ANALYSIS OF LANDSCAPE CHANGE OF THE RIO VISTA DAM

IN SAN MARCOS, TEXAS

THESIS

Presented to the Graduate Council of
Texas State University-San Marcos
in Partial Fulfillment
of the Requirements

for the Degree

Master of SCIENCE

by

Michelle Bussemey

San Marcos, Texas
May 2007

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Committee Members Approved:

David R. Butler, Chair

Joanna C. Curran

Nathan A. Currit

Approved:

J. Michael Willoughby
Dean of the Graduate College

ACKNOWLEDGEMENTS

I would foremost like to thank my advisor David Butler for his insightfulness, criticism, and unending support over the past two years, challenging me to strive for increased knowledge and allowing me to be myself. His enthusiasm and humorous demeanor towards discussing geomorphic topics is quite motivating to want to keep learning more and more. And thanks to him, I will never think of a badger or mushroom again without breaking out into a song and dance.

I would also like to thank my committee members, Joanna Curran for introducing me to fluvial processes, encouraging me to seek a Master's degree, and always willing to talk when I would pop by; and Nate Currit for his insight with GIS and helping me out in tight times. Special thanks to Allison Glass for all her help, patience, and comfort in making sure I maintained sanity and connectedness, and for letting me just unwind in confidence. My sincerest thanks to Carol Sawyer, Mindy Conyers, and Bernadette Marion for guidance, assistance, and mentorship during graduate school, for their words helped reassure me on countless occasions; Brock Brown for always making me feel like I could change the world and achieve greatness (at least in gardening); and to Mark Fonstad for bestowing his wisdom, testing me to think outside the box.

Thanks to Dianne Wassenich for her willingness to share information with me about the San Marcos River for my various research ventures; Jack Fairchild and Ernest Cummings for sharing memories and knowledge about San Marcos history and the use their family photographs of the Rio Vista Dam; and Melani Howard for supplying information I needed from the City of San Marcos about the reconstruction of the dam and GIS data.

Finally, I am eternally grateful to Monica Schultz, Jessica Bostick, and Carissa Belsky for their friendship, support, and laughter that helped me during rough times; my parents and grandparents for giving me life, love, and encouragement to succeed; and especially Tosca Cesaretti for all her dedication, patience, and compassion she shows me on a daily basis (and for making me chocolate chip pancakes in the middle of the night.)

This manuscript was submitted on March 26, 2007.

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ABSTRACT

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SUPERVISING PROFESSOR: DAVID R. BUTLER

This thesis analyzes large-scale environmental landscape change of the area around Rio Vista Dam on the San Marcos River due to reconstruction of the dam in the spring of 2006. The research uses repeat photography of the dam from 1917 to 2007. Riparian and riverine changes are analyzed by comparing the historic photos with those taken during fieldwork in 2006 and 2007. Ground-truthing of vegetation at the site supports analysis of differences found in the comparisons. Stark differences between the photo pairs show loss of vegetation, buildings, and open space; yet also illustrate the improvement of eroded riverbanks, a dam no longer threatening failure, and a more natural appearance of the area in opposition to concrete. The results of this analysis of

landscape change at Rio Vista Dam support the need for developing new methods of responsible redevelopment and growth for city planners and present a cost-effective opportunity to recognize temporal and scale differences ensuing from the effects of land management and human-induced activity.

CHAPTER 1

INTRODUCTION

Landscape change and its effects on the surrounding community are important issues facing central Texans as the population continues to increase. Although the physical landscape constantly and dynamically changes due to geomorphic agents of erosion and deposition, the modification attributed to human alteration of the landscape is often more immediately noticeable. A growing concern for the healthy sustainability of watersheds, aquifers, river systems, and coastal environments is leading to stricter regulations on the development and reshaping of lands. The impact of raising structures, increasing impervious cover, or other alterations of the landscape within environmentally sensitive areas should be considered in detail by local governments when undertaking a reconstruction project. Calculations of the ecological importance of lands by comparing historical and current information can help solve planning issues for future use and maintenance of renewable biological resources.

This research identifies the physical and fluvial landscape changes of the San Marcos River at Rio Vista Dam, after the reconstruction of the dam in the spring of 2006. I use repeat photography techniques to analyze the impact of the renovation of Rio Vista Dam on the surrounding landscape. Comparing historical photos of the dam dating from 1917 to 2006 with current photos, analyzing the landscape change over time, and measuring the effects the reconstruction of the dam has on the surrounding environment lend insight to this research. By evaluating repeat photographs of the dam from different angles, I illustrate in more depth and detail the effects the recent modifications had on the landscape in relation to various riparian habitat and fluvial channel alterations.

The purpose of my research is to provide further support for an effective method of measuring landscape change and a basic framework for the continued analysis of a highly sensitive urban area. An increased awareness, gained from inquiry into riparian landscape and fluvial channel modifications resulting from alterations of a delicate river system, directs a greater understanding of anthropogenic environmental impacts. This has led to studies using repeat photography and opportunities for testing hypotheses about the implications of a changing landscape in response to human activities.

Objectives

The objective of this investigation of the Rio Vista Dam on the San Marcos River in San Marcos, Texas, is to develop new knowledge about the changes that occurred at the site since 1907, including changes from reconstruction of the dam in the spring of 2006. Specific questions that guide the research include:

1) By use of repeat photography, how does the current riparian and riverine landscape of the Rio Vista Dam and San Marcos River compare to that of the historic landscape?
2) How does the landscape change from the remodeling of the dam differ in comparison to other anthropogenic landscape alterations?

Significance

Photos taken of landscapes over time are useful tools in analyzing the impact and transformation of an area. The use of rephotography as a field method is important for showing the changes and structural improvements made to the dam during the spring of 2006. When comparing the old and new photos, many subtle differences are noticed that may have been overlooked if only a sketch had been taken in the field instead of a photograph. Noting changes between before and after photographs is a simple and straightforward method of geographical analysis that can be applied to a wide variety of topics, from tsunami damage to the environmental effects of a culture. Repeat photography is vital to understanding the temporal changes of not only the physical landscape, but also transformations in the cultural landscape and human impact on a place.

From the applied perspective, repeat photography analysis can influence proposed construction and development within sensitive areas, with emphasis on habitat conservation and awareness of the long-lasting effects of population growth on the physical landscape. The documentation and management of landscape modification across a broad range of spatial and temporal scales is essential for certifying proper administration of environmentally sensitive regions. Repeat photography presents a cost-effective opportunity to recognize temporal and spatial scale differences resulting from the effects of land management and human-induced activity.

With an expected increase in human population within the next 25 years, having a pictorial history of the landscape will reiterate the importance of conservation and thoughtful planning at the various stages of development. The growing concerns of urban land-use, changes in the global climate, and the effects of man-made structures on geomorphic and fluvial systems address the relevancy of repeat photography as a technique in field studies. This research is important for future investigations analyzing both geomorphic and anthropogenic landscape alterations. The relevancy becomes more prominent when the ease of applying and understanding the method of repeat photography is taken into consideration. The determination of where and how environmental landscape change is occurring can be essential for managing the different goals represented by sustainable development and population growth.

CHAPTER 2

LITERATURE REVIEW

Repeat Photography

Repeat photography is a procedure detecting the site of an earlier photograph, reoccupying the original camera location, and taking a new picture of the same image (Rogers, Malde, & Turner, 1984). The technique of comparing matched pairs of photos is based on visual image interpretation and qualitative evaluations of the differences between the pictures (Harrison, 1974). An array of interdisciplinary academic fields employ the research method, including geology, physical geography, botany, architecture, and cultural geography.

The U.S. Department of Agriculture, Forest Service has defined, outlined, and analyzed the application of repeat photography as a ground-based monitoring method, detailing distinctive points on the proper and effective way of using the technique (Hall, 2001; 2002). Many "before and after" books have been published comparing old and new photographs of rivers, cities and highways, mountain range communities, and national parks (Hastings & Turner, 1965; Vale & Vale, 1983; Veblen & Lorenz, 1991; Webb, 1996; Turner, Webb, Bowers, & Hastings, 2003). The mainstream popularity of books presenting historical evaluations through the employment of repeat photography is a confirmation that the public understands and appreciates the impact such studies have on the human consciousness.

The exercise of repeat photography in the field has been a practical and simple interpretive tool to show geomorphic modifications in the physical landscape (Veatch, 1969; Harrison, 1974; Graf, 1987; Ives, 1987), vegetation changes in a riparian environment (Turner & Karpiscak, 1980; Pickard, 2002), and acreage transformation in range and forest lands in the western United States (Hart & Laycock, 1996). Cultural change can also be apparent through the use of repeat photography by looking at the land-use pattern variations of irrigated fields and population growth (Nüsser, 2001), analyzing revegetation and sustainable development methods by villagers (Kull, 2005), and evaluating landscape reclamation in old mountain mining communities (Veblen & Lorenz, 1991).

Repeat photography presents certain problems and difficulties in the analysis of landscape change. Many obstacles are encountered when performing repeat photography in the field. The original camera position of the historic photograph may be impossible to find due to changes in the landscape over the years. Major challenges faced when trying to orient the camera to the exact position range from the removal of the original site (Butler & DeChano, 2001), the alteration of the location due to geomorphic agents (Graf, 1987), or the transformation of the site into a major highway (Veblen & Lorenz, 1991). Times exist when this problem has to be compromised for the sake of the photographer's safety and the impossibility of obtaining the exact camera position.

The format of camera used in the original photograph has a distinctive view of the image. Depth of field and focal length differ among older cameras from the earlier part of the twentieth century and present-day digital cameras (Jakle, 2004). Although the exact format size is not of vital importance in repeat photography, knowing that the depth of field capabilities of the original camera are greater than the depth of field taken with modern cameras can alleviate the frustration of trying to find the exact camera location. Unless the same format of camera is used, chances are that the depth of field will be noticeably different between the two photographs (Harrison, 1974).

Concerns of scale and perspective are other problems that arise when trying to recapture a scene (Hall, 2001). The season and time of day contribute to problems with scale when reshooting the photographs. The angle of the sun and the foliage of trees can dramatically alter the view of a landscape. The removal of trees, buildings, or other large objects can change the appearance of an area, thus causing difficulty in trying to frame the new photo. When the vista has undergone significant modification, the task of finding any point of reference can be very challenging. Rephotographing certain areas leads to uncertainty in the final analysis when nothing is available for reference (Hall, 2001).

Landscape Photographs

The photographing of landscapes has been popular since the invention of the camera in 1840. The development of mass-marketed Eastman Kodak cameras during the late nineteenth century provided an opportunity for extensive landscape photographs to be taken by professionals and layman alike (Jakle, 2004). The camera has been an affordable and simple way of documenting field studies, travels, vacations, and family events, adding to the multitude of existing images for analysis. Aerial photography and remote sensing images also contribute to the landscape photographs used in repeat photography research, but are best utilized in small-scale studies because of the lack of fine detail in the images (Nüsser, 2001). Historical and current photographic records of landscapes are available from many different sources, including books, library and government archives, the Internet, and private or personal collections (Kull, 2005). Photographs obtained from individual collections present dilemmas about the scale and accuracy of the pictures. Personal photos can be out of focus, damaged from improper storage, or incorrectly exposed, making the use of such images ineffectual.

Picture Postcards

Picture postcards are postal cards depicting a photograph on the front and blank space for a written message and a mailing address on the reverse. The distribution of the picture postcard began increasing during the early 1900's, mainly attributed to camera technology development allowing photographs to be printed onto a postcard and the changing of federal laws permitting writing on the back of the postcards (Staff, 1966). The cards generally depicted landscape images, offering the public a view of distant places and beautiful scenery (Illustration 1). These picture postcards provide a stock of

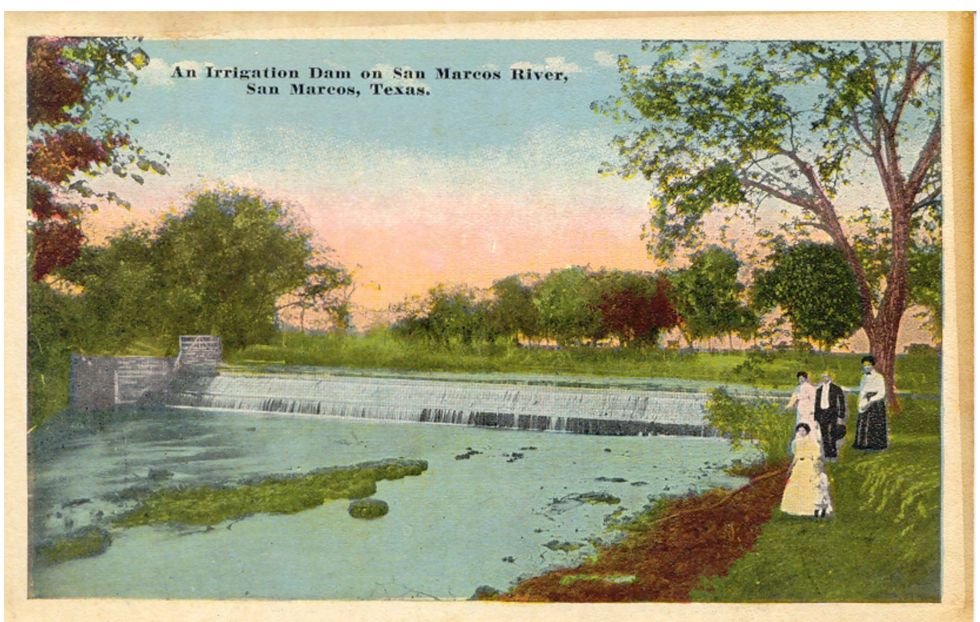

Illustration 1. Hand-tinted Picture Postcard. Source: San Marcos Public Library.

landscape illustrations that otherwise might not be available in historic photography collections.

The utilization of picture postcards as a reference tool in repeat photography presents problems for analyzing landscape change. Postcard publishers regularly modified the original scene by enhancing different aspects of the view, creating a false representation of the landscape (Sawyer & Butler, 2006). The deliberate or accidental distortion of the scenery by the coloration, enhancement, and addition or deletion of certain elements of the landscape leads to an incorrect depiction of the environment. The resulting displayed image on the postcard cannot be trusted as a true version of the landscape, requiring the reference of the original photograph to validate the accuracy of the postcard.

Repeat Photography of Geomorphic Landscape Change

Landscape change research extensively uses geomorphic analysis for investigating the processes of environmental modifications. The utilization of quantitative and qualitative measurements increased with geomorphic research concerning landslides, glacial processes, treeline advance, and global climate change. While alterations on the landscape can be investigated using different research methods, the present awareness and ability to analyze current changes on the environment with repeat photography is built upon a variety of studies examining over a century of available photographs.

A large, classic bibliography of repeat photography studies complied by Rogers, Malde, and Turner in 1984, supplies a list of several hundred publications employing the research method in physical and cultural sciences. Approximately ninety percent of the repeat photography studies noted in the bibliography center on ecological or geomorphic landscape change, with the remaining ten percent attributed to anthropogenic landscape change. Hart and Laycock (1996) expanded upon the tome, producing a bibliography that encompassed more repeat photography studies about land and range management. Butler (1994) introduced the practical use of repeat photography as an educational teaching tool, with a helpful bibliography containing categorical notations of the subject matter under investigation for each article. These bibliographies provide a wealth of literature covering repeat photography research.

Hastings and Turner's (1965) *The Changing Mile* popularly introduced the concept of using repeat photos to portray landscape change. The classic book established the fundamental components of rephotography and the impact the method can have on a myriad of studies. The research utilized ninety-seven historical photographs of the Sonoran Desert dating from 1883 through the turn of the twentieth century. The old photos were compared to photos retaken in 1962, noting the changing vegetation distribution over the length of time elapsed between the scenes. Hypothesized reasons for the difference in vegetation growth observed on the landscape were the impact of cattle, the effects of rodents, fire suppression programs, and climate change. Conclusions derived from the study found that the major driving forces explaining the vegetation differences could be attributed to the effects of the changing climate and minimally ascribed to cattle grazing on the landscape. The human influence on the environment was analyzed for its effect on the vegetation distribution, but the study found that climate change in conjunction with the introduction of cattle was most likely the cause of the observed differences.

Vetch (1969) set a standard for academic research using repeat photography after publishing an analysis of historic change of Nisqually Glacier in Mount Rainier National Park, Washington. He took annual photographs of the glacier with a handheld camera for twenty-four years from twenty different viewpoints, noting physical differences of the glacier over time. Twenty-six photographs were ultimately used in his study, comprising his primary data interspersed with secondary data of engineering survey photos from 1884 to 1941. Qualitative and quantitative measurements of glacial change derived from the photo pairs include analyses of debris flows, outburst floods, thickness and movement of the glacier, and slope fluctuations. Vetch recognized that photographing and analyzing an area over a period of time had important value because the method proved to be relatively swift and inexpensive, with the added benefit of gaining a wealth of information ordinarily inaccessible by historic surveying techniques. His conclusions provide support for repeat photography as a valuable asset in measuring landscape morphology over time.

Marston, Popchop, Kerr, Varuska, and Veryzer (1991) conducted research through the use of repeat photography on temporal and spatial changes of the Dinwoody Glacier in the Wind River Range, Wyoming. Qualitative measurements, from ground photos taken in 1935 compared with photographs taken in 1988, found that Dinwoody Glacier had retreated. Quantitative measurements of change in glacier volume were obtained from comparative analysis of aerial photos taken in 1958 and 1983. An isopach map of lost ice thickness was made from twenty-three points on the glacier. Aerial photographs showed that the volume of ice lost over the 35-year period was equal to the volume of ice remaining in the glacier at the time of the study. Marston *et al*. proposed that if the present rate of glacial melt continued, glaciers in the Wind River Range would disappear within the next three decades.

Butler and DeChano (2001) assessed environmental change using repeat photography from fire lookouts in Glacier National Park. Nineteen photographs taken by Lester M. Moe during the summers of 1935 and 1937 were rephotographed to analyze the areal changes in the landscape over the 65-year time span. The authors scrutinized the spatial changes of glaciers, forest cover, snow-avalanche paths, fluvial and mass-wasting processes, and human-induced activities outside the park boundaries. The original photographs were compared to 1:24,000-scale topographic maps, establishing a quantifiable scale for measuring the spatial amount of physical change. The concluding discussion notes dramatic landscape changes evident from the time-lapsed photographs, which attributes the changes to effects of climate change, fire suppression strategies, and predominately by increased human pressures on the periphery of the parkland.

Klasner and Fagre (2002) used of sequential aerial photography to document qualitative changes of the alpine treeline ecotone in Glacier National Park over a 46-year period. The analysis of an ecotone is an important indicator of climate change. For each of the six study sites, geo-rectified black-and-white aerial photographs from 1945 were compared to 1:12,000-scale 1991 black-and-white USGS Digital OrthoQuad images of the same area. Four ground-level photographs from the building of a major road through the park in the 1920’s were retaken, primarily for confirming vegetation patterns identified in the aerial photographs. The study concluded that the total patch area of krumholtz and patch-forest increased, especially around the existing patches of trees. Assessment of before and after photos illustrates the increased abruptness of the alpine treeline ecotone transition between the forest and tundra, the amplified density of forested areas, and the minimal human impact along trails. This study contributes to the growing amount of literature addressing the use of repeat photography as a means of illustrating the reality of changing global climates.

Repeat Photography of Anthropogenic Landscape Change

Cultural change and the effects of human impact on a place can be clarified through of repeat photography. While a majority of available studies concentrate on the geomorphic changes of a landscape, the implications from the research address anthropogenic impacts on the area under investigation, including the effects of fire suppression, logging, and human pressures for resources (Rogers, 1982; Byers, 1987; Butler & DeChano, 2001). Traditional research previously addressed the analysis of changes in land-use and land cover separately, with land-use differences being studied by social scientists and landscape alterations being investigated by natural scientists. Closing the gap of studies between human and natural sciences is of vital importance for a more thorough understanding of cultural landscapes and environmental change.

Turner and Karpiscak (1980) studied the impact of the construction of Glen Canyon Dam on the riparian landscape along the Colorado River between Glen Canyon Dam and Lake Mead. The historic photos used were from the time period before the creation of the dam, from 1872 to 1963. The comparison pictures, taken between 1972 and 1976, show that the density of riparian vegetation increased after the building of the dam and the controlling of the river's floodwaters. Exotic species coverage also increased, as did the accumulation of silt and sand deposits along the banks of the Colorado River. The influence of the dam on hydrologic variables affecting the annual maximum discharge, decreased sediment load, and transportation of amassed sand deposits was also addressed. The research indicates that although more time is required for a comprehensive study of the long-lasting effects of Glen Canyon Dam, immediate changes are apparent. This research lends to comparisons of other repeat photography investigations analyzing landscape change in response to man-made alterations of a river system.

Veblen and Lorenz (1986, 1988, and 1991) used repeat photography to study the spatial dynamics of high altitude forests and the effects humans have on the forest ecosystem. In 1991, the team analyzed the ecological change the Colorado Front Range forests endured since 1880. The study area contained Rocky Mountain National Park, large expanses of national forests and wilderness, and a growing population along the urban corridor from Fort Collins to Colorado Springs. The historic photographs date between 1880 and 1915, mostly taken by three prominent photographers during early exploration and settlement of the Rocky Mountains. The contemporary images date from 1984 to 1986. The sixty-nine photographic pairs illustrate the settlement and alterations of landscape, and how the much of the previously logged and mined areas rejuvenated over time. An obvious conclusion drawn from this research is the awareness that humans played a major role in shaping the landscape patterns in the area. The altering of the forests by logging and increased burning, the raising of livestock, and the destruction caused by mining lent to the intense impact humans had on the land. Veblen and Lorenz deduced the ecological changes related to the dramatic economic and social fluctuations that occurred in the Front Range over the past century. The historical perspective gained from rephotography created a better understanding of the importance of the method in describing landscape change.

Nüsser (2001) applied repeat photography methods to analyze cultural landscape changes in Chitral, Pakistan. The historic land-use pattern of irrigated fields was compared to current agricultural practices in response to population growth. Eight photographs taken of the landscape in Chitral during 1966 and 1978 were compared with images recaptured in 1997, targeting the development of cultivated areas and human settlement. The study indicates that the settlements and agricultural lands have increased in size, with the forests surrounding the villages acutely degraded because of local over-exploitation of natural resources. Nüsser believes a necessity exists within current geographical research to describe the interactions between landscapes and the human driving elements that contribute to environmental change.

Kull (2005) used repeat photography to explain cultural regional trends in the landscapes of the highlands of Madagascar. Fifty-six historical photos spanning an 80-year period from 1895 to 1974 were compared to newer pictures taken between 1996 and 2004. Major changes were the conversion of the grass-covered hills to a pine and eucalyptus forest, the expansion of cultivated fruit trees and agricultural crops, and a higher density of human settlements. Comparison of repeat photographs easily illustrated the expansion of street and utility infrastructure, along with the increase of community developments. The effects of fire, overgrazing, and poor agricultural techniques are attributed to the decrease in soil quality and increased gully development, although cases exist where farmers had improved soil conditions. Conclusions report a dynamic landscape formed by a community of people focused on securing a homestead and producing fertile farmland. Kull's study provides support for the present research comparing the anthropogenic effects of landscape change.

Present Research Needs

Existing knowledge about the use of repeat photography to measure the landscape response to human activities and the environmental impacts on the San Marcos River over time, including the reconstruction of the Rio Vista Dam, is incomplete in three areas:

1) deficiencies of current field data and investigations of the dam after reconstruction,
2) a comparatively small amount of repeat photography studies on anthropogenic landscape transformation, and
3) analyses of how environmental landscape change from the remodeling of a dam differs in comparison to other human-induced landscape modifications.

The first major gap in the research is the shortage of current field data and studies of the Rio Vista Dam after reconstruction in the spring of 2006. Recent riparian surveys, current fluvial measurements, and before and after photographs of the dam are needed for analyses about the study area. While older photos of the dam exist, current pictures taken from the same position are difficult to locate. Conversely, current images exist of the Rio Vista Dam after reconstruction, but to uncover historical photographs that match the current photo locations is very difficult. Fieldwork was conducted to collect riparian and riverine information, and to produce current photos composed at the same site as each historic photo. Through contact of local universities, public and academic library archives, the City of San Marcos, and local residents, historical photographs of the dam were obtained.

The relatively small amount of repeat photography articles that concentrate on anthropogenic landscape modification is the second major gap. Abundant literature is available on qualitative and quantitative geomorphic landscape alterations, especially focusing on providing a simple method to support global climate change research. Reports exist about the spatial distributions of riparian vegetation with regard to environmental fluctuations, but investigations on the concern of human-induced change on a sensitive river system are not widely obtainable. The proposed research from this study provides observations and analysis that can help increase the collection of literature on the subject.

The third major gap in the present research is an explanation of how environmental landscape change from the remodeling of a dam differs in comparison to other anthropogenic landscape modifications. The riparian and riverine effects that the reconstruction of the Rio Vista Dam has on the San Marcos River and surrounding area might be different compared to the effects of other human altered landscapes. Studies concerning urban and rural landscape change in response to human activities are plentiful, but the analyses are focused on the illustration of urban developmental sprawl, the revegetation policies of agricultural areas, or the changes along historic roadways. Research is needed documenting historical change on the cultural landscape of rivers that can be compared to the reconstruction effects on the San Marcos River. Human alterations of riparian and fluvial systems need to be analyzed and applied to the research to explain why land-use and habitat degradation have changed over time in sensitive environments. Results from the analysis of the effects from the reconstruction of the Rio Vista Dam will then be able to be compared with outcomes and conclusions of other studies done on landscapes modified by humans.

CHAPTER 3

STUDY AREA GEOGRAPHY

San Marcos and the River

The area under investigation is the reach of the San Marcos River around Rio Vista Dam in the city of San Marcos (Figure 1). San Marcos is located in central Texas, approximately halfway between Austin and San Antonio along the I-35 corridor. The

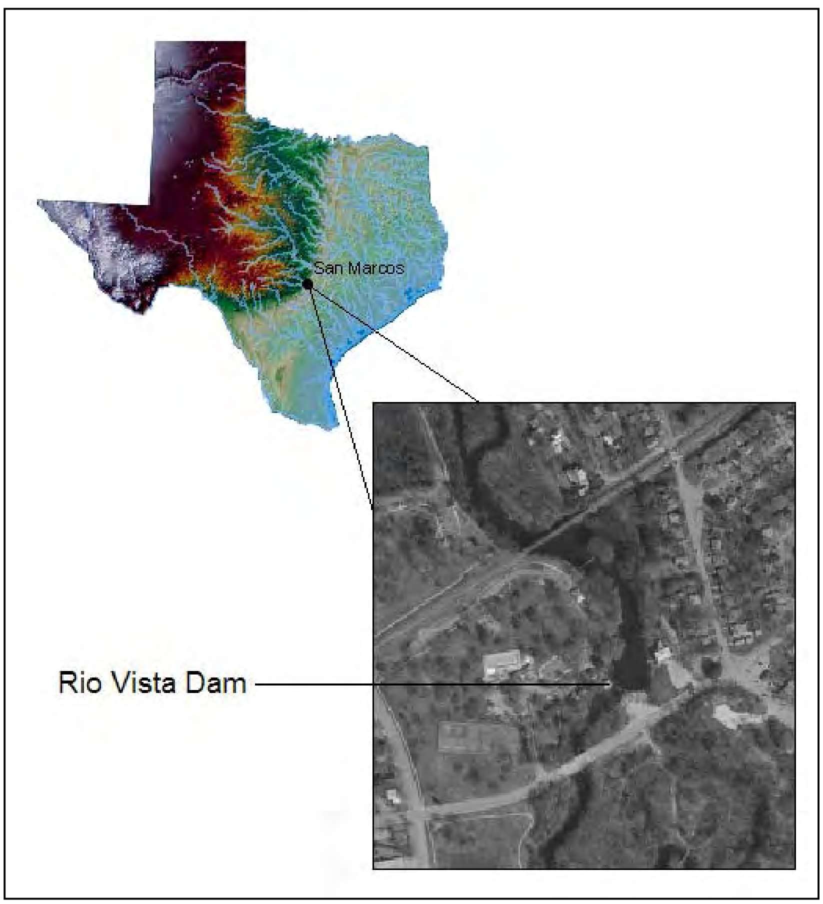

Figure 1. Study Area. Created by author from CAPCOG data, 2007.

city is situated on the Balcones Fault that separates the rugged limestone Edwards Plateau to the west from the flat Blackland Prairie to the east (Woodruff, 1979). Approximately half of the city drains into the recharge zone of the Edwards Aquifer. San Marcos is a rapidly growing population center with the highest population density between Austin and San Antonio. The area contains the highest agriculturally productive fields and the most intensive land-use in the region (Longley & Maler, 1990).

The San Marcos River originates from the Balcones Fault through a series of springs known as the San Marcos Springs (Saunders, Mayes, Jurgensen, Trungale, Kleinsasser, Aziz, Fields, & Moss, 2001), then meanders past the Texas State University-San Marcos campus and through the city in a southeasterly direction. The springs are now submerged under Spring Lake that was formed by the damming of the river in 1849 (Taylor, 1904). The source of the water is the Edwards Aquifer, a large underground reservoir that is recharged by streams flowing over the fault zone and rain falling on exposed outcrops of Edwards limestone (Kimmel, 2006). Roughly ninety percent of the Upper San Marcos River watershed is located over the Edwards Aquifer (Jenkins, 1985). The river has never ceased to flow in recorded history, with a long-term average flow of 51 cubic meters per second (cms) and the historical low flow of 14 cms during the 1956 drought of record (Saunders *et al*., 2001).

The upper portion of the San Marcos River is characteristic of a springrun, with clear, swift flowing, thermally constant water (Owens, Madsen, Smart, & Stewart, 2001). The river supports many city parks and recreational activities, with the riverbanks populated by students and families from the headwaters down to Rio Vista Dam during the warmer seasons. Texas State University-San Marcos maintains a park on the river and operates an outdoor center, which rents canoes, kayaks, and tubes to students. The San Marcos Lion's Club at City Park rent tens of thousands of tubes each year to locals and tourists who float downstream to the dam and over the falls.

Climate

The climate of San Marcos is typical of Central Texas, characterized by hot summers, mild winters, and irregular rain patterns. The annual precipitation is 79 centimeters (cm), but drought conditions exist quite frequently. The average temperature ranges from 3º Celsius (C) to 15.5ºC during the winter and 22ºC to 35.5ºC in the summer (CityTownInfo.com, 2006). Conversely, the temperature often varies widely in both spring and autumn, with abrupt fluctuations from day to day. The dry desert air from Mexico displaces the cold polar air during the winter and early spring, causing daytime temperatures to increase by 11ºC to 16ºC, while plunging down to freezing at night (Woodruff, 1979). Temperatures during the summer regularly rise over 37ºC.

The San Marcos area is prone to heavy rains in quantities and short time intervals too intense for the land to accommodate. Central Texas is susceptible to flash floods that originate from sudden cloudbursts, sending torrents of rainwater upon highly localized drainage basins (Longley & Mahler, 1990). The rapid peaking of the streamflow is followed by a rapid recession of the flow, quickly altering the riverine landscape as the water rushes downstream. The impact of the excessive rains induces runoff peaks most often in late spring and early summer, but may also occur in late summer and autumn. The Balcones Fault is cut in hundreds of places by rivers, streams, creeks, caves, and caverns that fill swiftly when abundant rains fall upstream on the watershed (Woodruff, 1979). The waterways overflow within a matter of minutes, making Central Texas one of the three most flash-flood prone regions of the United States (Jenkins, 1985).

Geomorphology and Soils

Cretaceous limestone and sandstone displaced by the Balcones Fault form the distinctive landscape of the San Marcos area. The upside of the fault consists of the more resistant Edwards and Glen Rose limestone formations that comprise the Edwards Plateau to the west; an area of thin soils, steep slopes, and streams entrenched in narrow valleys and canyons (Woodruff, 1979). The down-faulted side comprises younger, less resistant chalks and clays in rich, black clay soils of the Blackland Prairie to the east (Jenkins, 1985). The Edwards Aquifer lies below the surface, with the recharge zone located where the Edwards limestone is exposed at the surface and the artesian zone lying under the prairie.

The Blackland Prairie has low, rolling hills on predominately limy-clay substrate, with the subdued relief due to deep soils and the high erodibility of the Pecan Gap chalk and alluvial deposits (McCoig *et al*., 1986). The most fertile soils in the region are located on the Blackland Prairie. In contrast, the Edwards Plateau has thin, stony, clay-loamy soils that overlie limestone formations. The soils tend to be shallower and the strata more resistant than those of the prairie (Woodruff, 1979).

Pleistocene alluvium deposits, derived from erosion and deposition of sediments by streams and rivers, represent former floodplains along the riparian corridor (Woodruff, 1979). The weathering of the alluvial deposits produces low and gentle slopes, thick and fertile soils, and stable substrate material (Jenkins, 1985). The river is punctuated with shallow riffles and alternating deep pools flowing over a bed of sand, silt, clay, mud, and gravel (Saunders *et al*., 2001)

The Oakalla soil unit that occurs in the floodplain of the river and on the adjacent terraces is characterized by deep, calcareous, silty clay loam soil variations (Jenkins, 1985). Surface runoff is generally slow and erosion hazard is low to moderate depending on the bank slope (Longley & Maler, 1990). The soil contains about sixty percent calcium carbonate because the river flows through a drainage basin dominated by limestone uplands, causing the soil to be slightly alkaline and calcareous throughout (McCoig *et al*., 1986). The rich soil supports thick vegetation that provides wildlife habitat, but is not suited for agricultural land or urban development because of flooding hazards. The soil provides ideal sites for recreation because it creates banks that are relatively flat and allow easy access to the river.

Fauna and Flora

San Marcos Springs and its riverine system provide habitat for an abundance of plants and wildlife. The thermally constant and pristine waters attract migratory and residential birds to the river in search of nourishment. Great blue herons (*Ardea herodias*), red-tailed hawks (*Buteo jamaicensis*), and great white egrets (*Ardea alba*) are commonly found along the river’s edge throughout the year. Both native and exotic aquatic plant species have firmly established stands in the river and along the shores, providing lush habitat for turtles, fish, and insects.

The reach of the San Marcos River from the headwaters to just below the Rio Vista Dam is considered critical habitat for several unique, native animals and plants (Table 1) identified for protection under the Endangered Species Act (Campbell, 2003).

The Rio Vista Dam and the dam at the headwaters altered the ecology of the river by providing habitat to species adapted to slow-moving impounded waters (Owens *et al*., 2001). Therefore, the seriousness of maintaining a stable environment after the repair of the dam fosters governmental and public interest.

Table 1. Endangered and Threatened Species within the San Marcos River and Springs. Data source: Edwards Aquifer Research and Design Center, 2006.

Scientific Name	**Common Name**	**Status**
Etheostoma fonticola	Fountain Darter	Endangered
Eurycea nana	San Marcos Salamander	Threatened
Gambusia georgei	San Marcos Gambusia	Endangered (may be extinct)
Typhlomolge rathbuni	Texas Blind Salamander	Endangered
Zizania texana	Texas Wildrice	Endangered

The riparian vegetation found at the study site resembles the plant life established all along the San Marcos River (Table 2). The moisture in the habitat supports a high diversity of life along the riparian corridor. The bald cypress (*Taxodium distichum*) and pecan (*Carya illinoinesis*) grow to approximately 25 meters (m) along the riverbanks, with the anacua (*Ehretia anacua*) standing close behind at 15m (Wasowski & Wasowski, 1991). The grasses and groundcovers also thrive with the abundance of available water.

The favorable growing conditions provide an ideal environment for nonnative species to establish and become invasive. Owens *et al*. (2001) estimate nearly eighty percent of the native aquatic shoreline vegetation has been replaced by exotics since the 1930’s. Elephant ear (*Colocasia esculenta*) has firmly set root along the banks and is difficult to remove because of its ability to spread by plant fragments. The profusion of

Oriental trees and vines found along the river also indicates the rapid invasion nonnative species impose on the environment.

Table 2. Vegetation along the San Marcos River. Data source: fieldwork by author, 2006.

Scientific Name	Common Name	Location
Carya illinoinesis	Pecan	Riparian Corridor
Celtis laevigata	Hackberry	Riparian Corridor, Blackland Prairie
Colocasia esculenta	Elephant ear (exotic)	Riparian Corridor
Cynodon dactylon	Bermuda grass	Riparian Corridor
Eichhornia crassipes	Water hyacinth	Riparian Corridor
Ehretia anacua	Anacua	Riparian Corridor
Melia azedarach	Chinaberry (exotic)	Riparian Corridor, Blackland Prairie
Platanus acerifolia	London Planetree	Riparian Corridor
Quercus falcata	Southern Red Oak	Riparian Corridor
Quercus furiformis	Live Oak	Edwards Plateau, Riparian Corridor, Blackland Prairie
Quercus macrocarpa	Bur Oak	Riparian Corridor
Sapium sebiferum	Chinese Tallow (exotic)	Riparian Corridor, Blackland Prairie
Taxodium distichum	Bald Cypress	Riparian Corridor
Toxicodendron radicans	Poison-Ivy	Riparian Corridor, Blackland Prairie
Ulmus crassifolia	Cedar Elm	Edwards Plateau, Riparian Corridor
Wisteria sinensis	Chinese Wisteria (exotic)	Riparian Corridor

Historical Geography of Rio Vista Dam

The location of the Rio Vista Dam is approximately 1.5 kilometers (km) downstream from the headwaters of the San Marcos River. Many old dams exist along the river, built around the turn of the 20th century for irrigation and power needs (Stovall, 1986). One of the first erected on the river was an earthen dam that harnessed water for crops in 1866 (Taylor, 1904), at the present location of Rio Vista Dam. A sturdier structure was built for irrigation and power generation on the site of the old dam in 1904. The stronger dam made of cedar logs, big rocks, and concrete spanned 30.5m across and stood about 3m high (McCoig *et al*., 1986). During the early 1950's, the creation of a chute in the dam allowed more water to flow downstream. The dam eventually deteriorated to a dangerous state by 2005, needing serious repairs so that the structure would not collapse and human safety was not in jeopardy.

The water rights history of the Rio Vista Dam can be traced through its many different owners. Although the dam was originally constructed for irrigation purposes, Malone and Bost also obtained an industrial permit in 1904 to improve the earthen dam already on the site (Taylor, 1904). D.J. Woodward previously filed a claim that year to divert water from the river through a "millrace" and for the right to impound water in the San Marcos River (Taylor, 1904). Landowners further downstream raised objections surrounding the impoundment of the river, also demanding access to water for irrigation purposes. A special clause written into the dam permit required that the impoundment not exceed 50-acre ft. (McCoig *et al*., 1986). Woodward built the millrace, but did not obtain the rights to build a dam.

The ownership of the water rights and dam transferred many times over the next 25 years, until J.M. Cape bought the rights in 1929 (McCoig *et al.*, 1986). During the 1920's, local entrepreneur Arthur B. Rogers developed the river area immediately above the dam by dredging the river, installing trapezes from the trees and a "trolley" (zip line) across the river, and adding picnic facilities (Fairchild, 2007). The area came to be known as "Rogers Park" and the dam referred to as "Rogers Dam". Rogers also built screened summer cabins on the western bank of the San Marcos River, with the cabin overlooking Rogers Dam carrying the name "Rio Vista" (Fairchild, 2007). Over time, the dam generally became known as the "Rio Vista Dam". The Cape family owned the dam and water rights until 1981, when J. Henry bought the property.

The original use of the water changed from irrigation and industrial purposes to recreational purposes under the ownership of Henry (McCoig *et al.*, 1986). He planned to build a water theme park on the premises of the dam and land further downstream, but faced challenges due to zoning and floodplain restrictions on building construction. Henry donated the property to Southwest Texas State University in 1995. The school sold the property to the City of San Marcos that same year. The dam had become a major tourist attraction, which prompted the city to request changing the permit to recreational means because of the thousands of people who would tube down the river and through the chute each year.

The dam deteriorated over the century until it got to a point of disrepair that required immediate attention. Local kayaker Ben Kvanli brought this matter to the awareness of the City of San Marcos, who hired Recreation Engineering and Planning (REP), a Colorado company specializing in whitewater park design and planning. Much of the dam was found to be unsupported because of swift currents below the dam undermining the foundation. The concrete apron below the dam had cracked and separated from the dam by as much as 30.5cm (Illustration 2). Turbulent water severely destabilized the bank on the western side of the dam, causing big cracks in the ground above the dam near the old picnic pavilion.

Illustration 2. Damaged Concrete Apron of Rio Vista Dam, March 2006. Source: author.

CHAPTER 4

DATA AND METHODOLOGY

The goal of my data collection was to acquire a diverse array of historic images of the Rio Vista Dam of the San Marcos River that span the life of the structure before reconstruction. I sought the original camera location of each old photograph so I could take a new picture for comparison against the old scene, recording the location information with a Magellan Global Positioning System (GPS) unit. Next, the photo pairs were analyzed for occurrence of landscape changes, with special emphasis on riparian and riverine alterations. Ground-truthing of the riverbanks was conducted to validate the differences found between the repeat photographs. The purpose of this methodology is to illustrate the environmental changes that arise from the anthropogenic alterations of the area.

Historic Data Collection

I collected a total of twenty-nine images for this research. Twenty-eight historic photographs were gathered from both private and personal collections. Long-time San Marcos residents Jack Fairchild and Ernest Cummings provided seventeen of the old photographs of Rio Vista Dam from their family photo albums. Nine of the historic photos were from my personal collection, taken a month before the reconstruction began. Melissa Millecam, from the City of San Marcos, offered two of the photos used in this study from the same camera location, one taken moments before the groundbreaking and the other during reconstruction. Jack Fairchild's photographs date back to 1917, when his mother lived in San Marcos and swam at the dam as a young girl. He also supplied photos from 1932, when he and his family stayed at the "Rio Vista" cabin during the summer. Furthermore, a couple of his photos from the 1970's were chosen for this study. After retiring in the 1990's, Fairchild took pictures of the dam over almost two decades to determine the discharge rate of the river by observing how much water was flowing over the dam at a given moment in time. Included in my analysis are selections of his river flow pictures.

Ernest Cummings has lived in San Marcos since he was a child, and took many photographs of the San Marcos River and Rio Vista Dam. His parents bought the property along the west bank of the river at the dam in 1948, tearing down the screened cabins and building a house on the premises. Cummings took many of the photographs from the porch of the house over the next three decades, depicting the dam and east bank of the river. Cummings also supplied photos from summer holiday picnics during 1950, capturing views of the park on the west bank with the dam in the background.

The photographs taken in March 2006 were from my personal collection. The Rio Vista Dam was a place of enjoyment and excitement for me every summer for the past fifteen years. This trend continued after moving to San Marcos, with my family spending a few days over the summers tubing down the river and shooting through the spillway. Upon learning of the pending reconstruction of the dam and consequently the San Marcos River, photographing the local favorite landmark seemed important for not only personal memorabilia but also for historic documentation.

Two historic picture postcards were used in this analysis. The postcard of the irrigation dam was found in the archive collection at the San Marcos Public Library. The reproduction of the original photograph portrayed in the postcard image was located in the Southwest Texas State Normal School 1907 yearbook. The only noticeable alterations to the picture were the intentional coloration of the scene and the addition of people along the riverbank. Ernest Cummings provided the picture postcard of Rio Vista Park from his personal collection. Neither the original photograph nor the date of his postcard was discovered.

Current Data Collection

The composition of the twenty-nine repeat photographs occurred over a period of ten months, using a Canon digital camera. The new photos begin at the end of June 2006, a month after the dam area reopened to the public, with the last of the pictures taken in March 2007. The historic pictures in this study were compared with the contemporary ones for accuracy and integrity concerning camera angle and position. Photographs were disqualified that were not congruent with the standards of comparing historic photos with current ones. I refer to left bank and right bank, as facing downstream, in describing camera locations so as to have a clearer understanding of the site under discussion.

An effort was made in replicating the time of season, but the discovery of many of the old photos happened after the passing of the season. Format reproduction of the original photographs was also attempted in recapturing the scene, but Adobe Photoshop had to be used to crop a few of the pictures down to size. The exact position of the original image was sought in each photograph, but most locations used in the analysis were an approximation of the original. The area changed so dramatically that only a few sites provided positions that could be exactly matched with the originals. The GPS coordinates, elevation, and viewing direction were recorded at each location. The positions and directions were then illustrated on a site map. Vegetation data were also collected while in the field.

Creating the rephotographs of Sites 21, 22, 23, and 26 from the right bank required a 2.5m ladder because the house and high bank had been removed where the historic photographs had been taken. A taller ladder was needed, but for safety issues the smaller one was chosen. My research assistant held the ladder while I shot the photos. Although the pictures could have been taken from present ground level, I chose to use the ladder to more accurately portray the perspective of the scene. The trees on the opposite bank, the remaining concrete platform and poles next to the dam, and the angle of the dam were used as guidelines when composing the pictures.

The close-up views of the dam from the water posed a challenge because the reshaping of the river bottom caused the river to become deeper in those areas, almost putting me under the water at the original camera locations during higher flows. The fluvial dynamics had also undergone major renovation, with the fast-moving water channeled more towards the middle of the stream. The deeper riverbed, swifter current, and changed channel flow caused many problems when attempting to stand up against the current to take the picture. I found stable footing when taking the photos, but the water was to my chest and the current strong enough to jar the camera. The cypress trees and the top portion of the dam were used in lining up the new photographs.

The left bank had not undergone such radical change as the right bank and the riverbed itself, making the finding of the original camera position a bit simpler. The removal of the retention wall and picnic pavilion on the opposite bank, along with the reconstruction of the dam itself led to seeking minute points in the original photograph to compare with the present scene. The remaining trees and stationary structures on the opposite bank, along with the angle of the upstream top portion of the dam, were used to find the right perspective in framing the photographs.

Every day during the warmer months, the dam and surrounding vicinity were filled to capacity with people swimming, boating, tubing, picnicking, and sunbathing, enjoying the newly constructed white-water rapids. On occasion, the dam and chute were so cluttered with people that the structure could not be seen because of the mass of bodies upon it. An attempt was made to visit the site during early morning hours, but the sun angle and lighting disqualified the photos. Most of the original photographs were taken during the height of the day or in early evening, which meant I had to find a way to work around all the people and boats. Overcast, drizzly days tended to be the best.

CHAPTER 5

RESULTS

Data collected in the field support an environmental analysis of the landscape change of Rio Vista Dam. The twenty-nine field photographs taken matched the originals, with major changes noted that occurred after reconstruction of the dam. The arrangement of the photo pairs places the historic photograph first and the repeat photograph second. Occasionally, an intermediary photograph is also used to emphasize changes over a short period of time. The sets of images are grouped together by commonality of camera location. Finally, the arrangement of the overall results guide the discussion of the changes found on the opposing banks of the river and within the river itself. Illustrations 3 through 63 present the photo pairs arranged by groups.

GPS data provided geographic coordinates of the camera location, elevation, and the viewing direction of each photograph (Table 3). The generation of a GIS map from the coordinates that was not sufficient to conduct the detailed analysis needed because the background orthoimage resolution was too distorted. Points were plotted on a large-scale map to illustrate the original camera position, with arrows showing the viewing direction (Figure 2). The reconstruction project preliminary sketch composed by REP formed the base map, with added information inserted using Adobe Photoshop.

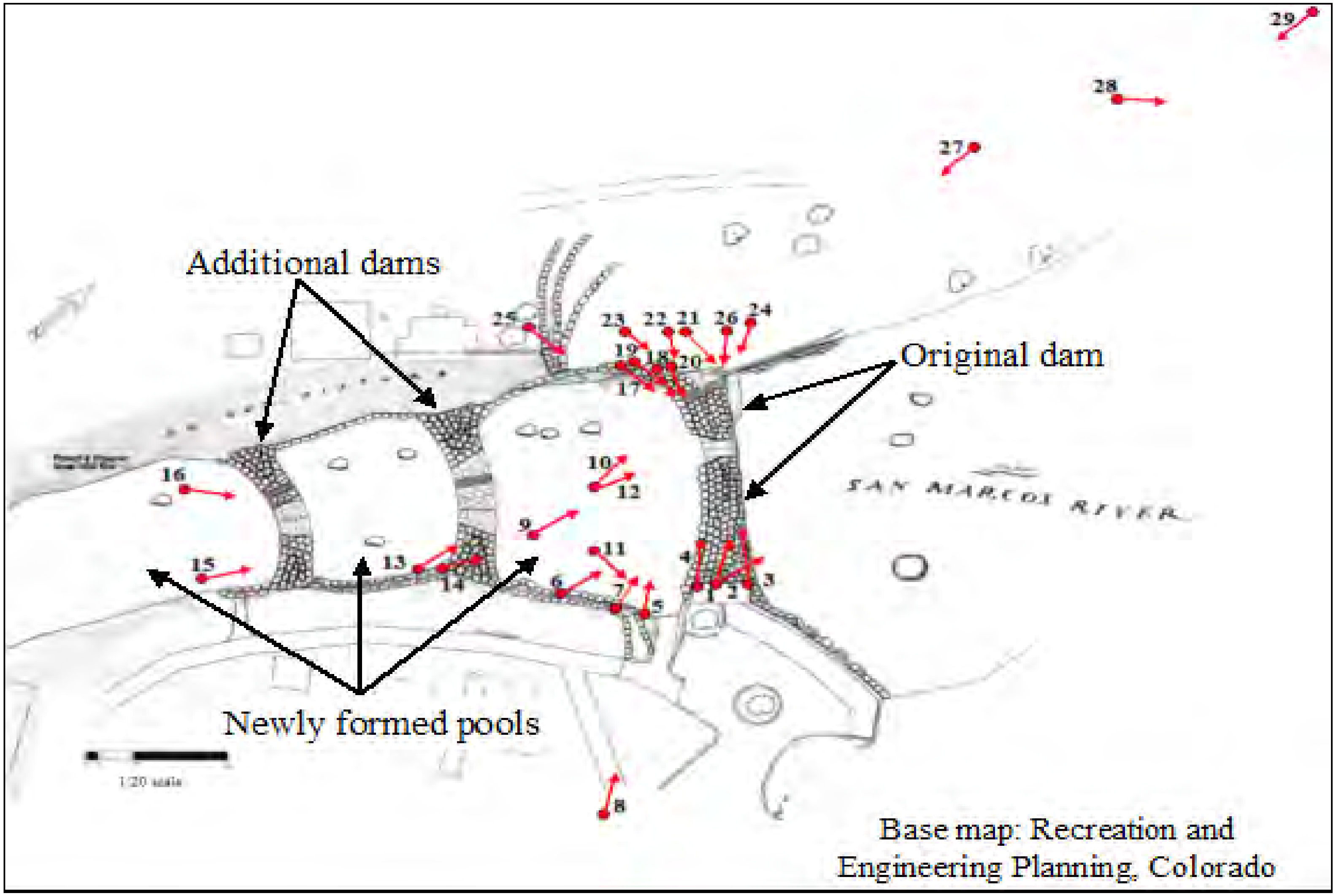

Figure 2. Point Source Data of Photographs. Source: Base map by REP with additional renderings by author, 2007.

GROUP A

Photographs from Left Bank Platform

Illustration 3. Site 1: Dam and Mural, March 2006. Source: author.

Illustration 4. Site 1: Dam without Mural, June 2006. Source: author.

Illustration 5. Site 1: Dam without Mural, February 2007. Source: author.

Illustration 6. Site 2: Cypress Trees and Mural, March 2006. Source: author.

Illustration 7. Site 2: Cypress Trees without Mural, June 2006. Source: author.

Illustration 8. Site 2: Cypress Trees without Mural, March 2007. Source: author.

Illustration 9. Site 3: View over Dam with Mural, March 2000. Source: Jack Fairchild.

Illustration 10. Site 3: View over Dam without Mural, March 2007. Source: author.

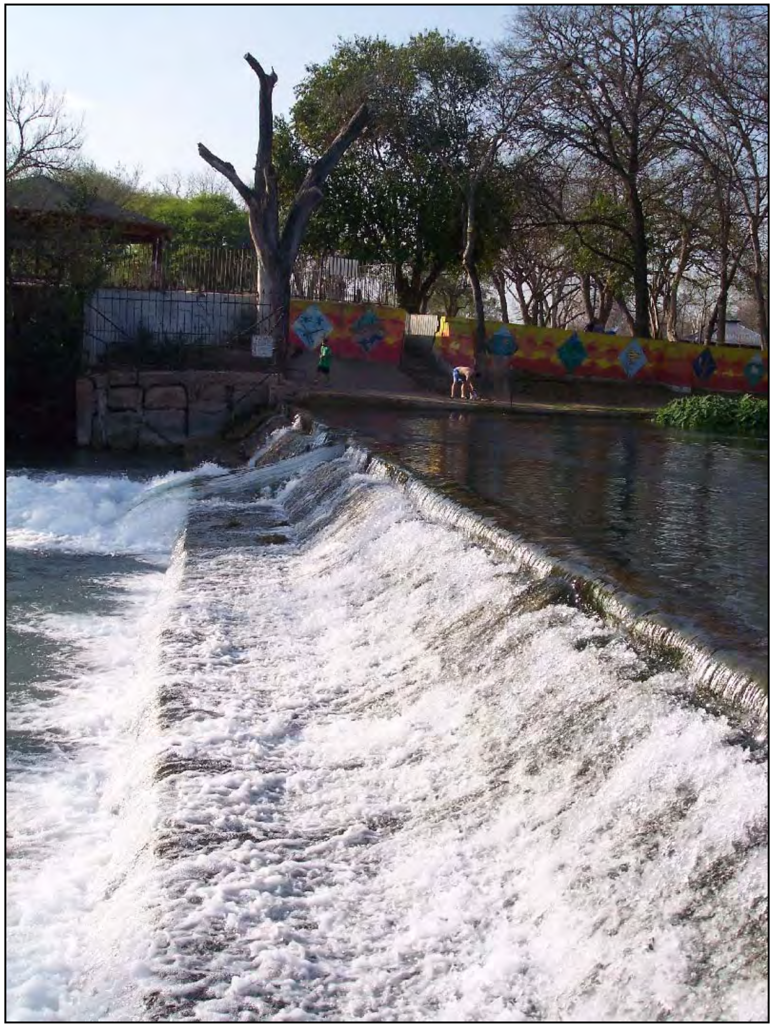

Illustration 11. Site 4: Vertical of Dam, March 2006.
Source: author.

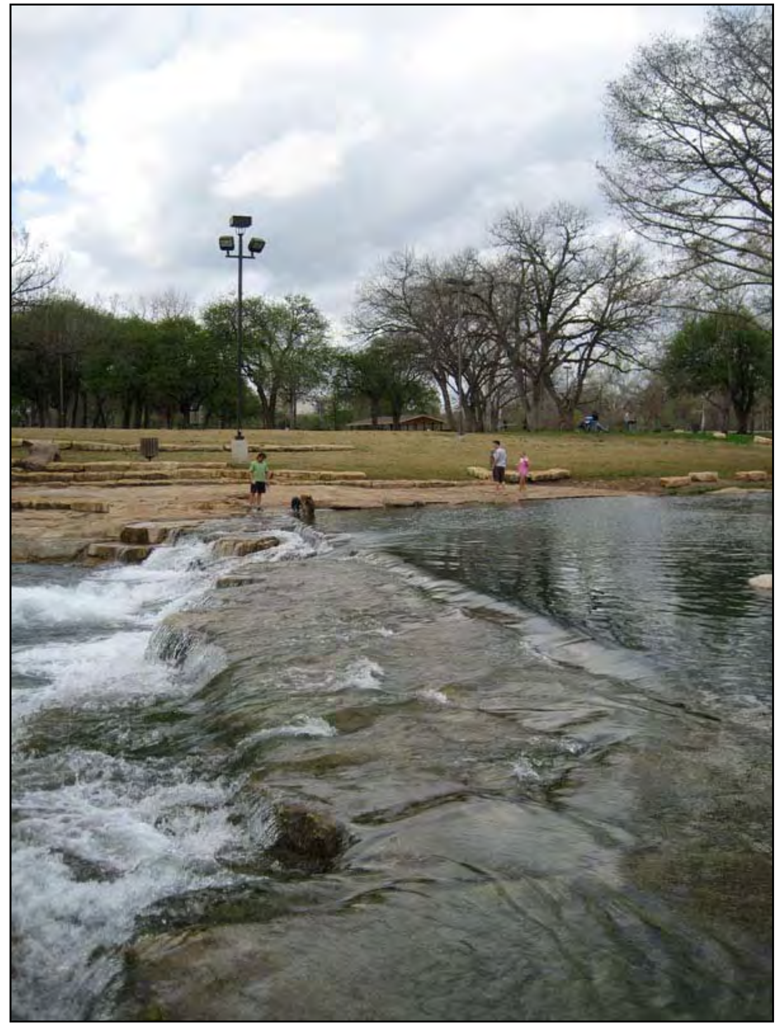

Illustration 12. Site 4: Vertical of Dam, March 2007.
Source: author.

GROUP B

Photographs from Left Bank at Dam

Illustration 13. Site 5. Cummings House with Dam, October 1971. Source: Ernest Cummings.

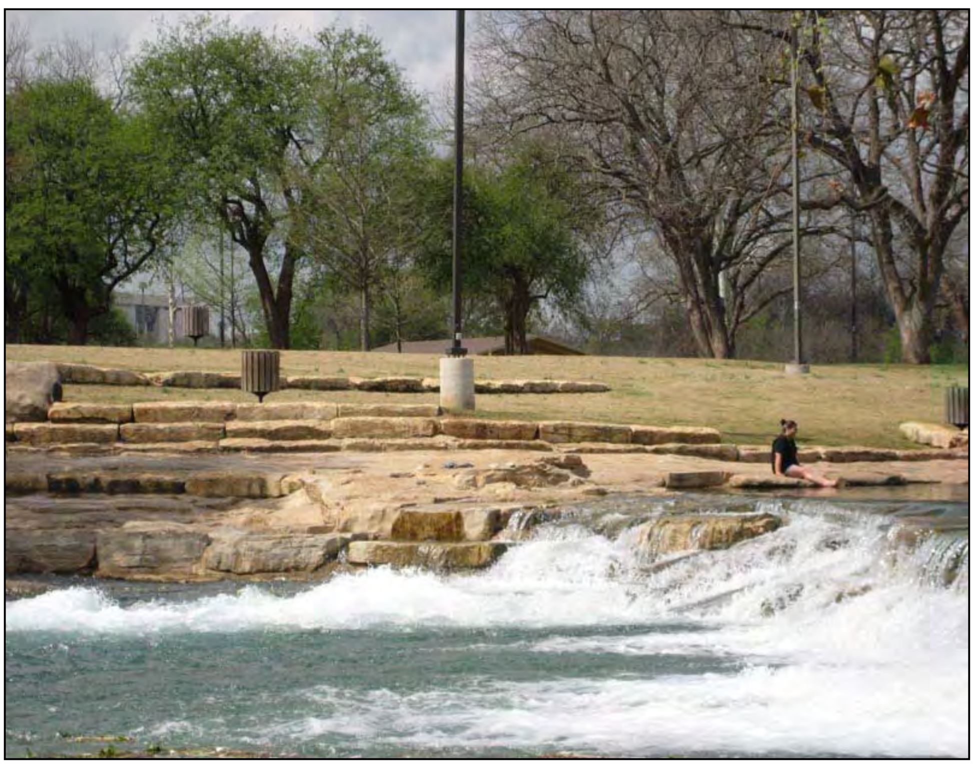

Illustration 14. Site 5: Site of Cummings House with Dam, March 2007. Source: author.

Illustration 15. Site 6: Dam from Left Bank with Mural, February 2000. Source: Jack Fairchild.

Illustration 16. Site 6: Dam from Left Bank without Mural, March 2007. Source: author.

Illustration 17. Site 7: Dam with Cummings House, August 1970. Source: Jack Fairchild.

Illustration 18. Site 7: Dam without Cummings House, February 2007. Source: author.

Illustration 19. Site 8: Rio Vista Dam Before Construction, March 2006. Source: Melissa Millecam.

Illustration 20. Site 8: Rio Vista Dam During Construction, April 2006. Source: Melissa Millecam.

Illustration 21. Site 8: Rio Vista Dam After Construction, March 2007. Source: author.

GROUP C

Photographs below Dam from the Water

Illustration 22. Site 9: Dam from Below the Falls with Mural, March 2006. Source: author.

Illustration 23. Site 9: Dam from Below the Falls without Mural, March 2007. Source: author.

Illustration 24. Site 10: Close-up of Break in Dam, March 2006. Source: author.

Illustration 25. Site 10: Close-up of Repaired Break in Dam, March 2007. Source: author.

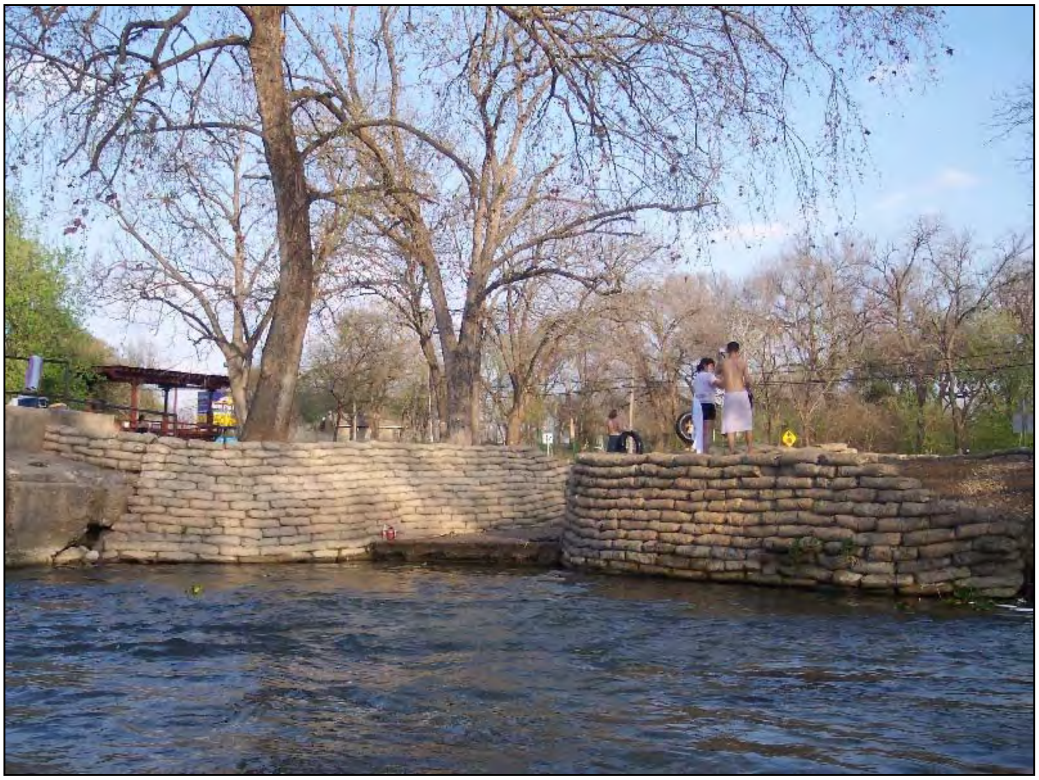

Illustration 26. Site 11: Sandbag Retention Wall, March 2006. Source: author.

Illustration 27. Site 11: Limestone Retention Wall, June 2006. Source: author.

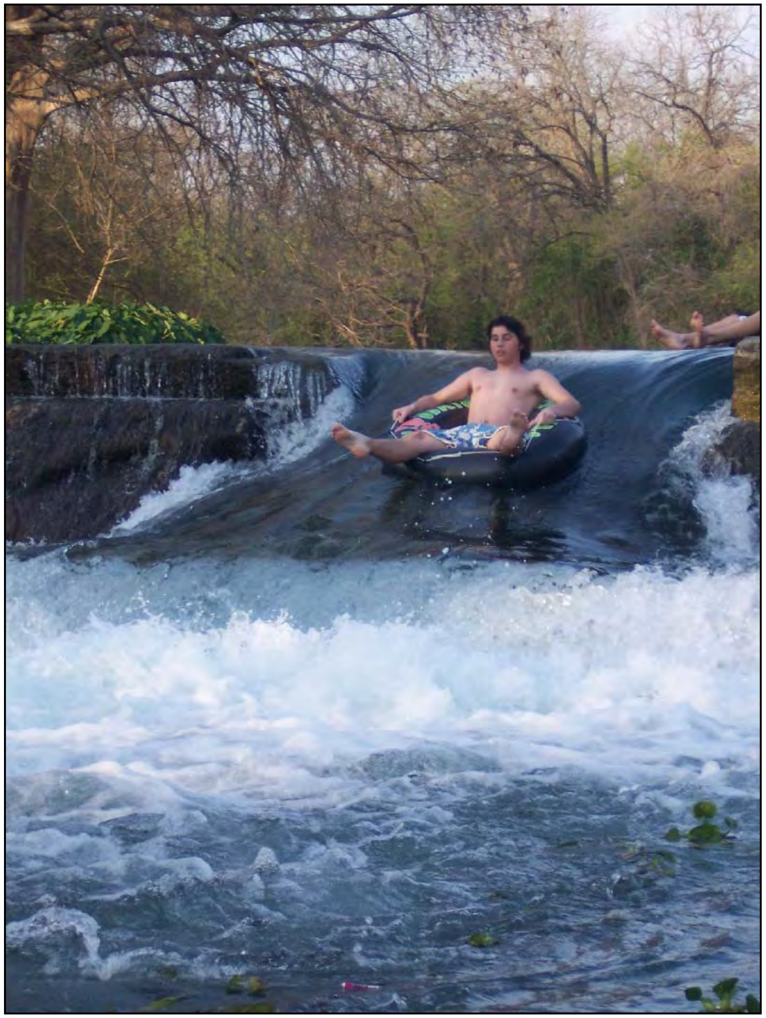

Illustration 28. Site 12: Rio Vista Chute, March 2006.
Source: author.

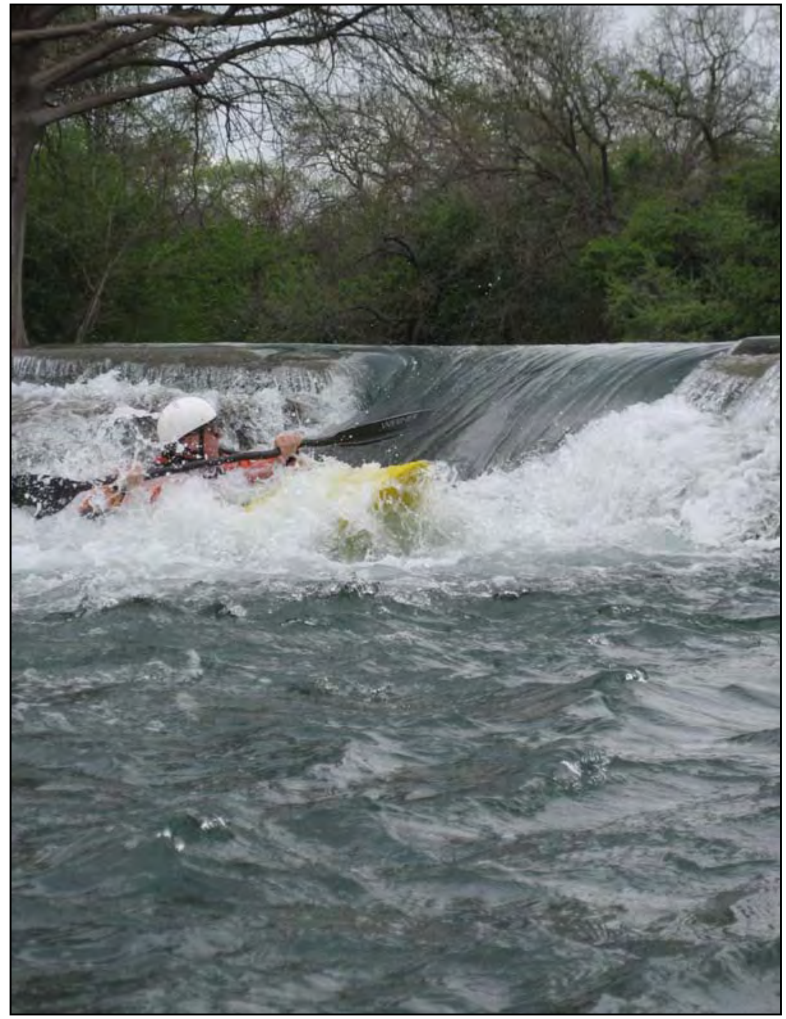

Illustration 29. Site 12: Rio Vista Chute, March 2007.
Source: author.

GROUP D

Photographs from Downstream

Illustration 30. Site 13: Rio Vista Dam and the River Pub, October 1996. Source: Jack Fairchild.

Illustration 31. Site 13: Rio Vista Dam and the River Pub, March 2007. Source: author.

Illustration 32. Site 14: Irrigation Dam Picture Postcard, circa 1907. Source: San Marcos Public Library.

Illustration 33. Site 14: Irrigation Dam, June 2006. Source: author.

Illustration 34. Site 15: Rio Vista Dam from Downstream, March 2006. Source: author.

Illustration 35. Site 15: Rio Vista Dam from Downstream, March 2007. Source: author.

Illustration 36. Site 16: River Pub with Dam, March 2006. Source: author.

Illustration 37. Site 16: River Pub with Dam, March 2007. Source: author.

GROUP E

Photographs from Right Bank at Dam

Illustration 38. Site 17: Woman on Dam, June 1917. Source: Jack Fairchild.

Illustration 39. Site 17: Woman on Dam, March 2007. Source: author.

Illustration 40. Site 18: Dam in July 1930. Source: Jack Fairchild.

Illustration 41. Site 18: Dam in March 2007. Source: author.

Illustration 42. Site 19: Dam with Low Flow, May 1937. Source: Jack Fairchild.

Illustration 43. Site 19: Dam with High Flow, March 2007. Source: author.

Illustration 44. Site 20: Bathers at Dam, July 1948. Source: Ernest Cummings.

Illustration 45. Site 20: Bathers at Dam, March 2007. Source: author.

Illustration 46. Site 21: Left Bank of Rio Vista Dam, May 1950. Source: Ernest Cummings.

Illustration 47. Site 21: Left Bank of Rio Vista Dam, March 2007. Source: author.

Illustration 48. Site 22: Rio Vista Dam from the Porch, April 1953. Source: Ernest Cummings.

Illustration 49. Site 22: Rio Vista Dam from the Ladder, March 2007. Source: author.

Illustration 50. Site 23: Canoes on the Dam, July 1972. Source: Ernest Cummings.

Illustration 51. Site 23: Tosca on the Dam, March 2007. Source: author.

Illustration 52. Site 24: Overview of Dam from Right Bank, September 1979.
Source: Ernest Cummings.

Illustration 53. Site 24: Overview of Dam from Right Bank, February 2007.
Source: author.

Illustration 54. Site 25: Left Bank from Downstream, April 1950. Source: Ernest Cummings.

Illustration 55. Site 25: Left Bank from Downstream, March 2007. Source: author.

Illustration 56. Site 26: Rio Vista Dam with Kayakers, September 1979. Source: Ernest Cummings.

Illustration 57. Site 26: Rio Vista Dam without Kayakers, March 2007. Source: author.

GROUP F

Photographs from Upstream

Illustration 58. Site 27: Picnic at Rio Vista Dam, July 1950. Source: Ernest Cummings.

Illustration 59. Site 27: Picnic at Rio Vista Dam, February 2007. Source: author.

Illustration 60. Site 28: Rio Vista Park, July 1950. Source: Ernest Cummings.

Illustration 61. Site 28: Rio Vista Park, February 2007. Source: author.

Illustration 62. Site 29: Rio Vista Park Picture Postcard, circa 1940's. Source: Ernest Cummings.

Illustration 63. Site 29: Rio Vista Park, March 2007. Source: author.

Table 3. GPS Data of Camera Positions. Source: fieldwork by author, 2006-2007.

Site	Longitude	Latitude	Elevation	Direction
1	-97.932460	29.878531	169 meters	NNW
2	-97.932460	29.878531	169 meters	NNW
3	-97.932441	29.878543	169 meters	NW
4	-97.932473	29.878517	169 meters	NNW
5	-97.932515	29.878481	169 meters	NNW
6	-97.032536	29.878473	169 meters	NNE
7	-97.932530	29.878478	169 meters	NNW
8	-97.932367	29.878280	169 meters	NNW
9	-97.932613	29.878472	169 meters	NNE
10	-97.932687	29.878572	169 meters	NNE
11	-97.932647	29.878494	169 meters	SE
12	-97.932687	29.878572	169 meters	NE
13	-97.932768	29.878368	169 meters	NNE
14	-97.932748	29.878333	169 meters	NNE
15	-97.932904	29.878229	169 meters	NE
16	-97.933046	29.878269	169 meters	ENE
17	-97.932779	29.878693	169 meters	SE
18	-97.932722	29.878722	169 meters	E
19	-97.932765	29.878710	169 meters	SE
20	-97.932764	29.878726	169 meters	SE
21	-97.932777	29.878746	169 meters	E
22	-97.932789	29.878732	171 meters	SSE
23	-97.932783	29.878717	171 meters	SE
24	-97.932742	29.878783	171 meters	S
25	-97.932843	29.878698	169 meters	E
26	-97.932755	29.878748	171 meters	SSE
27	-97.932697	29.878847	169 meters	S
28	-97.932914	29.879669	170 meters	E
29	-97.933107	29.880456	171 meters	S

CHAPTER 6

DISCUSSION AND CONCLUSIONS

The purpose of this research was to analyze landscape change at Rio Vista Dam after reconstruction in the spring of 2006. The study site represents an environmentally sensitive riverine system in an urbanized area. Increasing urbanization of the Upper San Marcos River watershed can cause severe damage to the river by tapping the aquifer for water-use, and by the increased flooding and erosion resulting from housing developments. The remodeling of the dam, shores, and river channel permanently altered the physical and fluvial dynamics of the river and its riparian corridor.

This research contributes to theories of anthropogenic landscape change by analyzing a large-scale area over a period of time. By observing the alterations of the dam and its surroundings at a close range with a hand-held camera, the environmental changes are noticeably apparent. The stark differences between the photo pairs showing loss of trees, shrubs, buildings, open pastures, and concrete embankments illustrate the effects man has had on the San Marcos River. Remote sensing and aerial photography methodologies can describe landscape change over a wider scale, but are not able to measure the detail that is important in ascertaining the human impact on the river.

The major difference noted at Rio Vista Dam was the change from a deteriorated dam to an improved structure with a downstream step-pool system. The area was transformed to large falls with sequentially smaller downstream falls 30.5m apart and pools in between. Limestone jetties emanating from the banks form the pools, leaving an open space that allows water to flow through and eddies to swirl behind the barriers. The study site is no longer just a river and a dam with a chute, but has become a whitewater park complete with rapids, swift currents, and swimming areas. The dam and its surrounding riverine playground have been renamed “Rio Vista Falls” in accordance to the newly improved area.

Table 4 depicts a categorization of significant changes found when comparing the before and after photographs. Vegetation, structural, fluvial, and bank changes were the most notable differences between the images. Some of the sites fall into both categories because vegetation had increased in the background but decreased in the foreground, or old structures had been removed but then replaced by different structures. Figure 3 summarizes the findings of Table 4, illustrating changes that occurred more frequently from the analysis of the repeat photographs. Figure 4 illustrates the percentage of sites that depict a specific change as tabulated in Table 4.

Table 4. Categorization of Significant Changes between Repeat Photographs.

Site	Increased Vegetation	Decreased Vegetation	Structure Addition	Structure Removal	Bank Stabilization	Improved Ingress/Egress	Fluvial Changes
1		✔	✔	✔	✔	✔	✔
2		✔		✔	✔	✔	
3		✔	✔	✔	✔	✔	✔
4		✔	✔	✔	✔	✔	✔
5		✔	✔	✔	✔	✔	✔
6		✔		✔	✔	✔	✔
7		✔	✔	✔	✔	✔	✔
8		✔	✔	✔	✔	✔	
9		✔	✔	✔	✔		✔
10		✔		✔	✔		✔
11				✔	✔	✔	
12		✔					✔
13		✔	✔	✔	✔	✔	✔
14	✔		✔	✔	✔	✔	✔
15		✔	✔		✔	✔	✔
16			✔				✔
17	✔	✔	✔			✔	✔
18	✔		✔		✔	✔	✔
19	✔		✔		✔	✔	✔
20	✔		✔				✔
21		✔	✔	✔	✔		✔
22			✔	✔			✔
23			✔	✔	✔		✔
24		✔	✔	✔	✔	✔	✔
25	✔	✔	✔		✔	✔	✔
26		✔	✔		✔	✔	
27		✔	✔	✔	✔	✔	
28	✔			✔			
29	✔			✔			

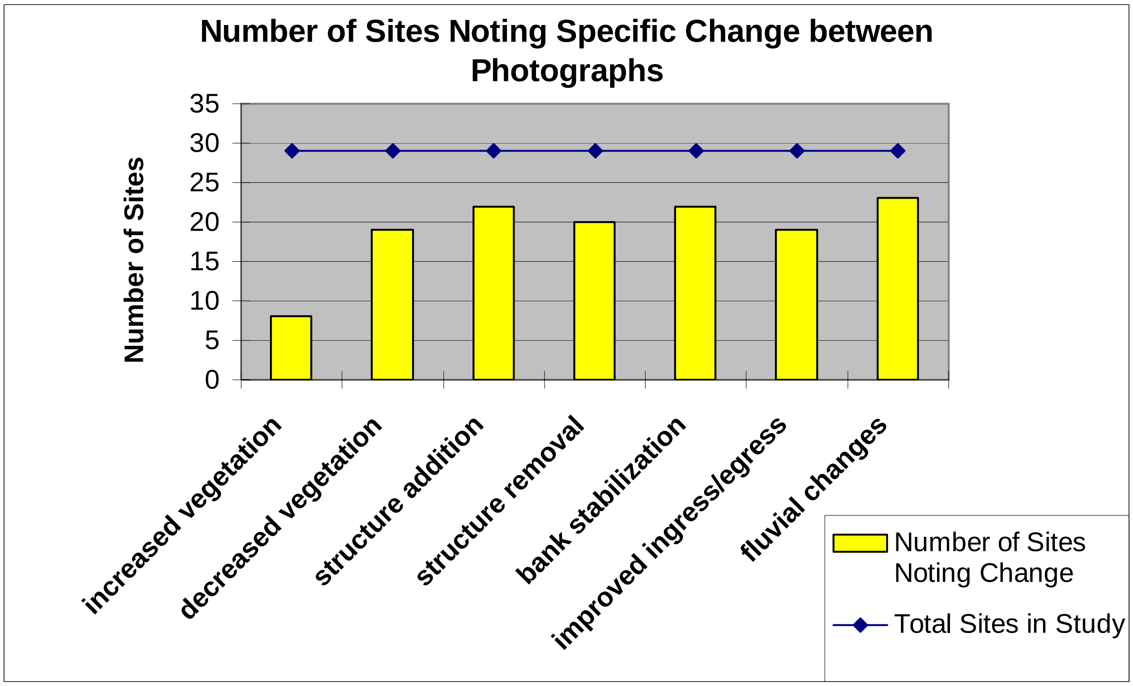

Figure 3. Number of Sites Noting Specific Change between Repeat Photographs.

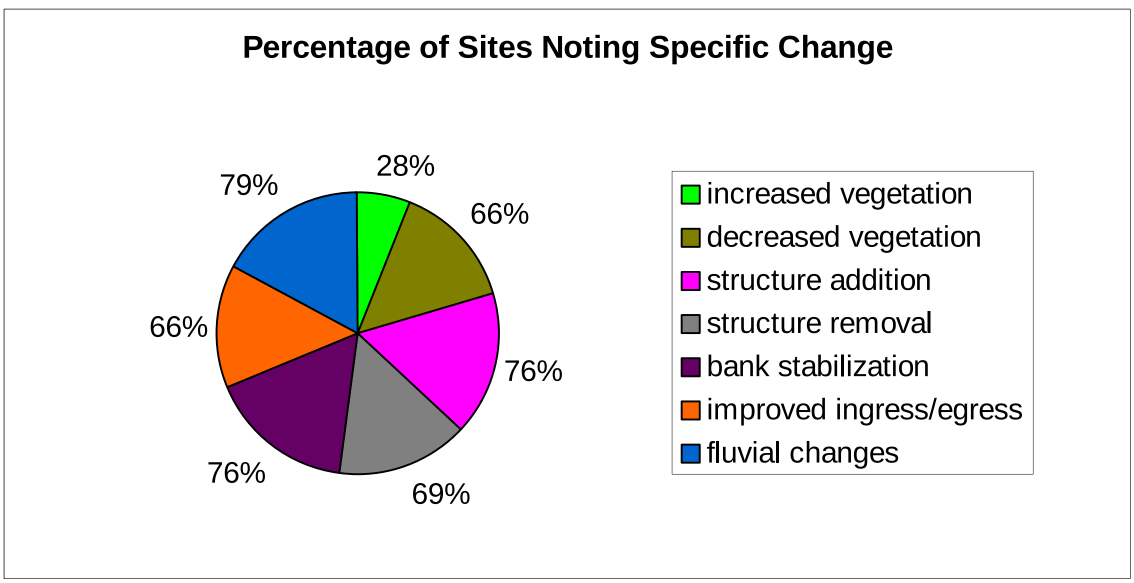

Figure 4. Percentage of Sites Noting Specific Change from Repeat Photography Analysis.

River and River Channel Changes

The major and unavoidable reason for all the change on this portion of the San Marcos River was the reconstruction of the old, decaying Rio Vista Dam. The one hundred year-old dam fell into a poor state of disrepair, where the foundation of the dam and right embankment were in danger of collapse. After the concrete dam was reinforced and stabilized, the creation of whitewater rapids altered the river and the surrounding habitat. The dam itself is sturdier, with a broader surface and terraced face that allows people to climb and sit on the limestone rocks. Almost every grouping of photo pairs, with the exception of Group F, illustrates the riverine change from the reconstruction of the area.

The right bank of the San Marcos River underwent severe reconstruction during the project. The repeat photographs from Groups A, B, and Site 9 from Group C clearly illustrate the landscape changes on the right side of the river. The first major difference noted was the removal of the colorful, cement retention wall, as seen at sites in Group A, Site 6, and Sites 8-10. The wall was replaced by a graded, grassy riverbank and terraced limestone ridges, redesigned to reduce erosion and give the area a more natural setting, exemplified clearly at Site 3. The old concrete wall was deteriorating and shifting, causing possibly dangerous situations and the feeling of disrepair of the park. Sites 1, 4, and 5 illustrate the gentle gradient of the right bank that was designed to retard erosion, as compared to the steep bank that was present before the reconstruction.

The high right bank that once housed the summer cabins and then the homestead of the Cummings was excavated and reshaped with the removal of the retention wall, iron fencing, dead pecan tree, and pavilions, as illustrated in photos from Group A and Site 9.

To accommodate the redesigning of the bank for a natural look, Sites 1, 3-5, 7, and 8 depict limestone materials that were used in the project along the river's edge and terraces. The added limestone terraces on the right bank also help alleviate erosional effects by providing a sculpted pathway down to the river and a seating area, thereby minimizing the impact of trampling and wallowing by mammals. The reconstructed bank is more stable, resistant to erosion and slumping, and aesthetically pleasing than it was before.

As opposed to the stark differences found on the right bank, the left bank of the San Marcos River primarily received river's edge structural improvements. The comparison of repeat photographs at Sites 8, 11, 13-15, 24, and 26 illustrates the bank changes along the river. Sites 13-15 show how the left bank was extended further in the river than it was before, reinforced and terraced with limestone boulders to help retard erosion on the narrow strip of land between the San Marcos River and Cheatham Street. The limestone terraces also provide a safer environment, with flatter and wider surfaces as compared to the eroded, craggy banks that existed before the reconstruction.

One of the major benefits of the Rio Vista Dam reconstruction on the left bank of the river was the improved ingress and egress points for people and boaters to access the water. The large rocks provide easy access to the river at Site 15 and help control erosion caused by people, dogs, and boats going in and out of the water. Illustration 26 shows the old sandbag retention wall and hazardous boat ramp that existed before the area was remodeled. The new, improved access point in Illustration 27 displays the restructured bank lined with limestone. The exit from the water is safer and more gradual than before, making the bank more stable in a natural setting. The comparison of repeat photos at

Sites 8, 11, 14, 15, 24, and 26 depicts the ingress and egress points for canoes and kayaks which are more specific along the bank, with low-impact areas for the boaters to enter and exit the water. Erosion is decreased with the better access points all along the bank and limestone rocks acting as stabilization control.

Overall, the riverine area above the dam underwent minor changes from the reconstruction, with the right bank receiving a greater impact than the left bank. As seen in the photographs from Group A and Site 6, the right shoreline edge of reinforced limestone rock stabilized the bank. The improved ingress and egress points on that bank allow ease of access for people and boats entering and exiting the river above the dam. The comparison of the repeat photos from Group A and Site 6 also show the changes made to the parkland above the dam after the removal of the retention wall.

The changes above the dam on the left shore cannot be attributed to the reconstruction, but are interesting to note. The repeat images at Sites 17-21 and 24-26 illustrate the left bank improvement made over time at the ingress and egress point immediately above the dam. The original photos of the aforementioned sites show the embankment had been slightly modified from a natural to a concrete bank. The repeat photographs of the same sites after reconstruction depict the addition of a metal staircase for ease of exiting the water and a concrete slab landing. The addition of large granite boulders can also be seen in the water above the dam at Sites 17-22 and 24-25. The placement of the boulders changed the fluvial dynamics of the river, shifting the currents to different parts of the river.

The repeat photographs of Sites 1, 3-5, 7, 18-20, and 22-26 particularly demonstrate the structural, functional, and aesthetic modifications of the dam. The fluvial changes at the dam are also apparent when analyzing the above mentioned repeat photos, with the abrupt drop altered to a more gradual drop over the dam. The terraced limestone boulders that create the new dam provide a safer environment for recreational activities and a more natural-looking waterfall. The functional improvements are well illustrated when analyzing the repeat photograph at Site 1, showing the amount of people that can now play and relax on the dam during low streamflows. The structural improvements from the remodeling of the break in the dam can be seen at Sites 9 and 10, with the damaged abutment replaced with limestone boulders.

The area downstream of Rio Vista Falls depicts the greatest impact from the reconstruction of the dam. The repeat photographs of Sites 15 and 16 illustrate how the area was converted into a whitewater playground, complete with three drops and two pools. The limestone jetties between the pools are one of the major additions to the new riverine area, attracting people to relax on the rocks and enjoy the river. The two pools offer a variety of depths that can accommodate both small children and adults. Less vigorous falls connect the pools, offering a place for novice kayakers to practice. The creation and enhancement of the lower portion of the river below the dam relieves the heavy impact that just one rapid has caused on the riparian environment. Although the generation of more accessibility to the river for the public increases the area of impact, the effects are not as great as if everyone were concentrated in one area.

A major downstream change that is not so apparent from the photographs is the reshaped riverbed resulting from the creation of the whitewater rapids. The repeat photographs of Group C were composed at approximate locations of the original image due to the increased depth of the water and shifted currents. The riverbed was scoured and is now considerably lower than before the reconstruction. These photo pairs illustrate the changes in the fluvial dynamics of the river by comparing the shift in the water current and eddies between the before and after photographs. The original camera locations for Sites 10 and 12 were in an eddy where the water was calmer and not as deep. The eddy has shifted to the left as a result of the current being altered by the remodeling of the dam and addition of boulders in the first pool.

The analysis of the repeat photographs of the Rio Vista Dam clearly show the river and river channel changes that resulted from the reconstruction of the area. Seventy-nine percent of the repeat images illustrate fluvial changes that were evident from this study, followed closely by 76% of the photographs depicting bank stabilization. Improved ingress and egress points also increased after the reconstruction, with 66% of the sites showing the change.

Vegetation Changes

The vegetation on the banks of the San Marcos River underwent much change over the temporal distribution of the photographs in this research. The analysis of the repeat images from Groups A, B, and F, along with Sites 9, 12, 13, 15, and 25, all demonstrate the decrease in vegetation that occurred on the right bank. Sites 1-4 clearly show the pecan, oak, and anacua trees that were removed during reconstruction, allowing space for the heavy machinery to maneuver during the project and for bank restructuring. The loss of trees could have had a significant effect on the stability of the right bank, but young native trees were planted along the pathways to replace the trees that had been unearthed. The original photographs of Group A and at Sites 5 and 7 also illustrate the fate of the large pecan tree that once dominated the right bank at the dam, from providing abundant shade to becoming a skeletal remain. The repeat photographs of these sites show the dead pecan tree was removed and replaced with a tall light fixture.

Sites 1-4, 5, and 7 portray the revegetation of the right bank parkland with drought-tolerant Bermuda grass (*Cynodon dactylon*) that can withstand heavy-impact and grows well in full sun. The chances of increased erosional deposits into the river from the relatively freshly planted grounds are higher during the first year of establishment, therefore extra care was taken to protect the grass sod and newly planted trees by fencing off the area, as seen in Illustrations 4 and 7. The analysis of the repeat photos at Sites 1 and 3-5 shows that the grass has firmly established, preventing heavy runoff and erosion by providing a protected covering for the soil. The removal of the invasive elephant ear growing in front of the two cypress trees at Sites 1-4, 6, 8-10, and 12 signifies an added benefit from the reconstruction of the dam, allowing native aquatic vegetation a chance to re-establish along the river.

The left side of the river portrays a different picture when analyzing the vegetation changes in the repeat photographs. Although many shrubs, cedar elms, and small pecan trees were removed in preparation for the project, the after images of Sites 24 and 26 depict enlarged, tree-covered parkland that can accommodate more people than before. The left bank parkland underwent heavy construction when two large pipes were installed to divert the San Marcos River before the dam could be remodeled. The land is slowly recovering from this impact, as seen in Illustrations 53 and 57 by the lack of grass and groundcover nine months after the reconstruction. The left bank and adjacent parkland are comprised of dirt and rocks, causing the area to be muddy, slippery, and highly erodible despite the structural improvements to the riverbanks.

An interesting observation from the temporal analysis of the repeat photographs is the increase in distant vegetation on the left side of the river, depicted at Sites 17-20. Illustration 38 from 1917 shows a few trees in the background, with the vegetation becoming more abundant by 1930 in Illustration 40, and even more so by 1948 in Illustration 44. Comparing the earlier photographs with the repeat images at these sites, the background vegetation cover is denser, even with the trees not foliated in the current pictures. In contrast though, Sites 21 and 25 portray the foreground vegetation has decreased over time, with the removal of the elephant ear from the water and the grassy bank transformed.

Vegetation changes above the dam are evident from the analysis of the repeat photos from Groups A and F, and at Sites 6, 9, 12-14, 17-21, and 24-26. The Group A and Sites 6, 9, 12, and 13 paired images demonstrate the changes that occurred with reconstruction of the dam, emphasizing the large, open, grassy parkland that was created with the removal of the trees. The repeat images of Sites 17-21 and 24-26 also show temporal vegetation changes in the area, but not as a result from the reconstruction project. Here, the vegetation has fluctuated because of the anthropogenic effects of development by deliberate planting or removal of trees and grasses.

Comparison of the repeat images from Sites 27-29 further upstream from the dam illustrate how much the vegetation in the riparian areas has changed over time. The cypress tree along the bank at Site 27 is small in the historic photograph from 1950, with the top of the tree almost visible in the image. By 2007, the cypress tree has grown out of the viewing frame and increased in thickness. The absence of the large, shady pecan trees is also evident in the repeat photo of Site 27, with grassy parkland replacing the missing trees. The paired photographs of Site 28 illustrate the increased density of pecan and cypress trees that have populated both banks of the river over fifty-seven years. Site 29 also offers an example of vegetation change as evidenced by the increased amount of trees in the repeat photograph.

The vegetation changes below the dam are evident when comparing the paired images at Sites 14, 15, and 24-26. The increased vegetation at Site 14 is clearly noticeable over the 100-year time span, with the cypress tree in the foreground overshadowing half of the picture. The vegetation changes are apparent when comparing the two photographs, with the density and height of the trees increasing over time. The background vegetation above the dam in the picture postcard seems inconsequential when compared to the repeat photo where the large trees dominate the scene.

The analysis of the repeat photograph at Site 15 demonstrates the decrease in vegetation below the dam after reconstruction. The trees along the left bank either have been trimmed back or replaced by boulders. The decreased density of the vegetation on the right bank below the dam is also perceptible in the repeat photo at this site. Sites 24 and 26 show the left bank below the dam, with less dense vegetation in the parkland after reconstruction. Vegetation has also decreased at Site 25, with the branches from the tree blocking most of the distant view in the historic image, but absent from the repeat photograph. The repeat photo at Site 6 and the before photo at Site 9 both show evidence of the invasive water hyacinth (*Eichhornia crassipes*) floating on the water, which originates upstream at Spring Lake.

The spatial and temporal analyses of the paired images of Rio Vista Dam depict both an increase and decrease in vegetation depending on the site. Sixty-six percent of the repeat photographs show a decrease in vegetation in the area, whereas only 28% portrayed an increase. While the change in vegetation seems rather prominent from the analysis, the percentage of sites that exemplify river and river channel changes still outweighs the number of sites noting vegetation changes.

Cultural Changes

Interesting cultural geographic observations were revealed when comparing the repeat photographs of the Rio Vista Dam over the time period of 1907-2007. As observed on the right bank at Sites 3, 5, 10, and 27-29, the use of the land adjacent to the dam has been a gathering place for people to relax and enjoy the river. Whether it was staying in cabins during the 1930's, swimming at Rio Vista Park in the 1940's, living in a house overlooking the dam from the 1950's to the 1970's, or playing at the park right above the dam from the 1980's through present day, the area at Rio Vista Dam has been a San Marcos attraction for many generations.

The historic photo at Site 3 shows two pavilions located on the right bank of the river, which were rented for parties or used as covered picnic areas for families enjoying the park. The pavilions were removed during reconstruction, as seen in Illustration 10. Although the repeat photo at Site 10 depicts people still congregating on the right bank of the river on the limestone terraces, the loss of the sheltered areas could hinder families and friends from gathering on this side of the river because the picnic tables and the protection from the sun or rain is no longer available. While the repeat photos from Sites 3, 5, 10, and 27-29 illustrate the area during February and March, accurately analyzing the impact the removed shelters will have on the parkland cannot be performed because not many people use the area during winter.

The cultural significance of the Cummings house, on the right bank of the San Marcos River at Sites 5, 7, and 27, had an impact on many people during the 1950's-1970's. Illustration 58 represents a Fourth of July picnic hosted by the Cummings, showing a community coming together in celebration of Independence Day, complete with white tablecloths, food servers, and plenty of shade for the people gathered by the river. Illustration 60 portrays another get together hosted by the Cummings, located just upstream from the house. Unfortunately, the repeat photographs of these sites were not taken in July, which would have demonstrated that the parkland surrounding the old homestead was still a gathering place for the community to enjoy the summer by the river.

Redefining the facilities and the addition of lights and trashcans enhanced the land-use on the right bank. The analysis of the repeat photos from Groups A and B, and Site 27 show the structural changes in the park and the open areas for public use. The images depict grassy areas for picnics, limestone terraces for seating, and a larger area that can provide people and boats easier access to the river. A compounding issue still remains when analyzing the photographs because of the time of season the repeat photographs were taken. The winter months are not the busiest time of year for people to be outside enjoying the river, but as seen from the photographs at these sites, a few people are relaxing along the banks watching kayakers at the falls.

The cultural landscape changes on the left bank of the river were apparent when comparing the photo pairs at Sites 14, 17-21 and 24-26. As evident when analyzing the images at Sites 17-21, the increased density of trees in the background from 1917 to 2007 indicates a transformation of agricultural lands to commercial and residential developments, with the deliberate planting of trees in the new neighborhoods. The enlargement of Cheatham Street and the increased traffic is shown specifically in Illustrations 24 and 26, although the traffic is not represented as intensely through just one photograph as when reshooting the scene over and over, with cars constantly driving by.

The overgrown left bank in Illustrations 38, 40, 42, 44, 46, and 54 was relatively undisturbed until the early 1990's, when the building that is now the San Marcos River Pub was constructed on the premises. The repeat photos depict that over the years, the owners have enlarged the parking lots, added a small, outdoor music stage, and cleared the waters of the invasive elephant ear to allow easy access to the restaurant. The popularity of the newly constructed whitewater rapids is drawing more people to the area, increasing the customer base and amount of cars at the River Pub.

The areas above Rio Vista Dam have historically been a popular place for people to congregate and enjoy the San Marcos River. As seen at Sites 28 and 29, the parkland above the dam drew many people to the area during the warmer months. The recreational area shown in the picture postcard in Illustration 62, created by A. B. Rogers during the 1930's, has been converted to a more natural setting over time, as seen in the repeat photograph in Illustration 63. The site of the bathhouse is now a concrete slab and the trolley is gone, but the area is still a gathering place for people to play and relax along the river. Again, the time of season that the repeat photograph was taken does not accurately show the popularity of the park during the warmer months, offering a place for families to congregate when the Rio Vista Falls downstream becomes overcrowded.

Another apparent cultural change that occurred above the dam was the addition of the San Marcos River Pub. The analysis of the paired images at Sites 17-21 and 25 illustrate the transition from an overgrown, grassy bank to a busy restaurant and bar. The River Pub is ideally situated, as seen at Site 16, with porches and window views for customers to observe the river and recreational activities at the falls. The added music pavilion provides free summer concerts that increase the human impact on the area. As can be seen in the repeat photographs from the above-mentioned sites, the owners have landscaped the bank and removed a large portion of invasive aquatic plants to ease access for customers arriving by boat.

The cultural changes noted at the dam itself are exemplified by comparing the paired photos at Sites 1, 2, 6, 10, 12, 17, 18, 20, and 23. The increase of people playing and relaxing on the dam after the reconstruction project shows the draw the newly created whitewater area will have during the warmer season, especially in Illustrations 4 and 7. While attempting to recapture the repeat photographs at Sites 1 and 2 during the month following the grand reopening of the area on Memorial Day, many times I could not even see the dam from the eastern bank because the dam was completely covered by people. The repeat images of the same sites, taken a year after the original photos showing the dam before reconstruction, portray the serene quality of the area when the weather does not permit thousands of people to be playing at the river. Illustrations 16, 18, and 25 portray people relaxing, spectating, or playing music on dam while enjoying the scenery and solitude the area offers.

Site 12 represents the main attraction that would bring people to Rio Vista Dam. The chute drew tubers and kayakers from around Central Texas, and was a highlight of the float down the river from City Park where the San Marcos Lion's Club rented tubes and kayaks. After reconstruction of the dam, the chute is still popular with both tubers and kayakers, but with the added two falls and pools below the chute, the area has become a major local and tourist attraction. Although the photos at Site 12 were taken during March, the images reveal that people will play at the chute despite the cool weather. Kayakers were a constant sight at the chute during the cooler season because they could practice without having to avoid all the tubers and people coming down the chute.

The differences noted by analyzing the repeat photographs at Sites 1, 17, 18, and 20 offer insight into how the culture has changes over a wide temporal scale. The woman in Illustration 38 wears the typical bathing attire that was appropriate for 1917, almost completely covered from head to toe. The women standing on the dam in Illustration 44 signify how relaxed the culture had become in thirty years, with the acceptance of bare legs and tight-fitting bathing suits. By 2007, the cultural differences become even more apparent by observing the women in Illustrations 4, 39, 45, and 51. Although some women still tend to wear revealing bathing suits, the women in these photos are choosing to cover up more by wearing t-shirts and shorts.

Another interesting observation of cultural activities on the dam can be seen in Illustration 50. The canoeists are struggling to get their boats over the dam because of the lack of the chute and portage sites available during the time. After the remodeling of the dam and the addition of improved ingress and egress points along the banks, portaging has become easier and the option is now available to just run the chute.

The area below the dam also portrays the cultural change observed by comparing the before and after photographs. Sites 9, 10, 14, 15, and 26 illustrate the use of Rio Vista Falls by sportspeople and tubers. The rapids are much more inviting to those who kayak or canoe, allowing training classes and professionals to practice their maneuvering skills in the whitewaters. The paired images at Sites 9 and 10 clearly depict the increase in use by kayakers, with as many as six to eight in the upper pool at a time. Watching the kayakers practice in the whitewater has become a pastime for people relaxing at the falls. The newly constructed dam allows easy access to the top of the river-run, encouraging tubers, swimmers, and boaters to shoot and surf the rapids all day.

Sites 14 and 15 illustrate how people have been drawn to the river for a variety of reasons. Although the people in Illustration 32 were added to the picture postcard image, it is not hard to imagine that people at the turn of the twentieth century would congregate at the river in their Sunday clothes. Illustration 33 shows that even during early morning hours, people today are still being drawn to the river for relaxation and sport, as evidenced by the bicyclist, kayaker, and the woman reading with coffee on the right side of the photograph. The increased use of the area during the month of March, demonstrated by comparing the photos at Site 15, further describes how the whitewater park has gained popularity and offered a venue for the community to interact.

Although the repeat photographs of these sites showing downstream use were composed during the cooler months, the increase in tubers, boaters, and people to the area is obvious on any given day during the summer, especially notable on the weekends. The increase in people visiting the falls is causing congestion in the river, muddiness of the waters, and trash to accumulate in the river and on the shore.

Future Concerns

The heavy use of Rio Vista Falls by families, kids, adults, boats, and dogs will have a great impact on the conditions of the river. The soil displaced and churned from the activity in the water, added with that eroding from the bank by natural processes and by trampling, will cause increased sediment to collect behind the dam. With the addition of two more "dams" formed by the limestone jetties further downstream, the sediment that used to be transported and deposited downstream will be trapped behind the jetties and could eventually silt in the pools over time. Illustration 64 depicts a sediment bar that has formed over the past year downstream from the whitewater falls. Without sufficient streamflows to wash the sediment downstream, the newly formed sediment bar will alter the channel and flow of the river.

Illustration 64. Sediment Bar Downstream from Rio Vista Falls, November 2006. Source: author.

The limestone terraces along both shores and into the water allow places for families to gather, parents to watch their children enjoy the rapids, and for sunbathers to relax. The major drawback, though, is that many people want to congregate on the left side of the river because of the closeness to the three rapids and the ease of getting in and out of the water. This convenient feature has highly impacted the small parkland on the left shore. With the area opened to the public shortly after reconstruction, the park was not equipped to accommodate the large amount of people that descended upon the river to enjoy the new whitewater rapids.

The increase in the amount of people enjoying the park and river will also generate much more trash than before. The existing number and placement of trashcans on the premises is not sufficient for the large amounts of trash that accumulate on a daily basis. The addition of recycling bins might help lessen the overfilling of the trashcans and encourage people to keep the river clean. The picnic areas do not have an adequate number of charcoal grills, causing people to bring their own and disposing the coals by burying them in the dirt. This presents serious hazard and safety issues with people running about without shoes.

The importance of maintaining a safe dam and recreation area is of economic interest to the city, especially in consideration of the large amounts of people gathering at the new whitewater park during the warmer and summer months. The area at the end of the last pool presents a hazard to people trying to exit the river on the left bank. Illustrations 65 and 66 depict the two diversion pipes and "temporary riprap" that could be dangerous if people climb on them when trying to get out of the water, even though the pipe openings are covered by metal grates. The City of San Marcos and the Parks and

Illustration 65. Temporary Riprap, November 2006. Source: author.

Illustration 66. Diversion Pipes, November 2006. Source: author.

Recreation Department should attempt to redesign the area to make it look more natural and congruent with the expensive remodeling of the area directly above this site.

Conclusions

Through the use of repeat photography techniques, this research offers an improved understanding of the factors affecting landscape change. Specifically, the analysis builds upon previous studies utilizing matched time-lapsed photographs to note how humans have altered their environment and the effects caused by such actions. This research shows the importance of the applicability of repeat photography in not only illustrating landscape change, but also in the powerful simplicity of displaying presentations of the photo pairs and research findings to the public.

The immense impact visual images have on the human psyche can aid in educating the public about sustainable growth and development with respect for the environment. Local civic organizations, municipal city councils and planning departments, and elected county officials respond with interest when presented with a pictorial study on how much their communities have changed over the years, and begin to evaluate other plans of development that will preserve the open space that is quickly disappearing.

The main causes of riparian habitat degradation arise from alterations of rivers by impoundments, diversions, urbanization, recreational or commercial developments, and overcrowding (Jenkins, 1985). Without proper supervision and restraints, the delicate San Marcos River system will feel the impact of overuse and overcrowding from the creation of Rio Vista Falls.

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VITA

Michelle Bussemey was born on January 7, 1968 in Houston, Texas. She graduated from The High School for the Performing and Visual Arts in Houston, Texas, in 1986, majoring in Vocal Performance. Her studies continued at The University of Houston where she completed her Bachelor of Arts in Business Administration with an emphasis in Marketing in 1990. Michelle then worked in the used and remainder book business, utilizing her management and marketing skills on a daily basis. Exhausted of retail after nine years, she became a residential child care counselor working with at-risk boys at a wilderness treatment facility. Here, her conflict management skills, listening capabilities, and personal growth increased, challenging her with a difficult job of helping troubled youth. After a special journey with her father rafting through the Grand Canyon in 2002, a greater interest sparked in physical geography and environmental science, especially in geology and river systems. Michelle decided to follow her lifelong passion to work for the environment, thus entering the Graduate College of Texas State University-San Marcos in January of 2005.

Permanent Address: 2608 Green Leaf

San Marcos, Texas 78666

This Thesis was typed by Michelle Bussemey.