A SUSTAINABLE STORMWATER MANAGEMENT DESIGN
FOR YANCHING INSTITUTE OF TECHNOLOGY,
LANG FANG DISTRICT, HEBEI PROVINCE, CHINA
A CREATIVE PROJECT
SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
MASTER OF LANDSCAPE ARCHITECTURE
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This creative project concentrates on improvement of managing stormwater runoff, efficiently harvesting rainwater and changing people’s attitudes about sustainability on the campus of Yanching Institute of Technology, Hebei Province, China. Also the design focuses on artful water design for communicating values of water management to increase public acceptance of water issues. The final solution proposes a new master plan to incorporate artful sustainable rainwater management principles. The design proposes campus redevelopment based on existing conditions and local area.

The final design applies artistic installations using sculpture, materials, and spatial definition to mitigate stormwater issues on campus and increase public awareness of sustainability.
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Introduction

Water is one of the most crucial environmental issues in landscape design projects today. In China, one of the most common strategies for stormwater management is to discharge it into public sewer systems without any treatment. Unfortunately, treating this water as waste loses opportunities to recycle the rainwater as a renewable resource; plus, lack of strategies to clean stormwater runoff pollutes water resources. With rapidly increasing population densities, urban communities should be harvesting stormwater for grey water uses, thus saving fresh water for human consumption.

University campuses often occupy huge parcels of lands and have a large human population. How to guarantee such land will be well planned, designed and operated is a major environmental responsibility that designers and planners must address. Ignoring stormwater issues causes serious environmental problems. Huge amounts of pollutants can be carried to their discharge destinations, typically rivers or other water resources, because the infrastructure cannot efficiently harvest stormwater; thus, ever rain event generates large amount of contaminated flows. Therefore, Campuses especially suitable places for planning and implementing sustainable water treatment strategies. With these strategies, landscape architects can plan and design to mitigate environmental issues near the source of the contaminate, while also celebrating water design as a theme, and adding its amenity value to the stormwater.

The creative project site--Yanching Institute of Technology--is a university campus that occupies 199 acres with a population of 20,000 people in the Yan Jiao City, Hebei Province,
China. Several water issues must to be addressed on the campus.

1. Water quantity: based on local precipitation, rainwater supply is not quite sufficient in most seasons. Since this rainfall is most concentrated in the summer, the need for efficient techniques to balance water quantity will be one of the main problems to solve.

2. Water quality: based on existing information and conditions, rainwater supply cannot be purified by existing infrastructural systems before enters the public sewer system to the nearby river. Therefore, increasing water quality by alternative water treatment systems becomes another considerable problem that must be addressed.

3. Changing people’s behavior: efficient water treatment design can help solve current water issues. But for long-term development, people’s attitude toward sustainability must be changed. This includes introducing people to sustainability, guiding them to be more aware of important water issues, and educating them how to prevent problems.

In recent years, the government has been gradually turning its attention from economic development to dealing with environmental problems. Two examples are the concept of “Build a City in the Forest” and the project preserving the Chaobai River, which is the main water body in the local district. As one of the crucial sites along Chaobai River, Yanching Institute of Technology has the responsibility to join the activity and to urgently explore and implement a sustainable stormwater management strategy.
Problem Statement

This creative project proposes solutions for improving sustainability on a college campus by focusing on water as the main issue. Applicable to many urban areas in China, the project explores a concept of water management cooperation with artful design to raise the aesthetic value of stormwater design on campus, while increasing the social value of the stormwater by providing amenity functions; and raising public awareness of sustainability. Finally, the research, analysis, design, and strategies for dealing with stormwater management proposed herein can guide people to important methodologies and principles in this field.

The Main problem:

How to promote sustainable stormwater management on the university campus

The Sub problems:

1. How to design a sustainable stormwater management system to balance water quantity
   1.1. How to optimize water supply on campus
   1.2. How to optimize water storage on campus
   1.3. How to reduce fresh water consumption on campus
2. How to design water-based strategies to balance water quality

2.1. How to reduce water pollution

2.2. How to reduce stormwater runoff

3. How to use sustainable methodology to improve people’s environment behavior

3.2. How to enhance public interaction with water

3.3. How to use art and aesthetic appreciation of water in landscape development to motivate people to practice sustainable water use

3.4. How to build a system to educate people about the knowledge of sustainability
Methodology

The following methodology engages sustainable water management to address campus sustainability issues concerned with stormwater management. The main methodologies are literature review, observation and case study.

1. Literature Review.

The literature review process included reading and researching books, journals and other research articles to analyze their theories, methodologies and design guidelines. The literature revealed two primary aspects for the design: water and human.

1.1 Environmental and Water Aspect

The design was informed by researching existing conditions in City of Yanjiao, Lang Fang District, Hebei Province, China. These conditions include topography, soil and precipitation, with techniques such as bioretention systems intended to balance water quality and quantity.

1.2 Human Aspect

The design will address artful design for stormwater management, adding aesthetic and amenity values to the system.

Stormwater Management and Rainwater Catchment Trends.

Several methods were used to determine the best design techniques for sustainable stormwater management in urbanized environments such as a college campus. Analyzing outstanding cases of stormwater management and rainwater catchment revealed best practice design strategies. Most cases were found in journals and books in the Ball State University
Architecture Library and online journal databases. Reviewing the literature reveals the amenity functions of sustainable stormwater management in urbanized campus environment design.

1.3 Artful Water Design

Research methods were used to compare the impact of artful water design with traditional water design. Artful water design adds values to the traditional water design to raise the amenity and change people’s attitude toward sustainability.

2. Case Study

Reading and researching successful projects through landscape architecture journals, the ASLA Website and other sources will help analyze their methodologies, design principles and guidelines.

3. Site Analysis

To create a place that guides people to experience sustainability, designers must visit the site, stand in different areas around campus, collect data, and analyze existing conditions. For this particular project, most analysis will focus on stormwater issues. Interviewing site engineers will gather more information about the site.
Hypothesis

Artful sustainable stormwater management design on the campus of Yanching Institute of Technology can help address water shortage and pollution issues, plus provide high amenity and aesthetic values for students and faculty.

Delimitations

1. The research and study will not consider water issues outside Yanching Institute of Technology campus.

2. The research and study will not discuss cost and funding problems for water management design in Yanching Institute of Technology campus.

3. The study will not involve policies of the Yanjiao City, Lang Fang District, Hebei Province, China.

Assumptions

1. Sustainable water design strategy on campus is environmentally friendly.

2. As a long-term sustainability development in China, dealing with stormwater management, and rainwater catchment will be continued.

3. Artful stormwater management design can beautify the campus, enhance aesthetic aspects, and increase University enrollment.
**Definition of Terms**

**Passive Rainwater and Stormwater Catchment:** “using such techniques as site grading and permeable surfaces, diverts and retains stormwater so that it benefits the landscape elements of a site” (Heather).

*Amenity:* A function of stormwater management design that enhances the design’s attraction to people; provides experiences and adds value (Stuart and Eliza).

**Sustainable Stormwater Management (SSM):** Water-efficient concepts and strategies of stormwater management design, such as rainwater runoff treatment and harvesting used as an alternative resource, or infiltrated underground for recharging aquifers.

**Artful Rainwater Design (ARD):** “In the context of ARD, amenity is understood as a feature focused on the experience of stormwater in a way that increases the landscape’s attractiveness or value” (Echols and Pennypacker, 270)
1. Introduction of Sustainable Stormwater Management Design and Campus Landscape Design
1.1 Natural Hydrology System

1.1.1 Hydrological Cycle

The hydrological cycle (see Figure 1) plays an essential role in the natural environment, as a system with continuous water circulation in the Earth’s atmosphere. Rain—a form of precipitation and primary source of water for lakes, rivers, and groundwater aquifers, is the first form of water in the hydrological cycle (Kinkade-Levario 11). After the first process of the cycle—rainfall—some water may infiltrate through Earth’s surface. Infiltrated water occupies the soil’s previously unsaturated zone, where it supplies water to plant and tree roots. Water transpired by plants and evaporated from water bodies returns to the atmosphere under the combined term “evapotranspiration.” Excess soil moisture continues down to groundwater in the saturated zone, where it gradually discharges to streams (Hopper 225).

Figure 1: Diagram of natural hydrological cycle (Strom, Nathan, and Woland, 158)
1.2 Stormwater Management

In his book *Introduction to Stormwater*, Bruce K. Ferguson mentioned,

“Stormwater management, like quality of human life, is influenced by, and influences in return, every detail of a site. Every roof, pavement, channel, and basin is located in the midst of a living community. While we protect the biophysical environment, we must live in humane and prosperous cities. Those who propose to aid urban development must be aware of human and natural ecology, so they can perceive the forms and processes of a place and call them forth to make the land whole” (13).

1.2.1 Stormwater Runoff

Stormwater runoff is one phase in hydrological cycle. Characteristics of runoff change as the landscape form alters. Increasingly, human construction activities, such as building a new house or shopping mall, affect runoff and change its characteristics. Deforesting activities also increase the amount of impervious paving, thereby increasing the rate of flow and affecting the quality of stormwater runoff as it carries pollutants or sedimentation to the water source that can impact natural biological and ecological systems (Pyzoha 3).

1.2.2 Historical Perspective of Stormwater Management

Stormwater management by humans has a long history dating back to the early third millennium BC. Two of the most interesting cases were Knossos and Pompeii. Knossos had a large drainage system throughout the city (see Figure 2). During ancient times, this stormwater management commonly used stone channels as the drainage system, instead of today’s the most
diverse systems include raingardens, bioswales, detention ponds, etc. The management system in Pompeii was located approximately 1 meter (3.28 feet) under the sidewalks or roadways. These systems solved the stormwater runoff, but also dealt with the water from residences (see Figure 3). Another case was the Roman city Ephesus (see Figure 4), in present-day Turkey, which was founded during the 10th Century BC as an Ionian city. Stormwater management in the city was further developed during the Roman period. During this period, they started using clay pipes and established a well maintenance structure for the systems (Mays 1.1-1.4). From these ancient cases, people started to think how to manage stormwater runoff in an early era. Although they did not have advanced techniques, they used simple but effective strategies to address stormwater runoff issues in urban areas.

Figure 2: Drainage system at Knossos (Mays, 1.2-1.3)
Figure 3: Drainage system at Pompeii (Mays, 1.4)

Figure 4: Pipe and drainage channel at Ephesus (Mays, 1.9-1.11)
1.3 Conventional Stormwater Management Methodologies

Because of impervious paving and different types of pollutants, stormwater in modern urban environments is usually treated as waste and discharged into sewage systems. Impervious paving is herein considered as any material that prevents or reduces water infiltration into the soil (Sipes 119).

Conventional drainage systems used a combined sewage system, which discharge stormwater into the underground piping system along with wastewater, and convey it to streams, lakes, and ponds. This causes serious issues, such as water body pollution, overloading of municipal treatment systems, and lose of rainwater as an alternative water resource. While mere recent systems separate stormwater and wastewater, the cost of using and maintaining curbs and gutters to handle the drainage remains extremely expensive. In addition, curbs and gutters have no opportunity to balance water quality and quantity (Sipes 120).

1.4 Relationship Between Sustainable Stormwater Management Methodologies and Landscape Architecture

1.4.1 Sustainable Development

UNESCO (United Nations Educational, Scientific and Cultural Organization) gave a definition of sustainable development, guided by the global conference on Environment and Development at Rio de Janeiro in 1992. In this definition, UNESCO said:

“Sustainable development denotes a development which meets the needs of present generations without compromising the ability of future generations to satisfy their needs.
The quest for sustainable development therefore transcends sectoral concerns, such as environmental protection, and requires an integrated and holistic approach” (UNESCO).

The conference published Agenda 21 to guide all counties in the world to find their own solutions to reach the goal of sustainable development.

1.4.2 Sustainable Stormwater Management Design

Low-Impact Development (LID) strives to retain as much stormwater as possible on the land by conserving forests, reusing water, and detaining and retaining stormwater runoff. There are many terms for sustainable stormwater management design, such as Best Management Practice (BMPs) and Sustainable Urban Drainage System (SUDS).

Best Management Practice (BMPs) is an application that can efficiently solve the problems. Several aspects should be considered when determining BMP, such as reducing the cost on maintenance cost, removing the pollution, controlling stormwater runoff, and creating an opportunity for multi-use applications (Sipes 254).

SUDS is a practice that drains surface water into watercourses in a sustainable way instead of conventional methods. This practice reduces accidents that may cause water pollution, reduces polluting activities and materials, reduces the occurrence overflows of tanks, and water harvesting (SEPA). SUDS also address the quality, quantity, and amenity issues of sustainable stormwater management. SUDS advocates believe that by raising the value of water as an amenity, the result can increase public awareness, acceptance, and even participation in sustainable stormwater management design, while also enhancing the community value and the
multi-use of spaces (CIRIA).

1.4.3 Benefits of Sustainable Stormwater Harvesting Design

Stormwater harvesting has been used for a long time. The term includes collecting water from precipitation and impervious surfaces, and storing it for future use, such as fire-fighting, landscape irrigation, and flushing toilets. As such, stormwater harvesting has essential potential to provide environmental and economic benefits. These benefits include:

- Providing an inexpensive supply of water
- Preventing drinking water supplies from being used for other purposes
- Reducing stormwater runoff and pollution
- Reducing erosion in urban environments
- Providing water that needs little treatment for irrigation or non-potable indoor uses
- Helping reduce peak summer demands
- Helping introduce demand management for drinking water systems (Kloss).

1.4.4 Basic Scope of Landscape Architecture for Sustainable Stormwater Management Design

In his book *Introduction to Stormwater*, Bruce K. Ferguson said:

“Stormwater management lies near the heart of basic landscape architecture and site engineering. Professional ethics demand that every practitioner integrate stormwater safely and meaningfully with every urban community and ecosystem. To do it well is to preserve both the functioning of urban watersheds and the quality of life of the people who live within them” (preface).
In modern society, the tasks for landscape architects include creating places with multi-functions and ecological function, but also offering places with high amenities and aesthetic values for people to experience. Many of these interventions can be achieved through sustainable water design. In his book Waterscape, Chris van Uffelen said: “water should be a source of joy for the visitors and liven up the landscape. But waterscapes are more than just fountains. As an aesthetic or contemplative moment in the design of the environment, the calm surface of a pool, which serves as mirror for the surroundings or the sky, is also a waterscape” (7).

Methods for sustainable stormwater management (SSM) can be defined at two scales: macro and micro. For macro-scale, SSM is a holistic planning concept with different strategies that can guide the whole planning and design process. At this scale, SSM builds a connection between stormwater management features and natural hydrological systems. Creating a buffer that protects the main water body such as lakes, streams, and rivers can also preserve water quality.

At the micro-scale, SSM is a site-level design strategy that builds from the macro-scale’s strategies to develop specific site-based solutions for stormwater treatment. Common micro-scale infrastructures include raingardens, infiltration trenches, biosales, constructed wetlands, stormwater retention and detention structures, roof water harvesting, pervious pavement, and other strategies to clean, store and transport stormwater.
1.5 Current Situation in China

1.5.1 Environmental Situation in China

China has a long history of stormwater management. The ancient Chinese used their intelligence to efficiently deal with water issues. However, in today’s China, with escalating population growth, rapid urbanization, and massive demands for irrigation and industries, many unaddressed water issues need to be urgently solved. Unless these are solved, water can cause serious disasters under the current poor management conditions. Potential disasters include massive erosion of hills, drowning of crops, and even destroying cities. The uneven distribution of water, both in terms of geography and seasons is also a particular characteristic in China. This situation causes the water shortage in part of China. For example, in Beijing, the capital of China, the water table has decreased 45 meters from 1950 to 2013. Water pollution is another issue that adversely influences water resources in China (Vajpeyi 33).

1.5.2 Limitations in Sustainable Stormwater Management in China

The primary SSM limitation in China is lack of water policy and financial support. Unlike the US and European countries, China does not have efficient and adequate policies to support sustainable stormwater management. In most urban areas of China, stormwater is discharged into underground sewer systems along with wastewater in combined sewer systems.

Recently, sustainability in China is gaining popularity, since water issues are becoming increasingly problematic. As a result, the Chinese government has started to pay more attention to this field. Through established policies to promote sustainable development, some cities have
started separating stormwater and wastewater through building separate sewer systems. However, although a series of policies has started to support sustainable stormwater management, the lack of experience, education, public awareness, and acceptance remain as the largest barrier to effective stormwater management in China. Only a few investors and contractors have started to add sustainable aspects in their projects. However, due to the lack of mature supervision and management systems, most clients do not consider sustainable stormwater management but only focus on profit.

Although people concerned with water management in China are studying western standards and codes, few standards and codes regarding sustainable stormwater management have been enacted in China. Most urban design professionals in China are also unfamiliar with these technologies. Furthermore, insufficient education causes a low public awareness of sustainability, causes people lack motivation to support sustainable stormwater management.

1.6 Sustainable Campus Landscape Design

1.6.1 The Role of Landscape in Campus Design

As environmental awareness is growing dramatically in the U.S., more Americans are enrolling in degree-granting institutions to earn degrees in higher education. Universities in the U.S. try to keep pace with the growing number of students, which means that these campuses need more housing, larger libraries, and more open green spaces. Universities and colleges throughout the U.S. are using their new environmental conscientious and advanced technologies to develop sustainable institutions in these facilities. As a result, U.S. universities understand that
sustainable campus landscape design should respect natural systems and function as a tool to improve the environment. From this perspective, the microsystem of a sustainable campus could become one component of a regional ecological system (Simpson 209-210).

1.6.2 The Green Campus

Campus landscapes used to be beautiful but far from sustainable. Adequate consideration was rarely given to high water quantities of lawn irrigation, non-diverse plants, and stormwater runoff and pollutant discharged into sewer systems to be subsequently released far from the site. In the early 90s, universities developed a series activities focused on greening campuses through university policies, developing and operating greening initiatives by staff, students, and projects. Campus should be educational places, teaching tools, and research facilities for finding solutions to diverse environmental issues. This environmental focus sought to ensure that every student understood the principles of sustainability when they graduated (Calkins 38-40).

1.6.3 Sustainable Stormwater Management on Campus

Reducing stormwater runoff and increasing rainwater harvesting are key ideas in the shift to sustainable campus design. Reducing impervious pavement and adding green infrastructures, such as bio-retention and detention systems, can reduce and slow down the runoff, which can also help balance water quantity. Purifying the water during the infiltration process will likewise increase water quality. In addition, building green roofs and cisterns will capture rainwater as a reusable resource.

This creative project integrates Sustainable Stormwater Management (SSM) practice with
the hydrological process into a new vision of campus design for China. It includes strategies for on-site rainwater harvesting and treatment with the intent of balancing water quantity and quality. The harvested rainwater is used as an alternative resource for fire fighting and landscape irrigation, and to purify and infiltrated it to recharge natural water systems. Adding and promoting the amenity and aesthetic values of water, the new approach enhances public interaction and invites people to engage in terms of education for sustainable stormwater management design.
2. Literature Review for Artful Sustainable Stormwater Management on Campus landscape design

2.1 Stormwater Management Design

In her book *Design for Water* (2007), Heather Kinkade-Lavario mainly discusses rainwater catchment. At the beginning, she introduces the concept of rainwater harvesting. Then, she explains six basic components of rainwater harvesting systems: catchment area, conveyance, roof washing, storage, distribution, and purification (see Figures 5 and 6). The two main rainwater catchment methods include harvesting water from hard surfaces and roofs. Of the two methods, roof catchment is the easiest and most commonly used to harvest rainwater. This method was appropriate for this creative project because most buildings on the existing campus have pitched roofs, so rainwater can easily be directed to the catchment system.

![Rainwater harvesting process diagram](image)

*Figure 5. Rainwater harvesting process (Kinkade-Lavario, 15)*
Kinkade-Lavario also introduces several terms for different types of rainwater harvesting, including passive catchment and active catchment.

Passive Rainwater and Stormwater Catchment.

This natural approach uses techniques such as site grading and using particular landforms to catch rainwater and benefit the landscape on site. This slows down the stormwater for
catchment by using efficient system such as microbasins, bioswales, bio retention, curbs, permeable pavements, and site grading design. It also can prevent slope destabilization. Imitating natural cycles, such as hydrology, is another passive method (Kinkade-Levario 47).

Low-Impact Development (LID) has been widely used in the city of Portland, Oregon, where the municipality developed, Green Streets program, as an idea of natural approach. The program identified eight actions as their guideline for development: managing stormwater close to its source to prevent runoff and pollution, increasing use of native plants, reducing impacts from different paving surfaces, creating buffers of vegetation to avoid disrupting streams, keeping development away from floodplains and natural restoration areas, controlling erosion, choosing a suitable site to reduce problems, and educating of local authorities about the importance of sustainable stormwater management.

Kinkade-Levario’s theory of passive rainwater, stormwater catchment, and Portland’s example were used in this thesis to help reach the goal of balance water quantity and quality, and to expand understanding of the system beyond just raingardens, swales and basins. It also informed this thesis to build its own design method is based on Kinkade-Levario’s theory, using raingardens, bioswales, microbasins and site grading to create a passive rainwater and stormwater catchment system on campus by mimicking the natural hydrological cycle. Kinkade-Levario also specifically introduced every system and the maintenance of passive rainwater and stormwater features.
Active Rainwater Catchment System.

This method captures rainwater by roof catchment. Kinkade-Lavario discusses each component of the system, gives maintenance information, uses this information for rainwater capturing from rooftops, and gives detailed design guidance for storage. The creative project uses this theory to help balance rainwater quantity on site (Kinkade-Lavario 65).

Kinkade-Lavario specially discusses the case study of Roy Lee Walker Elementary School, McKinney, Texas. Several education areas for children and students include a window into the equipment room and a pipe exhibition to show how the whole rainwater harvesting system (RWH) works (see Figure 7). This is a good approach for school design, although its aesthetics could be improved, especially in its aesthetic aspects. Increasing public interaction with water is
a crucial, to educate students and faculties, and motivate them to behave sustainability in relation to water use.

Heritage Middle School, Raleigh, North Carolina, is an outstanding sustainable school campus design in the U.S. The school has five underground cisterns, which store 125,000 gallons of rainwater, which is then used to irrigate the school’s adjacent football field. The school also has wetlands to prevent stormwater runoff to the Neuse River, plus an education area for students to experience and better understand how the structure and features work. The underground tanks are an outstanding idea. This strategy can also deal with campus water supply, especially as a source of irrigation water for the landscape, so the campus could achieve the goal of optimize water supply.

Stephen Epler Residence Hall at Portland State University is a five-floor mixed-use building with new sustainable technologies intended to maximize benefit from different aspects of the project. One goal for the design was to make stormwater management more interesting and appealing for students and faculties. Several planters with gravel and rocks receive rainwater from the rooftop to infiltrate and clean the water. Also the project uses an underground retention system to collect rainwater (see Figure 8). Stephen Epler Residence Hall was seen herein as an ideal case study to balance water quality and quantity, use high aesthetic design to attract people walk in and then to educate them and finally change their behavior in relation to water.
In his book *Water Storage: Tanks, Cisterns, Aquifers and Ponds* (2005), Art Ludwig introduces general principles for designing water storage features or systems. In the beginning, Ludwig gives several reasons for storing water. He contends then that design should address larger demands for water supply such as showers and fountains. It should also address fluctuating supply, such as the rainless dry season. Protecting safety of the water source is also important. Catchment systems such as retention ponds can help with fire protection. The treatment system can also help improve the water quality. Finally, the system can also prevent freezing and supply temperature sources to the geo-thermal system.

Next, Ludwig defines water storage and describes its basic principles. He illustrates several ways to store water, such as normal tanks, open tanks, and swimming pools. He contends...
that tanks, cisterns, pools and ponds are all crucial for campus water design. Through this publication, readers develop a three-dimensional understanding of each system after he gives their particular size. In the rest of chapters, Ludwig provides specific design details in relation to the water storage strategies he discusses, such as Water Tank Design (28). He provides information about construction materials, specific size and impact of different tank shapes.

Ludwig’s book was a crucial resource for the creative project expands the knowledge about different types of water systems. This book educates readers about more specific details of sustainable water design, such as the particular size for storing water systems and the sustainable impact of the design.

2.2 Artful Stormwater Design

In their article “From Stormwater Management to Artful Rainwater Design”, Stuart Echols and Eliza Pennypacker introduce the concept of artful rainwater design (ARD). They indicate that new strategies can either daylight and celebrate the stormwater management process or conceal it underground. They also speak about early 2000s, policies in the United Kingdom that involved the amenity functions in urban stormwater management. These include the “urban drainage triangle” (see Figure 9), which was a new policy that requires consideration of quantity, quality, and amenity during the stormwater management design process (289).
Echols and Pennypacker identified several goals of ARD. Aesthetic aspect includes: forms, colors, and sounds, which together address the visual, auditory, tactile, and olfactory experience.

They introduce three ARD techniques: Visual emphasis, Repetition of stormwater-focused elements, and contrast color and texture.
1) Visual emphasis

Echols and Pennypacker suggest using strong and bold line as a design language to make the stormwater management process visible, such as the stormwater trail at Cedar River Watershed Education Center, Cedar Falls, Washington. In that project, a meandering stone channel along the road enhanced the visual impact; and grates protected the curve and extended the theme (see Figure 11) (282).

2) Repetition of stormwater-focused elements

Echols and Pennypacker also suggest using several small treatment elements such as bioswales, bio-retention basins, and weirs instead of a single big treatment system. They suggest this as a way to create a spatial rhythm. For example, the SW 12th Avenue Green Street Project in the City of Portland, Oregon, has four stormwater runoff infiltration basins. Runoff flows from one basin to the next (see Figure 12). The design creates a visual sequence (283).

Figure 11: Stormwater trail at Cedar River Watershed Education Center, WA (Stuart P. Echol, 285)

Figure 12: Repeating sunken basins at 12th Avenue Green Street Project, Portland, OR (Stuart P. Echols, 286)
3) Contrast color and texture

Echols and Pennypacker also suggest using local materials or theme-related materials and color such as river rocks and plants to connect the design concept (283).

The stated goal of ARD is to transform conventional stormwater management design into a rich experience of rainwater design. ARD results include:

- Addressing amenity functions to raise the property value, thereby motivating developers to consider stormwater management aspects in their projects.
- Encouraging policy planners to develop related policies under the stormwater management amenity function.
- Making the stormwater management process visible, enhancing education and increasing public awareness to protect the hydrological system.
- Presenting a site-wide strategy of cooperating with stormwater management.
- Clearly defining the stormwater management system for regular maintenance.
- Inspiring and motivating designers to address stormwater management aspects in their project (285).

In their article “Artful Rainwater Design: Creating Amenity”, Stuart Echols and Eliza Pennypacker offer several useful methods for managing stormwater. At the beginning, they talk about the rather than pragmatic aspect of stormwater design, concentrating more on hydrological outcomes rather than aesthetic design elements. They identify two gaps between aesthetics and engineering in stormwater design: public perceptions and developers’ investment attitude. They
contend that stormwater design often looks messy, unsightly and unkemptly, which they contend discourage most public support. They also contend that most stormwater design lacks financial incentives so developers are not willing to invest in such projects, which do not have values other than the basic functions such as ecological systems. The importance of “added value” to stormwater management design could raise public awareness and encourage more people to experience the fascination of the design. Finally, they identify potential advantages of artful stormwater design to include enhancing public participation, providing inspiration for urban development, influencing government policy, and raising property values.

In his book *new waterscape* (2001), Herbert Dreiseitl mentioned,

> Water is far from being just a designer’s resource or a material. It begs to have its vital possibilities rediscovered. This starts at the beginning of the planning process... and involves linking up and integrating elemental themes. Knowledge of water’s particular qualities as a material is needed, and often experiments need to be conducted to give a real idea of what the result will be. (42)

In their article “Stormwater as amenity: The application of artful rainwater design,” Stuart Echols and Eliza Pennypacker emphasize enhancing the value of stormwater: “Design that not only addresses stormwater management in better ways, but also transforms these management systems into stormwater based amenities” (1). The authors give numerous cases to illustrate their idea, which is to create amenity-focused stormwater management design. They use qualitative
analysis to assess design techniques among the case studies. The authors identify five types of amenities: education, recreation, safety, public relation, and aesthetic richness.

**Education:**

- Making stormwater treatment systems visible to people
- Building a hydrologic cycle that mimics the hydrological cycle in nature
- Enhancing the aesthetic aspect during stormwater events
- Making the design more interesting to attract people
- Using different stormwater visual systems in design
- Creating habitats for wildlife such as birds and squirrels
- Building an exhibition area for the public (4)

**Recreation:**

- Creating a place overlooking positive views of the stormwater system
- Creating a similar recreation opportunity along the stormwater treatment system route to guide people to encounter the stormwater treatment system
- Providing resting areas with benches and walls where close to the stormwater treatment system
- Designing signage that welcomes and guides people to walk through the system (5)

**Safety:**

- Limiting accessibility to stormwater by using walls and physical screens
- Using plants as hedges to prevent access to stormwater while still providing views
• Building bridges and boardwalks to allow people to enjoy the view from above

• Reducing stormwater overflow by controlling the depth of the system (6)

Public relations:

• Locating a suitable site for the system close to people to provide educational opportunities

• Using brief descriptions and signage to introduce the stormwater system

• Making the system visible

• Considering local, cost-efficient materials (6)

Aesthetic richness:

• Designing a water treatment system as a focal point and building an axis for the whole site; unify different water system features such as raingardens, bioswales, basins, ponds, etc

• Creating an environment with interesting sounds by varying stormwater falling and flowing through the site

• Using geometric or symmetric patterns as design language (7)

Informed by the resources, this thesis takes the position that although these guidelines are good, several disadvantages should be avoided and some additional considerations are needed during the design process. The article gradually enhances the value of stormwater management design. Basically, the design method for artful and amenity stormwater management design is
achieved through enhancing different functions, such as recreation, education, safety and public relations to build a beautiful, attractive system with high aesthetic value.

In his article “Exposing Stormwater: using creativity, art, and science to increase human awareness and environmental quality” (Landscape architecture Magazine 2002), Jones Stanton informs the readers of the necessity to build a connection between humans and stormwater management design. He introduces an Oregon project called Eugene Millrace--a historic channel, used as a recreation area and stormwater conveyor. A student-team from University of Oregon was challenged to “daylight” the runoff, slow it down, and purify it. The method of this project “brings together naturalistic forms such as swales and combines them with geometric shapes such as circles, squares, and trapezoids” (30). Three circular ponds have their own particular function on the site. The team used sustainable local materials and native vegetation, such as cedar and concrete. Standing on the bridge above the second pond, people can see the stormwater management system slows down the stormwater runoff (see Figure 13, 14). The example is a wonderful case to illustrate the idea of stormwater management design for balancing water quantity and quality, but also making the process visible, and with high public awareness, the idea will raise the value of stormwater management design to a new level (30-32).
Figure 13: The three circulation ponds (Jones, 32)

Figure 14: Detailed drawing section to show the components of the system (Jones, 32)
2.3 Summary

Through researching methodologies and solutions of artful sustainable stormwater management, this creative project will focus on the main problem and sub problems. Referring to the methods from resources, the project develops an inefficient, artful, and sustainable stormwater management strategy for the campus of Yanching Institute of Technology. The next chapter discusses application design cases for knowledge mentioned in the literature review.
3. Case Studies on Sustainable Stormwater Management Design and Campus Landscape Design

3.1 Sustainable Stormwater Management Design and Campus Design Case Studies in the US

3.1.1 Introduction

In the U.S., many projects emphasize sustainable stormwater management. The following projects were selected from different publications that represent the current level of sustainable stormwater management design and campus landscape design in the U.S.. The projects are recommended by *ASLA Magazine*, the ASLA website or other publications.

3.1.2 Illinois Institute of Technology, Chicago, Illinois, USA

Illinois Institute of Technology (IIT) is an ASLA award-winning project. The jury commented, “Productive landscape and a beautiful landscape…this will put the students directly in touch with agriculture…biggest stroke is to put test plots in the middle of campus” (2005 Professional Awards Jury). The landscape designers and planners created an artful and charming campus in Chicago. The campus was originally designed by Ludwig Mies van der Rohe and landscape architect Alfred Caldwell during the 90s. They created a campus that “flowed like

![Figure 15: Images of fall color and plaza at Illinois Institute of Technology (Introduction of Peter Lindsay Schaudt, 2008)](image-url)
water around stones into the open and compressed spaces created by buildings sliding past one another” (Phyllis Lambert). Later development by the firm of Peter Lindsay Schaudt Landscape Architecture, Inc., enhanced the great legacy of Mies and Caldwell, establishing several gorgeous spaces established. This is an excellent case for artful campus design. The designer used shade, light, and vegetation colors in different seasons to create an attractive space (See Figure 15 and 16) (ASLA 2005 Awards, 2005).

3.1.3 Thomas Jefferson University Lubert Plaza, Philadelphia, Pennsylvania, USA

Lubert Plaza is a 1.6-acre plaza located on the campus of Thomas Jefferson University in Philadelphia. The plaza used to be just an impervious paved plaza. But in 2006, Andropogon Associates redesigned it as a new “heart of campus” with a fine elliptical form and multi-function plaza (See Figure 18). They replaced 33% of the paving with permeable materials to reduce stormwater runoff. A green roof over the new underground parking increases the water-holding capacity. Roofs of surrounding building capture rainwater and store it in an
underground tank for reuse (See Figure 17). The design won the 2006 Stormwater BMP Award in the City of Philadelphia (Thomas Jefferson University Lubert Plaza, 2006).

3.1.4 Tanner Springs Park, Portland, Oregon, USA

Tanner Springs Park is located in Portland, Oregon. Gerhard Hauber designed the 1-acre site, transforming an industrial field into a new city wetland park. Stormwater runoff from
surrounding streets flows into the wetland with springs and is well treated through natural purification systems and is also well treated. Besides sustainable stormwater management, Hauber designed an art piece, a “railroad tracks wall” that reminds people about the site’s history, and the pond perfectly reflects the railroad track wall. A floating pontoon across the pond brings visitors close to the “skin from the past” and close to the stormwater management systems. The park provides enough seating space for celebration events. Tanner Springs Park is a successful case that includes artful sustainable stormwater management and multi-functional park design (see Figure 19).

Figure 19: Images of Tanner Springs Park (Sessions, 2006; dancing performance, 2013, on of artful rainwater)

3.1.5 10th@Hoyt Courtyard, Portland, Oregon, USA

Located in the heart of Portland, 10th@Hoyt Courtyard is an 8,500-square-foot enclosed
space surrounded by apartment buildings. The project won the ASLA Oregon Award, and the jury said: “This courtyard forms the heart of the entire building project. Drawing from Persian traditions, the space is a lush oasis” (Rode 1). The successful project makes the sustainable stormwater management design visible. Stormwater is captured by the surrounding rooftops, and the process is 3-dimensionally displayed through channels, cascades and fountains. The courtyard provides residents a refreshing and enjoyable plaza to relax. The artful stormwater management is well placed in the area. During the night, the lights and water create an amazing and charming environment (see Figure 20).

Figure 20: Images of 10th@Hoyt Courtyard (Introduction of 10th@Hoyt apartment, 2012)
3.1.6 The Omega Center, Rhinebeck, New York, USA

The Omega Center is a 4.5-acre sustainable campus with a multi-function building that meets the US Green Building Council’s LEED Platinum standard. This project mainly addresses stormwater runoff, rainwater catchment, and wastewater treatment, but it also educates visitors about sustainability. This project features constructed wetlands and a living machine that collects and purifies the wastewater; raingardens, lawns, and pervious paving reduce stormwater runoff; and bioswales in the parking lot transfer water to the treatment areas (see Figure 21). However, there is no cistern on or under the ground to store rainwater, so it cannot be used as efficiently as it would if storage had been provided.

Figure 21: Images of the Omega Center (BNIM Architects, 2007)
3.1.7 Summary

These above five successful projects have different scale and serve different groups. The Illinois Institute of Technology, example shows how amenity and aesthetic values can be presented as colors, lights, and shade. Lubert Plaza at Thomas Jefferson University, demonstrates that adjacent buildings can contribute to rainwater harvesting; and that it is crucial to reduce the impervious paving. In the case of Tanner Springs Park, demonstrates that sustainable stormwater design can be incorporated with art pieces to illustrate the culture of the site. In addition, the park efficiently treats on-site and off-site stormwater runoff, plus adds on-site amenity functions such as relaxing areas for people, enhancing public awareness by using education features on the site. The 10th@Hoyt Courtyard successful treats stormwater issues on a small courtyard with different types of features, such as fountains, channels, and gravel basins. The design uses different elements to raise amenity and aesthetic values, such as water sound and night lighting. The Omega Center shows how to combine different sustainable stormwater features such as bioswales, raingardens, and constructed wetlands, as a whole system to treat on-site runoff.

3.2 Sustainable Stormwater Management Design and Campus Design Case Studies in Europe

3.2.1 Introduction

Some European countries such as Germany are considered more advanced in sustainable development design than the U.S. As result, there are many excellent European case studies of artful campus stormwater design. Herbert Dreiesitl was the pioneer of stormwater management
design in Germany. As stated in his comments in the book *New Waterscape (2005)*, “water needs a great deal of respect when you are working with it; it is mysterious, and likes for be investigated sensitively. It created the atmosphere and expressed a living relationship between a town and its surrounding area” (42).

3.2.2 The Water System in the University of Applied Science in Constance, Germany

The University of Applied Science is located in Constance, Germany. In this project, a square and 25-centimeter (9.8-inch) deep rainwater harvesting pond surrounds the cafeteria building. The rainwater can supply the water that is used for the pond. The form for the design was based on the principle of reduction, which followed design goals for the campus—defining the campus in a new way.

3.3 Sustainable Stormwater Management Design Case Studies in China

3.3.1 History of Stormwater Management in China

China has a long history of stormwater management, originating from the Qing and Ming Dynasties (14th century to 19th century). During these periods, rainwater catchment infrastructures were designed in different forms. Thus, artistic features became part of the ancient Chinese landscape tradition. The most representative example is the Imperial Palace in the Forbidden City. The rainwater downspouts were designed as sculptural dragons’ heads, which represented the royal power (see Figure 22). During rainy days, rainwater came out from the dragons’ mouths, creating a sense of dignity. Another case is the private Chinese garden. Due to environmental conditions, water was a scarce resource. Common residents in the area were not
allowed to draw water from nearby lakes, rivers, and streams; which were reserved for royal people. Two main ways of residents to collect water were to use a well near a pond and to deliver the water by trench and by using trenches hanging along the buildings (Jia, 52-66).

3.3.2 Beijing Olympic Forest Park, Beijing, China

The Beijing Tsinghua Urban Planning and Design Institute designed this ASLA-winning project in 2009. The ASLA jury commented, “This project was planned for the Olympics, but planted for the future. The landscape architects had an incredible opportunity to create something astounding on a monumental scale and they look it. This will transform Beijing as Central Park did New York City” (ASLA).

The site is located north of Beijing city on the historical center axis, along with several
National Monuments, including the Forbidden City, Tian’an Men Square, and Coal Mountain, etc. Seizing the great opportunity of the 2008 Beijing Olympic Games, the landscape architects completed an amazing transformation from urban to nature on a former 180-acre residential site.

To fit conditions of Beijing’s the particularly dry climate and high evaporation rates in Beijing, the design group required developed solutions and strategies to face these issues. The uniqueness of this project is that it is the first attempt in China to create a large-scale urban park to use a site-based water-retention system as its main water resource. The sustainable stormwater management features include a constructed wetland, wetland greenhouse, meandering lake, and retention pond (see Figure 23).

The wetland is also designed for education. Boardwalks cross the wetland, so visitors can walk closely to the features to see how the system works. The wetland greenhouse is an education center for sustainable development and for the demonstration of the ecological design of Beijing Forest Park. In addition, the large green space provides a wonderful environment for leisure and recreation (see Figure 24) (ASLA, 2009 Honor Award).

Figure 24: Sustainable features and amenity functions at Beijing Forest Park (ASLA 2009 Awards, 2009)
3.3.3 Qunli Stormwater Park

Designed by Turenscape and Peking University, the Stormwater Park is an 84-acre site located at Qunli New Town, a fast-developing urban district in Haerbin, Heilongjiang province, China. The tasks for the designers were preserving the existing wetland and to fit with the northern climate in China, which is seasonal precipitation from June to August (see Figure 25). The design group created a place with multi-functions: collecting, and storing stormwater, and recharging the underground water resource (see Figure 26). In addition, the park provides amenity functions for the surrounding residents. This project won the 2012 ASLA excellence award, and the jury commented, “Refreshing. It functions in a way that isn’t necessarily part of our vocabulary. There are different moments in the design” (ASLA, 2012 Professional Awards).

Figure 25: Bird’s-eye view of Qunli Stormwater Park (ASLA 2012 Awards, 2012)
3.4 Campus Design Case Study in China

3.4.1 Introduction

Sustainable landscape development design in China is a new concept. Traditional campus landscape design did not consider this during the planning process; instead, planners and designers concentrated on aesthetics and culture. Many campuses in China have a long history; therefore, the main goal of landscape design is often to enhance and continue the cultural history with high aesthetic value. However, through studying sustainable design standards and codes from the U.S. and other countries, landscape design professionals have started considering sustainability aspects during their design process for campus projects. Although no appropriate projects fully illustrate sustainable stormwater management in campus design in China, landscape design professionals have added elements of the concept of sustainable development into the campus design (Yang).

3.4.2 Trends of Campus Landscape Design

Green, ecology and sustainability are the themes of environmental development. Sustainable green campus design is becoming the first priority trend in this field. Sustainable
green campus design strategies include: protecting the existing natural conditions, reducing the damage to ecological systems, efficiently using lands, etc. The second priority trend is developing regional humanistic campuses. Based on the concept of green sustainable campus, urban designers are adding regional cultural and historical aspects into campus design (Fan).

3.4.3 Shenyang Architectural University

In 2002, the government of Shenyang City in northern China commissioned Turenscape and Peking University to design a 197-acre land for Shenyang Architectural University. Their design had to preserve existing conditions because the land has been used as a rice field with high quality soil. Under finance pressure, they had to design with a low budget and complete the project in a year to make sure the college could open in 2003 to meet the growing enrollment. The design group did a wonderful job integrating agriculture and landscape (see Figure 27). The rice paddy is a landscape feature, but also serves for food production with a complete self-irrigation system. Students and faculty can participate in the harvesting (see Figure 28). The design group successfully built a connection between human and nature. Platforms throughout the field provide education and relaxation functions, enhancing the amenity. Golden color creates gorgeous landscape scenery, much like an artistic masterpiece.
This project won a 2005 ASLA General Design Award of Honor. The jury’s comment perfectly describe the project: “Productive landscape and a beautiful landscape…this will put the students directly in touch with agriculture…biggest stroke is to put test plots in the middle of campus” (ASLA 2005 Professional Awards).

Although this project does not focus on sustainable stormwater management design, Shenyang Architecture University is an excellent case that shows Chinese sustainable landscape development as the integration of amenity and art.
3.4.4 Summary

In the case of Shenyang Architectural University, the designer emphasis the interaction of humans and nature. By participating in the crop harvesting process, students can enlarge their knowledge on agriculture. The rainfall helps irrigation the crop, and another design solves stormwater issues. This is a success example of a design that has a strong cultural symbol. The designers also addressed amenity and aesthetic values in this project, such as creating a wonderful seating area in the field and providing an allee along the crop field.
4. Introduction of Creative Project Design Site
4.1 Introduction of Yan Jiao City, Lang Fang District, Hebei Province, China

4.1.1 History of Yan Jiao City

During The Spring and Autumn Period and Warring States, China was separated into seven kingdoms. Yan Jiao was the capital of “Yan.” The city has a special location, 18 miles west of the Forbidden City (see Figure 29), which used to be the heart of ancient China. During Qing dynasty, Yan Jiao was a royal park for emperors.

![Figure 29: Context map of Yanjiao City.](image-url)
4.1.2 Urban Development of Yanjiao City

Today, Yan Jiao City is located in Lang Fang district, Hebei Province, China. It has an area of 25,995.5 acres, and the population is 104,800 (Yan Jiao government, 2012). In the past, agriculture was the main type of economy in Lang Fang district, especially Yan Jiao city. The city map still shows large areas of farmland, but in recent years, the government of Yan Jiao City has been transforming the economic structure from a single type (agriculture), to a mixed economic structure with agriculture, warehousing industry, tourism, transportation, and distribution of goods all playing major roles.

Addressing the concept of city development, in 2008, Yan Jiao government launched the “Building a Green and Ecological Yan Jiao” activity that ensure 60% green coverage rate in the city to reach the goal of “Build a City in the Forest.” The development activity attracted many large companies to launch their branches or manufacturing facilities in Yan Jiao City.

Enhancing the quality of education is another main goal for city development, since Yan Jiao has eight universities. The city is also located along the east bank of the Chaobai River, the main water resource in the region. In 2008, the government also started preserving the Chaobai River.

4.1.3 Climate of Yanjiao City

Yanjiao City is located in the North China Plain, about 93 miles east of Bohai Sea. It has a monsoon-influenced humid continental climate. With high temperatures in summer and dry, cold
temperatures in winter. Spring and fall are shorter than the other two seasons (Beijing Climate Center).

In Yan Jiao City, the average annual precipitation is 23 inches, but most of the annual rainfall in Yanjiao City occurs from June to September. In July 2012, heavy rainfall of 3 inches per hour flooded most areas of the city.

4.2 Introduction of Yanching Institute of Technology

Located in northern Yan Jiao City (see Figure 30), Yanching Institute of Technology (YIT) is a brand new university designed by Tianjin University Research Institute of Architectural Design & Urban Planning. YIT campus construction started in 2005. After only eight years’ development, the campus already has 306 acres and 20,000 students. The Chaobai River lies along the west side of the campus. Unlike other rivers around Beijing, Chaobai River is the only one unpolluted water-body. Thus protecting the river has become the main focus among adjacent areas. YIT has its responsibility to prevent pollution of the Chaobai River. The region

Figure 30: Location of Yanching Institute of Technology.
surrounding the campus has a regular pattern of farmlands and warehouses. Also, the university is close to the Jingping Highway, which is one of the main connections to downtown Beijing and the Beijing Capital International Airport.

Most of the northern part of campus is student dormitories and cafeterias. The west is mainly for faculty housing. Other areas are for education. The campus has plenty of green spaces, including three symbolic areas: the central park, administration building (college of art) and celebration plaza form the focal point of YIT campus. By changing topography, planting diversification, and a water feature, central park gives people a sense of garden and enclosure. Stormwater will be delivered towards the south and east by an underground stormwater system. Although the campus already has 40% green space (Li), it is seen as necessary to plan a sustainable strategy to treat stormwater on site.

Site analysis identified the following issues must be addressed:

- Impervious pavement occupies most areas on campus. Pervious paving is urgently needed and enlarge the green space, etc.
- Two existing standard athletics fields and large areas of landscape need to be irrigated.

However, lack of rainwater storage strategies prevents efficient water use. So it is crucial to develop stormwater treatment system including bio-retention instead of normal ponds.
- Most buildings’ roofs are angled with no rainwater catchment system. Rainwater is not collected but is discharged to the sewer system.
The central park of the campus has only one function: decoration. It must be reconsidered and expanded to include more sustainable functions.

Figure 31: Existing Master Plan of Yanching Institute of Technology (Drawing by Tianjin University Research Institute of Architectural Design & Urban Planning, 2005)
Figure 32: Campus landuse of Yanching Institute of Technology.

Figure 33: Existing condition photo.
Figure 34: Existing conditions
Figure 35: Existing conditions
4.2.1 Water Issues Related to Sustainable Stormwater Management at Yanching Institute of Technology

1) Stormwater Runoff

Due to inefficient stormwater strategies, runoff often occurs after heavy rains, especially in the rainy season from June through August. Runoff flushes pollutants from the large areas of impervious pavement and discharges into the underground sewer system. The polluted stormwater that cannot be discharged accumulates on the roads, plaza, and ground areas around buildings (see Figure 36). Although large areas of green space occupy almost half of the campus, there are no bioswales or other delivery channels for runoff, so flooding is resulted. The water quantity is degraded.

Figure 36: Stormwater runoff issues on campus
2) Rainwater Harvesting

Due to the particular climate on the site, precipitation often occurs from June through August. Rainwater from rooftops and structures cannot be efficiently collected and stored so it discharges into the sewer system (see Figure 37). During the rest of the year, the campus must pump water from underground to irrigate landscape and support water features. Also, the quality of water is affected.

Figure 37: Water accumulating on the ground
3) Social Issues

The notion of sustainable stormwater management is not widely understood in China. Lack of public awareness causes frequent problems. Inefficient education is another issue. Even in most classes addressing landscape architecture design, the topic of sustainable design is rarely mentioned. The university does not have related policies intended to address sustainable issues.

4.2.2 Site Condition

Yanching Institute of Technology is still under construction (since 2005). Over its 8-year development, 80% of campus has been completed. Remain construction is expected to finish around 2020 (Liu).

4.2.2 Conclusion

Due to water issues occurring at Yanching Institute of Technology, the campus urgently needs redevelopment to address issues of sustainability. This creative project will focus on three aspects: reducing stormwater runoff, optimizing rainwater harvesting, and changing student and faculty attitudes towards sustainability. The design that follows responds to the existing climate condition of Yanjiao City to develop efficient sustainable stormwater management strategies that deal with water issues on campus while also incorporating artful aspects into the design.
5. Artful Sustainable Stormwater Management Design Application in Yanching Institute of Technology Campus

5.1 Design Process

This creative project has two intentions. The first is to address site-based needs of the Tianjin University Research Institute of Architectural Design & Urban Planning’s development of Yanching Institute of Technology, a unique green campus in China. The second objective is to integrate artful sustainable stormwater management strategies and to consider them a main element design development of the campus. The diagrams (see Figure 38 and 39) show the

![Diagram showing the design process](image)

**Figure 38: The big idea**

**Figure 39: Design process diagram**
5.1.1 Goals and Objectives

Goal 1: Improve the quality of people’s lives at Yanching Institute of Technology by enhancing connections between humans and nature.
- Construct on wide-open plazas, include shaded areas for pedestrians.
- Develop more green parks for students and faculty
- Build recreation loops for people on site to experience in nature.

Goal 2: Develop an environmentally friendly campus in terms of stormwater issues.
- Increase water efficiency of green spaces.
- Replace impervious pavement with pervious material to reduce stormwater runoff and pollution.
- Design stormwater treatment systems to enhance water quality and to reduce runoff.
- Install rainwater harvesting systems and store the water to serve as an alternative resource for irrigation purposes.
- Build retention ponds for water storage in underground aquifers.
- Include educational features such as signage and explanation boards to enhance public awareness of how the issue of sustainability is addressed on campus.
- Daylight the stormwater treatment process to make it visible and as a reminder of the campus as an environmentally friendly campus.
- Use different forms or create different senses of spaces to invite people into the environment, to enjoy the campus landscape and to thereby enhance the public relation with sustainability.
5.2 Site Inventory

5.2.1 Water Features

The existing master plan shows one large water feature on campus (see Figure 40), located in a central green space. An interview with Junsheng Li, the chief engineer of the campus, confirmed that the pond is only decorative and does not serve any stormwater management or treatment intentions.

Figure 40: Existing water feature

5.2.2 Surface Area

Green spaces occupy 40% of the whole campus (Li). As indicated in the master plan, trees and lawn areas are abundant. Although there are large areas covered by trees and lawns, their
functions currently do not address the issue of using water in a resource-efficient matter; or affectively as art that raises awareness of water management issues.

Through visiting the site, the author confirmed that plazas are all impervious pavements, which generate large amounts of stormwater runoff after heavy rainfalls.

5.2.3 Housing

Due to the large campus population, student dormitories and faculty apartments are all 6-floor high-rise buildings. Black tar roofs are impervious, so they cannot catch any rainwater.

5.2.4 Stormwater System

The site topography (see Figure 41) slopes from the north to the south, so stormwater therefore drains to the underground stormwater system and from discharges into public

Figure 41: Existing topography.
stormwater sewerage system at the south and east sides of the campus (see Figure 42). Lack of stormwater treatment strategies allows this water to enter the public stormwater sewerage system in a polluted condition.

5.2.5 Circulation

Y.I.T’s main entrance is located at the south edge of the campus and connects people from areas off-campus to the central area. The main entrance normally is closed, because the southern part of the campus is still under construction. There are two secondary entrances at the south and east. The east entrance faces one of the main boulevards that connect to the highway to central
areas of Beijing. From the width of roads on campus, it is easy to see the road hierarchy (see Figure 43). Pedestrian sidewalks run along both sides of the roads.

![Figure 43: Existing circulation diagram](image)

5.2.6 Wastewater

Although wastewater treatment is not the topic of this research, it is another aspect that should be considered. Without on-site wastewater treatment strategies, wastewater is collected from buildings and discharged into the public wastewater sewer system (see Figure 44). Yan Jiao City has its own public wastewater treatment plants; however, under pressure of the large
population and housing, the recommendation herein is that Yanching Institute of Technology should develop its own on-site wastewater treatment strategy.

5.3 Analysis

5.3.1 Land Use

Due to the large campus population, students’ dormitories and faculty housing occupy most of the area on campus. The central building cluster is mixed-use with administration and education. The green space is for recreation and relaxation. Undeveloped zones currently are all vegetated areas (see Figure 45). The connection herein is that it is necessary to design more gathering places such as green spaces and relaxation nodes for people on the campus.
5.3.2 Pedestrian Flows and Circulation

In the morning (8:00-9:00), the main traffic flows from the northern part of the campus towards the center. Students always pick the shortest path to their destination. So to understand flow during this time period, the author visited the site in the morning and summarized the most common paths (see Figure 46).

Figure 45: Land use analysis diagram

Figure 46: Morning flow circulation
During lunchtime (11:50-1:30), the characteristic of the pedestrian flow spreads from the center of the campus to the north and west. Three cafeterias are located in the north and west. Some people choose to cross the recreational park to access cafeterias. After lunch, most students who still have class in the afternoon commonly choose the same way back to their classrooms. The whole central plaza is exposed to the sun. Especially during the summer, people suffer the effect of strong sunlight when they cross the plaza. So it is necessary to design a green corridor that can create shade areas (see Figure 47).

![Figure 47: Noon flow circulation](image)

After class (5:30-9:30 pm), the noon flow pattern is reversed. In addition some people choose to stay outside for a while before they return to their dormitories or apartments. There are five popular gathering places: central green space, sport fields, community green space, and seating areas along the celebration plaza (see Figure 48). To better serve the large campus population, it is necessary to build more places for gathering and recreation.
The creative project design strategy overlapped three time period diagrams (see Figure 49), identified the most common routes, and then selected key places along the route as the focus of
detailed illustrative site development proposals.

5.4 Conceptual Design

5.4.1 Design Concept

The design concept includes the use of natural-curved riprap channels and bioswales as its main design form language, mimicking the natural water flows, and forming a closed hydrological loop on campus. The concept also integrates the water system with the recreation system that flows along with the hydrological loop. Addressing artful rainwater design methodologies to invite people into the design and educate them about sustainability in terms of stormwater issues.

5.4.2 Holistic Hydrological Concept

1. Hydrological Zones

Due to the site topography (see Figure 41) and using roads as boundaries, the campus is divided into three hydrological areas from north to south (see Figure 50). Each area has its own

![Figure 50: Proposed hydrological zones](image)
stormwater management systems to reduce runoff, harvest rainwater, and support on-site water features. Based on the topography on campus, overflows will be discharged to the next area from north to south.

2. Stormwater Flows Concept

In each hydrological zone, stormwater runoff is collected from roads, structures, and roofs, and carried to the retention systems in each hydrological zone (see Figure 51) by bioswales, underground pipes, and vegetated channels for supporting the water features such as fountains.

![Figure 51: Proposed stormwater flows in each hydrological zone](image)

3. Rainwater Harvesting Concept

Yanching Institute of Technology (YIT) has many courtyards surrounded by different buildings, so many of them can be potential sites of rainwater harvesting systems (see Figure 52). The contention herein is that rainwater from rooftops should be stored as alternative resource for
toilet flushing and fire fighting. The rainwater harvesting system proposed herein also includes pipes on campus includes pipes for guiding rainwater to the storage systems, and an underground cistern for storing the water (see Figure 53). Riprap tanks infiltrate and purify the rainwater from

Figure 52: Potential rainwater harvesting site

Figure 53: Proposed rainwater harvesting strategy in courtyard
rooftops. Rainwater falls from the downspout. The visual and sound effects can increase the amenity and artistic values.

5.4.5 Design Scope

There are two scales in this design: macro and micro. The macro-design scale develops the campus-level holistic stormwater strategies. The master plan (macro scale) shows the big ideas and design concept. Micro-design concentrates on the scale and address site details, systems and forms.

5.4.6 Macro Master Plan

Because the campus has previously been developed, the concept is based on the existing 40% green space (see Figure 54). The design herein seeks to reduce impervious pavements, expanded green space to 50% (see Figure 55), and add sustainable stormwater management strategies, such as replacing impervious pavements surrounding the sports fields with vegetated areas (see Figure 56); and replacing the pavements in front of the building of the College of Art and Design (see Figure 57). The use of riprap channels and bioswales as a main design language, and also mimicking the natural hydrological flows pattern around the campus (see Figure 58) are clearly shown in this design. Three more major retention water ponds herein also been added on the campus (see Figure 59). Those ponds collect and store stormwater from other places on site. In addition each hydrological zone has its own central areas: the Community Green Space at the northwest, the focus area for the whole campus at center, and a relaxing green space at the south (see Figure 60).
Vehicular circulation was not changed. However, a system of recreation paths system was added through the whole campus (see Figure 61). The path provides comfortable environment for people, including seating areas and fully-shaded spaces. An artful water trail accompanies
with the water systems, some paths cross the water to invite people closer to the water systems (see Figure 62).

Figure 56: Replaced impervious paving with vegetated areas at the sports field

Figure 57: Replaced impervious paving in vegetated areas in front of the building of the College of Art and Design
Figure 58: Mimicking the natural hydrological flow pattern by using riprap, bioswales, and ponds

Figure 59: Major retention ponds collect stormwater from surrounding areas on campus

Figure 60: Central retention areas in each hydrological zone
In each hydrological zone, raingardens collect and infiltrate stormwater, and runoff travels...
through channels, underground pipes (see Figure 63), and bioswales to the central retention area as alternative water resources.

Figure 63: Stormwater management plan for each hydrological zone
Figure 64: Proposed macro master plan
The macro master plan (see Figure 64) incorporates all the concepts previously discussed, according to the previous site and population flows analysis. Four selected areas were designed to apply these issues at the site scale. The following sections illustrate the ideas and concepts at site-level: Community Green Space, Celebration Plaza, Central Green Space, and the courtyard surrounded by the administration building and the College of Art (see Figure 65).

**Figure 65: Site-level detailed design sites**

### 5.5 Site-level Design

#### 5.5.1 Community Green Space

The Community Green Space is located northeast of the campus. The area is mainly for student dormitories. The space is also located between two cafeterias. This is a key place for student recreation and relaxation. The space is also the central stormwater retention area of hydrological zone one. Based on the concept of spatial repetitions, from the master plan (see
Figure 66). Compared with northeast and southwest, the northwest and southeast are more open (see Figure 67).

Figure 66: Micro master plan of Community Green Space

Figure 67: Bird’s-eye view of Community Green Space
Stormwater transported through channels, pipes and bioswales to the Community Green Space for supporting the water features and landscape irrigation. Two channels, one from northwest and the other from southeast are collecting and transporting stormwater from other places in zone one, and two corners also offering seating areas for people to observe the stormwater features at two areas (see Figure 68, 69). The large section (see Figure 70) shows the spatial relations between the amphitheater and central retention pond. People sit on the benches on the terraces and watch the central water features: Another section (see Figure 71) shows the elevated plaza. The plaza provides a comparably private space for people to sit relax and take

Figure 68: Hydrological diagram
advantage of the visual prospect provided by the elevation change (see Figure 72). The space also offers a cool and pleasant environment for people in the summer because the plaza is fully shaded. People can also see the central water features from this plaza, while will be one of the best relaxing places on campus. A sculpture sits on the center of retention pond (see Figure 73). Incorporating with fountain blow the sculpture, creating visual and auditory effects to meet the goal of experience in artful water design. The water features in this area can also help to increase the areal humidity, while will provide a mere comfortable space for people. Wood deck with benches surrounds the retention pond, increasing the sense of relaxation and comfort.

Figure 69: Raingarden and retention pond system diagram with educational signage

Figure 70: Spatial relations between the amphitheater and retention pond with artful sculpture fountain
The two stormwater depression basins (see Figure 69) at the west and northeast also educate people about stormwater, with explanation boards and signage that allow people to appreciate the process of stormwater management. The southwest area is also for student
recreation. The plaza provides exercise equipment and seating areas, and function as part of the green corridor system. In response to the strong sunlight, the paths are shaded during the hot season. The elevated gathering plaza is a fully shaded area for people relaxing after lunch or dinner.

5.5.2 The Campus Central Green Space

The Campus Central Green Space is located in the central area of Yanching Institute of Technology. Compared with other places, the park appears more natural. The goal for this area is to create a place that invites people to walk in nature. The master plan (see Figure 74) shows large amounts of plantings with shaded areas creating a sense of enclosure. Small hills around the park edges provide visual separation from the surroundings (see Figure 75, 79, 82). The

Figure 74: Micro master plan of the central green space
curved riprap channel in the park is forming plazas are located at south and west. One is vegetated, and another is paved. Two pavilions sit atop the small hills, providing places for people to observe the nice views of the space. Another pavilion next to the pond provides a relaxing place for people to enjoy the views of the water. The amphitheater provides a large space for different events (see Figure 76).

Figure 75: Bird’s-eye view of the green space

As the central retention area in hydrological zone two, the area has two main water entrances: one at the west and the other at the northeast. Stormwater is carried to the park by underground pipes and surface-flow by riprap channels. A large pond stores the stormwater for landscape irrigation and water features. Stormwater is purified on the way to the pond by
vegetation, soil, and rocks in riprap. Raingardens with education signage are located at the east of the amphitheater and south part of the green space. They collect, purify, and infiltrate stormwater runoff from adjacent areas to charge the water bodies (see Figure 77).

Figure 76: Stormwater management system diagram of the space

Figure 77: Stormwater flows from adjacent areas
Paths are fully shaded to create a cooling environment for pedestrians during hot weather.

The boardwalks over riprap channels provide a closer opportunity for people to view the stormwater system (see Figure 81, 83). Educational signage provides the knowledge of stormwater management techniques. Wetlands surround the pond. Boardwalks above the water offer an opportunity to invite people closer to the wetland. A big fountain activates the center of the pond (see Figure 78). Water features create sound environment that helps separate people from outside areas.
Figure 80: Boardwalks and riprap channel

Figure 81: Relaxing and stormwater management system education area

Figure 82: Central Green Space entrance and small hedge hills
Figure 83: Stormwater management system display area

Figure 84: Retention pond
5.5.3 The Celebration Plaza

The Celebration Plaza is located at the central area of Yanching Institute of Technology (see Figure 85). Due to its special location, facing the main entrance, the plaza is designed to have formal dignity. It is the main symbolic place of the campus. As a celebration events plaza, it requires open space with large areas of hard paving. This plaza is also a crucial area for pedestrian circulation. Half the people on campus pass the plaza every day. People are otherwise exposed to sunlight when they pass the plaza, design this space as part of the green corridor system (see Figure 86).
transported to the retention pond. There are several raingardens on the celebration plaza site for infiltration. Rainwater from rooftops is collected and infiltrated to underground cisterns by riprap.

Figure 86: Bird’s-eye view of the Celebration Plaza

Figure 87: Hydrological diagram
tanks. All the stored water is used to irrigate on-site landscape areas and to support water features (see Figure 87).

As one of the first primary places on the Yanching Institute of Technology campus, the plaza provides the following functions:

- **Green corridor (see Figure 86).** Numerous people pass through the plaza every day, so planting shade trees along the movement routes creates a cool environment for people during hot weather. The master plan (see Figure 85) clearly shows green corridors forming a series of routes for the pedestrian.

- **A place of relaxation with artful stormwater design:** The front yards (see Figure 88) at east and west provide sitting areas for people. Rainwater from the rooftops runs through the runnels in the front yards. People can play with the water while they relax in the spaces (see Figure 89). Two fully shaded plazas at the lower elevations also provide resting areas. People can view the fountains at the center-bottom pond. The dry fountain plaza, step pools, and the pond become a fountain entertainment system (see Figure 90), which provides a space where people can interact with water (see Figure 91, 92).

- **Education about sustainable stormwater management:** Riprap tanks collect and store rainwater from the rooftops of surround buildings. Part of this rainwater from rooftops flows through the front yards to the raingardens (see Figure 93). Each system has its own explanation board, so people can understand how the systems work (see Figure 94).
Symbolic area: The master plan shows the geometric and formal shape of the plaza. The plaza works as a multi-function area that includes sustainable education, entertainment, and celebration events (see Figure 95).

Figure 88: Building’s front yard for people to relax

Figure 89: Rainwater flows through runnels along the area
Figure 90: Fountain entertainment system

Figure 91: Dry fountain plaza for people to play with water

Figure 92: Raingarden with step pools, fountain features, and the pond
Figure 93: Raingarden for collecting and infiltrating the stormwater from the runnels on the front yard

Figure 94: Education signage conveys information about the raingarden to people while they are relaxing under the fully shaded plaza
Figure 95: Overview of the Celebration Plaza
5.5.4 Administration Courtyard

The Administration Building and the College of Art and Design surround the courtyard. The goals for this area are to create a place that provides good views from the windows of surrounding buildings, a place with an efficient stormwater management strategy, and a place for students and faculty to take short breaks. To reach these goals, artful stormwater management design was addressed in this design. The master plan (see Figure 95) shows a pavilion at the southeast corner that serves as an interior relaxing space (see Figure 96). Part of this pavilion is opened, and faces the central pond, so people can view the beautiful landscape of the courtyard while they are sitting in the area (see Figure 97, 98). Behind this pavilion is a private space. After rainfall, the water that has been purified by the vegetated green roof, and water drops down to

Figure 96: Micro master plan of the Administration Courtyard
the riprap tank, which creates a sound effect as the water hit the rocks. Meanwhile, an explanation board illustrates the process of rainwater harvesting (see Figure 99). There is also another fully shaded and gravel-paved plaza at the northwest (see Figure 100). From here, people can see the fountains in the central pond and the riprap channels along the surrounded buildings. A modern sculpture is located at the center of the pond (see Figure 101). By working with the fountains, these elements decorate the space and create an artful water atmosphere in this area.

Rainwater from the rooftops is guided by wall-pipes to the riprap tanks (see Figure 102)

Figure 97: Bird’s-eye view of the courtyard

where it is then infiltrated and purified into underground cisterns as an alternative resource for surrounding buildings. The raingarden reduces stormwater runoff, collects the water, and transports it to the central retention pond and to underground pipes that supply the water features.
The evaporation of the water also increases humidity in the courtyard and creates a comfortable and relaxed environment during hot weather (see Figure 103).

Figure 98: Views from inside the pavilion

Figure 99: Fountain pond with sculpture and resting pavilion are the main structures in the courtyard
Figure 100: The outdoor backyard of the pavilion provides an opportunity to invite people to interact with water.

Figure 101: Gravel-paved plaza provides a comfortable environment for people, and permeable paving material reduces stormwater runoff.
Figure 102: Fountain pond with sculpture

Figure 103: Riprap tanks with dropping water create a special sound effect, and the accompanying education board helps people understand the process of rainwater harvesting
Figure 104: Main functions of on-site raingardens and riprap tanks
6. Conclusion

The most challenging aspect of this creative project was respecting the previous design, while developing suitable stormwater management strategies with high amenity and aesthetic values. The project also required understanding sustainable stormwater management and artful rainwater design methodologies, plus people’s habits, such as their preferred routes to destinations.

The primary goal of this creative project was to transform a university campus to provide high sustainable value in terms of stormwater issues. Yanching Institute of Technology, the design application site, includes student dormitories, educational buildings, and courtyards to open plazas, all unified by the sustainable stormwater systems designed through this project. These stormwater management systems designed in this creative project reduce on-site runoff and prevent pollutants from discharging into ground water, streams or rivers, thereby avoiding polluting water bodies. Rainwater harvesting systems store the water during monsoon season as an alternative resource for on-site landscape irrigation and fire fighting in dry seasons. The two systems designed herein therefore optimize the campus water supply and help solve the water shortage problem. The two systems also help balance the water quantity and help sustain water quality on the campus.

The creative project incorporates the notion and methods of artful rainwater design, and increases amenity and aesthetic values to enhance public participation. This includes using visual, auditory, and tactile experiences to invite pedestrians into the campus. Educational features and
signage improve on-site education. Making the stormwater management process visible draws people closer to the systems, so the strategies can therefore help change people’s attitudes and can motivate them to live with sustainability.

As an economic benefit, with high amenity and aesthetic values, the campus as designed can attract more students and increase the enrollment of the university. Efficient stormwater treatment strategies can also reduce the cost of water use.

While this project addressed the basic principles of sustainable stormwater management and artful design, future research development such as this project can also incorporate wastewater treatment strategies. They can also develop more innovated strategies for public education; and engage more artful rainwater design methodologies.
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