of work performed, not all knowledge gained from education was used in the hydrology profession. Engineers and hydrologists specialized and focused their professions in areas like water quality, hydraulics and surface and groundwater hydrology. It was not clear whether all of the reported modeling tools were used in education, but it was shown they are heavily used in practice.

Landscape architects seemed to hold a more affirmative view than hydrologists regarding an overlap in services. The theme here was that a landscape architect could perform many of the services of an engineer or hydrologist. However, in each case, the landscape architect deferred to the hydrologist or engineer for the technical details relating to most water issues. The hydrologists delineated a more clear separation between the two professions. They appeared to be most willing to defer to landscape architects when plants, aesthetics, or other cultural or social activities were involved.

The following sections discuss overall themes retrieved from interviews, and some specific thematic areas are discussed.

4.3.1.1 The Term “Hydrology”

Data from interviews showed that language varies between the fields of landscape architecture and hydrology or engineering. Throughout the study, landscape architects used or viewed the word “hydrology” as interchangeable with “water”. They had not been as heavily exposed to the study of water or its movement as the hydrologists had. The hydrologists pointed out that hydrology is purely the study of water’s movement in its cycle. They differentiated between hydraulics and hydrology, and even between surface and ground water hydrology.

4.3.1.2 Low Impact Development (LID)

LID was discussed in almost every interview in this research. As previously mentioned, the professionals interviewed have been practicing for more years than LID has existed. So, exposure to LID in education was nonexistent or very little. Some informants had been exposed to various BMPs in education, such as detention and retention elements, but did not study or design projects with integrated, low impact treatments. The informants described LID as a new trend.

Each informant viewed LID as an entity that causes collaboration between the fields of landscape architecture and hydrology. One informant in hydrology worded this statement differently: LID has brought the hydrology side and the landscape architecture side of site development together. For example, a landscape architect might design a site with several low impact BMPs. While he may calculate the necessary sizes of rain gardens and bioretention areas, an engineer should confirm the calculations. The same was reported to be true for the grading of bioswales and the sizing of drainage pipes.

There was also unanimous agreement on the growing popularity of LID and other similar methodologies. Some similar methodologies mentioned include integrated stormwater management (iSWM), which the North Central Texas Council of Governments (NCTCOG) has been advocating. The organization was reported to be encouraging each municipality in North Texas to implement iSWM BMPs. The City of Dallas was said to be implementing Complete Streets, which integrates some green infrastructure into urban streets. Some BMPs discussed included increased vegetation and permeable areas.

Each informant believed that the use of BMPs from these similarly water-friendly methodologies would increase in the future. This point was illustrated by the increase in the use of these BMPs over time and the recent trend for government entities and planning organizations to emphasize them. Some informants also indicated that the way these BMPs work influences other water topics, like water supply and water quality. Their responses confirm findings in literature review about applying knowledge of hydrology to BMPs, such as treatment wetlands, to clean water and provide a means for reuse (Green, 2012). Another example is from an informant in landscape architecture, who discussed water capturing and reuse techniques on an 80-acre campus. Catching water from cooling towers (for air conditioning) and treating it made it available for use on campus. The informant indicated a need for creativity and looking for ways to use BMPs for sustainability purposes. Informant responses confirm findings in literature about applying knowledge of hydrology to BMPs, such as treatment wetlands, to clean water and provide a means for reuse (Green, 2012).

4.3.1.2.1 Location Determines Function

Some informants agreed that LID and similar BMPs are not practical in some instances, or that certain BMPs were more fitting in some instances than others. For example, in drought-stricken areas of North Texas a designer would want to capture as much water as possible for use and reuse. In wetter areas, treating water while moving it away from a site would be desirable. Flash flooding was reported to be more likely in areas of high drought, so there must be consideration in designs for this as well. Another aspect of location besides climatology that was discussed was soil type: Some BMPs would not function as well in different soil types, or their size would need to be adjusted due to soil type.

4.3.1.3 Water Supply and Quality

Some informants described the way LID BMPs (and other similar methodologies) affect water supply: Allowing water to percolate through the ground to aquifers helps keep these supplies steady. Maintaining the pre-built hydrology of a site upon development decreases changes in the flow of water downstream in the watershed. This was also reported to affect water supplies.

Similarly, allowing percolation of water into soils, and slowing, retaining or detaining it, was said to affect water quality. It was explained that decreasing permeability of surfaces and maneuvering water through soils and bioretention areas cleans the water. One informant described projects they work on in China, where wastewater is dumped into streams and other water bodies. This informant emphasized the importance of a landscape architect knowing how to implement BMPs to keep polluted water from spreading, as well as to remove nutrients from (clean) the water and make it usable for recreation, habitats, or food production.

4.4 Overall Findings

Informants in this study practice in various niches of their professions and have practiced for various lengths of time. The majority of informants have a graduate level education and have practiced for more than ten years. A minority of informants has no graduate level education and three informants in landscape architecture do not deal with water on a weekly basis.

The responses to questions illustrated that there are disconnects between knowledge acquired in education and that required for professional practice. In the case of landscape architects, much of their hydrology and/or water knowledge is in the form of stormwater management and LID. According to respondents of this research, most acquired this knowledge in practice. In the case of hydrologists, their education provided more hydrology and water knowledge with well-defined courses and tracks in their education, and possibly more than they need to specialize in a particular area.

The perception of an overlap of services is conflicting between the professions, but most respondents described collaboration, such as the creation of models by engineers and their subsequent use by landscape architects. Other collaboration has recently been in the form of LID. Shifts in attitudes of the public, governments, and other organizations have created a demand for dealing with stormwater more efficiently. Though popular in landscape design, LID has been shown by this research to also be an important part of contemporary engineering/hydrology practice. This creates a clear agreement that landscape architects and engineers should both know how to deal with stormwater to improve water quality and reduce the impacts of use (irrigation, wastewater) through reuse.

4.5 Chapter Summary

This chapter presented the findings of this research and analyzed the data for conclusion in the final chapter. Interview responses were discussed question by question. The organization consisted of sections for each question set (profile questions, in-depth questions, and follow up questions), and each individual question was discussed in separate subsections. Responses by landscape architects and hydrologists were similarly separated into sections.

Data derived from informant interviews, paired with background knowledge of literature pertaining to water and landscape architecture, prepared the researcher to make concluding comments. The following chapter includes conclusions derived from the research.

Chapter 5

Conclusion

5.1 Introduction

The final chapter of this research summarizes knowledge uncovered in the study to make conclusions. The research questions that needed to be answered were listed in Chapter 1, along with a brief overview of methodology and other introductory discussion. The researcher used topics discovered in existing literature from Chapter 2 to form a knowledge base on the topic of hydrology knowledge in landscape architecture. By using interviewing methods described in Chapter 3 to uncover qualitative data on the topic, analysis was possible, and it was presented in Chapter 4.

To summarize findings and discuss the importance, relevance and implications of the research questions, the researcher explores each separately. In this chapter, however, data acquired from both landscape architects and hydrologists are compiled for discussion. Next, the researcher discusses the study as a whole, and suggests related topics for future research. Then, the researcher discusses the relevance to the education and profession of landscape architecture, and, finally, suggestions for related topics of research are made.

5.2 Research Questions

5.2.1 What is the level of competency in hydrology needed by a landscape architect in routine professional practice?

The level of competency needed by professionals practicing landscape architecture has been shown to be minimal, but increasing within the recent decades based on the type of work performed. For instance, professionals who deal primarily with high-end residential planting designs suggested that they rarely (less than 5 percent of weekly activities) need knowledge and/or skills in hydrology. Professionals who typically deal with larger sites or who work for public entities are more concerned with water and hydrology. For these professionals the amount of time spent dealing with water on a weekly basis is still less than half of all other topics covered in their typical work week. Although it was found that knowledge concerning water and hydrology is a necessary component of a landscape architect's skill set, this knowledge is just a portion of the overall knowledge needed in practice.

The term "hydrology" is not defined literally in most instances by professionals in North Texas, so not all knowledge described by informants pertains strictly to hydrology. Stormwater management and Low Impact Development (LID) are recurring themes when discussing hydrology with landscape architects in North Texas. Most Best Management Practices (BMPs) used to deal with stormwater directly affect the movement of water so they do apply to the term. For example, permeable paving allows water to flow through a surface and then laterally across another or directly into the ground. Bioswales, rain gardens and constructed wetlands all retain or detain water and alter its flow. In the cases of informant interviews of this study, managing stormwater on a site at all levels is the extent of knowledge needed in hydrology. This knowledge in hydrology affects the various water issues discussed in this research.

Engineers and professionals practicing hydrology did not have the same interpretation of the definition of hydrology. Data indicate that hydrologists have more exposure to hydrology and its meaning in engineering, so would have a different opinion on the topic. Furthermore, engineers and hydrologists have a broader technical vocabulary regarding hydrology and water, so they are better able to describe topics that most other professionals would consider a part of the study of water, its movement, and its qualities.

5.2.2 What knowledge about hydrology is acquired in landscape architecture education?

The findings from informant responses pertaining to this question indicate that knowledge about hydrology or water acquired in landscape architecture education is more limited among North Texas practitioners than is needed for practice. This is a goal for all education in any area of study. The coverage of topics on hydrology and water seems to be more implicit as literature review and findings in this research illustrate. For example, while informants in landscape architecture in North Texas discuss LID BMPs as tools in practice, they were not exposed to them in education. The informants for this study completed their education before LID became popular and they acquired this knowledge in practice. However, some knowledge gained in their education did pertain to hydrology.

Each of the landscape architecture practitioners has taken courses, or components of courses, on site grading and drainage. Topography and its manipulation by grading affect the movement of water, so grading directly pertains to hydrology. Dealing with stormwater is the principal piece of water knowledge acquired in education, although it is shown that the location of undergraduate or graduate study plays a role. For example, those professionals who study in a program at an agricultural or scientific institution are exposed to additional topics in hydrology. These include the movement of water through soils and the water's resulting quality from such movement. Overall, the trend has been that it takes time and training in professional practice outside the educational setting to become competent in designing with hydrology in mind.

As expected, hydrologist informants in this study are exposed to many more concepts of hydrology in their education. Research shows that these informants were exposed to a broader range of topics in hydrology in education and their practice has caused them to specialize. This is in contrast with the knowledge acquired in education and used in the practice of landscape architecture. For example, the informants in landscape architecture in this study reportedly learned only basic topics like site grading and drainage. Only in their professional practice have they expanded their knowledge to apply solutions to stormwater management. This research suggests that the key topic in hydrology needed by informants in practice in North Texas is stormwater management. The solutions mentioned above include the various methods of collecting, conveying and treating stormwater (LID, iSWM, ISI Vision).

5.2.3 Is there an overlap of services between landscape architects and other professionals who practice hydrology?

The findings of the research illustrated varying views among the practitioners in different fields regarding an overlap of services. The conflicting responses to this question by informants from each field illustrate the perception of professional services each field performs and the capabilities that professionals in each field possess. The landscape architects generally agree that there is some overlap, but that the dynamic between the two professions is more collaborative. Both professions can design stormwater treatments, but landscape architects do so in a manner that is more holistic, meaning that they integrate ecological and environmental principles while paying attention to aesthetics to optimize human experience. Landscape architects tend to rely on modeling, done by hydrologists, to inform their designs. Similarly, they rely on hydrologists to check the hydraulics of their designs.

The hydrologists in this research view the relationship between themselves and landscape architects as purely collaborative. These professionals prefer to have the final opinion on the hydrology of a site, and they defer to landscape architects for the development of the site's aesthetic. While the opinions and perceptions about service overlap, data confirm that there is a slight overlap of services: professionals of each type can preserve the basic hydrological function of a site if they have all the tools necessary to do so.

5.3 Discussion

Based on this study, a landscape architect needs to know about the movement and quality of water, particularly during storm events and drought. This knowledge is principally acquired on the job through design and construction strategies, such as Low Impact Development. This research found that gaps exist in knowledge and skill between preparation in education and professional practice among North Texas practitioners interviewed in this research.

The gap of knowledge in hydrology discovered in this study may be explained on a temporal level. The niche of hydrology that focuses on stormwater management and LID is a relatively new concept. As mentioned in the Chapter 2 literature review, LID was developed less than 15 years ago (PGC, 1999). Even so, it has gained prominence only in the last 10 years. Many of the professionals interviewed have been practicing longer than that, and those who were studying while stormwater gained popularity still missed out on detailed instruction on the topic in education. This suggests that the educational paradigm has been developing at a slower pace than the profession. The researcher entered landscape architecture education more recently than any informants, and it is apparent that he received more exposure to LID and stormwater management in education. So, it may be concluded from the findings of this research that as the topic has become more prominent, landscape architecture curricula should keep up with some of these trends and have a keener understanding of hydrology (specifically stormwater management). Because no detailed study of curricula was found by this researcher up to this point, it may be that academic pedagogy has shifted in recent years to include more instruction in these topics.

The portion of the literature review (Chapter 2) that discusses policies the American Society of Landscape Architects (ASLA) has developed on water topics exemplifies this researcher's findings concerning the need for knowledge in hydrology (as it pertains to stormwater management). The subject of each policy statement (environmental sustainability, water quality and conservation, waterways, wetlands, and coastal zones) is directly influenced by how landscape architects and engineers treat stormwater as it enters, lingers, and leaves a site. These policy statements suggest to the researcher that, nationwide, the landscape architecture profession recognizes a need for knowledge in hydrology and advocates for smart use of water and stormwater in various social and environmental arenas.

With any profession knowledge is gained on the job that may not be presented in education. However, as new generations of landscape architects are trained, any extra knowledge they have upon entering the profession gives them an edge on the competition. The recent push by governments and planning organizations indicates that water issues will be increasingly scrutinized. This push is due to current droughts and climate change, as well as the projections of population growth, water supply, and water demand. A level of understanding of hydrology will be increasingly important among landscape architects to broaden their services to changing dynamics of ecology and environment.

Perceptions of overlap in services were different among the professions because the informants in hydrology have specialized knowledge and education on the topic. Landscape architects reported that they work often with civil engineers. It is possible that these professionals do not have the extensive knowledge and skill in hydrology, compared to hydrologists who deal specifically with water-related issues. In this case it is even more important that the landscape architect have a firm understanding of hydrology.

The translation of the term “hydrology” by landscape architects to include other water-related issues is not so unfounded. Hydrology affects water quality, which affects water supply. Applying hydrological knowledge in certain instances alleviates water quality problems and water scarcity. For example, in some locations throughout the world, sewage and industrial waste is being pumped untreated into waterways. Not only does this pollute surface waters, it removes them from the overall water supply. Landscape architects use hydrological knowledge, along with knowledge of ecology, plants, soils, recreation and aesthetics to design efficient ways to treat such environments. The best example of this concept is derived from literature reviews and one interview with a landscape architect: The developing world regulates water and waste less stringently than the developed world.

Landscape architects are working on projects that support the holding of water onsite and allowing for percolation into groundwater stores. Not only does this process of recharge clean the water, but it also bolsters supply. This is becoming increasingly important in drought-stricken areas like North Texas. Applying knowledge in hydrology also supports the environment and its aquatic and wetland ecosystems. The practice of draining and developing wetlands may not occur when the designer has knowledge of hydrology and its effect on these environments.

5.4 Relevance to Landscape Architecture

5.4.1 Education

This study illustrates the importance of hydrology or keener understanding of water as a component to landscape architecture education. According to the findings of this research there has not been a clearly defined focus on hydrology in landscape architectural practice and curricula. Stormwater management concepts like LID should be ubiquitous in every project on which a student works. This kind of exposure will create a generation of landscape architects who use their knowledge in hydrology to promote LID or similar sustainable methods in every professional project. This exposure may reduce the time for on-the-job training with such topics. As previously mentioned, a shift in educational content may have happened or be currently happening. Educators have a commitment to stay current with methodologies that protect site hydrology and conform to ever changing government regulation. It is the one of the new and more recognized ways their students can have an edge upon entering the profession.

5.4.2 Professional Practice

The most relevant discussion in this research for the profession of landscape architecture is on the perception of service overlap. The perceptions of each profession on this topic differ, so it is important to understand the roles of each. Because landscape architects focus on form in addition to function, they should be cognizant of when their skill matches the task at hand.

There is rarely time to perform modeling procedures in the practice of landscape architecture, and some projects require extensive study of hydrology. There are instances where collaboration with engineers is needed. A landscape architect needs to be able to recognize when such collaboration is required. For example, a bioretention area that fits with the aesthetic of the design might not function properly to handle storm events at every level (50-year, 100-year floods, etc.). Collaboration with an engineer and simulation with a model help the professional make important decisions pertaining to hydrology.

Conversely, a landscape architect needs to recognize when engineers of varying types are uninformed on a topic of stormwater management. For example, an engineer who does not specialize in or practice hydrology may not consider an entire watershed, downstream effects on water bodies and ecosystems, or even soil types and water quality. If the engineer's focus is only to move water from a site and prevent flooding of the site, collaboration with a landscape architect is necessary. Landscape architects are professionally charged with protecting the health, safety, and welfare of the public (ASLA, 2003) and should recognize when they require collaboration with other professionals, as well as when others need their input. Professionals in North Texas interviewed in this study seem to recognize this and do collaborate when necessary, although some believe it should be more often.

5.5 Suggestions for Future Research

This study is a systematic look at the knowledge needs in hydrology, which are necessary for practice in landscape architecture in North Texas. It explores other topics, like the level of preparation a student receives in education and the similarities among other professions. Further study is needed in different topics discussed in this research. For instance, the research conducted in this study may be expanded to a larger geography with wider set of respondents to further illustrate the changing practices of hydrology knowledge in landscape architecture and educational needs.

Regarding the landscape architecture portion of this study, research could be done on the makeup of curricula across the United States and across the world to determine exactly what is being taught in landscape architecture programs regarding hydrology and/or water related issues. Then, suggestions for any changes to curricula could be made. Similar study could also be done for engineering programs to identify areas of concentration. It would be useful to understand the differences between the different types of engineering curricula and the hydrological concepts they present. This would inform landscape architects how to choose the best collaborator for a project.

Finally, it would be of interest to determine whether any other professions, such as those mentioned by informants (civil engineering and ecology/life science), share similarities with landscape architects concerning knowledge about hydrology in education and practice. The perceptions of each of these similar professions towards one another could also be studied.

There are many possible "next steps" of this research. Water is an increasingly important topic, as Serageldin (2009) proclaimed (regarding the subjects of water shortages and future wars), that continuing research and knowledge creation on these topics are essential in the profession and education of landscape architecture.

Appendix A

Institutional Review Board Documentation

IRB Approval:

Office of Research Administration
Regulatory Services
817-272-3723
regulatoryservices@uta.edu
http://www.uta.edu/ra/oric/

Institutional Review Board
Notification of Exemption

April 01, 2013

Kent Matthew Elliott
Dr. Taner r Ozdil
School of Architecture
Box 19108

Protocol Number: 2013-0512

Protocol Title: What does a landscape architect need to know about water? Assessing knowledge needs of professionals in North Texas.

Type of Review: **Exemption Determination**

The UT Arlington Institutional Review Board (IRB) Chair, or designee, has reviewed the above referenced study and found that it qualified for exemption under the federal guidelines for the protection of human subjects as referenced at Title 45 Part 46.101(b) (2).You are therefore authorized to begin the research as of April 01, 2013.

Pursuant to Title 45 CFR 46.103(b)(4)(iii), investigators are required to, "promptly report to the IRB ***any*** proposed changes in the research activity, and to ensure that such changes in approved research, during the period for which IRB approval has already been given, are **not initiated without prior IRB review and approval** except when necessary to eliminate apparent immediate hazards to the subject." Please be advised that as the principal investigator, you are required to report local adverse (unanticipated) events to the Office of Research Administration; Regulatory Services within 24 hours of the occurrence or upon acknowledgement of the occurrence.

All investigators and key personnel identified in the protocol must have documented Human Subject Protection (HSP) Training on file with this office. Completion certificates are valid for 2 years from completion date.

The UT Arlington Office of Research Administration; Regulatory Services appreciates your continuing commitment to the protection of human subjects in research. Should you have questions, or need to report completion of study procedures, please contact Robin Dickey at 817-272-9329 or robind@uta.edu. You may also contact Regulatory Services at 817-272-3723 or regulatoryservices@uta.edu.

Recruitment Email Script:

RECRUITMENT SCRIPT: ELECTRONIC (EMAIL)

Dear ___________:

I am writing to invite you to participate in a study I am performing for my master's thesis in UTA's Program in Landscape Architecture. The study, titled *What do landscape architects need to know about water? Assessing knowledge needs of professionals in North Texas*, seeks to identify the level of competency in hydrology a landscape architect needs to perform services pertaining to water in routine practice.

Your participation in the study is anonymous and consists of a 30-minute face-to-face or telephone interview and possible follow-up questions at a later time. The interviews will be recorded with a smart phone device and transcribed for analysis (again, this is an anonymous study). Transcripts are typed word-for-word and kept with the recordings in the advising faculty member's office at UTA until the end of the study.

At the end of our meeting I ask that you recommend other landscape architects or hydrology professionals to interview. This is unfunded academic research and compensation is not awarded.

I will perform the study this month and will seek to arrange an interview at your earliest convenience at a place also convenient to you.

I appreciate your consideration in participating in my study!

Best Regards,

Kent Elliott
The University of Texas at Arlington
School of Architecture
Program in Landscape Architecture
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EMAIL RECRUITMENT SCRIPT—Kent Elliott—IRB Protocol #2013-0512—
The University of Texas at Arlington—Program in Landscape Architecture
Fall, 2013

Informed Consent Document, page 1:

UT Arlington
Informed Consent Document

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TITLE OF PROJECT

What does a landscape architect need to know about water?
Assessing knowledge needs of professionals in North Texas

INTRODUCTION

You are being asked to participate in a research study about hydrology in landscape architecture. Your participation is voluntary. Refusal to participate or discontinuing your participation at any time will involve no penalty. Please ask questions if there is anything you do not understand.

PURPOSE

The purpose of this study is to determine the level of competency in hydrology a landscape architect needs in professional practice, compared to that which they acquire in their education, to adequately perform services pertaining to the hydrological function of land. The research also explores the hydrological knowledge and skill of other professionals practicing hydrology and determines the amount of each that was gained from education and practical experience.

1

IRB Approval Date:

IRB Expiration Date:

Informed Consent Document, page 2:

UT Arlington
Informed Consent Document

DURATION

Your participation in this study will take approximately 30 minutes. You may be contacted to answer follow-up questions over the phone. Follow-up conversations will last no longer than 30 minutes.

NUMBER OF PARTICIPANTS

The anticipated number of participants in this study is 50.

PROCEDURES

As previously mentioned, this anonymous study is done by interviewing professionals in landscape architecture and hydrology. Face-to-face or telephone interviews are anonymous and your name is not used. Interviews last no longer than 30 minutes. Interviews are recorded via smart phone device and the recordings are transcribed to text with a word processor. Following protocols from UTA's Institutional Review Board (IRB), transcripts and recordings are kept with the researcher's faculty advisor until the end of the study.

POSSIBLE BENEFITS

The field of landscape architecture benefits most from this research. This research is a starting point for explorations into the topic of hydrology in landscape architecture in academia and professional practice. With hydrology being the other field of study, it will also benefit from the outcomes of this research, by understanding the similarities and differences of knowledge among landscape architecture and hydrology.

POSSIBLE RISKS/DISCOMFORTS

There are no perceived risks or discomforts for participating in this research study. Should you experience any discomfort please inform the researcher, you have the right to quit any study procedures at any time at no consequence.

COMPENSATION

There is no compensation for participation in this research.

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ALTERNATIVE PROCEDURES

There are no alternative procedures offered for this study. However, you can elect not to participate in the study or quit at any time at no consequence.

VOLUNTARY PARTICIPATION

Participation in this research study is voluntary. You have the right to decline participation in any or all study procedures or quit at any time at no consequence.

CONFIDENTIALITY

Every attempt will be made to see that individual responses are kept anonymous and confidential. A copy of this signed consent form and all data collected, including transcriptions/recordings from this study, will be stored in Dr. Taner Özdil's office at the University of Texas at Arlington's Architecture building, room 417, for at least three (3) years after the end of this research. The results of this study may be published and/or presented at meetings without naming you as a participant. Additional research studies could evolve from the information you have provided, but your information will not be linked to you in anyway; it will be anonymous. Although your rights and privacy will be maintained, the Secretary of the Department of Health and Human Services, the UTA Institutional Review Board (IRB), and personnel particular to this research have access to the study records. Your records will be kept completely confidential according to current legal requirements. They will not be revealed unless required by law, or as noted above. The IRB at UTA has reviewed and approved this study and the information within this consent form. If in the unlikely event it becomes necessary for the Institutional Review Board to review your research records, the University of Texas at Arlington will protect the confidentiality of those records to the extent permitted by law.

CONTACT FOR QUESTIONS

Questions about this research study may be directed to Kent Elliott at (214) 601-5794 or kent.elliott@mavs.uta.edu. Questions about this research study may also be directed to the researcher's advisor, Dr. Taner Özdil, at 817- 272-5089 or tozdil@uta.edu. Any questions you may have about your rights as a research participant or a research-related

Informed Consent Document, page 4:

injury may be directed to the Office of Research Administration; Regulatory Services at 817-272-2105 or regulatoryservices@uta.edu.

As a representative of this study, I have explained the purpose, the procedures, the benefits, and the risks that are involved in this research study:

____

Signature and printed name of principal investigator or person obtaining consent **Date**

CONSENT

By signing below, you confirm that you are 18 years of age or older and have read or had this document read to you. You have been informed about this study's purpose, procedures, possible benefits and risks, and you have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights. Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits, to which you are otherwise entitled.

____

SIGNATURE OF VOLUNTEER **DATE**

IRB Approval Date:

IRB Expiration Date:

Appendix B

ASLA Public Policy Statements Concerning Water

On environmental sustainability:

In order to provide a healthy, productive, and socially enriching life for all, the Society urges public and private decision makers to employ sustainable design policies and practices, minimize environmental degradation, avoid excessive consumption, and respect the needs of future generations.
(ASLA 2007a, p. 1)

On water quality and conservation:

[ASLA] urges efficient use of available water supplies, equitable allocation of water resources, and the provision of safe drinking water. ASLA encourages land use practices that conserve and protect water resources and related ecosystems and eliminate all forms of water pollution. The Society urges multi-functional integration of water resource facilities with natural ecosystems and human communities.
(ASLA 2007b, p. 1)

On waterways:

[ASLA] believes waterways are vital corridors of natural and cultural life, comprised of and sustained by diverse biological resources of terrestrial and aquatic origin. In addition, they also contain compelling elements of our heritage while providing recreational potential. The Society supports the protection, enhancement and/or rehabilitation of waterways and their corridors through wise planning and use of best management practices. In addition, the designation of national, state, and local river systems

and greenways ensures their integrity and function as well as use by all citizens for present and future generations.
(ASLA 2007c, p. 1)

On wetlands:

As development pressure on wetlands continues to increase, the Society encourages careful and site-specific development and management efforts that allow for compatible land uses while preserving the ongoing function of wetlands.
(ASLA 2007d, p. 1)

On coastal zones:

[ASLA] believes that preservation, development, and use of the coastal zone and its resources should be carefully planned, regulated, and managed. Where significant natural, cultural, recreational, and scenic coastal resources exist, both public and private efforts should be directed at protecting them and guaranteeing their integrity. Where commercial interests and economic potential exist, only that development or use that allows the primary ecosystems to remain fully functional, or otherwise provides proper mitigation, should be allowed. Such development or use should be consistent with sound wetland ecosystem management practices and should recognize the extremely dynamic biological and geomorphological processes that shape and influence the local and regional areas.
(ASLA 2007e, p. 1)

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Biographical Information

Kent Elliott grew up in Kansas and has lived in North Texas for over 10 years. He earned a BS in biology at the University of North Texas before starting his graduate career at the University of Texas at Arlington. He has experience in residential design-build and hopes to marry his design knowledge, love of plants, and scientific background to enjoy a career in environmental planning or environmental design.