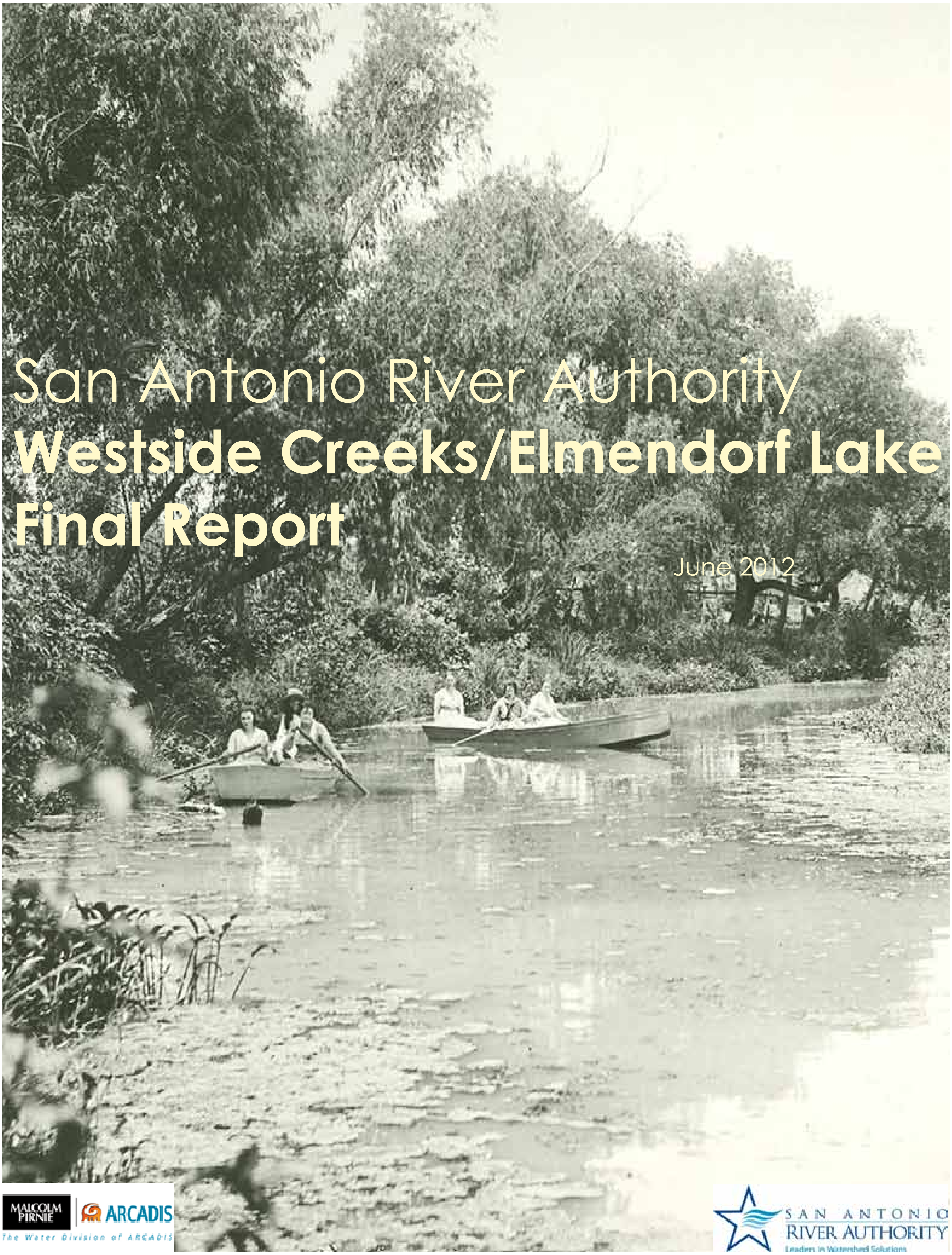

San Antonio River Authority
Westside Creeks/Elmendorf Lake Final Report

June 2012

Malcolm Pirnie | ARCADIS
The Water Division of ARCADIS

San Antonio River Authority
Leaders in Watershed Solutions

Acknowledgements

Malcolm Pirnie/ARCADIS, Terra Design Group and RTKL wish to thank the San Antonio River Authority for the opportunity to work on this extremely important project. We also thank SARA and its partners, Bexar County, the City of San Antonio and Our Lady of the Lake University, for the tremendous amount of assistance and support during the evaluation and planning processes. We greatly appreciate the thorough and timely input provided by each of the organizations during the development of the alternatives, conceptual plans and the final report.

At the risk of overlooking someone, we express our appreciation to Project Manager Rudy Farias and the other professional staff members who greatly assisted the study team by attending the initial visioning workshop and assisting in the development of a Vision for a Great People Place in the Westside.

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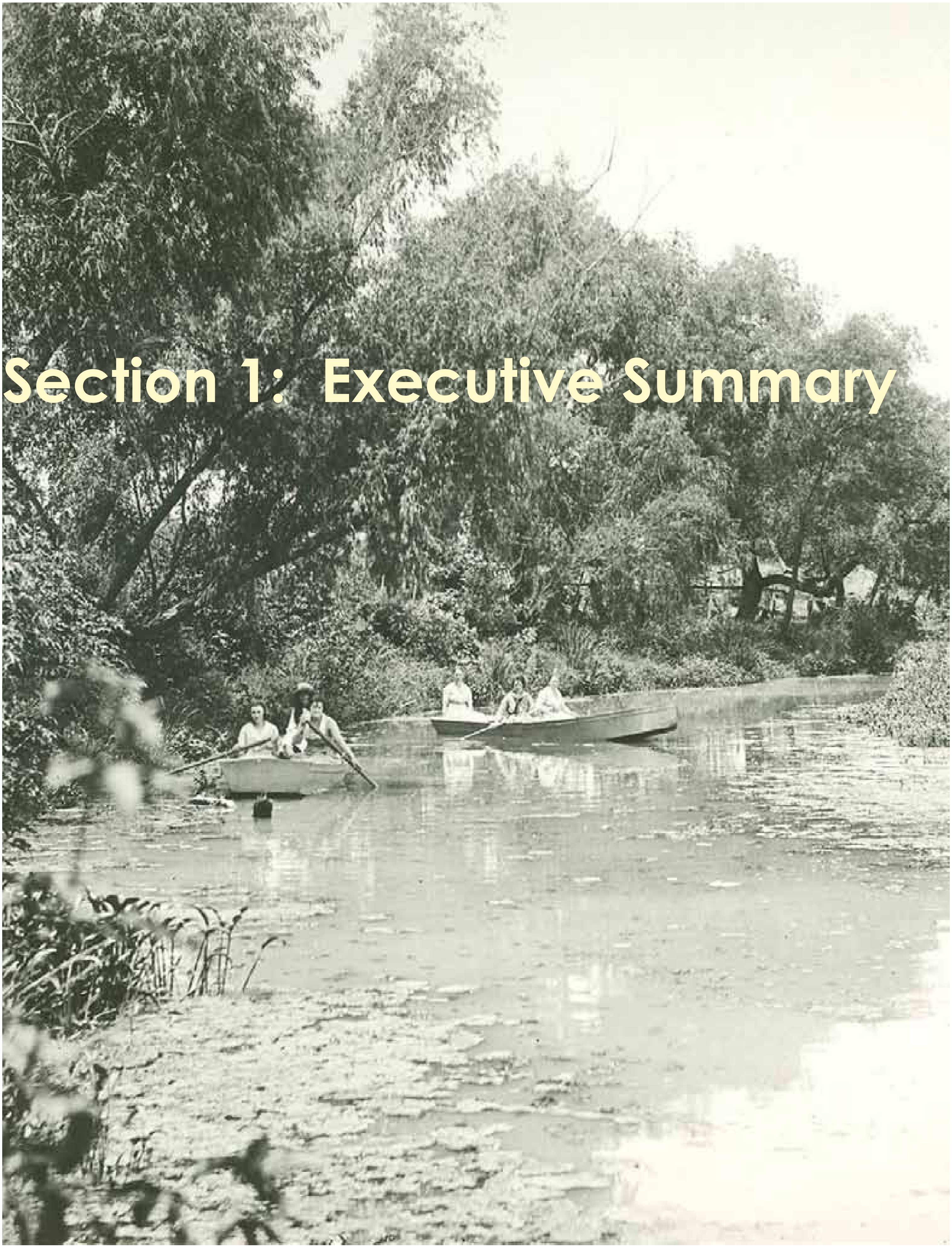
Section 1: Executive Summary



1. Executive Summary

1.1 Introduction
The San Antonio River Authority (SARA) has recently completed the Westside Creeks Restoration Project Conceptual Plan (the "Conceptual Plan") and in June 2011 the Conceptual Plan was adopted by the SARA Board of Directors. One of the first creek segments planned for implementation is Apache Creek Reach No. 1 which lies between North General McMullen Drive and Southwest 19th Street). This reach is essentially the entirety of Elmendorf Lake, including the dam. See Figure 2.1 in the final report.

As SARA and its partners (including Bexar County, the City of San Antonio, and Our Lady of the Lake University) move forward with implementation of the Conceptual Plan, there are a number of additional activities, studies and plans that must be considered. SARA and its partners wish to create a vision within the Elmendorf Lake area that produces a "Great People Place in the Westside" based upon these various studies, as well as additional community input. Therefore, on August 30, 2011 SARA engaged Malcolm Pirnie, the Water Division of ARCADIS-US, to use existing hydrologic and hydraulic (H&H) models, and other tools to review the existing studies, plans and projects in order to:

- Evaluate the flood mitigation benefits of the Dredging Project and channel modification projects proposed in the Conceptual Plan, and determine the potential benefits of projects proposed in the Upper San Antonio River Master Plan;
- Determine opportunities to refine the existing plans to make them more cohesive and integrated;
- Determine opportunities to link the current plans with other facilities and features in the area;
- Verify and validate cost estimates and look for potential savings;
- Perform an cursory evaluation of the Dredging Project to see if there are ways to achieve the same results without dredging portions of Elmendorf Lake or in the alternative, to reduce the costs of the Dredging Project;
- Develop a preliminary conceptual plan for improvements to Elmendorf Lake Park; and
- Produce a set of graphics that accurately and clearly describe the vision for the Elmendorf Lake area.

1.2 Existing Conditions
The history of Elmendorf Lake is linked directly to the history of Our Lady of the Lake University (OLLU) and the local Westside Community. OLLU, a private Catholic university, was founded in 1895. The students and faculty have been using Apache Creek and the lake since that time.

Elmendorf Lake Dam is a labyrinth weir structure constructed in 1974. The total effective length of the weir is 1,700 feet, and the height is approximately 12 feet. The dam does not have a service or emergency spillway. There are a series of outlet pipes through the weir that are controlled by individual manually-operated gate valves.

Although the Conceptual Plan refers primarily to Apache Creek, the upstream end of the lake is actually on Zarzamora Creek. Zarzamora Creek provides most of the drainage area for the lake. Another major tributary to the lake is Bandera Branch. Within the main body of Elmendorf Lake an island runs with the length of the lake generally between 24th Street and the dam.

1.3 H&H Analysis and Flood Mitigation
The most recent comprehensive hydrology study of Apache Creek and its tributaries was completed in 2006 as part of the Upper San Antonio River Flood Insurance Rate Map (FIRM) updates, published by

FEMA. This effective hydrology model was also the basis for the Conceptual Plan and the Upper San Antonio River Watershed Masterplan both published in June 2011.

The study teams analysis of the effective hydrology model consisted of a review of the methodology, duplication of the effective model results, and verification of the effective flows calculated in HEC-HMS using regression equations. The extent of this review was limited to the drainage area from Elmendorf Lake Dam to General McMullen Drive.

HEC-HMS model results show the effective peak 100-year (1%) discharge at the confluence of Apache Creek and Zarzamora Creek is 24,724 cubic feet per second (cfs). The effective peak 100-year discharge immediately downstream of the 24th Street bridge is 25,307 cfs.

During the workshop held on August 31, 2011 with SARA and its partners, the goal with regard to flood mitigation was identified as “100-year flood protection for structures around the lake.” This goal was used to guide the identification and evaluation of alternatives to lower the peak water elevation during major flood events. The following three alternatives were identified and evaluated in some detail during the development of the plan for Elmendorf Lake Park:

- Alternative 1 – Re-grading portions of Rosedale Park and across Zarzamora Creek south to Faust Street for flood storage
- Alternative 2 – Re-grading portions of Rosedale Park along Apache Creek for flood storage
- Alternative 3 – Constructing for flood storage a diversion channel through the existing levee on the north side of Zarzamora Creek

Several other alternatives were considered but not studied in as much detail. These included additional storage upstream of General McMullen Drive and adding additional discharge capacity at Elmendorf Lake Dam. This might be achieved through construction of a side channel spillgate. At SARA’s request, the proposed condition with dredging portions of the lake was modeled to determine whether dredging of the lake provides additional flood protection benefits.

Although the Elmendorf Lake Park improvements were conceptually designed to be compatible with flooding, the Pirnie/ARCADIS team was tasked with the responsibility to also look for viable options to reduce flooding within the constraints of the site and park planning process. Alternative 1 and a flood control gate at Elmendorf Lake Dam provide the greatest reduction in peak water surface elevations during flood events. Further study of the proposed flood control gate at the dam is recommended to evaluate the gate size and operation required to provide the most flood reduction. That study should also investigate the impact of flood flow releases on the area of Apache Creek downstream of the Elmendorf Lake Dam.

1.4 Water Quality Analysis

Apache Creek and Elmendorf Lake are tributaries to the Upper San Antonio River Watershed (Texas Commission on Environmental Quality [TCEQ] Segment 1911). Segment 1911 is designated for contact recreation, although the City of San Antonio (COSA or “San Antonio”) has placed restrictions on swimming within the San Antonio River or its tributaries within the city limits. The segment also has a high aquatic use designation. Elmendorf Lake provides habitat for fish, turtle, and bird species.
Water quality concerns within the study area include low dissolved oxygen, high bacterial loading (i.e., E. coli concentrations), elevated nutrient concentrations, high turbidity and floatable trash and debris following storm events, and periodic unpleasant odors. In previous studies, Lake dredging was identified as a

recommended approach to improve water quality and lake habitat, coupled with implementation of short and long-term storm water BMPs.

Relevant data and studies were reviewed to confirm the primary water quality concerns to be addressed under the Conceptual Plan. The data and analyses are described in detail in Section 5. In summary, the data show several trends:

- Dissolved Oxygen. Average dissolved oxygen concentrations for samples collected between 1983 and 2007 were above the Segment Specific State Standard ("State Standard") at each sampling location. However, minimum dissolved oxygen concentrations measured at two sampling locations were below the State Standard. The measurements were also below concentrations required to support aquatic life.

- Nutrients. Maximum measured concentrations for ammonia, nitrate and total phosphate in samples collected from one or more of the TCEQ locations were above the State nutrient screening criteria. Elevated nutrient concentrations can enhance algae growth in the lake and exacerbate eutrophic conditions, leading to a decrease in dissolved oxygen concentrations.

- Total organic carbon. Total organic carbon (TOC) concentrations ranged from 2 to 25 milligrams per liter (mg/L). Organic matter (measured as TOC) can create an oxygen demand either through chemical or biological reactions. Accumulation of organic matter in the lake sediments can serve as a "sink" for continual consumption of dissolved oxygen within the lake.

- Chlorophyll a. Chlorophyll a data are limited but generally show significant algal activity in the lake. Chlorophyll a is a pigment found in algae; concentrations of the pigment above 10 micrograms per liter (ug/L) can be used as a guideline for algal activity that can create quality issues for contact recreation.

- E.Coli. Mean and peak E. coli concentrations measured at Elmendorf Lake are above the State Standard for contact recreation, and the data show significant bacterial loading to the study area.

Based on a review of available water quality data, sediment data and past studies, the primary water quality concerns for Elmendorf Lake and Segment AP-1 are:
- Dissolved oxygen concentrations below the State Standard during certain seasons and/or rainfall events with impacts to aquatic life;
- E. coli concentrations several orders of magnitude above the State Standard for contact recreation; and
- Sediment accumulation in the lake leading to reports of high turbidity during rain events and exacerbating anoxic conditions.

Additional concerns include nutrient concentrations above the State nutrient screening criteria and TOC concentrations exceeding 10 mg/L, both of which can exacerbate eutrophic conditions. Concentrations of certain synthetic organic compounds in the sediments are above the TCEQ health screening levels, but do not currently present an immediate health concern. Aesthetic concerns include accumulation of trash & debris following rain events and adverse odors, likely due to growth of blue-green algae and/or anoxic conditions in the lake.

SARA and Bexar County have identified lake dredging as one of the potential projects to restore and improve conditions in Elmendorf Lake. Recognizing the high cost and short-term benefit of dredging unless upstream stormwater best management practices (BMPs) are implemented, additional strategies to address water quality concerns were reviewed. Specifically, three technologies to increase dissolved oxygen concentrations in the lake were evaluated:

- Aeration fountains, potentially installed in conjunction with air diffusers
- SolarBee mixers
- Side stream super-saturation
-

Water quality priorities must be carefully considered to select the most cost-effective approach to meet water quality goals for Elmendorf Lake and Apache Creek. Based on evaluation of historical water quality data, one of the most pressing concerns related to lake water quality is seasonal occurrence of low dissolved oxygen concentrations in the lake, which can be detrimental to aquatic life and can reduce overall lake water quality. Dissolved oxygen in the lake could be increased in the short term at a relatively low cost by implementing one of various technologies on the market to add oxygen to the water. The installed system could continue to be used following implementation of stormwater BMPs and lake dredging.

Sustainable stormwater BMPs discussed in Section 6 should be implemented for near-term reduction in trash & debris, nutrients, and TSS loading to the lake. Stormwater BMPS outlined in other SARA reports should also be considered to address additional water quality goals. Over the long term, BMPs should be incorporated to address a comprehensive set of water quality concerns, including:

- Semi-volatile compounds and other synthetic organic compounds from storm water runoff;
- Wise use of herbicides and pesticides in the watershed and especially right around the lake;
- Bacteria and pathogenic microorganisms from pet wastes;
- Nutrients and pathogens from any failure points within nearby sewer collection systems; and
- Total suspended solids from construction activities and storm water runoff.

Dredging to partially or fully restore the lake volume should be re-evaluated following implementation of initial stormwater BMPs, particularly if dissolved oxygen concentrations are increased in the near term through an oxygenation system.

1.5 Stormwater Best Management Practices

One of the objectives of this evaluation was to recommend BMPs that can be employed to improve water quality and aesthetics in and around Elmendorf Lake. According to earlier studies performed for SARA, focus should be placed on installing BMPs near the lake. Trash and other floatable debris were specifically mentioned as problems, and representatives of OLLU confirmed this.

Section 6 of this report describes the methodology used to characterize the extent of effect on the Lake by various land use areas in the watershed, and it describes the types of BMPs recommended to manage stormwater runoff and improve its quality.

The recommended BMPs range from public education and regulations to specific structural measures such as trash booms, catch basin inserts and netting devices. The report also discusses recommended sustainable BMPs related to low impact development techniques such as bioretention cells and rain gardens.

1.6 Vision Plan

Section 7 describes a conceptual vision developed by the Pirnie/ARCADIS team, SARA and its partners for the study area shown in Figure 7.4. By merging previous work with new creative thinking, we produced ideas and concepts for a cohesive sustainable solution that creates a **Great People Place in the Westside**. As this vision moves through the implementation process, more public input will be needed to finalize the plan. As described in Sections 7 and 8 of this report, public investment by the COSA and Bexar County, and private investment by OLLU and others could be used to implement the vision.

The proposed vision for the Elmendorf Lake reach of Apache Creek has connectivity as one of its primary focal points. The proposed plan reconnects valuable resources to their surroundings, to the community and the city.

Perhaps the most crucial of all connections is between Elmendorf Lake Park, the lake and OLLU. The ultimate conceptual plan shown in Figure 1.1 (below considers Rosedale and Elmendorf Lake Parks as a unit linked by a hike and bike trail connection through the Apache Creek Linear Park. In a later phase Jose

Figure 1.1: Elmendorf Lake Conceptual Plan

Antonio Navarro Park would also be connected and improved. Trails would be provided on both sides of the lake creating an optimal user experience going to and from the three parks. The parks would then form a cohesive unit as each meets distinctive needs in the community. The proposed Jose Navarro Park Link would carry a ribbon of green from the lake deep into the heart of the surrounding community. This level of local accessibility would encourage more frequent and extended interaction between the linear resources along the creeks, the community and the parks.

The vision will obviously have to be implemented in phases, and this report focuses on ideas and opportunities for the first phases, primarily within an improved Elmendorf Lake Park. Section 7 describes concepts related to features such as: gateways and public art; the central portion of the park; an environmental study and research center; the island that runs through the lake; an aquatics center and marina; a wetland area; trails; security and safety; and the potential relocation of Buena Vista Street. The first phase of the implementation for Elmendorf Lake Park is shown below in Figure 1.2. The roles and responsibilities of the COSA, Bexar County and private entities are described.

Figure 1.2: Elmendorf Lake Park Plan - Phase 1A

1.7 Cost Estimates and Allocation of Cost

During the evaluation and planning process, the Pirnie/ARCADIS team developed a series of cost estimates for property acquisition in floodprone areas; flood detention/storage areas; stream restoration; water quality enhancements; trash and debris management strategies; and park improvements to Elmendorf Lake Park and linkage of the park facilities surrounding Elmendorf Lake. As various alternatives were evaluated, the cost estimates were updated and/or modified for use at meetings between SARA and its partners. These estimates were used in the decision-making process and are an integral part of this evaluation. In addition, the team assisted SARA in developing an allocation matrix that showed how the various components of the first phases of the overall plan would be funded by the COSA and Bexar County.

The total cost of the overall conceptual vision described in the final report is about $40 million.

With the passage of the May 2012 COSA bond election and other COSA funding sources, it is possible for the City to contribute approximately $7.5 million toward the implementation of the first phase of the vision. The County may contribute approximately $7 million.

1.8 Conclusions and Recommendations

Flood Mitigation

H&H modeling and the evaluation of flood mitigation alternatives are discussed in detail in Section 4 of this report. The Pirnie/ARCADIS team was tasked with the responsibility to look for viable options to reduce flooding within the constraints of the site and park planning process. The study found that constructing flood detention or storage in Rosedale Park along Zarzamora and Apache Creeks (Alternative 1) and a flood control gate at Elmendorf Lake dam provide the greatest reduction in peak water surface elevations through the lake during flood events. Because of the high cost of constructing detention areas and/or purchasing all of the properties within the floodprone area, it was determined that the final vision plan would not initially include the construction of detention storage in Rosedale Park.

The study team recommends further study of the proposed flood control gate to evaluate the gate size and operation required to provide the most flood reduction benefits. That study should also investigate the impact of flood flow releases on the area of Apache Creek downstream of the dam.

At SARA's request, the concept of dredging portions of the lake bottom was modeled to determine whether dredging provides additional flood protection benefits. The results of the modeling demonstrated that the water surface elevations during the 100-year flood event are the same with and without dredging.

Water Quality

The water quality evaluation and recommendations are discussed in detail in Section 5 of this report. Based on a review of available water quality data, sediment data and past studies, the primary water quality concerns for Elmendorf Lake are:

- Dissolved oxygen concentrations below the State Standard during certain seasons and/or rainfall events.
- E. coli concentrations above the State Standard for contact recreation.
- Sediment accumulation in the lake leading to reports of high turbidity during rain events and exacerbating anoxic conditions.

Additional concerns include nutrient concentrations and total organic carbon (TOC) concentrations, both of which can exacerbate eutrophic conditions. Concentrations of certain synthetic organic compounds in the sediments are above the TCEQ health screening levels, but do not currently present an immediate health concern. Aesthetic concerns include accumulation of trash & debris following rain events and adverse odors, likely due to growth of blue-green algae and/or anoxic conditions in the lake.

The Pirnie/ARCADIS team recommends SolarBee mixers be further evaluated as a strategy for improving water quality in the lake. A limnologist should be engaged to facilitate appropriate design of the system. The team also recommends that the stormwater BMPs discussed in Section 6 be implemented for near-term reduction in trash & debris, nutrients, and total suspended solids (TSS) loading to the lake. Over the long term, BMPs should be incorporated to address a comprehensive set of water quality concerns, including:

- Synthetic organic compounds from stormwater runoff.
- Wise use of herbicides and pesticides in the watershed and especially right around the lake.
- Bacteria and pathogenic microorganisms from pet wastes.
- Nutrients and pathogens from any failure points within nearby sewer collection systems.
- Total suspended solids from construction activities and storm water runoff.

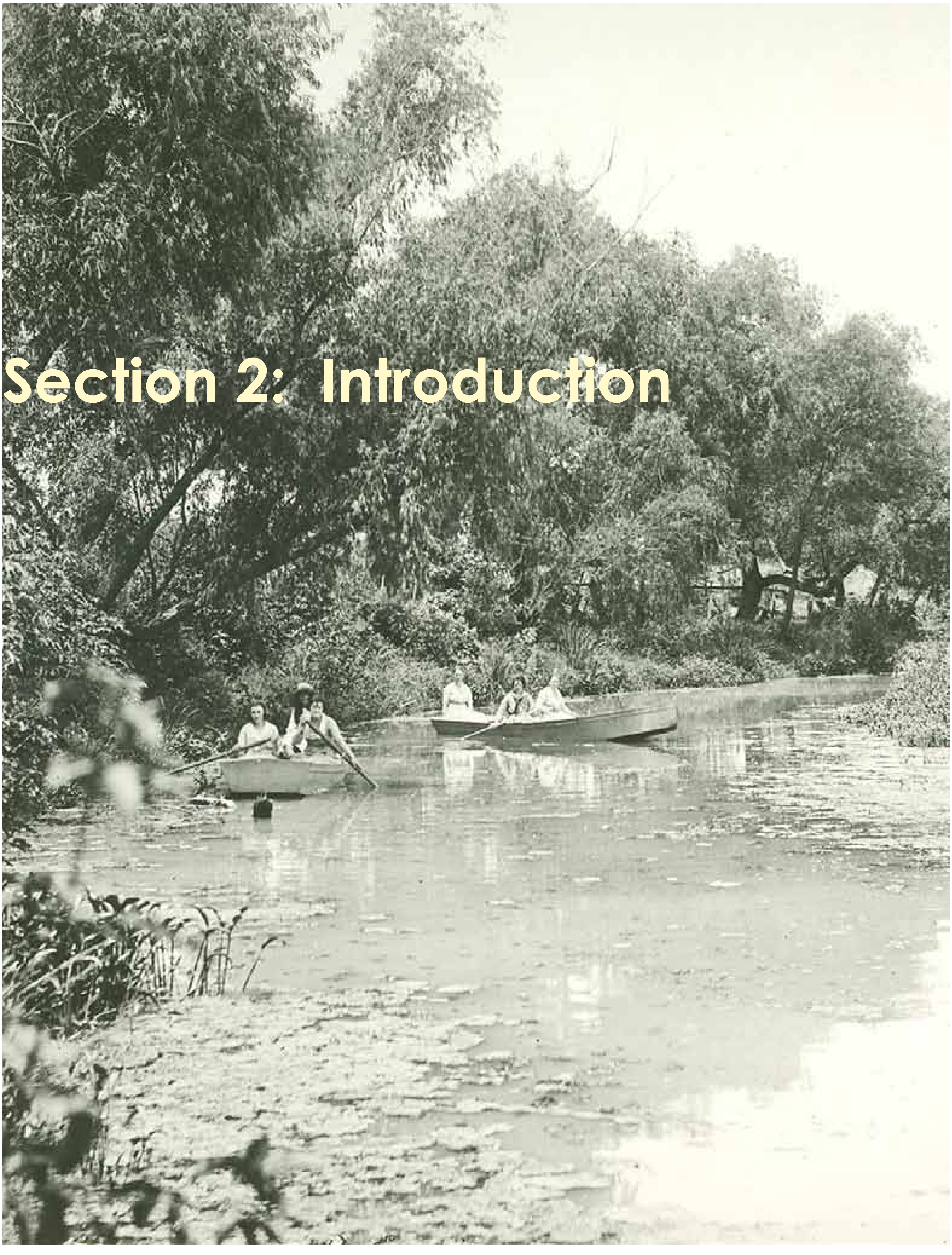
The Pirnie team recommends the Dredging Project be re-evaluated following implementation of initial stormwater BMPs. The team also recommends additional water quality analysis. Stormwater BMPs and continued maintenance of wastewater collection systems would be expected to reduce pathogen loading, but additional water quality analysis is recommended.

Sustainable Best Management Practices (BMPs)
Section 6 of the report includes a discussion of various BMPs that can provide sustainable solutions by improving the water quality in Elmendorf Lake and reducing the sediment reaching the lake. SARA, its partners and numerous stakeholders identified trash and debris as a major water quality and aesthetic problem at Elmendorf Lake.

As BMPs are implemented, the Pirnie team recommends that their effectiveness be evaluated.

Vision Plan
The overall vision of a **Great People Place in the Westside** is described in Section 7. It is shown in Figure 1.1 above. The vision includes Elmendorf Lake, Elmendorf Lake Park and the surrounding community. To stay within funding constraints, the vision is implemented through a series of phases. The initial phases focus on improvements to Elmendorf Lake Park. The overall vision considers Rosedale and Elmendorf Lake Parks as a unit linked by a hike and bike trail connection through Apache Creek Linear Park. This revitalization of the parks and restored connectivity to the lake, the community and OLLU also presents a significant opportunity for private sector redevelopment adjacent to the park and along Apache Creek.

Section 2: Introduction



2. Introduction

The San Antonio River Authority (SARA) recently completed the Westside Creeks Restoration Project Conceptual Plan (the "Conceptual Plan") and in June 2011 the Conceptual Plan was adopted by the SARA Board of Directors. The planning project involved a conceptual evaluation of restoration options and opportunities for four creeks on the West Side of San Antonio. The creeks are tributaries of the San Antonio River. One of the first segments or reaches that is planned for implementation is Apache Creek Reach 1 (designated as "AP-1" in the Conceptual Plan) which lies between North General McMullen Drive (upstream end) and Southwest 19th Street (downstream end). Reach AP-1 is bisected by two major streets, Commerce Street and 24th Street. This reach is essentially the entirety of Elmendorf Lake, including the dam. See Figure 2.1.

As SARA and its partners (including Bexar County, the City of San Antonio, and Our Lady of the Lake University) are moving forward with implementation of the Conceptual Plan, a number of additional activities, studies and plans were considered. These additional considerations include the following:

- The Upper San Antonio River Master Plan (the "Master Plan") which has been prepared for SARA and is in draft form. The Master Plan is essentially a flood damage evaluation and reduction study which includes AP-1.
- The Elmendorf Lake BMP Dredging Project (the "Dredging Project") which has been designed for SARA in order to potentially improve the water quality in Elmendorf Lake, and possibly improve the flood carrying capacity of Apache Creek through the lake. At the current time the project is on hold pending the outcome of this evaluation and others.
- The City of San Antonio (the "City" or "San Antonio") is in the process of implementing street improvements along 24th Street (the "24th Street Improvements") which crosses the middle of Elmendorf Lake in the immediate area of the OLLU campus.
- The San Antonio Parks & Recreation Department recently recommended new projects for the Linear Creekway Parks Development Program (the "Linear Parks Program"). These creekway projects would expand outdoor recreation opportunities by the creation of linear open space corridors along tributaries of the San Antonio River. The recommended projects are to be implemented with Proposition 2 funds approved by voters in November 2010, subject to final approval by the City Council. The projects would include improvements to a 0.3 mile segment of AP-1, from Commerce Street to 24th Street. That project was ranked as the top priority activity. The eighth ranked project (Apache Creek Trail to San Antonio River Confluence) proposes the construction of 2.9 miles of trails and connects to the existing thirteenth-ranked project on the Apache Creek which includes renovation of existing trails along 1.9 miles of Apache Creek. At the present time, there are gaps in the hike and bike trails along Apache Creek in AP-1, but if completed, the Linear Parks Program has the potential to link AP-1 downstream all the way to the Mission Reach of the San Antonio River.
- The San Antonio Parks & Recreation Department has plans to make significant improvements to Elmendorf Lake Park which lies along the north side of the lake between 24th Street and 19th Street.
- The mission and vision of the San Antonio bicycle master plan, Bike Plan 2011, is to plan and implement a comprehensive bicycle network throughout the city. The plan includes opportunities within AP-1.
- VIA's 2035 Long Range Transportation Plan outlines the policies, corridor improvements, technologies, timelines and funding options for transportation improvements in the city through 2035. The plan includes a light rail system along Commerce Street through the study area, with a "Super Stop" in the area of 24th Street, and a major Transit Center at the intersection with General McMullen Drive.

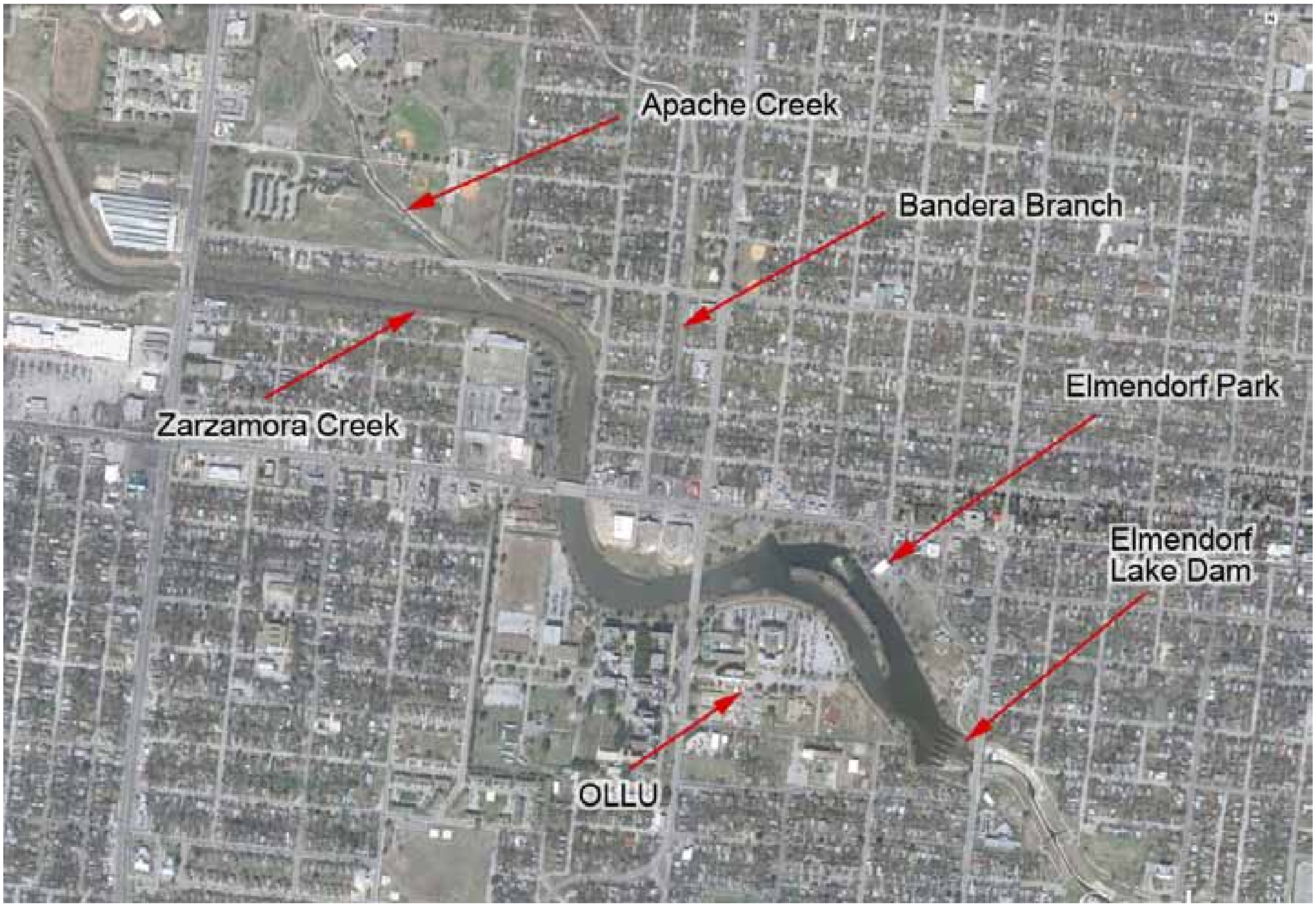


Figure 2.1: Elmendorf Lake Study Area

In addition to these public projects, Our Lake of the Lake University (OLLU) has prepared a master plan for its campus (the "OLLU Master Plan"). The OLLU Master Plan is designed to serve as a long-term vision for the development of the campus, which lies along the south side of Elmendorf Lake.

At the present time, SARA and its partners wish to create a vision within AP-1 that produces a "**Great People Place in the Westside**" based upon these studies and additional input. Funding to implement the vision may be available from future bond programs that are currently being planned, as well as other City, Bexar County, VIA and private sources to be determined.

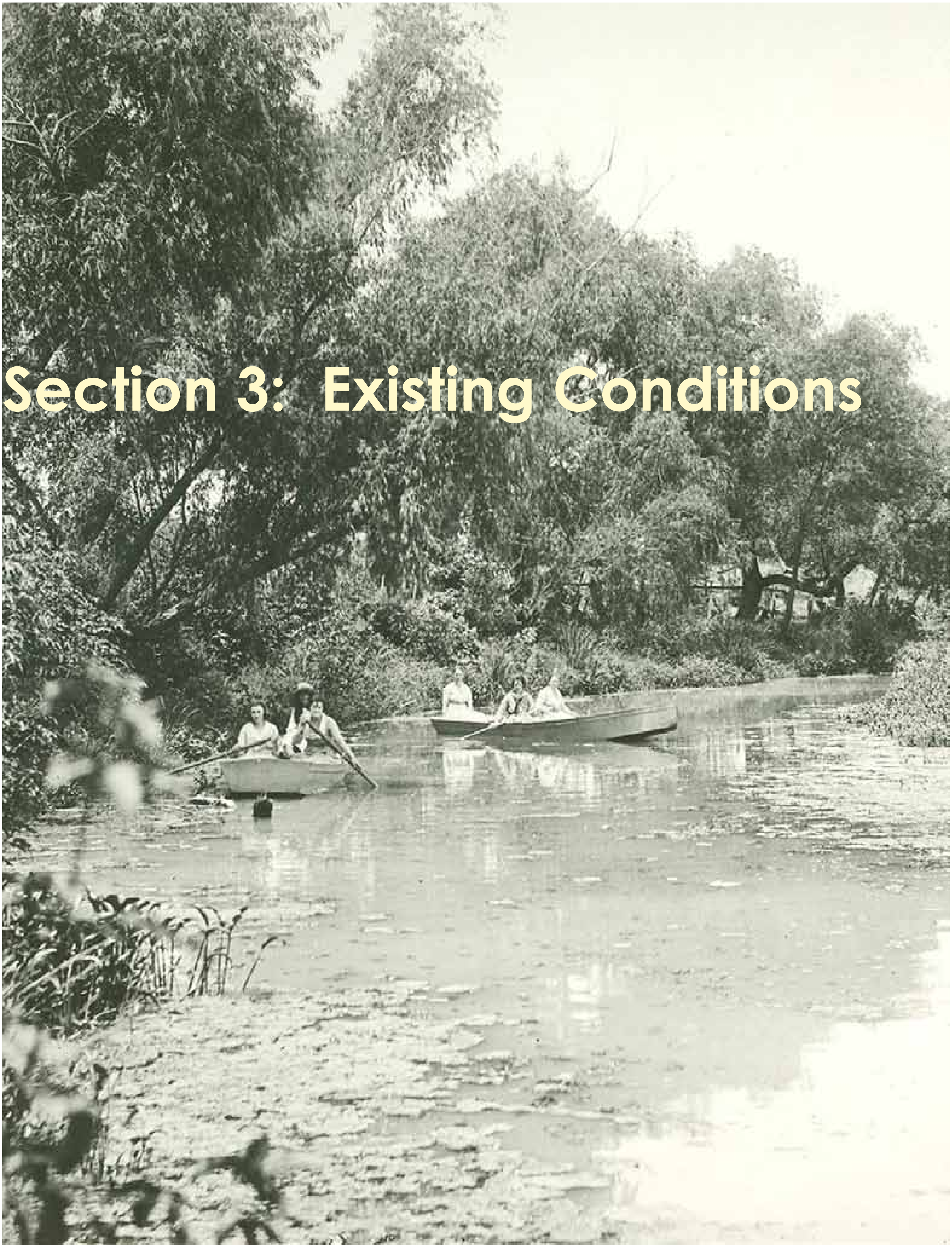
Therefore, on August 30, 2011 SARA engaged Malcolm Pirnie, the Water Division of ARCADIS-US, to use existing hydrologic and hydraulic (H&H) models, and other tools to review the current studies, plans and projects described above in order to:

- Evaluate the flood mitigation and water quality benefits of the Dredging Project and the channel modification projects proposed in the Conceptual Plan, and determine the potential benefits of projects proposed in the Upper San Antonio River Master Plan;
- Determine, by using a holistic planning approach, opportunities to refine the existing plans to make them more cohesive and integrated;
- Determine opportunities to link the current plans with other facilities and features in the area (e.g. linking Rosedale Park to Elmendorf Lake and ultimately to Elmendorf Lake Park, and on to Cassiano/ Amistad Parks and then on to the confluence of the San Antonio River Mission Reach project);
- Verify and validate cost estimates and look for potential savings;
- Perform an cursory evaluation of the Dredging Project to see if there are ways to achieve the same results without dredging portions of Elmendorf Lake or in the alternative, to reduce the costs of the Dredging Project;
- Develop a preliminary conceptual plan for Elmendorf Lake Park; and
- Produce a set of graphics that accurately and clearly describe the vision for Reach AP-1 and how that vision can be achieved within existing sources of funding and with potential bond proceeds.

In addition, Malcolm Pirnie supported SARA by providing materials and presentations for meetings with its partners and elected officials.

Throughout the work on this evaluation, the Malcolm Pirnie Team (Pirnie Team) has kept in mind SARA's mission and vision, and SARA's objectives for a holistic, integrated planning process that seeks sustainable solutions that maximize the potential for multi-purpose programs, processes and projects. The evaluation is intended to assist SARA and its partners determine the most appropriate and beneficial vision for AP-1, the Elmendorf Lake segment of Apache Creek. The evaluation will also be aligned with SARA's initiatives to assess and maintain the health of the San Antonio River Watershed.

Section 3: Existing Conditions



3. Existing Conditions

3.1 History of Elmendorf Dam and Lake

The history of Elmendorf Lake is linked directly to the history of OLLU and the local Westside Community. OLLU, a private Catholic university, was founded in 1895. The students and faculty have been using Apache Creek and the lake since that time.

The current Elmendorf Lake dam is a labyrinth weir structure constructed in 1973. The total effective length of the weir is 1,700 feet, and the height is approximately 12 feet. The dam does not have a service or emergency spillway. There are a series of outlet pipes through the weir that are controlled by individual manually-operated gate valves. More details are provided in Section 4.

In many ways, the history of Lake Elmendorf can best be told in the following historic photographs obtained from the Archives of Our Lady of the Lake University.

Figure 3.1: Elmendorf Lake, 1938

Figure 3.2: Boating on Elmendorf Lake, 1940's

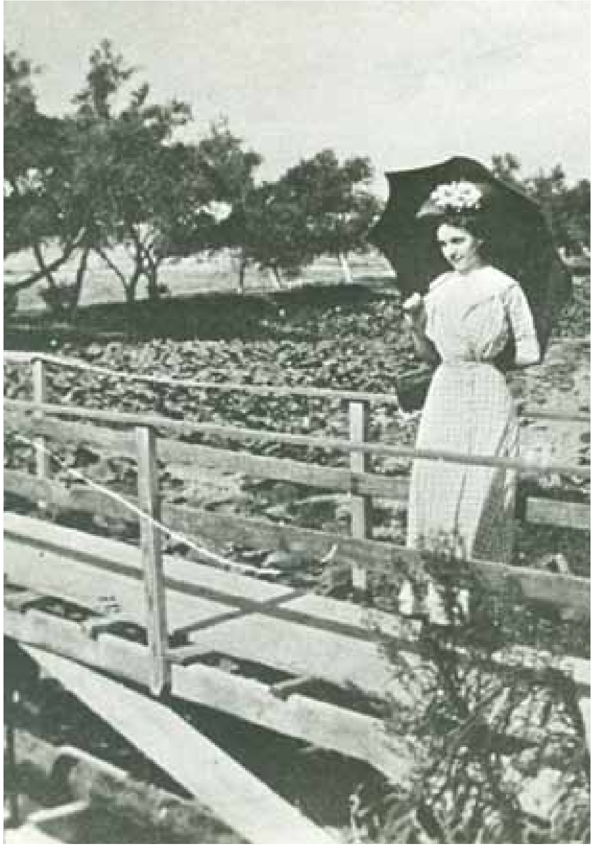


Figure 3.3: Foot Bridge 1930's

Figure 3.4: Our Lady of the Lake University from Elmendorf Lake, 1932

Figure 3.5: Elmendorf Park, 1927

Figure 3.6: Elmendorf Lake Dam, 2011

3.2 Description of Apache Creek and Elmendorf Lake

Although the Conceptual Plan refers primarily to Apache Creek and Elmendorf Lake, the upstream end of the lake is actually on Zarzamora Creek. Zarzamora Creek provides most of the drainage area for the lake. Apache Creek enters the lake from the northwest, and Bandera Branch, another tributary, enters from the north. See Figure 2.1.

The Zarzamora Creek segment of Elmendorf Lake is heavily vegetated on both sides. The banks of the creek are stable and invasive species do not appear to be a problem. On the north side of the creek, there is an existing berm between the creek and a row of houses. Martin Street and Rosedale Park are located on the north side of the Zarzamora Creek segment of the lake.

Within the main body of Elmendorf Lake an island known by various names, including (Memorial Island) runs with the length of the lake generally between 24th Street and the dam.

3.3 Description of Study Area

The study area is along Zarzamora and Apache Creeks and is designated as AP-1 in the Conceptual Plan. It lies between North General McMullen Drive (upstream end) and Southwest 19th Street (downstream end). The study area is bisected by two major streets, Commerce Street running east and west, and 24th Street running north and south through the OLLU campus. The major features are Elmendorf Lake, OLLU, Elmendorf Lake Park and Rosedale Park.

The Conceptual Plan includes a definition of the key parameters for each reach of the Westside Creeks. In summary, AP-1 is described in the following manner:

- General Conditions: Elmendorf Lake
- Right-of-Way Constraints: Limited above Commerce Street; public park on the north shore between 24th and 19th Street
- Flood Hazards: Extreme (extensive 10 year) above Commerce Street
- Vegetation: Wood riparian zone in upper end; grasses in lower end
- Socio-Economic: Residential; public housing; retail; adjacent to Our Lady of the Lake University

Within the study area, there is a mixture of public (parks, OLLU and Elmendorf Lake), residential and commercial land uses. Most of the commercial property is along Commerce Street and General McMullen Drive.

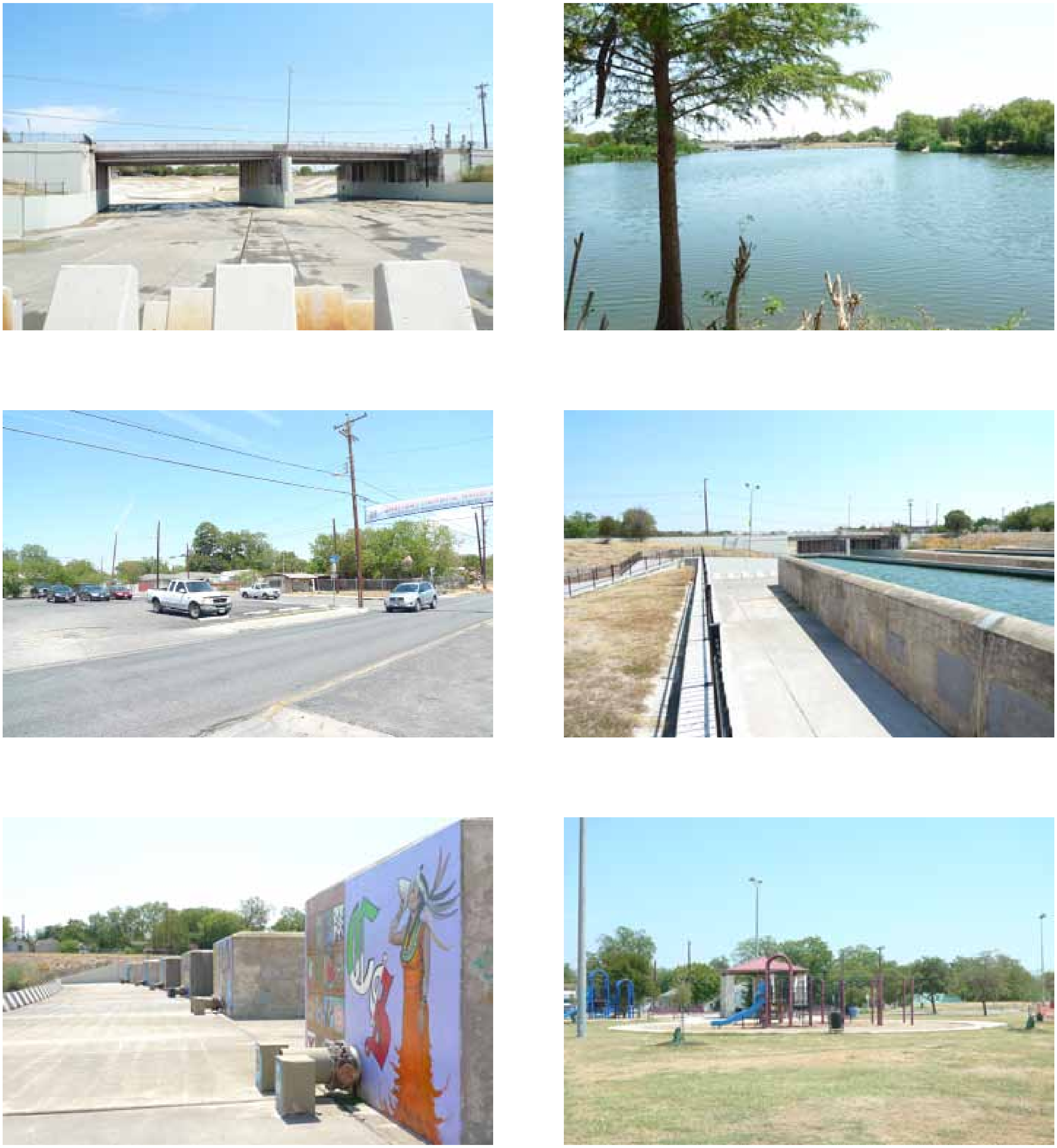
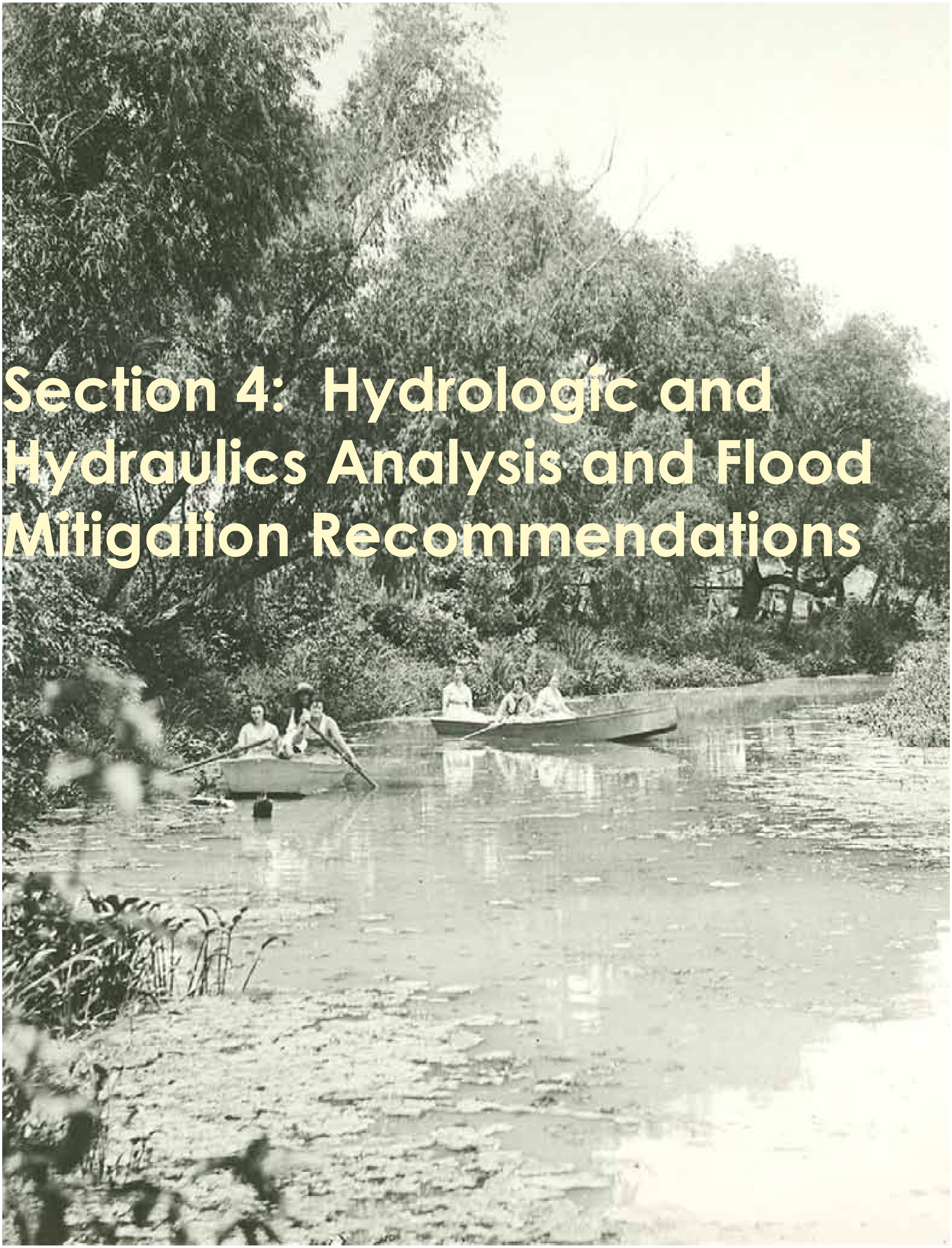


Figure 3.7: Existing Site Photos

Section 4: Hydrologic and Hydraulics Analysis and Flood Mitigation Recommendations



4. Hydorlogic and Hydraulics Analysis and Flood Mitigation

4.1 Introduction and Background

The City of San Antonio has historically experienced severe flooding, most notably during the floods of 1921, 1946, 1965, 1972, 1978, 1997, 1998, and 2002. A portion of the community around Lake Elmendorf, primarily north of the lake is located in what the Federal Emergency Management Agency (FEMA) refers to as "the effective 100-year floodplain" and has experienced repeated flooding (both street and structural flooding) during past flood events. The San Antonio River Authority (SARA), as part of this evaluation of the Elmendorf Lake (Apache Creek) reach of the Westside Creeks Concept Plan, requested Malcolm Pirnie/ARCADIS review existing Apache Creek/Zarzamora Creek hydrologic and hydraulic (H&H) studies. Following review of these studies (including hydrologic and hydraulic models), the Malcolm Pirnie/ARCADIS team developed, analyzed and evaluated improvements that would provide additional flood protection to the community around Elmendorf Lake. These conceptual hydraulic improvements were developed congruently with the Elmendorf Lake park planning effort conducted by other members of the team.

Elmendorf Lake, located along Apache Creek just downstream from the confluence of Zarzamora Creek and Apache Creek was enlarged through construction of a dam by the U.S. Army Corps of Engineers (USACE) in 1973 and then modified to its current configuration between 1993 and 1995 by SARA. The existing Elmendorf Lake dam (formerly known as 19th Street Labyrinth Weir Dam) has an effective weir length of 1,700 feet and a weir height of 12.3 feet. The depth of the lake varies between 4 ft. and 16 ft. The upstream catchment is 17.5 square miles. The lake has a surface area of approximately 32 acres at the normal pool elevation of 657.34 feet mean sea level (msl).

4.2 Existing Conditions Hydrology

The most recent comprehensive hydrology study of Apache Creek and its tributaries including Zarzamora Creek and Bandera Branch was completed in 2006 as part of the Upper San Antonio River Flood Insurance Rate Map (FIRM) updates, published by FEMA. The USACE Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) was used to model Apache Creek and its tributaries in order to update the Flood Insurance Rate Maps. This effective hydrology model was also the basis for the Westside Creeks Restoration Project Conceptual Plan and the Upper San Antonio River Watershed Masterplan both published in June 2011.

Our analysis of the effective hydrology model consisted of a review of the methodology, duplication of the effective model results, and verification of the effective flows calculated in HEC-HMS using regression equations. The extent of this review was limited to the catchment upstream of Elmendorf Lake dam to General McMullen Drive. The Soil Conservation Service (now the Natural Resources Conservation Service) unit hydrograph technique is the method employed to calculate the runoff hydrographs for Apache Creek and its tributaries. Apache Creek and Zarzamora Creek curve numbers and lag times in the HEC-HMS model were reviewed and found to be consistent with observed subbasin land uses, soils, and topography. The Muskingum Cunge routing method was selected for Apache Creek and Zarzamora Creek. The routing model input data (length, slope, and roughness) were compared against and are consistent with available GIS topographic data and aerial photographs. The precipitation and arial reduction factors described in detail on page 10 of the Hydrology Technical Support Data Notebook (TSDN) of the Upper San Antonio River (July 2006) were given a cursory review and appear to be reasonable.

HEC-HMS model results show the effective peak 100-year (1%) discharge at the confluence of Apache

Creek and Zarzamora Creek is 24,724 cubic feet per second (cfs). The effective peak 100-year discharge immediately downstream of the 24th street bridge is 25,307 cfs.

The Austin Urban Regression Equations published by the U.S. Geological Survey (USGS) in 1993, titled "Nationwide Summary of U.S. Geological Survey Regional Regression Equations for Estimating Magnitude and Frequency of Floods for Ungaged Sites was employed to verify HEC-HMS peak discharges at Elmendorf Lake. The Austin Urban Regression equation to calculate the 100-year peak discharge is:

Q100 =1,554 (CDA)0.678 (1+TIMP/100) 1.474

CDA = contributing drainage area (square miles)
TIMP = Total percentage drainage area that is impervious

A= 17.5 sq. mi. ; TIMP= 62.5% (based on HEC-HMS input)

The resulting Q100 is 25,917 cfs. This is 2.4% higher than the effective flow of 25,307 cfs, which is within the standard error of 30%.

A search for recorded discharges and stages from gauges on Apache Creek and Zarzamora Creek was performed, however none were found.

The effective HEC-HMS model was calibrated using USGS gauges primarily on the San Antonio River as described on page 7 of the TSDN. The events to which the hydrology model was calibrated are the storm events of June 1997, October 1998, and July 2002. Both stage and discharge data were utilized to calibrate the H&H models.

Based on this review, the best available data were used to develop the Upper San Antonio River hydrology model, and the effective peak 100-year flows ranging from 24,724 to 25,307 cfs at Elmendorf Lake are reasonable.

4.3 Existing Condition Hydraulics

There are four hydraulic models which include all or a portion of the Elmendorf Lake reach that were provided by SARA for our review. These four hydraulic models are:

1. Effective HEC-RAS model developed by Pape Dawson in 2006 for FIRM Updates;
2. Modified effective HEC-RAS model developed by AECOM in 2011 for the Westside Creeks Restoration Project Conceptual Plan;
3. Modified effective HEC-RAS model developed by Pape Dawson in 2011 for the Upper San Antonio River Watershed Masterplan;
4. 1D/2D XPSTORM model developed by Pape Dawson in 2011 for the Upper San Antonio River Watershed Masterplan.

These four models were reviewed to identify which model was best suited for use in this study of the Elmendorf Lake reach of Apache Creek. The effective HEC-RAS models of Apache Creek and its tributaries were developed by Pape Dawson to update the Flood Insurance Rate Maps (FIRM). Figure 4.1 shows the parcels and structures in the current effective floodplain. This Apache Creek HEC-RAS model was modified by AECOM by removing the hydraulic structures for use in development of the Westside Creeks Restoration Conceptual Plan. The effective HEC-RAS model of the Elmendorf Lake reach represents the Elmendorf Lake (labyrinth weir) dam as an inline structure.

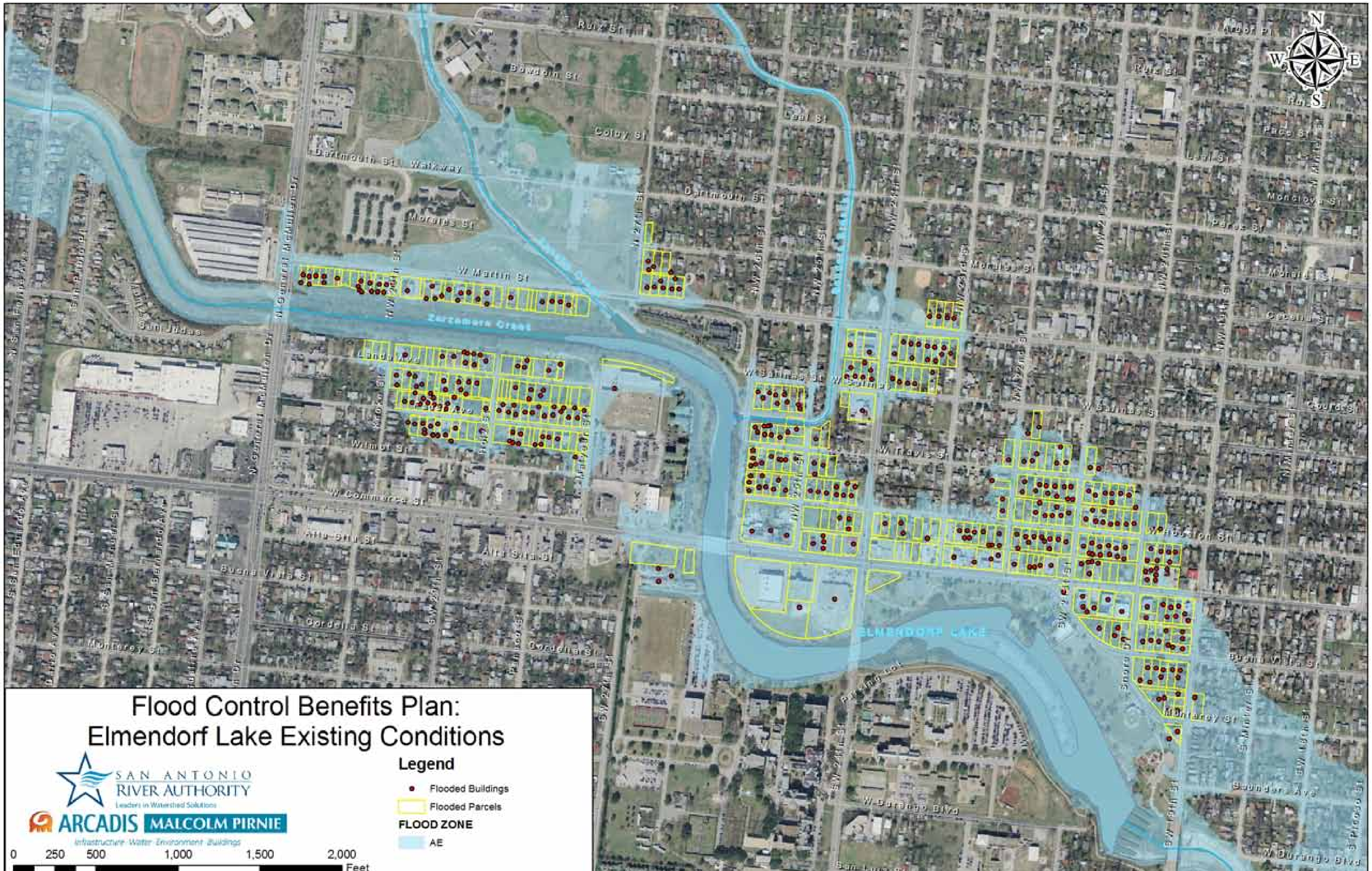


Figure 4.1: Elmendorf Lake Existing Conditions

The Upper San Antonio River Watershed Masterplan report stated that the head loss over the dam for the 100-year event is approximately 5 feet. Based on published labyrinth weir equations, the head loss for the 100-year event at the Elmendorf dam should be 2.7 ft based on the equation below published in World Applied Sciences Journal 3; 2008; titled "An Approach to Optimal Design of Trapezoidal Labyrinth Weirs."

$Q = (2/3)\ C_d\ L 2 g^{0.5} H^{1.5}$

$C_d = 0.1714\ \ln (H/P) + 0.8671$

Q: Flow Capacity (cfs)

P: Weir Height = 12.3 feet

H: Head on Weir (feet)

L: Effective Length of Weir = 1,700 feet

C_d: Discharge Coefficient

Additionally, the effective model attempts to account for split flow immediately upstream of the dam. During large storm events, water flows out of the main channel of Elmendorf Lake and into the area north of the lake bounded by 19th Street, 24th Street and W. Travis Street. The effective model attempts to represent this split flow condition, however, HEC-RAS is a one-dimensional (1-D) model and is therefore limited in its ability to represent surface flow in the overbank condition outside the main channel.

Due to the deficiencies of the effective model and the AECOM model in predicting the 100-year water surface elevation in the Elmendorf Lake reach, neither the effective HEC-RAS model nor the AECOM version of the effective model were used in this study. The following paragraphs describe the models that were used and the reasons why they were selected.

Since the effective model was completed in 2006, cross-sections of Elmendorf Lake have been field surveyed under the direction of SARA between Elmendorf Lake dam and the confluence of Zarzamora and Apache Creeks. The effective Apache Creek HEC-RAS model upstream of Commerce Street was modified by Pape Dawson to include these field surveyed sections. Additionally, Pape Dawson appended the five most downstream cross sections from the effective Zarzamora Creek model to the effective Apache Creek model, and replaced the inline structure representing Elmendorf dam with a rating curve based on the labyrinth weir equation described in the Upper San Antonio River Watershed Masterplan. Furthermore, Pape Dawson, developed two 1D/2D XPSTORM models of Elmendorf Lake. The first model between 24th Street and the dam includes a grid representing the overbank/floodplain to the north of the lake. The second 1D/2D XPSTORM model extends from the dam upstream to General McMullen Drive with a grid that extends from the dam to 26th Street. The Pape Dawson modified effective Apache Creek HEC-RAS model more accurately represents the lake channel and flow at the dam compared to the effective model. The second 1D/2D XPSTORM model developed by Pape Dawson better represents surface flow between 26th Street and the dam in the overbank north of the lake compared to the effective model. Therefore, the Pape Dawson modified effective HEC-RAS and the Pape Dawson XPSTORM models were reviewed and considered more suitable for this evaluation.

The Pape Dawson-modified effective Apache Creek HEC-RAS model consists of proposed cross-sections with portions of the lake dredged between Commerce Street and the dam. For purposes of our evaluation, these sections downstream of Commerce Street were replaced with new cross-sections developed by ARCADIS from field survey and 2011 Bexar County LIDAR data provided by SARA.

Boundary conditions, roughness coefficients, channel geometry and hydraulic structures model inputs were reviewed in both the XPSTORM and the HEC-RAS models. In general, model input for both models appeared to be reasonable, however, some corrections to the channel bottom elevations and the bridge geometry representing the 24th Street and Commerce Street bridges were made. The HEC-RAS and XPSTORM models were run, and the results were found to be similar. The revised HEC-RAS and XP-STORM models predict an existing conditions peak 100-year water surface elevation in Elmendorf Lake up to approximately 1.5 feet lower than the effective model between the dam and General McMullen Drive. This is primarily due to the revised boundary conditions at the dam.

4.4 Proposed Alternatives for Flood Mitigation

A series of flood reduction alternatives were discussed with SARA and its partners and considered by the Pirnie/ARCADIS team. The following three alternatives were identified and evaluated in more detail during the development of the plan for Elmendorf Lake Park:

Alternative 1 – Regrade portions of Rosedale Park and across Zarzamora Creek south to Faust Street for flood storage

Alternative 2 - Regrade portions of Rosedale Park along Apache Creek for flood storage

Alternative 3 - Construct for flood storage a diversion channel through the existing berm on the north side of Zarzamora Creek

During the workshop held on August 31, 2011 with SARA and project stakeholders, the goal with regard to flood mitigation was identified as “100-year flood protection for structures around the lake.” This goal was used to guide the identification and evaluation of alternatives to lower the peak water elevation during major flood events.

<u>Alternative 1</u>

This conceptual alternative maximizes the potential flood storage in Rosedale Park (including areas along Apache Creek and Martin Street) and across Zarzamora Creek south to Faust Street. The storage or detention areas were selected to maximize flood reduction benefits, given the constraints of the site and the park planning effort. The concept assumes excavation and re-grading of these areas resulting in total flood storage or detention area of approximately 550 acre-feet (ac-ft). During flood events, floodwater would be diverted into the detention areas via channels on the upstream or south end of Rosedale Park and Zarzamora and Apache Creeks.

The storage facilities described above were added to the effective HEC-HMS model to calculate the reduction in flow immediately downstream of the proposed detention in this upstream area of Elmendorf Lake. Model results show that the peak lake inflows would be reduced from 25,300 to 22,000 cfs.

The reduced flows were then input into the HEC-RAS and XPSTORM models, and the results show a reduction in the peak water surface elevation of up to 0.8 feet for the 100-year storm.

In order to identify structures in the 100-year floodplain with the proposed Alternative 1 improvements, a geodatabase containing building outlines was provided by SARA. The DEM developed from the 2011 LIDAR was sampled at each building and the average ground elevation was assumed to be the building finished floor elevation. Finished floor elevation surveys of buildings in the floodplain around Lake Elmendorf were not available for this study.

Figure 4.2 shows the parcels remaining in the effective floodplain after property buyouts necessary for the construction of the storage proposed in Alternative 1. Figure 4.3 shows the parcels remaining in the effective floodplain after Alternative 1 storage is constructed. Table 4.1 includes the number of properties with and without structures flooded during the effective 100-year event and also following the installation of Alternative 1 and the corresponding property buyout costs for each condition.

Alternative 2

Alternative 2 is similar to Alternative 1 but it only includes approximately 164 ac-ft. of detention in Rosedale Park along Apache Creek. This alternative does not include detention along Zarzamora Creek. HEC-HMS results show that the peak inflow to the lake would be reduced from 25,300 to 24,500 cfs. The HEC-RAS and XPSTORM models showed an insignificant reduction in the 100-year water surface elevation of approximately 1 inch through the lake area.

Alternative 3

This alternative attempts to utilize for storage the area behind the existing berm between Martin Street and Zarzamora Creek. In order to detain floodwater in this area, the existing berm would need to be extended around the southwest side of Apache Creek up into Rosedale Park. The available storage volume would be significantly less than Alternative 2. Given the results of Alternative 2 described above, the reduction in the 100-year water surface elevation through the lake with this alternative would be minimal and therefore was not further analyzed.

Other Alternatives Considered But Not Evaluated in Detail

Additional storage upstream of General McMullen Drive to provide 100-year protection to all structures in the existing floodplain was also considered. However, assuming the storage described in Alternative 1 was constructed, an additional storage facility many times larger than the Alternative 1 would be required upstream to provide 100-year flood protection to the existing structures around Elmendorf Lake. Upstream along Zarzamora and Apache Creeks, additional property buyouts would be required to construct off-channel storage, and therefore this does not appear to be a cost effective alternative.

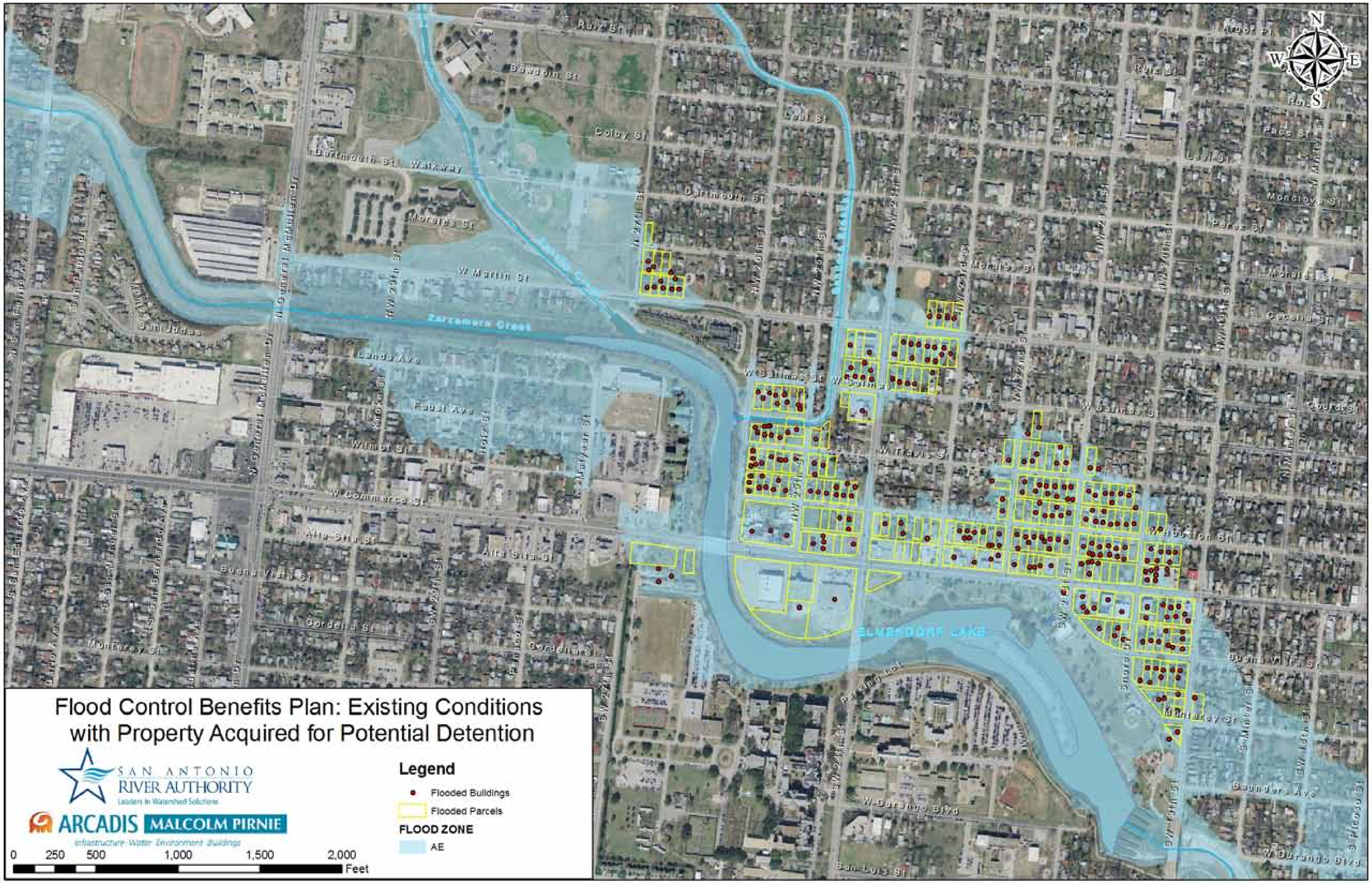


Figure 4.2: Elmendorf Lake Existing Conditions with Property Acquired for Potential Detention

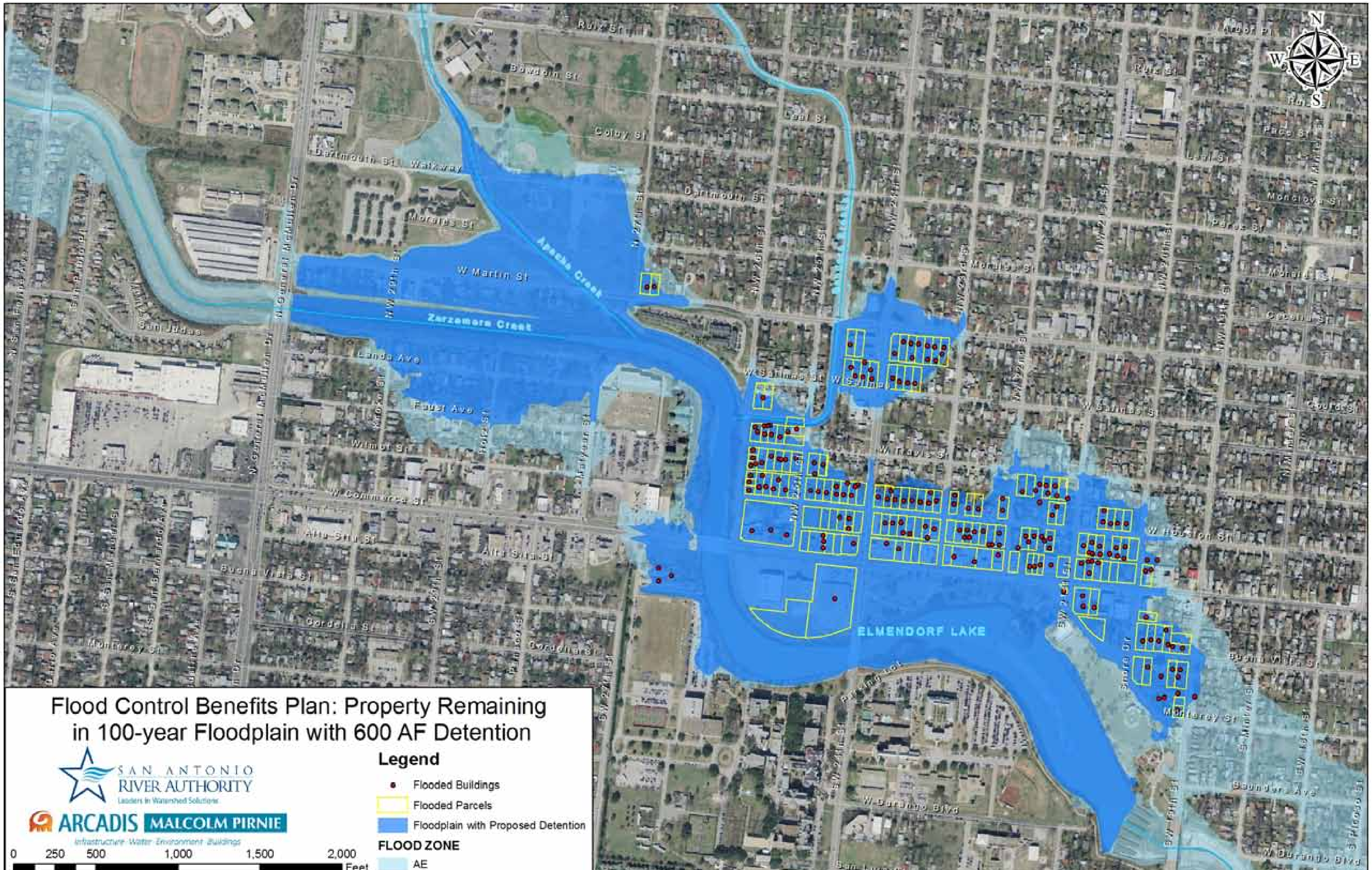


Figure 4.3: Property Remaining in 100-year Floodplan with 600 AF Detention

Summary of Property Acquisition Costs
Westside Creeks/Elemendorf Lake Project

13-Jan-12

		Parcels w/o Structures		Parcels with Structures				Total	Bexar Co	Total Cost
No.	**Description**	**No.**	**Bexar $**	**No.**	**Bexar $ Land**	**Bexar $ Impr**	**Bexar $ Subtotal**	**Parcels**	**Total Value**	**w/Multiplier** (Multiplier 1.50)
1	Total properties in floodplain	94	$ 3,850,532	257	$ 3,107,880	$ 10,402,288	$ 13,510,168	351	$ 17,360,700	$ 26,041,050
2	Zarzamora Cr. buy-out only	47	$ 635,730	87	$ 802,760	$ 2,856,950	$ 3,659,710	134	$ 4,295,440	$ 6,443,160
3	Remaining after detention	36	$ 1,146,352	117	$ 1,832,330	$ 4,781,778	$ 6,614,108	153	$ 7,760,460	$ 11,640,690
4	Martin St. only (no. side Zar Cr.)	11	$ 84,240	25	$ 203,570	$ 930,980	$ 1,134,550	36	$ 1,218,790	$ 1,828,185

Table 4.1: Summary of Property Acquistion Cost

Another alternative considered is to add additional discharge capacity at Elmendorf Lake dam. This might be achieved through construction of a side channel spillgate. This gate would allow an operator to lower the lake water surface elevation by several feet prior to a storm event and also provide additional discharge capacity at the dam during a flood event. In order to determine whether the option of additional discharge capacity at the dam warrants further study, the Pirnie/ARCADIS team theoretically "removed" from the XPSTORM model the Elmendorf Lake dam and the pedestrian walkway downstream of 19th Street. Model results showed that between 21st Street and the dam site, the 100-year peak water surface elevation was reduced by up to 1.5 feet. The impacts of increased discharge from Elmendorf Lake dam downstream in Apache Creek would need to be evaluated if this alternative is studied in more detail.

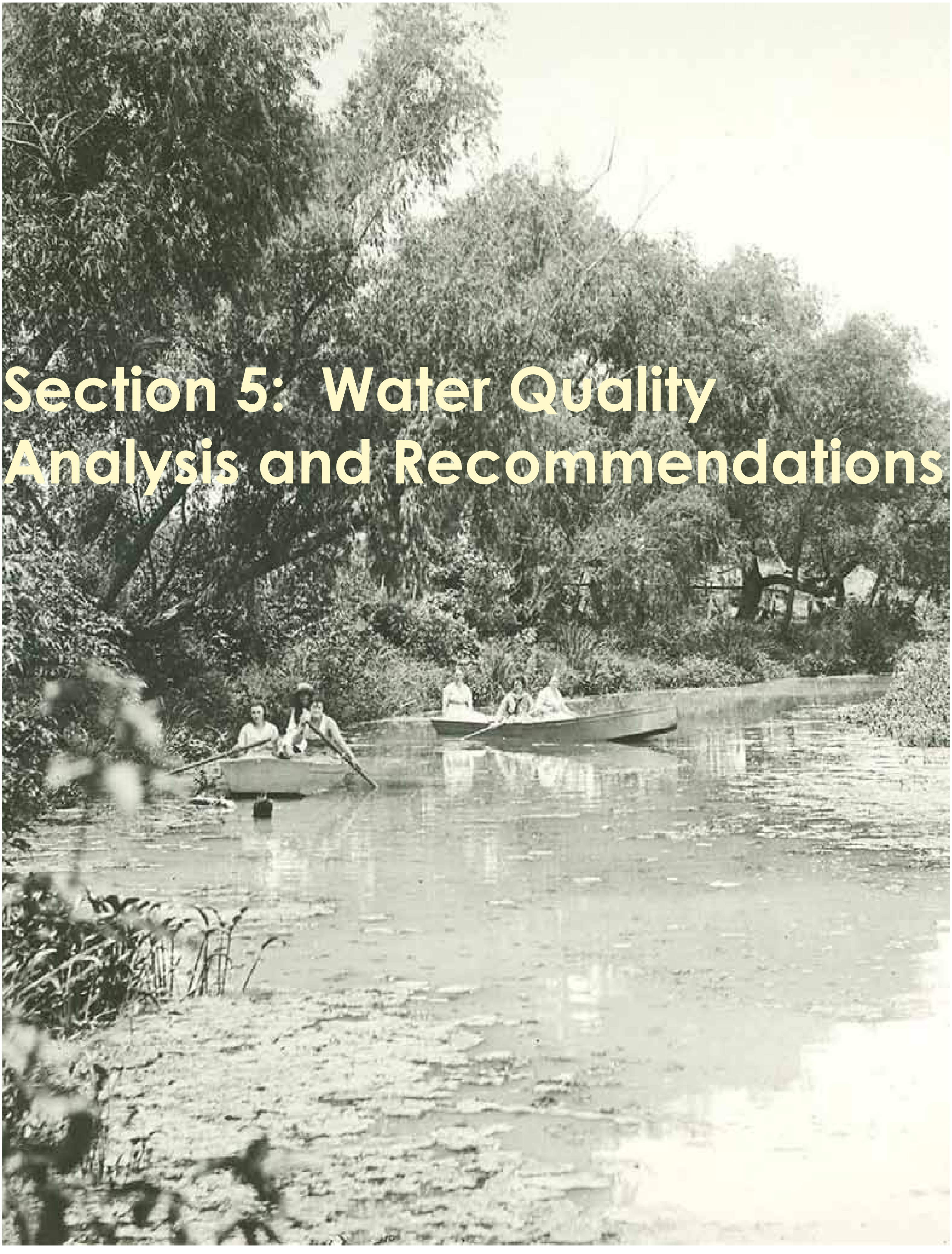
Proposed Dredging

At SARA's request, the Dredging Project which included dredging portions of the lake bottom (approximately 4 to 5 feet on average) was modeled to determine whether dredging of the lake provides additional flood protection benefits. The basis for the evaluation was the plan developed by SARA for the BMP Dredging Project. The rating curve in the XPSTORM model was replaced with an inline weir representing the Elmendorf Lake dam. In the model, the discharge coefficient for the weir was set at 3 which produced a head loss of approximately 2.7 feet at the weir, consistent with the labyrinth weir rating curve. The initial water surface elevation of the lake was set to 657.34 (weir crest). The 100-year event was modeled with and without the lake bottom dredging. Model results showed no reduction in the peak water surface elevation of the lake with the dredged condition, when compared to the existing condition. The labyrinth weir controls the flow with and without the lake dredging. Assuming the lake is at normal pool (657.34) at the beginning of a flood, the resulting water surface elevations during the 100-year event are the same with and without the dredging.

4.5 Conclusions

Although the Elmendorf Lake park improvements were conceptually designed to be compatible with flooding, the Pirnie/ARCADIS team was tasked with the responsibility to also look for viable options to reduce flooding within the constraints of the site and park planning process. Alternative 1 and/or a flood control gate at Elmendorf Lake dam provide the greatest reduction in peak water surface elevations through the lake during flood events. Further study of the proposed flood control gate at the dam is recommended to evaluate the gate size and operation required to provide the most flood reduction. That study should also investigate the impact of flood flow releases on the area of Apache Creek downstream of the Elmendorf Lake dam.

Section 5: Water Quality Analysis and Recommendations



5.1 Introduction

One of the identified projects to restore and improve AP-1 is hydraulic dredging of a portion of Elmendorf Lake at an estimated total cost of $10.6 million in 2011 dollars. This section reviews the current water quality condition of Elmendorf Lake, the water quality concerns that could be addressed by the Dredging Project and potential alternatives that could be implemented in place of, or prior to, dredging. Conceptual level costs for the alternatives and a subjective comparison of pros and cons are also provided.

5.2 Background and Approach

The study area consists of Elmendorf Lake and its two major tributaries—Zarzamora Creek and Apache Creek. Elmendorf Lake (Figure 5.1) is located on the west side of San Antonio, TX and adjacent to Our Lady of the Lake University (OLLU). The lake watershed covers approximately 11,600 acres (Michael Baker Jr., 2010), approximately 85% of which is developed with residential and commercial properties. An estimated 35% of the watershed is impervious area. Three major storm water outfalls discharge runoff from impervious areas within the watershed to the lake (Figure5.1), at the confluence of Bandera Branch with Apache Creek, at Commerce Street, and at 24th Street.

Apache Creek and Elmendorf Lake are tributaries to the Upper San Antonio River Watershed (TCEQ Segment 1911). Segment 1911 is designated by TCEQ for contact recreation, although the City of San Antonio (the "City" or "San Antonio") has placed restrictions on swimming within the San Antonio River or its tributaries within city limits. The segment also has a high aquatic use designation; Elmendorf Lake provides habitat for fish, turtle, and bird species.

A fish kill occurred on July 18, 2005, prompting concerns regarding lake water quality (Arias Jr., 2010). Water quality concerns within the study area include low dissolved oxygen (the probable cause of the fish kill), high bacterial loading (i.e., E. coli concentrations), elevated nutrient concentrations, high turbidity and floatable trash and debris following storm events, and periodic unpleasant odors. Lake dredging was identified as a recommended approach to improve water quality and lake habitat (Baker, 2010a), coupled with implementation of short and long-term storm water BMPs.

5.2.1. Approach

Relevant data and studies were reviewed to confirm the primary water quality concerns to be addressed under the Conceptual Plan for AP-1. Water quality data reviewed for the project included:

- Data for TCEQ SWQMIS Stations 18814, 12712, and 15707 (Figure 5.1). TCEQ SWQMIS Station 15707 is outside of the project area, but included in analysis to assess water quality immediately downstream of the Elmendorf Lake Dam.

- Tabulated data from the Elmendorf Lake Water Quality Study (Appendix VI of the Elmendorf Lake Watershed Water Quality Study; Michael J. Baker, Inc., June 2011).

- Sediment data from the Sediment Quality Assessment Memorandum submitted to San Antonio River Authority on August 31, 2010 by Michael Baker Jr. Inc.

Section 5.6 includes a list of studies reviewed for the water quality analysis.

Strategies to address water quality concerns in AP-1 were identified based on a review of the data and past studies, and based on discussions during the August 31, 2011 project workshop. Conceptual level costs for those strategies were developed based on site-specific conditions and vendor quotes.

Figure 5.1: Map of Elmendorf Lake and TCEQ SWQMIS Sampling Locations

5.3 Summary of Water Quality Data

5.3.1. Water Quality

Table 5.1 summarizes historical water quality data for the two TCEQ SWQMIS Stations within the study area and Station 15707 just downstream of Elmendorf Lake Dam. Water quality data is also listed for samples collected from Elmendorf Lake 13 meters downstream of 24th Street, reported in Appendix VI of the Elmendorf Lake Watershed Water Quality Study (Baker, 2011). The sampling point 13 meters downstream of 24th St. is in the same proximity as TCEQ SWQMIS Station 12712.

The data show several trends:

- **Dissolved Oxygen.** Average dissolved oxygen concentrations for samples collected between 1983 and 2007 were above the Segment Specific State Standard ("State Standard") at each sampling location. However, minimum dissolved oxygen concentrations measured at Station 12712, Elmendorf Lake 13 meters downstream of 24th Street and at Station 15707 were below the State Standard. The measurements were also below concentrations required to support aquatic life.

- **Nutrients.** Maximum measured concentrations for ammonia, nitrate and total phosphate in samples collected from one or more of the TCEQ SWQMIS Stations were above the State nutrient screening criteria. Elevated nutrient concentrations can enhance algae growth in the lake and exacerbate eutrophic conditions, leading to a decrease in dissolved oxygen concentrations.

- **Total organic carbon.** Total organic carbon (TOC) concentrations measured in samples collected at Stations 12712, Elmendorf Lake 13 meters downstream of 24th Street, and at Station 15707 ranged from 2 to 25 mg/L[1]. Organic matter (measured as TOC) can create an oxygen demand either through chemical or biological reactions. Accumulation of organic matter in the lake sediments can serve as a "sink" for continual consumption of dissolved oxygen within the lake.

[1] As a comparison, TOC concentrations in most surface waters used as potable water supplies are less than 10 mg/L.

Parameter	Segment Specific State Standard/ Nutrient Screening Criteria(TCEQ Segment 1911)	Segment 1911 – Upper San Antonio River															
		Station 18814[1]				Station 12712[1]				Elmendorf Lake 13 meters downstream from 24th Street[2]				Station 15707[1]			
		Number of Samples	Min.	Mean	Max.	Number of Samples	Min.	Mean	Max.	Number of Samples	Min.	Mean	Max.	Number of Samples	Min.	Mean	Max.
pH, S.U.	-	14	7.5	7.9	8.2	64	7.6	8.1	8.7	69	7.6	8.1	9.2	78	7.1	8.0	9.2
Temperature, °C	32.2	14	19	23	29	64	8.0	23	31	69	8	22.6	31.4	80	7.2	21.1	34.1
Dissolved Oxygen, mg/L	> 5	14	4.1	6.5	8.6	64	2.5	7.9	16	69	2.5	8.0	16.2	80	0.9	8.2	21
Turbidity, NTU	-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	10	10	10
Specific Conductance, µS/cm	-	NA	NA	NA	NA	7	245	284	354	69	160	357	577	NA	NA	NA	NA
Alkalinity, mg/L as $CaCO_3$	-	NA	NA	NA	NA	6	87	98	113	5	87	97	113	NA	NA	NA	NA
Salinity																	
Chloride, mg/L	150	NA	NA	NA	NA	20	10	24	39	19	10	23.87	39.1	21	22	60	118
Sulfate,mg/L	150	NA	NA	NA	NA	20	10	19	35	19	10	17.76	33.8	21	27	110	230
Nutrients																	
Ammonia, mg/L as Nitrogen	0.33	NA	NA	NA	NA	20	0.02	0.09	0.36	22	0	0.08	0.36	21	0.02	0.11	0.55
Nitrate, mg/L as N	1.95	NA	NA	NA	NA	20	0.01	0.06	0.28	22	0	0.06	0.28	21	0.02	0.48	3.2
Orthophosphate, mg/L as PO_4	0.37	NA	NA	NA	NA	6	0.03	0.04	0.09	NA	NA	NA	NA	NA	NA	NA	NA
Total Phosphate, mg/L as PO_4	0.69	NA	NA	NA	NA	6	0.03	0.52	1.53	NA	NA	NA	NA	NA	NA	NA	NA
Organics																	
Total Organic Carbon, mg/L	-	NA	NA	NA	NA	18	5.2	9.3	25	17	5.2	8.9	18	19	2.0	6.6	16
Chlorophyll a, µg/L	14.1	NA	NA	NA	NA	6	28	79	289	NA	NA	NA	NA	NA	NA	NA	NA
E. Coli, MPN/100mL	126[3]	NA	NA	NA	NA	NA	NA	NA	NA	3	104	2109	6000	6	240	4703	> 24000

[1] Samples collected between November 1983 and June 2007. Data from TCEQ SWQMIS Database.
[2] Data from Appendix VI of the Elmendorf Lake Watershed Water Quality Study
[3] 2000 Standard for Contact Recreation; 2010 draft standard for Primary Contact Recreation.

Table 5.1: Water Quality Data for TCEQ SWQMIS Stations 18814, 12712 and 15707

- **Chlorophyll a.** Chlorophyll a data are limited but generally show significant algal activity in the lake. Chlorophyll a concentrations in all samples collected at Station 12712 between November 1983 and June 1985 were above the 14.1 micrograms per liter (ug/L) State nutrient screening criteria. Samples collected at five locations between Commerce Street and the dam at 19th Street on October 8, 2009 (Table 2) had chlorophyll a concentrations ranging from 9 to 66 ug/L. Chlorophyll a is a pigment found in algae; concentrations of the pigment above 10 ug/L can be used as a guideline for algal activity which can create quality issues for contact recreation and potable water treatment. Algae growth is a defining characteristic of lake eutrophication and an associated deterioration in dissolved oxygen concentrations within the lake hypolimnium. Certain algae can also generate by-products that impart adverse tastes and odors to the water.

- **E.Coli.** Mean and peak E. coli concentrations measured at Elmendorf Lake are above the State Standard for contact recreation, and the data show significant bacterial loading to the study area.

Turbidity is an indication of the clarity of the water and the amount of particulate matter in the water. Turbidity data for the study area are limited, with only one data point available for Station 15707 for samples collected between 1983 and 2011 (and none for Stations 18814 and 12712). Sediment accumulation in the lake, reducing the effective depth to 50% of the 1974 as-built conditions (Attachment 1), demonstrates that there is probably significant particulate loading to Elmendorf Lake. As outlined in the Upper San Antonio River Master Plan, the banks of the lake appear to be relatively stable, indicating that the sediments are probably coming from upstream and/or from the stormwater outfalls during storm events.

Grab samples were collected from five locations along the length of the lake on October 8, 2009 (at Commerce St., 24th Street, the island, above the dam, and downstream of the dam at 19th Street). Results from the sampling event were reported in Appendix VI of the Elmendorf Lake Watershed Water Quality Study (Baker, 2011). Table 5.2 summarizes the results from the grab sampling event, which occurred four days following a precipitation event. Several trends are worth noting:

- Biochemical oxygen demand (BOD) decreased along the length of the lake, indicating the demand was met in the upstream portion of the lake. Dissolved oxygen concentrations were highest at Commerce Street (9 mg/L) and decreased to 4.4 mg/L at the dam. The dissolved oxygen concentration was higher in Apache Creek, below the dam, likely reflecting the impact of aeration caused by flow over the dam weir.

- E. coli concentrations were slightly lower at the dam, potentially reflecting the impact of particle settling on the bacterial concentrations in the water column (i.e., aqueous phase).

Parameter	Commerce St.	24th St.	At the Island(1)	Above the Dam	19th Street
Ammonia, mg/L as Nitrogen	< 0.10	< 0.10	< 0.10	0.126	0.127
Biochemical Oxygen Demand – 5 Days, mg/L	6.0	5.0	< 2.0	2.0	2.0
Chloride, mg/L	8.3	7.5	7.7	5.3	5.4
Chlorophyll a, µg/L	66	61	27	9	14
Field Dissolved Orthophosphate, mg/L	0.031	0.046	0.052	0.072	0.066
E. Coli, MPN/100mL	1100	3400	2400	1700	870
Field Conductivity, µS/cm	249	240	244	210	200
Field Dissolved Oxygen, mg/L	9.0	8.4	5.0	4.4	11
Field pH, S.U.	8.6	8.5	7.8	7.8	9.0
Field Water Temperature, °C	28	28	27	25	27
Nitrate, mg/L as N	0.18	0.26	0.26	0.33	0.19
Nitrite, mg/L as N	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Secchi Depth, m	0.27	0.29	0.32	0.22	0.29
Sulfate, mg/L	12	11	11	7.6	7.5
Total Kjeldahl Nitrogen, mg/L	1.0	0.92	0.87	0.61	0.59
Total Organic Carbon, mg/L	3.9	3.8	3.9	4.0	3.9
Total Phosphorus, mg/L	0.14	0.15	0.13	0.14	0.14
Total Suspended Solids, mg/L	21	22	22	16	17

Table 5.2: SARA Water Quality Data for October 8, 2009 (Source: Appendix VI of the Elmendorf Lake Watershed Water Quality Study)

Figure 5.2 shows a time-series plot of dissolved oxygen concentrations measured 13 meters downstream of 24th Street between January 2006 and June 2007. The data show dissolved oxygen concentrations below the 5 mg/L State Standard for approximately 50% of the samples collected between May and November 2006. Depth profiling conducted on August 5, 2010 (Baker, 2011, Appendix VI) shows a thermocline in the lake, with anoxic conditions at a depth of 8 feet or more below the water surface.

Figure 5.3 shows a time-series plot of E. coli concentrations measured 13 meters downstream of 24th Street between January 2006 and June 2007. More than 50% of the samples had concentrations above the 126 MPN/100 mL State Standard for contact recreation, with several samples showing concentrations several orders of magnitude above the standard.

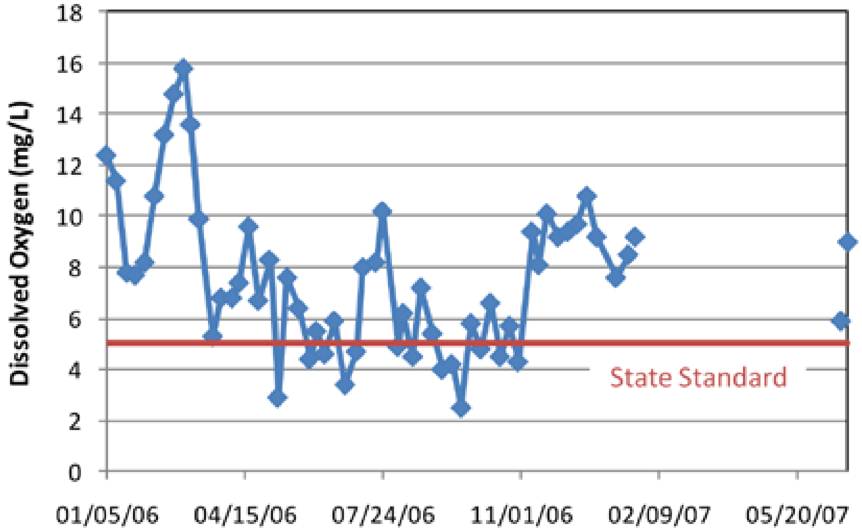


Figure 5.2: Dissolved Oxygen Concentrations Measured at Elmendorf Lake 13 Meters Downstream from 24th Street

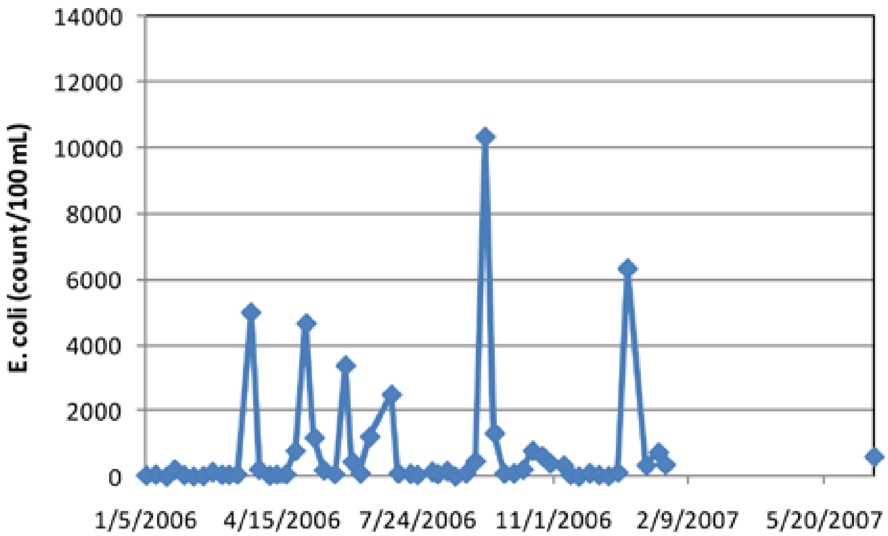


Figure 5.3: E. Coli Concentrations Measured at Elmendorf Lake 13 Meters Downstream from 24th Street

5.3.2. Sediment Quality

Lake sediments can be both a sink and source of aqueous contamination. Sorption of inorganic and organic contaminants to sediment particles can lower the contaminant concentrations in the water, whereas contaminant desorption from sediments can be a source of contamination within lake water. Sediments were removed from Elmendorf Lake in 1974 as part of a U.S. Army Corps of Engineers project to improve the lake bottom conditions for potential corresponding improvements to water quality. Sediments have not been addressed in the lake since the 1974 project, resulting in accumulation of up to 12 feet of sediments at certain cross sections (Arias Jr., 2010). The accumulation of these lake sediments appears to be causing the following water quality issues:

- Low dissolved oxygen,
- High turbidity during rain events due to sediment re-suspension, and
- Potential adverse impacts to human health and benthic community populations.

Michael Baker Jr. Inc. conducted an analysis of sediment quality and had HVJ Associates perform sediment sampling in 2010. Sediment sampling and analytical chemistry tests of the lake sediment were conducted to aid in determining the potential risk posed by the sediment to human health and the ecology of the lake, as well as to determine any potential beneficial uses of the sediment and its proper classification (under Texas rules and regulations) for disposal in a landfill. The analytical chemistry results from this sediment sampling indicated that detected levels of various compounds eliminate the possibility of using this material in beneficial uses like land application on pasture or crop land. Baker (2010a) determined that this material must be disposed of at a landfill as a waste, and dredging bid documents were developed according to this requirement.

The Texas Commission on Environmental Quality (TCEQ) has published the Texas Risk Reduction Program (TRRP) rule to establish response action requirements for the corrective action program areas of TCEQ. The TRRP has established Tier 1 protective concentration levels (PCLs) for chemicals in environmental media (e.g. soil groundwater and sediments) for both human and ecological receptors. These PCLs are used as screening tools to evaluate in-situ sediment quality. In addition, Reactivity, Corrosivity and Ignitibility (RCI) tests were conducted to determine acceptable waste classification disposal options for the dredged material.

The results of the sediment sampling were compared to the more stringent of the human health and ecological screening levels as contained in the TRRP by the TCEQ, which incorporates conservative assumptions for exposure levels (e.g., assuming recreational use with a high-end estimate of exposure). As discussed in more detail below, some semi-volatile compounds were detected at levels that indicate the possibility of causing adverse impacts to human health. The identified semi-volatile compounds were: benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene. Semi-volatile compounds, metals and pesticides were detected at levels that indicate the possibility of causing adverse impacts to the ecological community. These compounds were found at different concentrations at different sampling locations with the highest concentrations detected at sample location B-15 generally posing the highest potential for adverse impacts (Figure 5.1).

Based on the sediment analysis, the results do not indicate a need to remove the sediments to reduce human or ecological exposure to the identified semi-volatile compounds:

- Only 3 of 34 analyzed contaminants were detected in the samples at concentrations above the human health sediment screening values. The screening values were only exceeded in one of the 11 sampling sites.

- The screening level is based on ingestion of or dermal contact with the sediment (not the lake water itself) and assumes an exposure frequency of 39 days per year and exposed skin surface area of forearms, hands, lower legs, feet, and face (TCEQ, 2007).

Dredging could provide benefits in terms of restoring lake volume, reducing particle re-suspension during rain events, and improving dissolved oxygen concentrations, if the sediment material is exerting an oxygen demand.

It is recommended that inorganic (e.g., metals) and organic (e.g., semi-volatiles and pesticides) loading to the lake could be reduced through stormwater BMPs to minimize contaminant accumulation over time and potential long-term impacts to the aquatic life community.

5.3.3. Summary of Key Water Quality Issues

Based on a review of available water quality data, sediment data and past studies, the primary water quality concerns for Elmendorf Lake and Segment AP-1 are:

- Dissolved oxygen concentrations below the State Standard during certain seasons and/or rainfall events with impacts to aquatic life, leading to fish kills in extreme cases.

- E. coli concentrations several orders of magnitude above the State Standard for contact recreation. While E. coli itself does not pose a health concern, it is used as an indicator organism for the presence of pathogens in water.

- Sediment accumulation in the lake leading to reports of high turbidity during rain events and exacerbating anoxic conditions.

Additional concerns include nutrient concentrations above the State nutrient screening criteria and TOC concentrations exceeding 10 mg/L, both of which can exacerbate eutrophic conditions. Concentrations of certain synthetic organic compounds in the sediments are above the TCEQ health screening levels, but do not currently present an immediate health concern. Aesthetic concerns include accumulation of trash & debris following rain events and adverse odors, likely due to growth of blue-green algae and/or anoxic conditions in the lake.

5.4 Options to Improve Water Quality

SARA and Bexar County have identified lake dredging as one of the potential projects to restore and improve conditions in AP-1. Recognizing the high cost and short-term benefit of dredging unless upstream stormwater BMPs are implemented, additional strategies to address water quality concerns were also reviewed. Specifically, three technologies to increase dissolved oxygen concentrations in the lake were evaluated:

- Aeration fountains, potentially installed in conjunction with air diffusers
- SolarBee mixers
- Side stream super-saturation

These three aeration technologies were selected because they represent a wide range of the systems available to aerate a reservoir. Specifically, they represent the use of aeration fountains or mixers that rely on ambient air as the oxygen supply compared to the use of side stream super-saturation that relies on high purity oxygen to aerate the water. A more comprehensive review of the technologies available on the market is recommended if SARA or other entities elect to pursue implementation of an aeration system to improve water quality in Elmendorf Lake. For example, a request for information (RFI) could be issued, including questions regarding vendor experience for similar applications and more refined costs for application of the system at Elmendorf Lake.

Strategies to reduce E. coli concentrations, sediment loading and trash & debris are discussed in other sections of this report as stormwater BMPs that could be adopted within AP-1. In addition, potential opportunities to reduce the cost of dredging are explored in Section 5.4.5.

5.4.1. Aeration Fountain

Aeration fountains can be used to increase the dissolved oxygen concentration near the lake surface, while providing an aesthetic impact to the lake. Aeration fountains provided by Kasco Marine ("Kasco") (www.kascomarine.com) were reviewed; however, additional vendors could be considered if the technology were evaluated further for implementation at Elmendorf Lake.

Kasco uses a combination of an aerating fountain coupled with air diffusers to increase the dissolved oxygen content of the area of influence in an aesthetically-pleasing display. Kasco's largest aeration fountain would be required for Elmendorf Lake. The 5.1VFX (Figure 5.4) can supply up to 10 pounds (lbs) of oxygen per hour to a seven foot depth and an estimated 3-acre radial area with a 5 horsepower (hp) power supply. Critical design considerations for the aeration include required supply of single phase power within 300 to 400 feet of where the aeration is installed.

The aeration fountains would be expected to increase the dissolved oxygen concentration near the lake surface with potential reduction in algal growth (Table 3). Based on an aerial image of the lake, Kasco indicated that ten (10) of the 5.1VFX units would be required to aerate the entire lake. Upon assessment of the lake dimensions, Kasco recommended a combination of fountains (for display) and diffused aeration (Robust-Aire Aquatic Aeration Systems), to supply dissolved oxygen to the lake. Kasco's diffusers are a similar concept to line diffusers supplied by Mobley Engineers (discussed below, Section 5.4.3), with the exception that the Kasco Marine diffusers use ambient air as the oxygen supply in contrast to the use of high purity oxygen in the Mobley Engineering design.

Figure 5.4: Kasco Aeration Fountain (Source: www.kascomarine.com)

5.4.2. SolarBee Mixers

SolarBee Mixers (Figure 5.5) are floating solar-powered pumping systems that draw water from the lower depths of a reservoir and spread it over the surface. This mixing action utilizes the surface area of the reservoir to oxygenate the water, which can prevent the release of metals and other constituents from the sediments. Anoxic water is drawn out of the hypolimnion layer and replaced with fresh oxygenated water.

Figure 5.5: Diagram and Image of SolarBee Mixer

SolarBee Mixers can be used to add up to 200 to 300 lbs of oxygen per acre per day, preventing fish kills and helping prevent the growth of blue-green algae that can impart adverse odors to water (Table 3). Benefits of SolarBee Mixers include:

- A low profile (minimal noise, or disturbance to lake recreation).
- Use of solar-power (eliminates the need for electrical power supply).
- Mixers can be easily removed for dredging or lake activities.

Initial facility sizing and cost information developed by SolarBee is provided in Attachment 2. SolarBee recommends installation of three (3) mixers to control algal growth and increase dissolved oxygen in the water column. Figure 5.6 illustrates the proposed locations of the mixers. SolarBee expects that the three mixers will be adequate, but propose two additional units if the three initial units prove inadequate to meet water quality goals in the lake. SolarBee provides both a purchasing and a leasing option (Attachment 2).

Figure 5.6: Proposed Locations of SolarBee Mixers (Source of satellite image: Google Earth)

5.4.3. Side Stream Super-Saturation

Side stream super-saturation systems (such as supplied by Mobley Engineering) draws the coldest water from the lake (e.g., drawing water from the deepest portion of the reservoir, adds oxygen, and then distributes the oxygenated water back into the reservoir. The colder water sinks to the bottom of the reservoir, supplying oxygen to the hypolimnium during transport.

The system consists of:

- Piping to provide contact time and mixing to dissolve the oxygen gas bubbles.
- Below surface diffuser and nozzles for mixing.
- Oxygen supply facility with truck access.

Use of high purity oxygen enables introduction of up to 100 lbs per acre per day to a reservoir. Based on communication with Mobley Engineering, the system could be temporarily moved to the side if dredging is conducted in the future. Mobley Engineers also supplies a line diffuser system that applies high purity oxygen in situ. However, side stream super-saturation is recommended rather than line diffusers based on the dimensions of Elmendorf Lake (i.e., maximum effective depth less than 20 feet even at 1974 as-built conditions).

5.4.4. Dredging of Contaminated Sediments

The dredging analysis conducted for SARA was reviewed to assess recommendations and compare it to the alternate strategies presented above. An approximate volume of 100,000 cubic yards (yd^3) of sediment would need to be removed to return the lake to near 1974 as-built conditions (Baker, 2010b). The approximate volume of sediment to be removed and sediment sampling results were incorporated by SARA into a Bid Package that included other detailed engineering information (such as potential waste classification of the various sections of sediment). The Bid Package was used to solicit potential dredging, material handling and disposal costs from dredging companies. Bids received from several respondents ranged from approximately $7.5 million to $8.5 million in 2010 dollars. The Bid Package and the responses to the questions posed by potential bidders prior to submittal were comprehensive and thorough in scope and detail. The bids that were received appear to be consistent with general industry practices. The costs seem reasonable given the present level of information available for review by the Pirnie team.

Based on the Bid Package, the volume of material to be removed was generally divided as follows: (i) 2/3 to be disposed of as (Texas) Class 2 waste (± 68K yd^3); and (ii) 1/3 (± 32K yd^3) to be disposed of as Class 1 waste. The waste classification is based on definitions provided in Texas Administrative Code, 30 TAC 335.503, for disposal of non-hazardous waste. Concentrations of total petroleum hydrocarbons (TPH) in sediment from Sample B-15 above the maximum concentration listed in 30 TAC 335.521(a)(1) define sediments from that location as Class 1 wastes. Sediments collected from the other sample locations in Elmendorf Lake are defined as Class 2 wastes under 30 TAC 335.306.

Disposal of the Type 1 waste was estimated to cost approximately $40/yd^3$ and Type 2 waste disposal was estimated to cost approximately $20/yd^3$. It appears that the Type I waste volume was calculated based upon the results centered on sample B-15, and extended from approximately sample B-10 to sample B-17 (Figure 5.1). The results of these samples do not appear to be significantly different from the other sample results. Further, the Class 1 Waste Limit for Lead included in Table 1 seems to be unreasonably low at 1.5 mg/Kg.

Therefore, further delineation sampling and analysis around the suspected "hot-spots" such as sample site B-15 could lead to potential project cost savings by reducing the volume of material requiring Type I disposal. This delineation sampling could be performed before the dredging project is implemented to achieve a higher level of cost containment prior to contract execution. Since it appears that a testing protocol during removal is required in the Bid Package, the testing could be performed during the removal action and any cost saving could be passed along as part of the conditions of the contract. Since the results from the B-15 site are not that significantly higher than those from the other locations, there is a reasonable chance for some level of reduction of the higher waste classification volume. Finally, these disposal figures appear to be estimates. Malcolm Pirnie/ARCADIS recommends that SARA communicate with landfills that will potentially accept this material for firmer costs. Based upon a number of factors such as total volume, ability to segregate, transportation method and need, the landfill may provide lower costs than originally estimated.

For dredging projects such as Elmendorf Lake, sediment removal should be predicated upon elimination or control of pollution sources during the project. Without controlling or eliminating sources of contamination, the area is likely to be "re-contaminated". It is not always practical or cost-effective to eliminate all sources of potential contamination – especially those from non-point sources – but such efforts should be coordinated. In this particular case, it is still unclear if the chemical profile of the detected constituents is having a significant, direct impact on the water quality of Lake Elmendorf or if there are other factors contributing in greater detail to degradation of the water quality. Certainly, the removal of this volume of material will significantly help in reducing re-suspension of particles in the water column, as well as providing aesthetic improvements. However, without the implementation of upstream BMPs, dredging will only produce short-term improvements.

5.4.5. Alternatives Evaluation

Table 5.3 summarizes the advantages and disadvantages of the strategies evaluated to improve lake water quality in Elmendorf Lake and Apache Creek, including strategies considered during development of the Conceptual Plan. The three technologies reviewed with the specific goal of increasing the dissolved oxygen content in the lake are significantly less expensive (based on Level 5 Association for Advancement of Cost Engineering [AACE] capital costs) than dredging and implementing the necessary stormwater BMPs. However, dredging and stormwater BMPs achieve additional goals that would not be met through installation of aeration fountains, SolarBee mixers, or side stream super-saturation.

Table 5.4 summarizes the water quality issues addressed by each mitigation strategy. All of the strategies can increase the dissolved oxygen content of the water, although to varying degrees. Aeration fountains, SolarBee mixers, or side stream super-saturation could be implemented in the near-term to increase dissolved oxygen in the water column, reduce algal growth and associated adverse odors, and improve aquatic life. These technologies could continue to be used to augment the dissolved oxygen content in the reservoir in addition to dredging if sediments are removed in the future. Dredging could improve the dissolved oxygen content in two ways: (1) by removing any oxygen demand associated with the sediments, and (2) increasing the depth below the water surface of the anoxic zone and hypolimnium during lake stratification. However, dredging will only have a short-term impact on dissolved oxygen and other water quality issues if upstream and shoreline BMPs are not initiated to reduce sediment loading to the lake. Stormwater BMPs could improve dissolved oxygen in the lake by reducing constituents that impart an oxygen demand.

Mitigation Strategy	Advantages	Disadvantages	Capital Costs (2011 dollars)(1)
Aeration Fountain	• Visual display becomes an amenity for the lake • 80 lbs O_2 per acre-day to a maximum 7 ft depth	• Less oxygen to the lake compared to other options) • Could enhance lake evaporation • Requires electrical power supply at multiple locations along the lake shore, depending on number and placement of fountains • Annual power cost	$150,000 for 10 fountains(2) Costs could be lower if a combination of fountains and diffusers are installed.
SolarBee Mixers	• 200 – 300 lbs O_2 per acre-day • "Green" technlology using solar power to operate mixers • Low profile (noise, etc.) • Leasing is a financing option	• Less visually-stimulating than aeration fountain	$200,000(3)
Side Stream Super-Saturation	• 100 lbs O_2 per acre-day	• Noise from oxygen generator • Annual power cost • Less visually-stimulating than aeration fountain • Could enhance contaminant desorption from the sediments	$600,000(4)
Dredging - Partial	• PAH and semi-volatiles removed	• Sediments could quickly re-accumulate, if dredging is not coupled with BMPs • Expensive	$7.6M
Dredging to 1974 as-built conditions	• PAH and semi-volatiles removed	• Sediments could quickly re-accumulate, if dredging is not coupled with BMPs • Expensive	$10.6M
Stormwater BMPs – 5-year, near-lake plan (per Baker, 2010b)	• Long-term solution to reducing contaminant loading to the lake • Addresses multiple contaminants	• Could take up to 5 years for benefits to accrue (Baker, 2010b)	$1.3 to 1.7M
Stormwater BMPs – 10-year (per Baker, 2010b)	• Long-term solution to reducing contaminant loading to the lake • Addresses multiple contaminants	• Could take up to a decade for benefits to accrue (Baker, 2010b)	$11.4 to 15.2M

Table 5.3: Summary of Advantages, Disadvantages and Costs for Water Quality Strategies

(1) Conceptual level costs, AACE Level 5, with an expected accuracy range of +50% and -30%. ENR 20-Cities Construction Cost Indices were used to adjust costs from Baker (2010b) to 2011 dollars.
(2) Assuming a 400-ft cord is requested, each unit has a quoted cost of $9,500. A 30% adjustment was included for construction of electrical facilities to supply power. A 30% contingency was applied for additional site work, taxes, etc.
(3) Based on SolarBee quote (Attachment 2) to purchase equipment and applying 30% contingency.
(4) Based on quote from Mobley Engineers covering equipment and construction.

The aeration fountain, SolarBee mixers, and side stream super-saturation provide different amounts of oxygen to the water column and to different depths. For example, SolarBee mixers focus on aerating the epilimnium (i.e., portion of the water column above the thermocline), whereas diffusers (e.g., supplied by Kasco Marine, or an alternate vendor, in conjunction with aeration fountains) would be installed at the bottom of the lake, supplying oxygen directly to the hypolimnium. Each approach has its own advantages/disadvantages, depending on the water quality goals for the reservoir (i.e., maintaining or eliminating lake stratification). A limnologist could be engaged as a next step towards selecting and implementing a technology to add dissolved oxygen to the lake to assess the best approach to improve (and minimize disruptions to) aquatic life and general lake ecology.

A combination of dredging and implementation of stormwater BMPs is required to reduce total suspended solids (TSS) and turbidity in the water following rain events. Stormwater BMPs provide a more effective long-term solution to solids loading in the reservoir.

Table 5.4 illustrates the importance of implementing stormwater BMPs over the long-term. None of the other strategies considered for Elmendorf Lake address the full suite of identified water quality issues. While dredging could remove inorganic and organic contaminants that may have already accumulated in the sediments, stormwater BMPs are required to reduce further loading of these compounds (e.g., polyaromatic hydrocarbons (PAHs), polychlorinated bi-phenols (PCBs) and other synthetic-organic compounds) that can be present in urban stormwater runoff.

Water Quality Issue	Mitigation Strategy					
	Aeration Fountain	SolarBee Mixer	Side Stream Super-Saturation	Dredging - Partial	Dredging – to 1974 as-built	Stormwater BMPs
Dissolved Oxygen	L	M	H	L	M	L
Turbidity/TSS				L	M	M
Nutrients						L
Pathogen loading						L
Algae / associated T&O	M	M	M	L	M	M
Metals		L	L	L	L	
Synthetic organic compounds				L	L	M
Trash & Debris						M

Potential Benefit: L - Low; M - Moderate; H - High

Table 5.4: Ability of Strategies to Address Specific Water Quality Issues in Elmendorf Lake

5.5 Recommendations

The water quality priorities must be carefully considered to select the most cost-effective approach for Elmendorf Lake and Apache Creek. Based on evaluation of historical water quality data, one of the most pressing concerns related to lake water quality is seasonal occurrence of low dissolved oxygen concentrations in the lake, which can be detrimental to aquatic life and can reduce overall lake water quality. Dissolved oxygen in the lake could be increased in the short term at a relatively low cost by implementing one of various technologies on the market to add oxygen to the water. The installed system could continue to be used following implementation of stormwater BMPs and eventual lake dredging. Selection and implementation of a technology to oxygenate the lake should consist of the following steps:

- Conduct a more comprehensive review of the technologies available to add oxygen to the water column. A qualified limnologist could be involved in the evaluation to assess the best approach to improve (and minimize disruptions to) aquatic life and general lake ecology. A Request for Information (RFI) could be issued to vendors to obtain information on experience achieving similar goals at other lakes and more refined cost estimates.

- Select and implement the preferred system(s) to oxygenate the lake.

- Monitor water quality, specifically, dissolved oxygen at various depths and throughout the lake, to assess performance of the system.

Stormwater BMPs discussed in Section 6 should be implemented for near-term reduction in trash & debris, nutrients, and TSS loading to the lake. Stormwater BMPS outlined in other SARA reports should also be considered to address additional water quality goals. Over the long term, BMPs should be incorporated to address:

- Semi-volatile compounds (e.g., PAHs), PCBs, and other synthetic organic compounds from storm water runoff.

- Wise use of herbicides and pesticides in the watershed and especially right around the lake—including the City Parks and Recreation Department and OLLU.

- Bacteria and pathogenic microorganisms from pet wastes. For example providing additional “mutt mitt” stations along the pedestrian trail and extending upstream of Elmendorf Lake.

- Nutrients and pathogens from any failure points within nearby sewer collection systems.

- Total suspended solids from construction activities and storm water runoff.

Dredging to partially or fully restore the lake volume should be re-evaluated following implementation of initial stormwater BMPs, particularly if dissolved oxygen concentrations are increased in the near term through an oxygenation system. If the dredging project is implemented, there may be opportunities to reduce costs by:

1. Further delineating the sediment quality around the suspected "hot-spots" such as sample site B-15. This delineation sampling could be performed pre-dredging to achieve a higher level of cost containment prior to contract execution, or the testing could be performed during the removal action and any cost saving passed along as part of the conditions of the contract.

2. Communicating with the specific landfills that will potentially accept this material for firmer costs. Based upon a number of factors such as total volume, ability to segregate, transportation method and needs, the landfill may provide lower costs than originally estimated.

Water quality data are limited for Elmendorf Lake and Apache Creek, specifically related to concentrations of synthetic organic compounds (e.g., herbicides and pesticides), dissolved oxygen concentrations at various depths of the lake and at different seasons, and average (non-peak) flow rates through the lake. Dissolved oxygen profiles and flow rate data are required to carefully design an oxygenation system. In addition to augmenting SARA's existing water quality sampling program, water quality sampling could be adopted as an educational and community involvement activity conducted through the Environmental Science Center proposed in Section 7.

Peak E. coli concentrations are order(s) of magnitude above the standard for contact recreation. Although the lake is not routinely used for contact recreation, residents or visitors to the lake could be exposed to pathogens if they engage in activities in the water. A study evaluating the source of pathogens is recommended to identify optimal approaches to reduce loading. Additional stormwater BMPs and continued maintenance of wastewater collection systems would be expected to reduce pathogen loading.

5.6 References

Arias Jr., R. 2010. Elmendorf Lake Dredging Project, CE6103 Semester Project.

Baker, 2011. Elmendorf Lake Watershed Water Quality Study, prepared for San Antonio River Authority (SARA) by Michael J. Baker, Inc., June 2011.

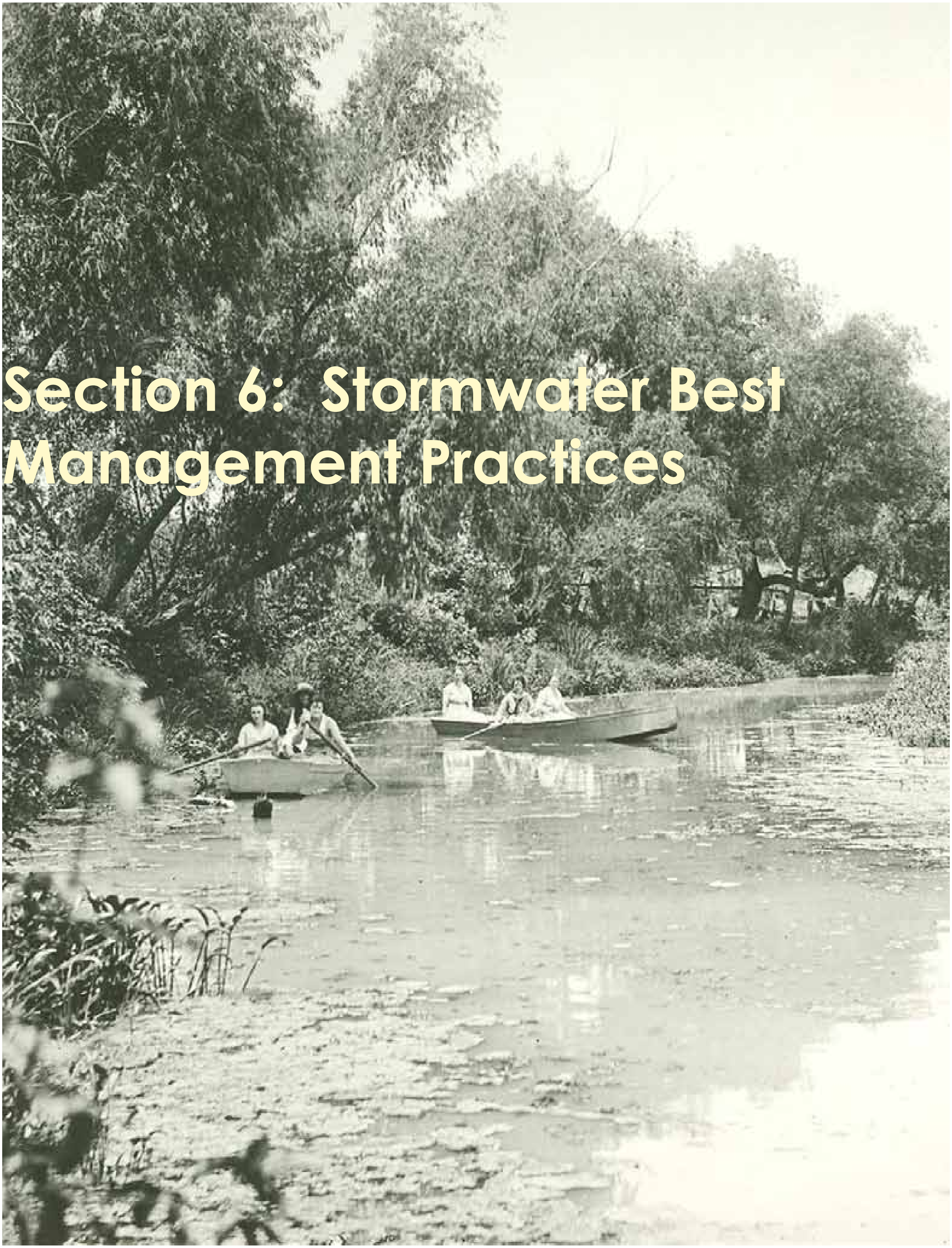
Baker, 2010a. Sediment Quality Assessment Memorandum Elmendorf Lake, San Antonio, TX, prepared for SARA by Michael J. Baker, Inc., Aug. 31, 2010.

Baker, 2010b. Elmendorf Lake Water Quality and Dredging Advisory Memorandum, San Antonio, TX, prepared for SARA by Michael J. Baker, Inc., September 9, 2010.

Baker, 2010c. Elmendorf Lake Water Quality and Dredging Memorandum, San Antonio, TX, prepared for SARA by Michael J. Baker, Inc., August 31, 2010.

Pape-Dawson, 2011. Upper San Antonio River Watershed Master Plan, draft final report prepared for SARA by Pape-Dawson Engineers, June 2011.

Section 6: Stormwater Best Management Practices



The Westside Creeks /Elmendorf Lake visioning process is part of the implementation phase of the Westside Creeks Restoration Project which was initiated in 2008 by SARA with a mission to develop concepts for the restoration of the Alazán, Apache, Martínez and San Pedro Creeks and to specifically improve water quality in the Westside Creeks.

The purpose of this memorandum is to recommend best management practices (BMPs) that can be employed to improve water quality and aesthetics in and around Elmendorf Lake. According to the Elmendorf Lake Watershed Water Quality Study (the "Study"), focus should be placed on installing BMPs near the lake. This report describes the methodology used to characterize the extent of effect on the Lake by various land use areas in the watershed, and it describes the types of BMPs recommended to manage storm water runoff and improve its quality. This report also combines the above-mentioned information with the development of potential BMP plans for improving water quality. The report does not specify what BMPs might be used or at which property they are to be applied.

The Study states, "Field visits find that debris and trash are swept by storm water runoff into nearby concrete channels rather than collected by structural or non-structural practices." It should be noted that gross solids are not listed as a pollutant of concern in the Study and therefore BMPs such as modifications to the City of San Antonio's (the "City") street sweeping program and a public awareness focus on litter control are not detailed as a recommended BMP. As seen in Figure 6.1 below, it is apparent that gross solids are a concern for the Lake which has an effect on water quality and aesthetics, a noted concern for the stakeholders involved.

6.1 Source Controls

No single BMP provides a comprehensive solution for floatables control in storm water runoff. Most municipalities that are addressing trash and debris in urban runoff are using a combination of structural controls and institutional controls. Street sweeping and public education are the most common non-structural or institutional BMPs for trash and floatables controls. Structural controls at storm water outfalls and along tributary streams are effective management practices to prevent gross solids from entering the Lake. These controls can be characterized as source controls.

Figure 6.1: Trash Along the Shoreline at Elmendorf Lake

6.1.1 Public Education

A study performed by Los Angeles County in 1997 concluded that the best mode for conveying anti-littering messages is through mass media advertising, and brochures, leaflets and flyers should be avoided as they have a high likelihood of being littered. It is perhaps a good approach to try reaching citizens while they are in their cars, which is when much littering occurs. This can be accomplished through billboards in the area, Our Lady of the Lake University campus television (KLFN), and bus advertising. SARA should develop litter education campaigns targeted at businesses and households (over 85% of the watershed is developed, being comprised of residential, commercial, and areas containing highways and other paved roads) informing them how streets, storm water drainage systems, rivers and lakes are interconnected and how daily activities affect storm water quality.

Also, upgraded litter collection operations can be developed with a better placement and design of litter bins and more frequent collection of litter. The placement of additional trash receptacles in the public areas around the Lake and in the parks can also help reduce debris in the Lake.

Cost effectiveness may vary depending on the extent of program implementation. It is believed that public education is effective for trash control. To date, the effectiveness of pollution prevention programs designed to educate residents on storm water pollution prevention practices has not been well documented. However, the need for such programs is evident.

6.1.2 Street Sweeping

Modifications to the City's regular sweeping program will further reduce the amount of material accumulating in catch basins and storm water facilities, reducing the amount of silt, debris and gross solids that will accumulate in the Lake. Along with silt and trash, total suspended solids (TSS), hydrocarbons, excessive nutrients such as phosphorus and nitrogen, and other chemicals from the roadside are removed by street sweeping. Increased sweeping near West Commerce Street in the Z5b (Zarzamora Creek) subwatershed will decrease the amount of trash and debris that is transported via storm water to the Lake. See the Figure 6.2.

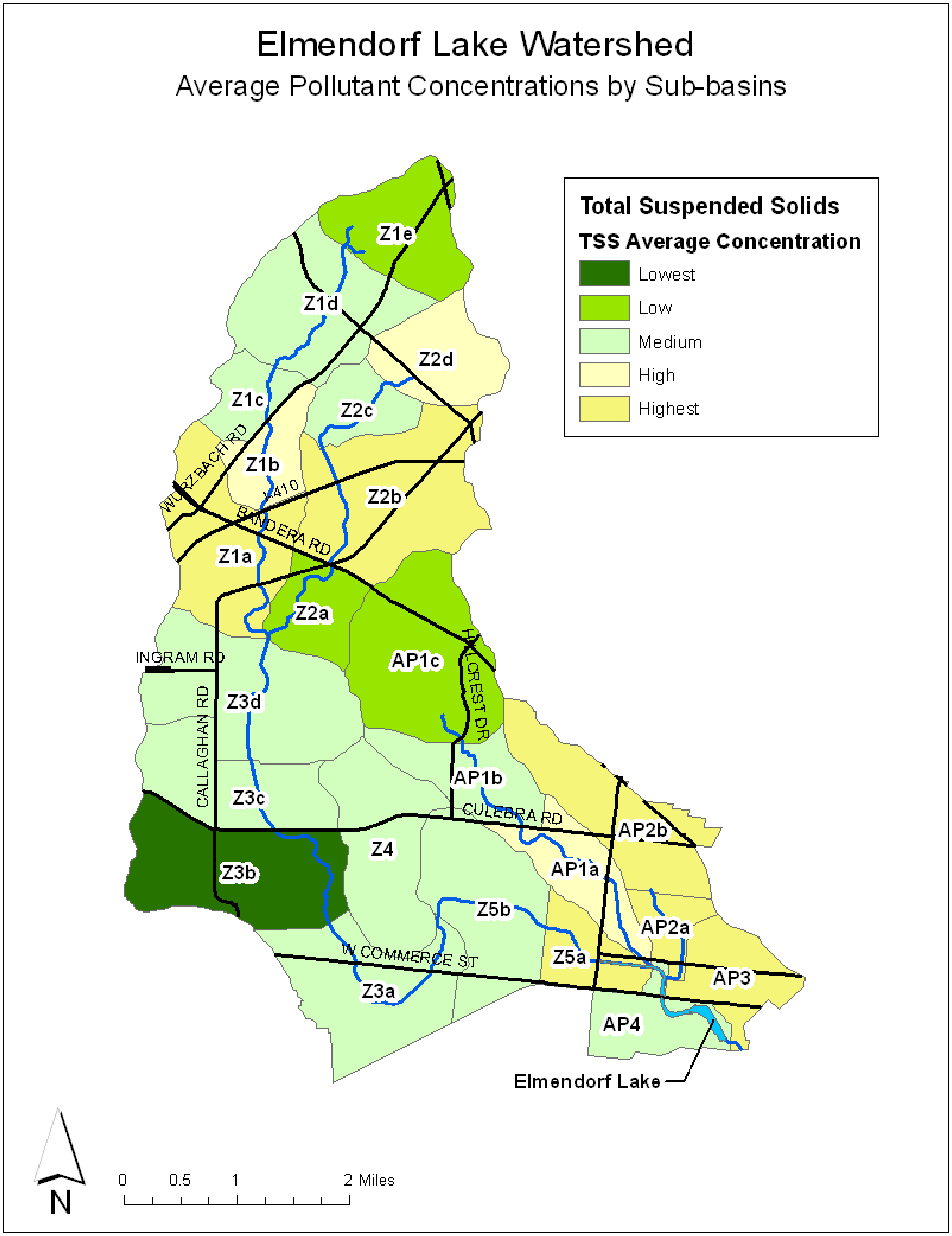


Figure 6.2: Average TSS Concentrations by Sub-Watershed

Source: Elmendorf Lake Watershed Water Quality Study, San Antonio River Authority

6.2 Structural Controls

Even though there is a maintenance requirement, structural controls can prove effective in the removal of gross solids from storm water runoff. In additional to the removal of solids, silt and other debris can also be removed from storm water runoff, which will offer reductions in total suspended solids, total phosphorus and total nitrogen concentrations.

On the campus of Our Lady of the Lake University (OLLU), there is a parking lot east of 24th Street on the southern shore of the Lake. This parking lot has at least two outfalls that discharge storm water runoff directly into the Lake, as seen in Figure 6.3. It is recommended that structural controls, such as the Coanda Hydroscreens (See Figure 6.5) be retrofitted to these concrete flumes to capture debris that is being discharged from this parking lot.

In addition to structural controls to treat the runoff from the parking lot at the outfalls, low impact development practices can be retrofitted onto this parking lot and this can reduce the amount of runoff from the parking lot, thereby reducing the amount of pollutant load that is discharged to Emendorf Lake. Bioretention is well suited for urban retrofit projects because they are easily integrated into the existing infrastructure such as this parking lot, and they are they don't require a lot of land. Bioretention areas function as soil and plant based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. These bioretention areas can be inserted into the parking lot perimeter and between parking lot stalls, as seen in Figure 6.4.

Figure 6.3: OLLU Parking Lot


Figure 6.4: Example of Bioretention Retrofit in a Parking Lot (www.flickriver.com)

Figure 6.5: Elmendorf Lake and Tributaries

Retrofitting structural controls at the confluence with Apache Creek and Bandera Branch is also recommended for consideration to control the amount of trash and debris that enters the Lake. As seen in Figure 6.2 these tributaries have high levels of TSS contribution in the watershed. According to the Study, the areas of the highest pollutant concentrations are found in the Loop 410 corridor and in the surrounding areas of the Lake. Figure 6.5 is an illustration of the Coanda Hydroscreens retrofitted into concrete stream channels.

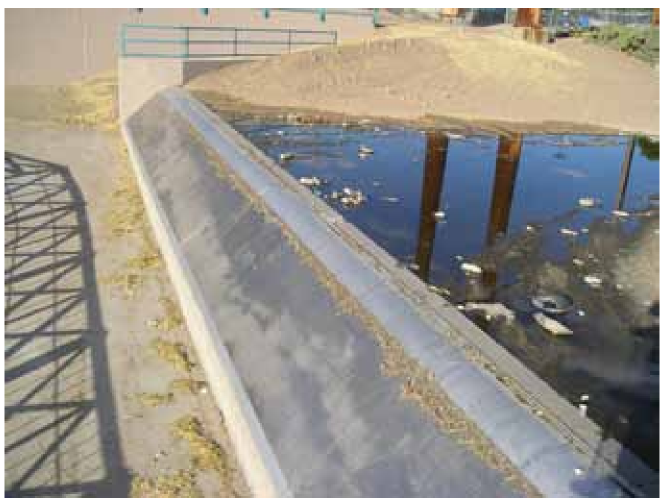


Figure 6.6: Channel Screen

Source: http://www.coanda.com/products/channelscreen.htm

The following paragraphs provide information on additional storm water BMPs that can be used to reduce trash and debris in the Apache Creek watershed.

6.3 Other Municipal Operations

Construction Debris

Control construction activity by ensuring that site management plans are in place to prevent contaminant spills and rubble from reaching the drainage system. This activity can be coordinated with MS4 NPDES programs in Bexar County.

Industrial and High Risk Commercial Activities

Use the industrial and high risk commercial inspection program to conduct business surveys to determine the nature and extent of activities likely to generate litter that can reach the storm water system. This could lead to, among other things, encouraging manufacturers to move to more environmentally-friendly packaging or to charge deposits on containers to encourage their return.

Illegal Dumping Control

Coordinated efforts among municipal departments and local governments can be a no cost BMP for trash and floatables control in the Lake watershed. Through an innovative program to coordinate existing efforts of the various MS4 NPDES Permits, the City's Departments of Public Works and other relevant departments and agencies can improve the ability to control floatables and possibly other pollutants in the watershed. This type of program can develop a framework for cooperation between previously uncoordinated efforts of City departments and, as such, represents a true best management practice. In short, the program can take advantage of one city department's field presence to garner and transmit valuable information to another city department for enforcement and cleanup.

For an example, agencies and/or departments conducting routine water quality monitoring can look for illegal dumping activities along the waterways, and if any such activities are noticed, the observing employees can notify the proper department. Best of all, the program is operating at virtually no additional cost to the City. Similar programs have been established to control floatables in New York City, and the information collected formed a valuable resource for the city to monitor and reduce illegal dumping activity. In its first few months, the program was directly responsible for initiating action that is anticipated to reduce the number of illegal dumping sites by 15 percent.[1]

[1] Newman, Thomas L. and Robert Gaffoglio. A No Cost, Best Management Practice for Floatables Control in New York City. http://www.hydroqual.com/Papers/tnewman/03/p_tln_03.pdf

<u>In-stream and Municipal Infrastructure Trash Reduction Measures</u>

There are several other categories of structural BMPs that are being used to control floatables and trash, including:

- Catch basin opening covers.

Figure 6.7: Catch Basin Screen Cover

- Catch basin inserts.

Figure 6.8: Catch Basin Inserts

- Hydrodynamic separators/vortex separators/nutrient separating baffle boxes.

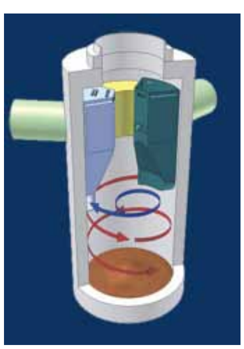


Figure 6.9: Hydrodynamic Separators

- End-of-pipe screening, basket and netting devices.


Figure 6.10: End-of-Pipe Screening

- Litter booms.


Figure 6.11: Litter Booms

Other controls can be placed within the storm water sewer system to capture pollutants at a particular point within the system, such as at a regulator diversion or a grit pit along an interceptor. Baffles, hydrodynamic separators and bar racks are some other examples. These are primarily used for solids separation in the storm water sewer system.

Since it is difficult to prevent all the litter from reaching the drainage system, the balance will probably have to be trapped and removed at the end of pipe or along the watercourse. Nets are most common end of pipe controls. End-of-pipe nets are installed directly at the end of the outfall pipe or on an apron extended from the outfall. Nets on the end of elevated outfall pipes are highly effective as long as velocities are not too high to damage the nets, but they are not as effective on closed level outfalls.

Boom controls are the most common trash traps in waterways, although booms may not be effective at high velocities. Nets and booms are most commonly used by municipalities to control the trash at the end-of-pipe or in the flowing streams. Containment booms are specially fabricated flotation structures with or without suspended curtains designed to capture buoyant materials. Booms typically are moored to a shoreline structure or to the bottom of the receiving water, and they skim floatables from the surface. Booms can be made of an elastomer or plastic and can include absorbent material to collect fats, oils, and grease. With proper maintenance, boom controls could be especially effective where Zarzamora Creek enters the Lake, and potentially at locations on Apache Creek. Some of the concerns that must be addressed are discussed below.

Boom materials and configurations vary widely but have limited uses, mainly at the head of a dead-end stream with quiescent conditions. Booms do not keep floatables from entering the watercourse. In fact, they use a portion of the watercourse for storage until cleaning can be completed. <u>Therefore, booms may exacerbate the aesthetic issues related to floatables, especially near the collection point.</u> Rough or fast-moving water can submerge a boom for a short period or damage it, allowing floatables to pass. Also, winds can disperse floatables back upstream, depositing them along the shoreline and making removal ineffective.

A 2-year pilot study of containment booms conducted for the City of New York Department of Environmental Protection Bureau of Engineering Design and Construction in Jamaica Bay indicated that the booms provided a retention efficiency of about 75%. After a rain event, collected materials can be removed using either a skimmer vessel or a land based vacuum truck. Booms require periodic maintenance to repair damaged or missing sections or to re-anchor at locations that have become unattached from their moorings. Much of the maintenance can be done by tying off one side of the boom to a long rope and pulling the boom over to the other side to perform maintenance.

However, at least a small boat will be necessary if the boom becomes completely severed or if pieces dislodge and have to be retrieved downstream.

Costs of installing and maintaining booms can vary widely. Booms moored to the shore can cost as little as $10,000 each, whereas a system attached to specially sunk permanent piles can cost more than $100,000 each.

6.4 In-reservoir Debris Removal Systems

Elmendorf Lake is not unique in having periodic problems with large debris getting into the reservoir. This debris can include large logs and portions of trees, dead animals, appliances and other items that come into the lake during high-flow and flood events.

Most river systems and reservoirs have some degree of problem with logs and debris following flood and high-water events. The problems often occur in situations where stream hydraulics create lower velocities, such as the upper end of reservoirs. Agencies such as the U.S. Army Corps of Engineers have been involved in “snagging” operations on major rivers such as the Mississippi since before the Civil War. The solutions are seldom easy or inexpensive because of the magnitude, size and weight of the material to be removed, the unique shapes and sizes, and the intermittent nature of these operations. It is difficult to organize for these types of operations, and the required equipment is normally unique and expensive.

Several Texas river authorities and water districts are involved in log-jamming and debris-removal operations. In rural areas, the debris is usually removed from the river bank or shore using heavy equipment such as a track-hoe, stacked with a bulldozer, and eventually burned or hauled to a landfill. When the debris has accumulated in more inaccessible locations, some type of snagging boat is used to push the debris or move it downstream to an appropriate location for removal.

Figures 6.12 and 6.13 below illustrate examples of such operations. In this case the shallow-draft, hydraulically powered snagging boat is designed in a catamaran shape so that a small track-hoe can reach logs positioned in between the two hulls. The boat was constructed in 2004 by Bollinger Shipyard in Houston, TX at a cost of approximately $300,000. Because of the intermittent nature of these operations, the track-hoe is only rented when the utility is engaged in log jam removal operations.

Figure 6.11: Log Jam Removal Boat.

Figure 6.12: Log Jam Removal Operations on the San Antonio River in Refugio County, TX.

Cost-Benefits of Trash Control BMPs

PRACTICE	EASE OF IMPLEMENTATION	COST	BENEFIT
Mid-drain Structural device retrofit	Not easy in many situations	H	H
Start-of-pipe structural device retrofit (e.g. catch basin opening screens and excluders)	Moderately easy in many situations	M	H
End-of-pipe structural device retrofit (e.g. trash racks, fabric mesh socks and wire screens)	Very easy in certain situations	M/L	H
Hydraulic disconnection and/or replacement of impervious surfaces	Disconnection: Moderately easy in some situations Repaving: Moderately easy for public areas	M	L/H
Street sweeping	Moderately easy	M	H
Adjustment of street sweeping routes; stricter enforcement of no-parking during street sweeping days; and, encouraging /sponsoring more public cleanup events.	Moderately easy	L	M
Open channel sweeping	Moderately easy	M/H	H
Performance-based open channel trash removal contracts	Easy	L	H
Private and public parking lot sweeping	Moderately difficult for private lots, moderately easy for public lots	M	H
Retrofit of catch basins on private parking lots	Moderately difficult	L/H	H
Increased or focused public education	Moderately easy	M	M
Dedicated hot line and response	Very easy	M	M
No-litter laws prohibiting certain products at recreational areas, such as cigarette butts, styrofoam cups, etc.	Moderately difficult	M	M
Product market-based reduction incentives and product substitution.	Moderately difficult	M	M
Sub-regional trash control facilities	Moderately easy in new development, difficult in developed areas	H	H

L-low; M-moderate; H-High (Adopted from County of Los Angeles Department of Public Works Technical Report on Trash Best Management Practices Aug. 5, 2004 Pages 16 &17)

Table 6.1: Trash Control BMPs Relative Ease of Implementation, Relative Cost and Relative Benefits

6.5 Effectiveness

While the ultimate goal of any sustainable BMP is to improve the quality of water bodies which receive stormwater, it can be very difficult to show the linkages between BMP implementation and changes in receiving water quality due to spatial and temporal variability in water quality parameters. Therefore, the measure of effectiveness of a single or combination of BMPs is typically dependent on the BMP and the level of change that the BMP is expected to make in water quality.

For BMPs designed to reduce or prevent trash and debris from entering water bodies, assessments can be conducted on the type BMP implemented. See Table 6.2. All BMPs can be considered and assessed at Level 1 which means documenting activities. Assessments at Levels 2 and 3, raising awareness and changing behavior respectively, are typical of public education and outreach efforts. Level 4 assessments correspond to reducing pollutant loads at the source and are a result of BMPs that prevent pollutants from entering the storm system. Effectiveness of treatment BMPs (in-system controls or end of pipe) results in a Level 5 outcome which is an improvement in water quality. Changes in receiving water quality (Level 6) are typically a measure of the effectiveness of an overall pollutant mitigation program, but instream trash collection can be assessed at this level because it immediately changes the quality of the receiving water with respect to trash.

With respect to the operation and maintenance of trash removal BMPs there are a few considerations that must be made. It is expected that municipal operations and most infrastructure BMPs would be installed, operated and maintained by the local government. If the local government requires a developer to install infrastructure BMPs or perform street sweeping in and around a commercial development for instance, an agreement would need to be executed between the municipality and the owner of the property to ensure that the BMP will be operated and maintained in to perpetuity by the owner of the property.

BMP Category	Most Applicable Effectiveness Assessment Outcome Levels					
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	Documenting Activities	Raising Awareness	Changing Behavior	Reducing Loads from Sources	Improving Runoff Quality	Protecting Receiving Water Quality
Infrastructure BMPs						
Racks and Screens	X				X	
Hydrodynamic Separators	X				X	
Litter Booms	X					X
Catch Basin Inserts	X				X	
Netting Devices	X				X	
Municipal Operations						
Street Sweeping	X			X		
Education and Outreach	X	X	X			
Regulations	X					

Table 6.2: BMP Implementation Effectiveness

6.6 Low Impact Development Practices

A trend in the U.S. since the early 1990's has been the effort to rebuild or preserve ecological functions and to create cumulative beneficial impacts, including pollutant removal, through a series of alternative stormwater management practices. This has become known as low impact development (LID). Compared to conventional stormwater management, LID consists of runoff volume reduction at the source using small, uniformly distributed decentralized controls. These controls can be used in residential and commercial applications as well as in transportation corridors as a more regional control.

The general principle of low impact development is to infiltrate stormwater into the ground to reduce the amount of runoff that results from developing an area that was previously undisturbed. Typical LID practices include: rain gardens, soil amendments, vegetated swales, permeable pavers, conservation development, disconnecting roof drains, minimizing imperviousness, bioretention and green roofs.

6.6.1 Bioretention Cells and Rain Gardens

A bioretention cell (strip or trench) is an engineered natural treatment system consisting of a slightly recessed landscaped area constructed with a specialized soil mixture, an aggregate base, an underdrain, and site appropriate plant materials that tolerate both moist and dry conditions. These practices are typically used in parking lots as islands, edges of paved areas, next to building clusters and in open spaces. They are suitable for new construction and retrofit projects.

Figure 6.13: Rain Garden (www.texaslid.org)

6.6.2 Soil Amendments and Aeration

Soil amendments increase the infiltration and water storage capabilities to reduce runoff from a site. Additionally, compost, lime, or organic materials alter the physical, chemical and biological characteristics of the soils to improve plant growth. Aeration of the soil can increase the storage, infiltration, and pollutant filtering capabilities of grassed areas.

6.6.3 Vegetated Swales

A vegetated or grassed swale is an area with dense vegetation that retains and filters the first flush of runoff from impervious surfaces. It is constructed downstream of a runoff source. After the soil-plant mixture below the channel becomes saturated, the swale acts as a conveyance structure to a bioretention cell, wetland, or infiltration area. Typical applications include edges of pavement, parking lot islands, open space or adjacent to buildings. These practices are easily retrofitted into existing buildings/open spaces.

6.6.4 Disconnecting Roof Drains

Downspouts can be disconnected from underdrains and the runoff directed to vegetated areas to reduce runoff volume, promote infiltration, and change runoff timing.

Figure 6.14: Vegetated Swale
(www.waterundergroundwordpress.com)

6.6.5 Green Roofs

Green roofs are vegetated rooftops that use a plant-soil complex to store, detain, and filter rainfall. They reduce runoff volume and improve runoff timing.

6.7 References

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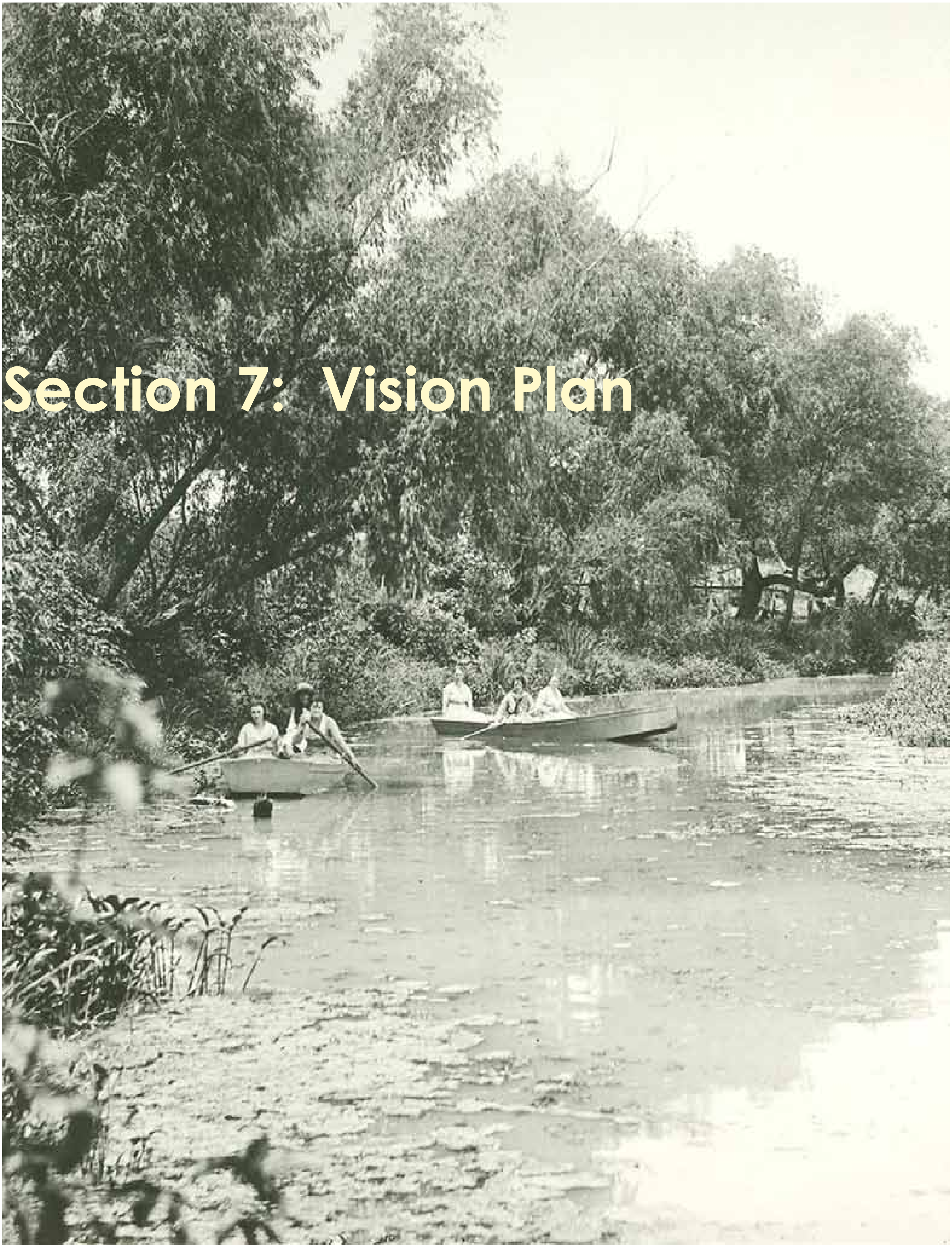
Figure 6.15: Green Roof at Chicago City Hall
(www.howstuffworks.com)

Section 7: Vision Plan



7.1 Introduction and Existing Conditions

Section 7 describes the vision developed by the Pirnie/ARCADIS team, SARA and its partners for the study area shown in Figure 7.4. By merging previous work with new creative thinking, we produced a cohesive sustainable solution that creates a **Great People Place in the Westside**. Figures 7.5 through 7.7 illustrate how the planning process evolved into the overall conceptual plan shown in Figure 7.8. As described in Sections 7 and 8 of this report, public investment by the City of San Antonio (COSA) and Bexar County, and private investment by Our Lady of the Lake University (OLLU) and others could be used to implement the vision.

Elmendorf Lake Park has the potential to be the center of a great people place although its existing conditions have limitations, and it generally lacks connection to the community and lake. The 29.6-acre park follows the north shoreline of Elmendorf Lake between 24th Street and 19th Street. Commerce Street generally runs parallel to the park on the north side. The narrow configuration creates limitations for development of the park's full potential. The closeness of busy streets and intersections causes traffic safety issues for park users.

The primary existing recreation features in the park are a swimming pool, a small shelter, 1.25 miles of trail, 24 picnic units, a little league field, playground and restrooms.

Of the 26 swimming pools in the COSA, the one at this park is among the most popular with 17,260 visitors in 2011. The swimming pool is also among the oldest as it appears in an aerial photograph from the 1930s. Although remodeled since that time, the pool is reaching the end of its useful life. Two other major amenities in the park are a playscape, which was installed in 1998, and a little league field that is currently leased to the Boys and Girls Club of San Antonio, located across 19th Street from the park.

Fishing is allowed in the lake although access is limited due to extensive vegetation along the banks. A peninsula contains a historic stage built in 1949 by Dionicio Rosales (no known relation to the renowned Dionicio Rodriguez) and restored in 2011. A bridge connects the park to a constricted and isolated island. Examination of aerial photographs shows that this narrow island was once the south bank of Apache Creek prior to the 1970s channel excavation.

Several physical qualities of the park reinforce its lack of connection to the surrounding Westside community. First, the narrowness of the park exposes it to Commerce Street, and no single area has adequate width to create a dynamic gathering place. The existing swim-

Figure 7.1: Restored Bandstand

ming pool creates interrupts the flow of the park with only enough room for a sidewalk along both the street frontage and lake edge. Therefore, the pool effectively divides the park into two segments.

OLLU installed a chain link fence along the park's south property line in the 1960s. When the channel was expanded in the 1970s, the university effectively lost its ability to connect to the park and the lake downstream of 24th Street. The connection and use of the park by the university has been greatly reduced over the past 40 years. The university now wishes to reconnect to the lake, park and local community.

A social quality that also limits the park's effective use is the presence of the adjacent methadone treatment clinic. The team understands that the clinic is in the process of relocation.

A connection to the environment is also largely absent from the park. Anecdotal evidence suggests that the ecology of the lake has changed over time, reducing the prevalence of wildlife. Dense vegetation along the banks keeps visitors from interacting with the lake.

Elmendorf Lake Park is also currently separated from other COSA park facilities in the area. Rosedale Park and Jose Navarro Park are located on tributaries of the lake, upstream of Elmendorf Lake Park. Rosedale Park is much larger than Elmendorf Lake Park, and it supports more recreational activities. Organized sports and community gathering facilities are amply provided at Rosedale Park. On its 61.8 acres, the park has playscapes, basketball courts, soccer fields, baseball fields, tennis courts, a softball field and a multi-use court. Several are lighted for evening use. Another section of Rosedale Park provides several pavilions and a large picnic facility with a kitchen and stage. These facilities are available for use by reservation only. The park includes several large parking lots and a short trail. A YMCA occupies the northwest portion of the park.

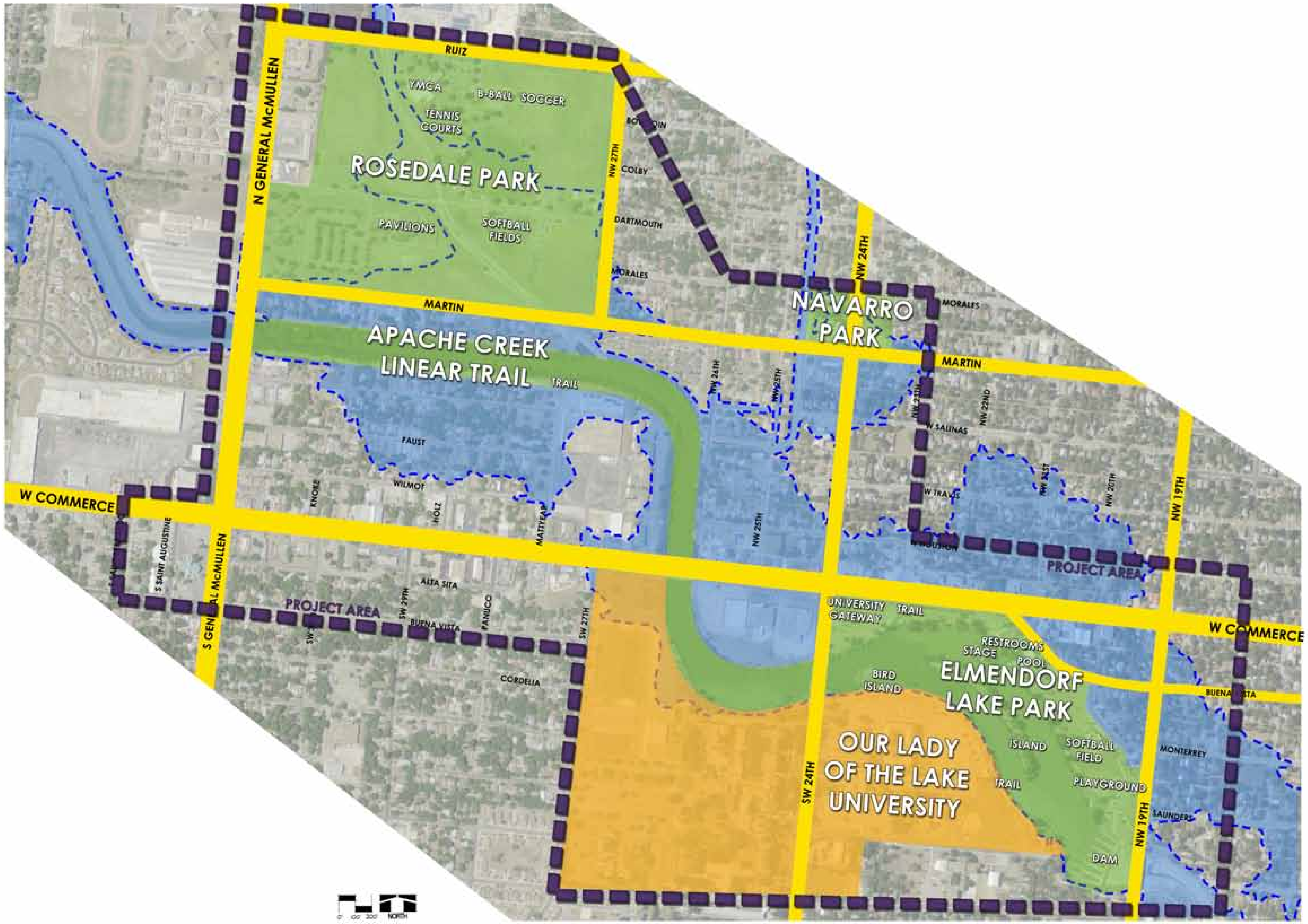
Figure 7.2: Our Lady of the Lake University

Figure 7.3: Elmendorf Lake Park from the Island

The facilities currently found in 3-acre Jose Antonio Navarro Park include a playground, three picnic units, two practice baseball fields and a basketball court. Morales Street marks the northern edge of the park while Martin Street defines the southern edge. Bandera Branch, a tributary to the lake, forms the western boundary, while residential property creates the eastern boundary. The park itself is divided in half by 24th Street.

Access and transportation also affect the current condition of the Elmendorf Lake area. With its 2035 Long Range Transportation Plan, VIA has planned for future growth in the area. Current ridership levels are shown in Figures 7.5 and 7.6. The VIA Plan suggests heavier use at the General McMullen and Commerce Street intersection. The potential of increased ridership of university students from OLLU is yet untapped. VIA plans a bus rapid transit station on General McMullen in the future, as well as potential light rail transit on Commerce Street in the years to come.

7.4 Planning Diagrams - Study Area



7.5 Planning Diagrams - VIA Transit Stops with Combined On/Off Daily Average Riderships

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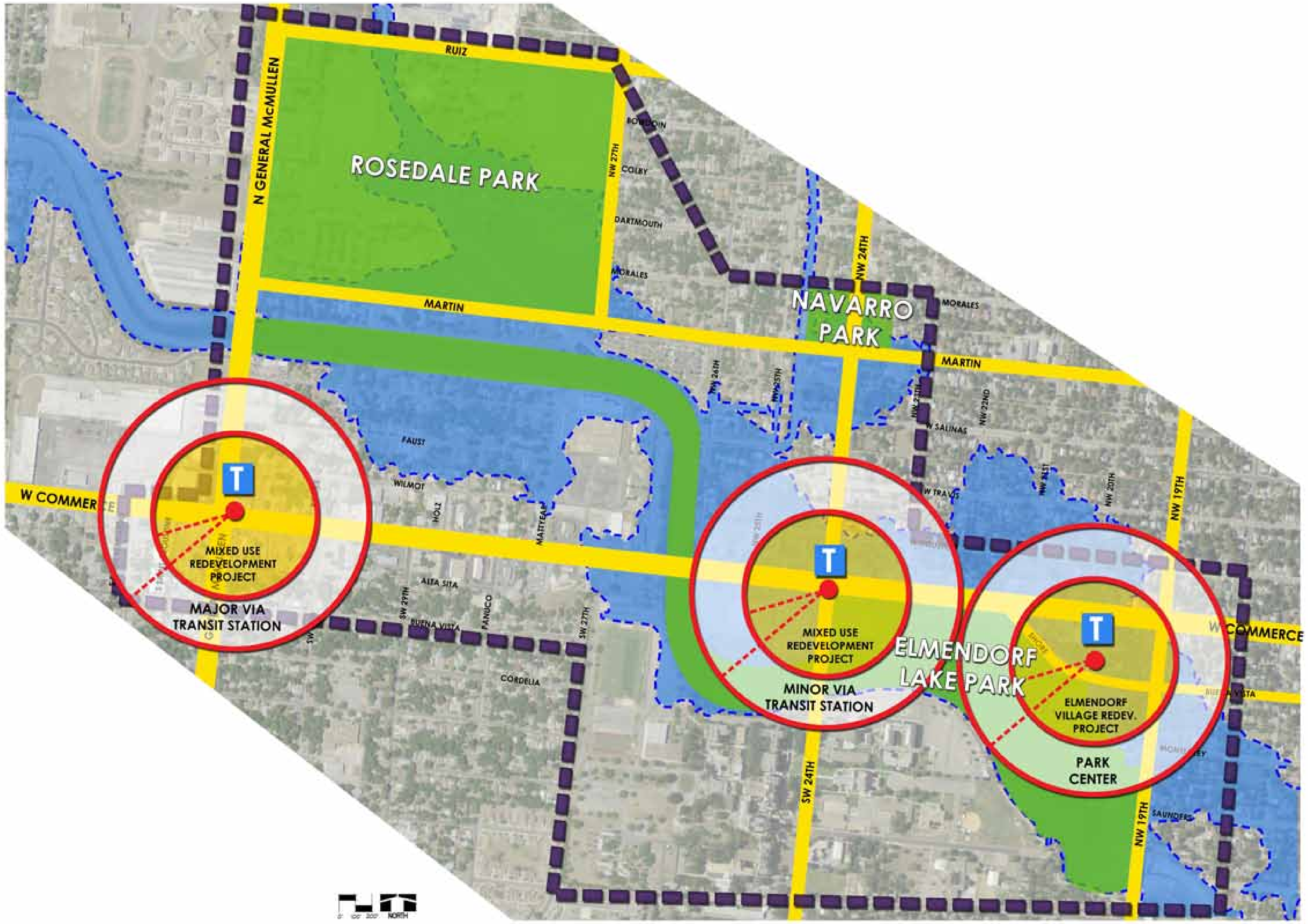
7.6 Planning Diagrams - Proposed Transit Stations



7.2 Connectivity

The proposed vision for the Elmendorf Lake reach of Apache Creek has connectivity as one of its primary focal points. The proposed plan reconnects valuable resources to their surroundings, to the community and the city.

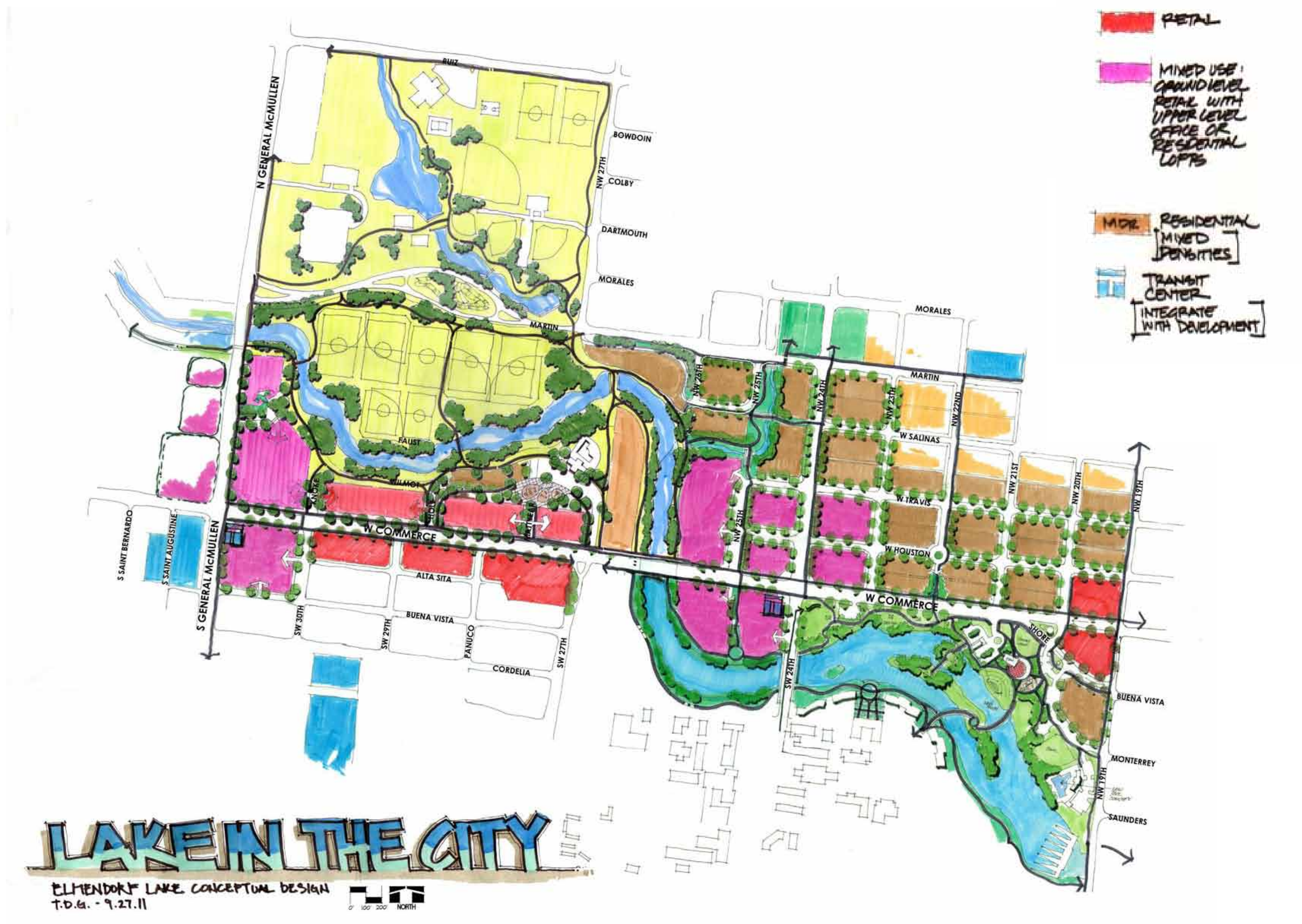
Perhaps the most crucial of all connections is between Elmendorf Lake Park, the lake and OLLU. The university has a population of students and faculty with various personal needs including a physical need for exercise, a psychological need for contact with nature and a social need for community. A greater number of park users would enhance safety and community perception. Lively parks discourage vandalism and suppress undesirable or illegal activities. These concurrent needs could be satisfied by means such as a bridge linking the university and park across the existing island. The university embraces the idea of a bridge from their future lake-side housing area to the park and sees it as a boost to quality of life for its students.

The ultimate conceptual plan shown in Figure 7.8 considers Rosedale and Elmendorf Lake Parks as a unit linked by a hike and bike trail connection through the Apache Creek Linear Park. In a later phase Jose Antonio Navarro Park could also be connected and improved. Pedestrians using the trails system could be protected from vehicles with below grade street crossings of both 24th Street and Commerce Street. Trails could be provided on both sides of the lake creating an optimal user experience going to and from the three parks. Collectively, the parks could then form a cohesive unit as each meets distinctive needs in the community. Within the vision, Elmendorf Lake Park would emphasize unique recreational and educational features that focus on nature and the lake, while Rosedale Park would continue to provide athletic and organized sports practice and play opportunities. Jose Antonio Navarro Park would continue to serve as an intimate neighborhood park.

The proposed Jose Antonio Navarro Park link could carry a ribbon of green from the lake deep into the heart of the surrounding community. This local neighborhood park could connect along a short trail beside Bandera Branch to the Apache Creek Linear Park Trail. From this point it would be possible to walk or bike to the sports fields in Rosedale Park, interact with the lake at Elmendorf Lake Park, or to downtown San Antonio. This level of local accessibility would encourage more frequent and extended interaction between the linear resources along the creeks, the community and the parks.

Trails already proposed and funded separately by the COSA would link Elmendorf Lake to the San Antonio River Mission Reach by following Apache Creek to San Pedro Creek and then to the San Antonio River. This connectivity would provide a regional route for hiking and biking, and would also increase the visibility and appreciation of the San Antonio River Watershed.

7.7 Conceptual Plan - Elmendorf Lake Conceptual Plan - Flood Storage and Restoration
Option 1: Re-channelization of Zarzamora Creek



7.8 Conceptual Plan - Elmendorf Lake Conceptual Plan - Flood Storage and Restoration
Option 2: No Channel Rerouting of Zarzamora Creek

Figure 7.9: Apache Creek Greenway Sign

Figure 7.10: Apache Creek Trail

Figure 7.11: Elmendorf Lake with OLLU in Background

7.3 Elmendorf Lake Park Plan

Introduction

The overall vision for the Elmendorf Lake reach of Apache Creek is shown in Figure 7.8. The vision creates a cohesive destination park and open space system, and a lake interwoven into the surrounding community.

The first major step in implementing the vision would be improvements and modifications to Elmendorf Lake Park. These improvements and modifications would be approved by the COSA following the terms identified in an inter-local agreement between the City and SARA as project manager.

The conceptual plan for Elmendorf Lake Park is shown in Figure 7.12, and its first two phases are shown in Figures 7.13 and 7.14. **In the following paragraphs, individual components of the plan, as shown on these figures, are referenced as item numbers in parentheses**.

Public sector and OLLU involvement in the overall conceptual plan is described in this section of the report and in Section 7.4. Private sector opportunities are described in Section 7.5.

7.12 Elmendorf Lake Park Plan

7.13 Elmendorf Lake Park Plan - Phase 1A

7.14 Elmendorf Lake Park Plan - Phase 1B

<u>Gateways and Public Art</u>

Within the boundaries of Elmendorf Lake Park, the vision plan incorporates entries and portals that would give the park greater presence in the community. OLLU currently has a small entry monument at the southeast corner of Commerce and 24th Streets. In a team meeting with the university, OLLU representatives expressed a willingness to share this space with the COSA for the creation of a joint entrance gateway visually showing transition into the university and into the park. The conceptual sketch in Figure 7.15 shows one way in which this could be achieved.

Figure 7.15: Elmendorf Lake and Lady of the Lake University Sign

The conceptual plan for Elmendorf Lake Park in Figure 7.12 indicates several places (items 1, 16, 17, 21 and 22) where signature gateway art or monuments could be incorporated. These include:

1. The intersection of West Commerce Street and 24th Street to create a gateway for both OLLU and the Elmendorf Park;
2. The intersection of West Commerce Street and Buena Vista Street;
3. Within the cental area of the park;
4. The new bridge connecting OLLU to Elmendorf Lake Park; and
5. The island.

A proposed privately funded Hispanic Veterans Monument has been presented to the Parks and Recreation Board and may have a presence in the park.

These gateways could provide landscape beautification and architectural detail thus becoming image-markers for the neighborhoods surrounding Elmendorf Lake Park. They may give this park a heightened presence in the city. Wayfinding and area identification themes at these points and throughout the park in common architectural styles, graphics, materials, and plantings assist to facilitate traffic in the park. Figure 7.16 shows some conceptual examples of park signage.

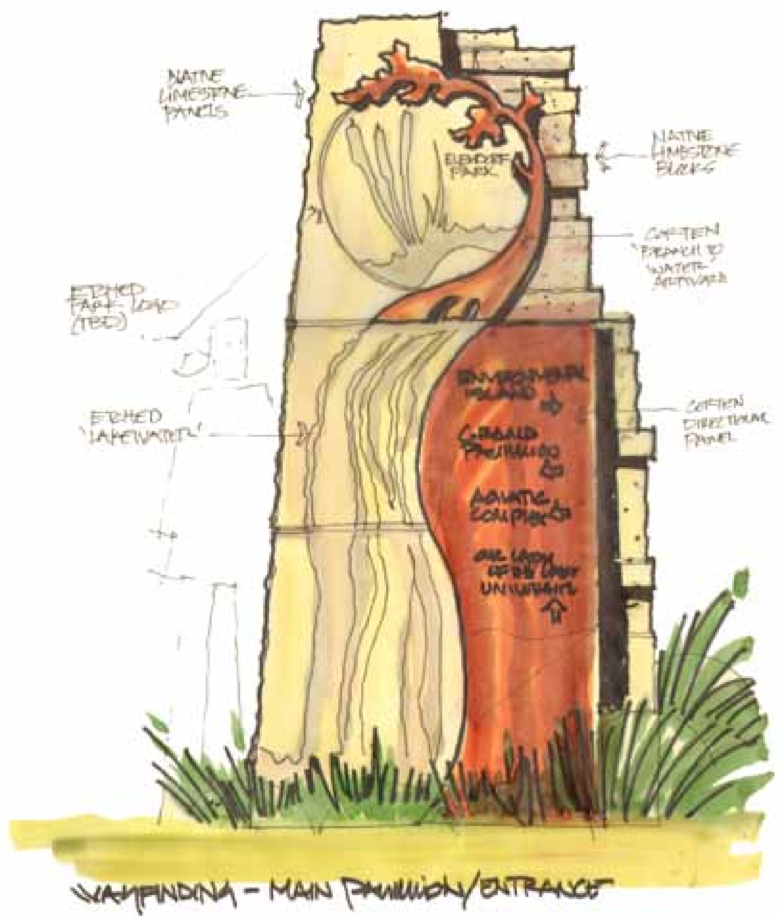


Figure 7.16: Elmendorf Lake Park Signage

<u>Park Central</u>

Park Central is a key activity area in an expanded northeast corner of the park. The development of Park Central is dependent upon the relocation of Buena Vista Street. With this additional land, several large pavilions or shade structures and a plaza could be constructed (items 12 and 14). The area could be used for community festivals, farmers' markets and similar activities. A "sprayground" as shown on page 90 may be included in the plaza. If this feature is included, water would jet through pavers in a dynamic pattern of motion and intensity. At night these water jets would be lighted with changing colors to create a light sculpture. The sprayground would only operate when it is initiated by users in the plaza, and the water would be captured, filtered, sterilized and re-circulated. The feature could serve as an example of conservation-conscious use of water features. OLLU may choose to do research on the water efficiency of the features.

South of the plaza is a proposed grass amphitheater with a shaded stage that would offer a venue for community events close to the lake's edge (item 9). The amphitheater would have a wide, tree lined promenade curving around the seating area connecting all of the features of the Park Central area. Adjacent and south of the plaza would be a large destination playground with separate areas to accommodate children two to five years of age and five to twelve years of age (item 15). The playground would be cushion-surfaced and have numerous adjacent shaded seating areas.

Environmental Science and Research Center

To support OLLU's achievement of the goals articulated in the kickoff workshop and to increase the university's involvement in the park and the community, the plan proposes incorporating an environmental education and research center (item 4) on the island next to the existing amphitheater. This section of land was turned into a peninsula in the 1970s. To improve flow and restore some of the park's history, this plan would return the area to its original form as an island. Existing retaining walls would be evaluated in the design phase to determine which walls need to be repaired or replaced.

The Environmental Science Center proposed by the Pirnie team could act as the headquarters for both interpretative activities and university-sponsored teaching and research, and for recreational programming throughout the park. The focus of the center would be the natural systems within the rivers and creeks of the city. The center could provide the opportunity to observe staff and citizens at work as they research and study these systems.

The Environmental Science Center building would be constructed above the 100-year floodplain, but would be closely connected to the water. An example is shown in Figure 7.17. The building would be designed to create the illusion that it is hovering over the water. OLLU already has a vibrant environmental education program in place with professors using the lake as an outdoor laboratory. The university focuses on giving local teachers training on environmental education, with about 500 teachers completing the program since its start in 1996. The proposed center in the park would benefit this program and would help increase the use of the park as college students visit for lab work, and families and schools visit for field trips.

Meeting and classroom space would be provided in the center, and it could be made available for use by citizens and interested organizations. The proposed facility presents the opportunity for schools and other similar groups to utilize it for tours and independent study.

Several similar environmental centers, including one at Phil Hardberger Park, as well as others such as Mission Verde near Amistad Park and a proposed center near Concepcion Park, are already in the works. The proposed Elmendorf Lake Environmental Science Center complements, but does not duplicate these other facilities. The proposed Environmental Science Center could be coordinated with OLLU and would focus more on the science of environmental care and education. Students, OLLU faculty and others could also monitor the ecological health of not only Elmendorf Lake but other creeks and rivers within San Antonio.

Figure 7.17: Example of Environmental Science Center

<u>The Island</u>

The long, thin island running along Elmendorf Lake is known locally as the Memorial Island. In the proposed plan, the island would be used as an educational resource for the science center and for recreation by the public. A proposed signature bridge would link the park to the island and OLLU, and the bridges and island would be lit for night use. A trail along the island's perimeter could incorporate interpretive signage, seating areas and several outdoor classrooms. Piers along the water's edge could allow more intimate connection to the water and its aquatic life for access, recreation and education. The vision reflects Memorial Island as a center for park educational activities with a focus on children.

Figure 7.18: Teaching Island

Aquatics Center and Marina

An aquatic center (item 7) could replace the existing swimming pool constructed in the late 1920s or early 1930s. The new aquatics center would include a swimming pool, as well as several interactive water toys. Around the pool would be numerous shade structures and a pool cabana that contains showers, restrooms and changing areas.

An adjacent marina, if built, (item 6) would provide a broad range of interaction with the water. It could include a boat storage shed and a boat launch ramp for kayaks, canoes or sailboats. The channel oxbow excavated to form the marina could also provide an excellent opportunity for recreational ventures such as boat rentals and even the addition of paddle boats or gondolas similar to those used on the waterways in parks in Mexico City. The Environmental Science Center's research boats might be stored here.

Wetland

A constructed wetland (item 5) is proposed in the area where the existing little league field is located adjacent to 19th street. The wetland would be constructed by the creation of marina oxbow channel. As stated above, the existing little league field would be relocated east of 19th Street on Apache Creek. This excavated area would consist of a four-acre demonstration wetland with boardwalks and an outdoor classroom. The wetland could also serve as part of the sustainable stormwater best management practices (BMP) system that would treat urban and parking lot runoff. It would be linked by trails to the Environmental Center and other park facilities. Special attention would be given to the growth of aquatic and other natural plant materials within the wetland and along the edge of the lake. The current sterile edge could be modified to create a visually pleasing edge that supports the natural ecosystem of the lake.

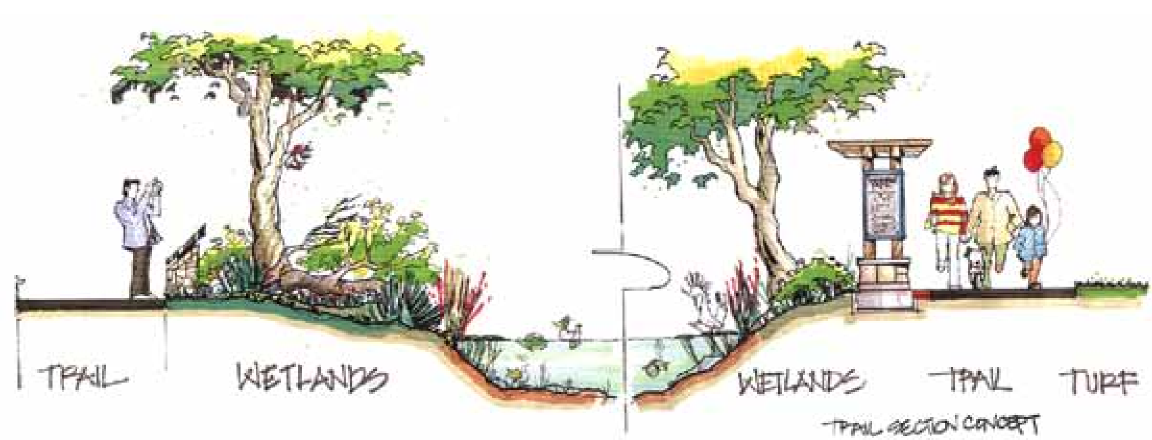


Figure 7.19: Trail Section Concept

Landscape and Security Lighting

Safety and security are the prime considerations for lighting in a park. The proposed gateways would be lighted to provide entry icons during the evening. Lighting would also be provided along the trails and at key areas to create safe routes through the park. Specific facilities could also be lighted to encourage night time use of the park. Appropriate lighting types and locations would be designed to limit the negative visual impact on the park and to adjacent residences.

Trails

As stated in Section 7.2, the proposed trail system within the park includes a continuation of the Apache Creek Linear Park Trails system that would be funded through the Proposition 2 (2010) Linear Creekway Sales Tax Initiative. The proposed trails would connect to existing trails to the north and provide for future trails to the south and east connecting ultimately to the Mission Reach of the San Antonio River. An inner park trail system is also planned to link various nodes of activity and connect the park to the adjacent neighborhoods. The regional level trails would be a minimum of ten feet wide and constructed of a flood resistant materials.

A regional trailhead could be located at the Park Central and adjacent to the Environmental Science Center (item 25). The regional trailhead would provide information to visitors on activities available in Elmendorf Lake Park and wayfinding information for the regional trail system. Restrooms, drinking fountains, shade, and seating areas would be provided at the Park Central facilities. The trailhead would also function as a gathering/assembly point for special activities and trail events.

Commerce Street Open Space

Open space along Commerce Street could be developed with shaded picnic areas and walks. There would also be low-level berms placed between parking lots and the street to provide a visual and physical buffer between these areas. Additional drinking fountains and seating are also strategically located in this area.

Proposed bioswales to collect and treat street drainage would provide a key sustainable water quality BMP along Commerce Street. A sawtooth curb or similar device would allow runoff to drain into wide planted swales, which would then purify the water through a high quality filtration medium. This water would ultimately be directed to the wetland or the stormwater drainage system which empties into Apache Creek downstream of the dam at 19th Street. The high visibility of the bioswales along Commerce Street (and a portion of 19th Street) would accomplish two purposes by signaling the park's presence to drivers and placing sustainable practices directly in the public realm for discussion and demonstration. OLLU could monitor and conduct research on the impact of the bioswales on stormwater quality.

<u>Buena Vista and Other Relocations</u>

As described in Section 7.1, Elmendorf Lake Park has very limited recreational area between the lake and surrounding streets. Existing facilities located in the park such as the swimming pool actually break the park into segments, physically and visually. Additional land is required to provide enough space for significant redevelopment of the park, and to link the park to the community.

The implementation of the proposed plan would likely include the acquisition of some properties located in the 100-year floodplain to the northeast of Buena Vista Street. This acquisition would facilitate the relocation of Buena Vista. This land acquisition and street relocation segment of the proposed plan would give the area adequate area to develop the features and facilities described in this section of the report.

In addition, the existing little league ball field would be relocated to COSA property east of 19th Street on Apache Creek. The relocation opens up Elmendorf Lake Park for other development, and the new location is closer to the Boys and Girls Club. It would also eliminate the need for children to cross 19th Street to get from the club to the ball field.

7.4 Bexar County Participation

Bexar County (the "County") has been an active participant in the Westside Creeks/Elmendorf Lake evaluation process. During the course of several meetings with SARA and the COSA, the County developed an understanding of the flood mitigation modeling and park planning conducted by the Pirnie/ARCADIS team. Based on that understanding and the Westside Creeks Conceptual Plan for the AP-1 reach of Apache Creek, the County prepared a conceptual plan for its participation in the Elmendorf Lake area improvements described in this report.

In the County's conceptual participation plan, the major emphasis is placed on: restoration activities in the segment from Commerce Street downstream to 24th Street; and water quality improvements in Elmendorf Lake. The major components of the County's participation include design, permitting and construction related to the following facilities.

- Restoration of the riparian area along the shoreline of Elmendorf Lake;
- Concrete trails (10-feet wide) along the shoreline of the lake

The total estimated cost of the County's restoration and water quality enhancements is projected to be $7 million.

7.5 Private Participation

One of the tasks of the Westside Creeks/Elmendorf Lake study team was to look for opportunities for the vision to serve as a catalyst, as described in the Westside Creeks Restoration Conceptual Plan, for potential private investment in the local community. Private development opportunities are closely tied to access and transportation, as well as the proposed parks improvements and a renewed Elmendorf Lake. For example, one catalyst is the proposed VIA transit center at the Commerce Street/24th Street intersection. The vision recommends the inclusion of three potential transit centers and redevelopment projects at the locations shown in Figure 7.6. Mixed use redevelopment projects centered on transit would have an effective radius of impact within the first 400 feet and some measurable influence within an 800-foot radius. Economic redevelopment activity within these zones should be strongly encouraged with the connected parks and renewed lake as the ancillary catalysts.

During the evaluation process, members of the team and SARA met with the owner of the property at the southwest corner of Commerce and 24th Streets. The property is currently used for commercial and retail stores such as Handy Andy, Conn's and a thrift store. During the meeting to discuss the vision for Elmendorf Lake, the developer realized that his property actually had two fronts—lake frontage with quality views of the university, as well as frontage on Commerce and 24th Streets.

To help illustrate the potential private opportunities, the study team developed a series of sketches. The potential re-development of the area around the Commerce Street-24th Street intersection is shown in Figure 7.20.

Figure 7.20: Elmendorf Lake Potential Private Economic Redevelopment Area

Figure 7.21 illustrates one potential concept for private dollars to be invested in economic development that uses the lakeside as a major natural amenity. Such development could be designed to be compatible with periodic high water. This sketch illustrates the concept of a restaurant along the lake with the building itself above the 100 year floodplain, and the terrace extending down toward the water.

Figure 7.21: Lakeside Development

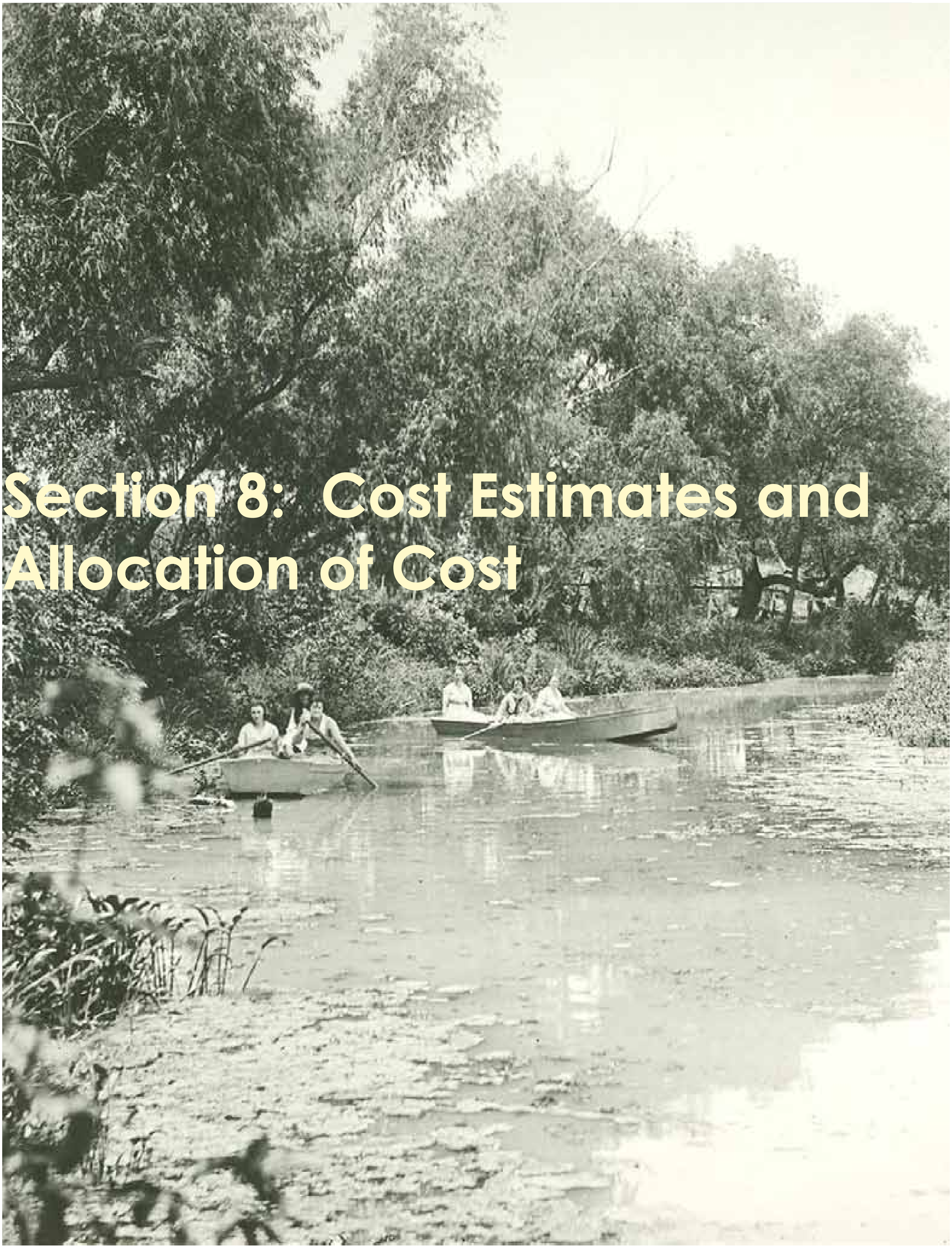
Additional sketches (Figures 7.22 and 7.23) show other examples of potential private investment in the community surrounding Elmendorf Lake. Figure 7.24 shows such a development with a view of OLLU.

Figure 7.22: Retail Street

Figure 7.23: Urban Core Sketch

Figure 7.24: Elmendorf Square with View of OLLU

Section 8: Cost Estimates and Allocation of Cost



8. Cost Estimates and Allocation of Cost

During the evaluation and planning process, the Pirnie/ARCADIS team developed a series of cost estimates for property acquisition in floodprone areas; flood detention/storage areas; stream restoration; water quality enhancements; trash and debris management strategies; and park improvements to Elmendorf Lake Park and linkage of the park facilities surrounding Elmendorf Lake. As various alternatives were evaluated, the cost estimates were updated and/or modified for use at meetings between SARA and its partners. These estimates were used in the decision-making process and are an integral part of this evaluation.

In addition, the team assisted SARA in developing an allocation matrix that showed how the various components of the overall plan would be funded by the City of San Antonio.

The final versions of the cost estimates and the allocation matrix are shown on the following pages.

The cost estimate for park improvements in the plan is comprised of three major components: Elmendorf Lake Park; Rosedale Park/Apache Creek Linear Park; and Jose Navarro Park Linkage. Due to the scope of work for Elmendorf Lake Park, this component is divided into three phases. Phase I is also broken into two parts. Each phase has an additional 20% included in the cost of components, which provides an additional 10% for design and 10% for contingency.

Phase IA of Elmendorf Lake Park is the immediate priority for funding. It includes the Park Central with gateway signage, an interactive fountain/sprayground, play areas, trails, and associated parking, lighting, landscaping and irrigation. A major item for this phase is the land acquisition and street relocation of Buena Vista Street, which opens up the space required for Park Central.

Elmendorf Lake Park's Phase IB provides other key park components. Main features include the aquatics center, large shade structures, the amphitheater and trails with accompanying trail lighting, site work, signage, utilities, landscaping and irrigation. This phase would relocate the existing baseball field to provide space for the aquatics center.

The last two phases for this component emphasize connection with the water. Phase II involves the excavation of the marina and the construction of the adjacent demonstration wetland. It also increases connectivity with pedestrian bridges and enhances the park's educational elements with an interpretive trail on the island. Phase III contains the environmental science center which could potentially obtain financial support from OLLU.

The Rosedale Park/Apache Creek Improvements component provides some major enhancements. These include the relocation of Martin Street, extensive additional trails, new athletic fields, gateway signage and a play area, as well as the related lighting, signage, pedestrian bridges, site work, parking and utilities. Martin Street could be relocated in an earlier phase as part of any flood detention projects in the area of Rosedale Park.

The Jose Navarro Park Linkage component gives a final piece of community connectivity with a trail uniting the existing Jose Navarro Park and the proposed trail system at Apache Creek Linear Park. Additional enhancements to this connection include lighting, site work, signage and landscaping.

Westside Creeks/Elmendorf Lake Evaluation

Estimate of Probable Costs

16-Dec-11

	Item	Cost		Funding Recommendations
	Elmendorf Lake Park - (Phase IA)			
1	**Play Areas**			
	Playground, observation/seating, lighting, drinking fountain and receptacles	$450,000		$450,000
2	**Entry Interactive Fountain***			
	Lighting, paving, recirculation system, filters and pumps	$850,000		$0 ***
3	**Streets Relocations (Buena Vista Street)**			
	Street adjustments**	$450,000		$450,000
3a	**Property Acquisition (Buena Vista Street Relocation)**			
	Floodplain property acquisition (13 total parcels)	$1,162,250		$1,162,250
4	**Public Parking**			
	Parking, bio-swales, vehicle control/curbing, landscape, irrigation and lighting	$850,000		$850,000
5	**Trails**			
	Hike/bike/nature trails, interpretive/picnic nodes, piers, signage, pedestals, seating and exercise nodes, and two below vehicular bridge trail connections - 3575 linear feet	$876,000		$805,920 ***
6	**Trail and Area Lighting**			
	Fixtures, poles and tree lighting.	$685,000		$630,200 ***
7	**Site Work**			
	Clearing, demolition and rough site grading	$100,000		$100,000
7a	**Elmendorf Lake Water Quality Strategies**			
	SolarBee Mixers and Trash Log Booms Best Management Practices (BMPs)	$500,000		$0 ***
8	**Wayfinding and Interpretive Signage**			
	Wayfinding, interpretive signage and pedestals	$110,000		$110,000
9	**Landscaping and Irrigation**			
	Turf, Trees and Irrigation - 12 acres	$280,000		$280,000
10	**Gateway Signage** 19th and Commerce Street and 24th and Commerce Street			
	19th and Commerce Street and 24th and Commerce Street - Stone work and lighting	$240,000		$240,000
		Subtotal:	$6,553,250	$5,078,370
		Contingency (10%) excludes 3a and 7a:	$489,100	$391,612
		Engineering and Design (10%) excludes 3a and 7a:	$489,100	$489,100
		Total:	$7,531,450	$5,959,082

* 10% Contingency excluded from Funding Recommendations column for Item 2
** Excludes demolition and relocation of stormwater sewer, sanitary sewer, water and other utilities.
*** The remaining costs would be funded by other sources or in future phases.

	Item	Cost		Funding Recommendations
	Elmendorf Lake Park - (Phase IB)			
11	**Large Group Pavilion and Amphitheater**			
	Structure with slab	$750,000		
12	**Trails**			
	Hike/bike/nature trails, interpretive/picnic nodes, piers, signage, pedestals, seating and exercise nodes, and two below vehicular bridge trail connections - 1225 linear feet	$300,000		
13	**Trail and Area Lighting**			
	Fixtures, poles and tree lighting.	$240,000		
14	**Aquatics Center**			
	Pool, sprayground, restrooms, cabana and parking	$1,950,000		
15	**Relocate Baseball Field**			
	New Baseball fields including fencing, irrigation, lighting, turf and bleachers	$390,000		
16	**Site Work**			
	Clearing, demolition and rough site grading	$50,000		
17	**Utilities**			
	Water, sewer, electricity, taps/meters, phone and internet	$50,000		
18	**Wayfinding and Interpretive Signage**			
	Wayfinding, interpretive signage and pedestals	$15,000		
19	**Utilities**			
	Water, sewer, electricity, taps/meters, phone and internet	$450,000		
20	**Landscaping and Irrigation**			
	Turf, Trees and Irrigation - 12 acres	$80,000		
		Subtotal:	$4,275,000	
		Contingency (10%):	$427,500	
		Engineering and Design (10%):	$427,500	$427,500
		Total:	$5,130,000	$427,500

Westside Creeks/Elmendorf Lake Evaluation

Estimate of Probable Costs

	Item	Cost		Funding Recommendations
Elmendorf Lake Park (Phase II)				
21	**Wetland and Observation Area**			
	Excavation, shaping and fine grade	$200,000		
	Boardwalk, Seating, shelter and planting	$575,000		
22	**Marina and Channel**			
	Excavation, shaping and fine grade	$500,000		
	Docks, boat storage and parking	$475,000		
23	**Interpretive Island**			
	Nodes, piers, interpretive signage and trails - 2,200 linear feet	$528,000		
24	**Pedestrian Bridges**			
	Piers, decking and support	$1,275,000		
		Subtotal:	$3,553,000	
		Contingency (10%):	$355,300	
		Engineering and Design (10%):	$355,300	$355,300
		Total:	$4,263,600	$355,300
Elmendorf Lake Park (Phase III)				
25	**Environmental Science Center and Teaching Laboratory**			
	Classrooms, display/research areas, restrooms, training rooms, storage,	$2,750,000		
		Subtotal:	$2,750,000	
		Contingency (10%):	$275,000	
		Engineering and Design (10%):	$275,000	$275,000
		Total:	$3,300,000	$275,000
Elmendorf Lake Park (All Phases - Total Cost)				
		Subtotal:	**$17,131,250**	$5,078,370
		Contingency:	**$1,546,900**	$391,612
		Engineering and Design:	**$1,546,900**	$1,546,900
		TOTAL BASE:	**$20,225,050**	**$7,016,882**

Westside Creeks/Elmendorf Lake Evaluation

Estimate of Probable Costs

	Item	Cost	
	Rosedale Park Expansion and Linkage		
1	**Relocation of Martin Street Between General McMullen and 27th Street**		
	Street and utility realignment, 2200 linear feet	$1,250,000	
1a	**Property Acquisition - Zarzamora Creek**		
	Floodplain property acquisition (134 total parcels)	$6,814,200	
2	**Athletic Fields**		
	30 acres, site grading, goals, backstops, turf, landscaping, and bleachers.	$950,000	
3	**Athletic Field Lighting**		
	Power centers, fixtures, and poles.	$675,000	
4	**Play Area**		
	Playground, lighting, drinking fountain and receptacles	$205,000	
5	**Gateway Signage**		
	Stone work and lighting	$220,000	
6	**Pedestrian Bridges**		
	Decking and support - 175 lin. ft.	$850,000	
7	**Public Parking (250 cars)**		
	Parking, bio-swales, vehicle control/curbing, landscape, irrigation and lighting	$725,000	
8	**Trails**		
	Hike/bike/nature trails, interpretive/picnic nodes, piers, signage, pedestals, seating and exercise nodes, and five below vehicular bridge trail connections - 13,400 linear feet	$2,750,000	
9	**Trail and Area Lighting**		
	Fixtures, poles and tree lighting.	$1,450,000	
10	**Site Work**		
	Clearing, demolition and fine site grading	$250,000	
10a	**Apache Creek Restoration in Rosedale Park**		
	Earthwork, concrete removal, trees, shrubs, seeding, contingency, design, and permitting	$535,100	
11	**Utilities**		
	Water, sewer, electricity, and taps/meters	$150,000	
12	**Wayfinding and Interpretive Signage**		
	Wayfinding, interpretive signage and pedestals	$75,000	
		Subtotal:	$16,899,300
		Contingency (10%) excludes 1a and 10a:	$955,000
		Engineering and Design (10%) excludes 1a and 10a:	$955,000
		TOTAL BASE:	**$18,809,300**

Jose Navarro Park Linkage			
1	**Trails**		
	Hike/bike/nature trails, interpretive/picnic nodes, piers, signage, pedestals, seating and exercise nodes - 1100 lin. feet.	$245,000	
2	**Trail and Area Lighting**		
	Fixtures, poles and tree lighting.	$375,000	
3	**Site Work**		
	Clearing, demolition and fine site grading	$75,000	
4	**Wayfinding and Interpretive Signage**		
	Wayfinding, interpretive signage and pedestals	$75,000	
5	**Landscaping**		
	Turf and trees- 2 acres	$105,000	
		Subtotal:	$875,000
		Contingency (10%):	$87,500
		Engineering and Design (10%):	$87,500
		TOTAL BASE:	**$1,050,000**

Total Park Improvements			
1	**Elmendorf Lake Park**		
	Phases IA, IB, II and III)	$17,131,250	
2	**Rosedale Park Expansion and Linkage**		
	Single Phase - Park Improvements & Linkage to Elmendorf Lake	$16,899,300	
3	**Jose Navarro Park Linkage**		
	Single Phase - Trail Linkage to Elmendorf Lake	$875,000	
		Subtotal:	**$34,905,550**
		Contingency:	**$2,589,400**
		Engineering and Design:	**$2,589,400**
		TOTAL BASE	**$40,084,350**

Elmendorf Lake Park
Funding Recommendations (1)

Park Improvements (Park Bond $2.25M)		Flood Control/Storm Water BMPs (Drainage Bond $1.5M) (Stormwater $1.5M)		Proposition 2 ($1.75M)	
Design: Park Improvements (10% of Subtotal for Phases IA, IB, II and approx. 36% of Phase III)	$ 1,370,000	Property Acquisition: Buena Vista Relocation	$ 1,162,250	Design: Park Improvements (10% of Subtotal for Phase III at approx. 64%)	$ 176,900
1. Play Areas	$ 450,000	3. Streets Relocations (Buena Vista Street)*	$ 450,000	5. Trails - Combined with Park Bond budget: Totals 92% of planned trails**	$ 744,600
5. Trails - Combined with Prop 2 budget: Totals 92% of planned trails**	$ 61,320	4. Public Parking	$ 850,000	6. Trails and Area Lighting - Combined with Park Bond budget: Totals 92% of planned trail lighting**	$ 582,250
6. Trail and Area Lighting** - Combined with Prop 2 budget: Totals 92% of planned trail lighting	$ 47,950	8. Educational Signage on BMPs	$ 110,000	7. Site Work	$ 100,000
10. Gateway Signage	$ 240,000	9. Landscaping and Irrigation	$ 280,000		
Contingency (10% for items 1, 5, 6, 10 listed above)	$ 79,927	Contingency (10% for items 3, 4, 8, 9 listed above)	$ 169,000	Contingency (10% for items 5, 6, 7 listed above)	$ 142,685
Total:	$ 2,249,197		$ 3,021,250		$ 1,746,435

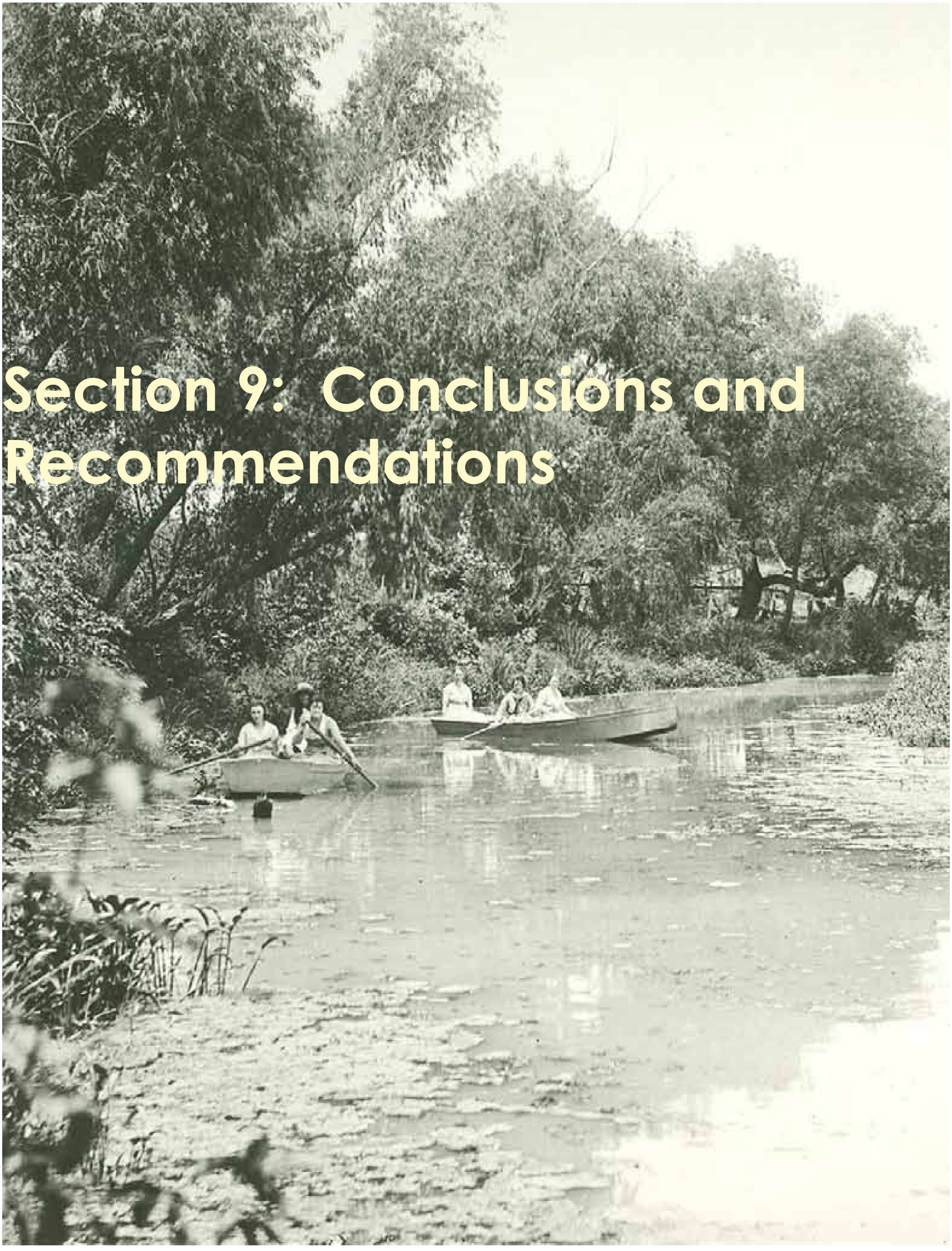
Grand Total: **$ 7,016,882** 12-Jan-12

Components

1. Phase IA Park Improvements related to recreation, plus 100% design for all Elmendorf Lake Park (Phases IA, IB, II, III).
2. Floodplain property acquisition for Buena Vista Street relocations. (13 parcels and associated structures.)
3. Due to budget constraints the Entry Interactive Fountain ($850,000) and Elmendorf Lake Water Quality Strategies ($500,000) were excluded and will be added into future phase(s).

Notes

* Required for Phase IA Park Improvements.
* Excludes removal and relocation of stormwater sewer, sanitary sewer, water and other public utilities.
** Trails estimated at $876,000 (92% is equal to $805,920; difference is $70,080); Trail and Area Lighting estimated at $685,000 (92% is equal to $630,200; difference is $54,800).
The remaining costs would be funded by other sources or in future phases.



Section 9: Conclusions and Recommendations

9.1 Introduction

SARA recently completed and adopted the Westside Creeks Restoration Project Conceptual Plan (the "Conceptual Plan"). The Conceptual Plan included recommendations for Reach AP-1, which is essentially the entirety of Elmendorf Lake.

As SARA and its partners, Bexar County, the City of San Antonio and Our Lady of the Lake University, move forward with implementation of the Conceptual Plan, there are a number of additional activities, studies and plans that needed to be considered in order to develop the best approach. In providing support to SARA and its partners, Malcolm Pirnie used existing H&H models, and other tools to review the current studies, plans and projects in order to:

- Evaluate the flood mitigation benefits and determine the most cost-effective approaches to achieve the goals of the Conceptual Plan;
- Identify opportunities to refine the existing plans to make them more cohesive and integrated;
- Identify opportunities to link the current plans with other facilities and features in the area;
- Verify and validate cost estimates and look for potential savings;
- Perform an cursory evaluation of the Dredging Project;
- Develop a preliminary conceptual plan for Elmendorf Lake Park; and
- Produce graphics that accurately and clearly describe the vision of Reach AP-1 and how that vision can be achieved within existing sources of funding and with potential bond proceeds.

Throughout this evaluation, the Pirnie Team kept in mind SARA's mission and vision, as well as SARA's objectives for a holistic, integrated process that seeks sustainable solutions which maximize the potential for multi-purpose programs, processes and projects. The evaluation is intended to assist SARA and its partners in determining the most appropriate and beneficial vision for AP-1, the Elmendorf Lake segment of Apache Creek.

9.2 Flood Mitigation

H&H modeling and the evaluation of flood mitigation alternatives are discussed in detail in Section 4 of this report. The Pirnie team was tasked with the responsibility to look for viable options to reduce flooding within the constraints of the site and park planning process. The study found that constructing flood detention or storage in Rosedale Park along Zarzamora and Apache Creeks (Alternative 1) and a flood control gate at Elmendorf Lake dam provides the greatest reduction in peak water surface elevations through the lake during flood events. Because of the high cost of constructing detention areas and/or purchasing all of the properties within the floodprone area, it was determined that the final vision plan would not initially include the construction of detention storage in Rosedale Park. The only floodprone properties recommended for purchase are those that are required for the improvements to Elmendorf Lake Park.

At SARA's request, the concept of dredging portions of the lake bottom was modeled to determine whether dredging provides additional flood protection benefits. The results of the modeling demonstrated that the labyrinth weir dam controls the flow with and without the lake dredging. Therefore, the resulting water surface elevations during the 100-year event are the same with and without dredging. The study found that flood elevations could be reduced around the lake by installation of a flood gate at the Elmendorf Lake Dam. The Pirnie team recommends further study of the proposed flood control gate to evaluate the gate size and operation required to provide the most flood reduction benefits. That study should also investigate the impact of flood flow releases on the area of Apache Creek downstream of the dam.

9.3 Water Quality

The water quality evaluation and recommendations are discussed in detail in Section 5 of this report. Based on a review of available water quality data, sediment data and past studies, the primary water quality concerns for Elmendorf Lake and Segment AP-1 are:

- Dissolved oxygen concentrations below the State Standard during certain seasons and/or rainfall events.
- E. coli concentrations above the State Standard for contact recreation.
- Sediment accumulation in the lake leading to reports of high turbidity during rain events and exacerbating anoxic conditions.

Additional concerns include nutrient concentrations above the State screening criteria and total organic carbon (TOC) concentrations exceeding 10 mg/L, both of which can exacerbate eutrophic conditions. Concentrations of certain synthetic organic compounds in the sediments are above the TCEQ health screening levels, but do not currently present an immediate health concern. Aesthetic concerns include accumulation of trash & debris following rain events and adverse odors, likely due to growth of blue-green algae and/or anoxic conditions in the lake.

The water quality priorities must be carefully considered to select the most cost-effective approach to meet water quality goals for Elmendorf Lake and Apache Creek. Based on evaluation of historical water quality data, one of the most pressing concerns related to lake water quality is seasonal occurrence of low dissolved oxygen concentrations. Dissolved oxygen in the lake could be increased in the short term at a relatively low cost by implementing one of technologies to add oxygen to the water. The Pirnie team recommends that SolarBee mixers be further evaluated. A limnologist should be engaged as part of the next step towards installing SolarBee mixers or an alternate technology to increase the dissolved oxygen to the lake to facilitate appropriate design of the system to maximize improvement (and minimize disruptions) to aquatic life and general lake ecology.

The team also recommends that the stormwater BMPs discussed in Section 6 be implemented for near-term reduction in trash & debris, nutrients, and total suspended solids (TSS) loading to the lake. Stormwater BMPS outlined in other SARA reports should also be considered to address additional water quality goals. Over the long term, BMPs should be incorporated to address a comprehensive set of water quality concerns, including:

- Synthetic organic compounds from stormwater runoff.

- Wise use of herbicides and pesticides in the watershed and especially right around the lake.
- Bacteria and pathogenic microorganisms from pet wastes.
- Nutrients and pathogens from any failure points within nearby sewer collection systems.
- Total suspended solids from construction activities and storm water runoff.

The Pirnie team also recommends that the Dredging Project be re-evaluated following implementation of initial stormwater BMPs.

The team also recommends additional water quality analysis. Water quality data are limited for Elmendorf Lake and Apache Creek, specifically related to concentrations of synthetic organic compounds (e.g., herbicides and pesticides) and dissolved oxygen concentrations in the lake at different seasons. Dissolved oxygen profiles and flow rate data are required to carefully design an oxygenation system. In addition to augmenting SARA's existing sampling program, water quality sampling could be adopted as an educational and community involvement activity conducted through the proposed Environmental Sciences Center.

Peak E. coli concentrations are currently above the standard for contact recreation. Although the lake is not routinely used for contact recreation, residents or visitors to the lake could be exposed to pathogens present if they engage in activities in the water. We recommend a study evaluating the source of pathogens in order to identify optimal approaches to reduce loading. Stormwater BMPs and maintenance of wastewater collection systems would be expected to reduce pathogen loading.

9.4 Sustainable Best Management Practices (BMPs)

Section 6 of the report includes a discussion of various BMPs that can provide sustainable solutions by improving the water quality in Elmendorf Lake and reducing the sediment reaching the lake. While the ultimate goal of any BMP is to improve the quality of water bodies which receive stormwater, it can be very difficult to show the linkages between BMP implementation and changes in receiving water quality. Therefore, the measure of effectiveness of a single or combination of BMPs is typically dependent on the BMP and the level of change that the BMP is expected to make in water quality.

SARA, its partners and numerous stakeholders identified trash and debris as a major water quality and aesthetic problem at Elmendorf Lake. For BMPs designed to reduce or prevent trash and debris from entering water bodies, assessments can be conducted on the type BMP implemented.

As BMPs are implemented, the Pirnie team recommends that their effectiveness be evaluated. All BMPs can be considered and assessed at Level 1 which means documenting activities. Assessments at Levels 2 and 3, raising awareness and changing behavior respectively, are typical of public education and outreach efforts. Level 4 assessments correspond to reducing pollutant loads at the source and are a result of BMPs that prevent pollutants from entering the storm system. The effectiveness of treatment BMPs (in-system controls or end of pipe) result in a Level 5 outcome which is an improvement in water quality of Elmendorf Lake. Changes in receiving water quality (Level 6) are typically a measure of the effectiveness of an overall pollutant mitigation program.

9.5 Vision Plan

The overall long term vision of a Great People Place for the Westside is described in Section 7. It is shown in Figure 7.8. The vision includes Elmendorf Lake, Elmendorf Lake Park and the surrounding community. For the reader's convenience, the overall vision is shown again in Figure 9.1.

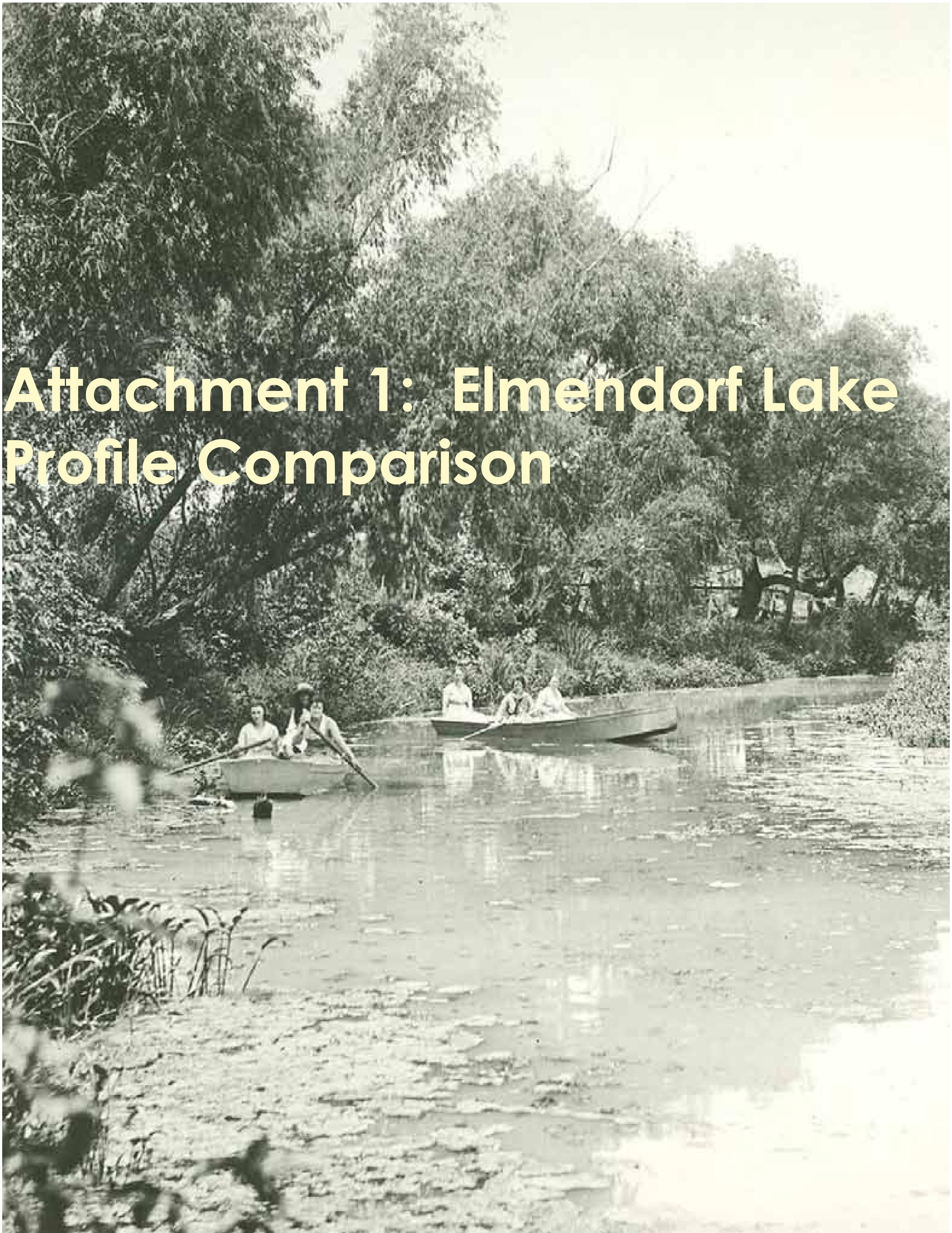
Figure 9.1: Lake in The City Conceptual Plan

As described in the report, Elmendorf Lake Park has tremendous potential to be a great people place although its existing conditions have limitations and lack connection to the community and the lake. The narrow configuration creates limitations for development of the park's full potential. The closeness of busy streets and intersections causes traffic safety issues for park users. For these reasons, the Pirnie team recommends that several floodprone properties be acquired and that Buena Vista Street be relocated before park improvements are implemented.

The vision described in Section 7 creates a destination park and lake interwoven into the community known as "The Lake in the City." The plan projects this park as a destination point on a citywide basis.

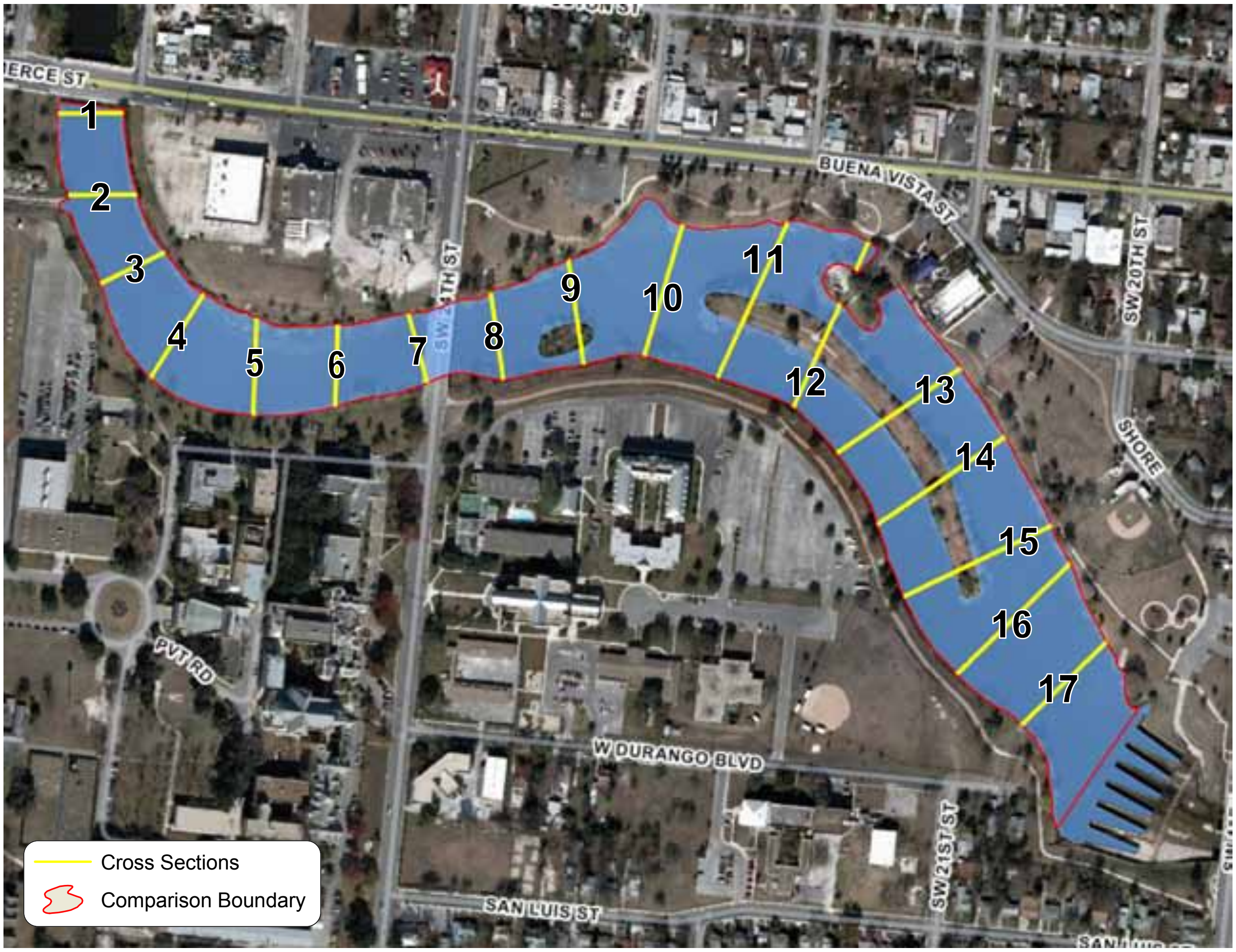
To stay within funding constraints, the vision is implemented through a series of phases. The plan considers Rosedale and Elmendorf Lake Parks as a unit linked by a hike and bike trail connection through Apache Creek Linear Park. In a later phase Jose Navarro Park is also connected and improved. The "super park" created by linking these three units will provide a full range of recreational services. Elmendorf Lake Park emphasizes unique recreational and educational features that focus on nature; Rosedale Park provides athletic and organized sports practice and play opportunities; and Jose Navarro provides an intimate neighborhood park.
This revitalization of the parks and restored connectivity to the lake, the community and OLLU also presents a significant opportunity for private sector redevelopment adjacent to the park and along Apache Creek.

Attachment 1: Elmendorf Lake Profile Comparison



Elmendorf Lake Improvement Project

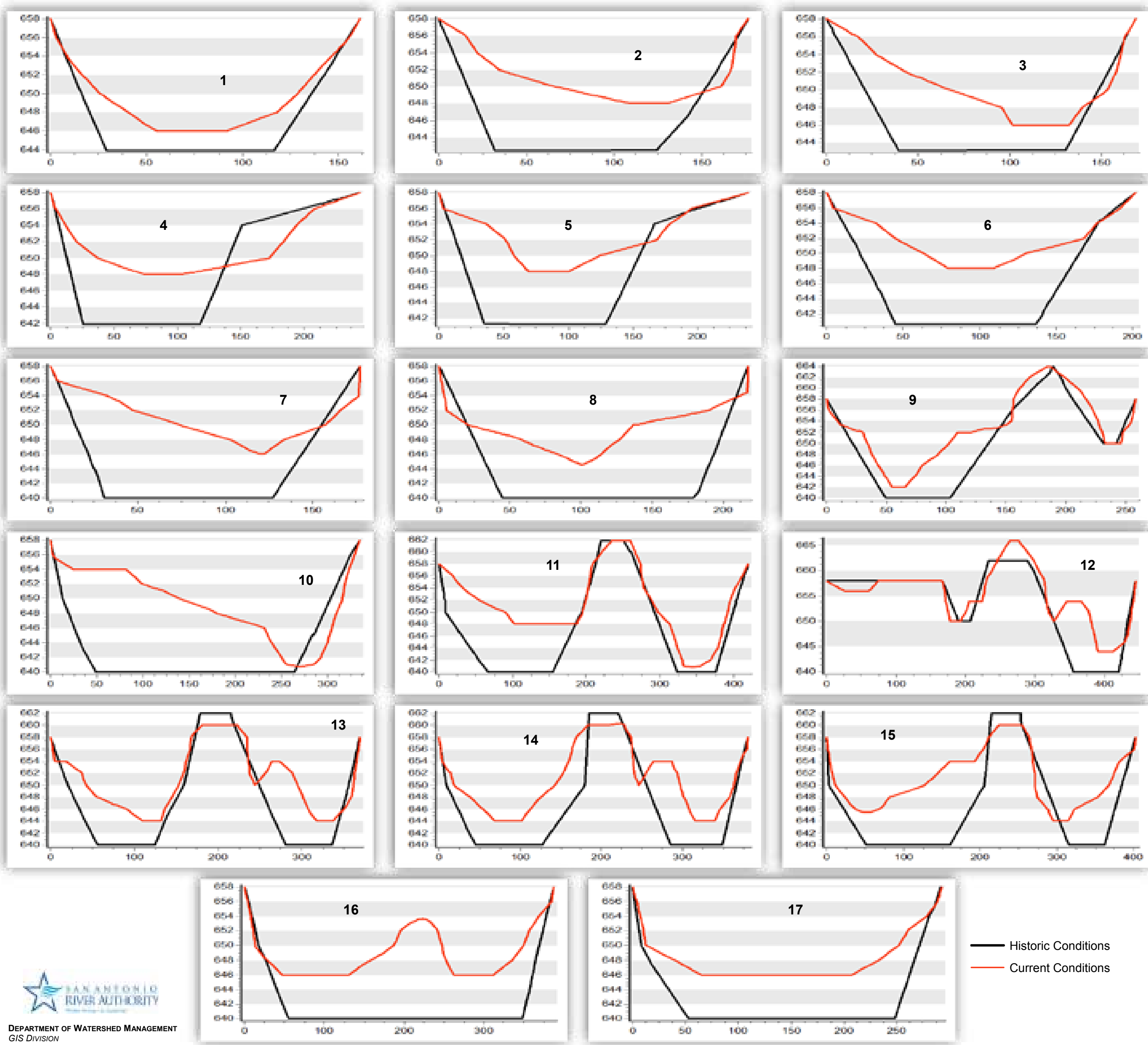
Profile Comparison



Elmendorf Lake Improvement Project

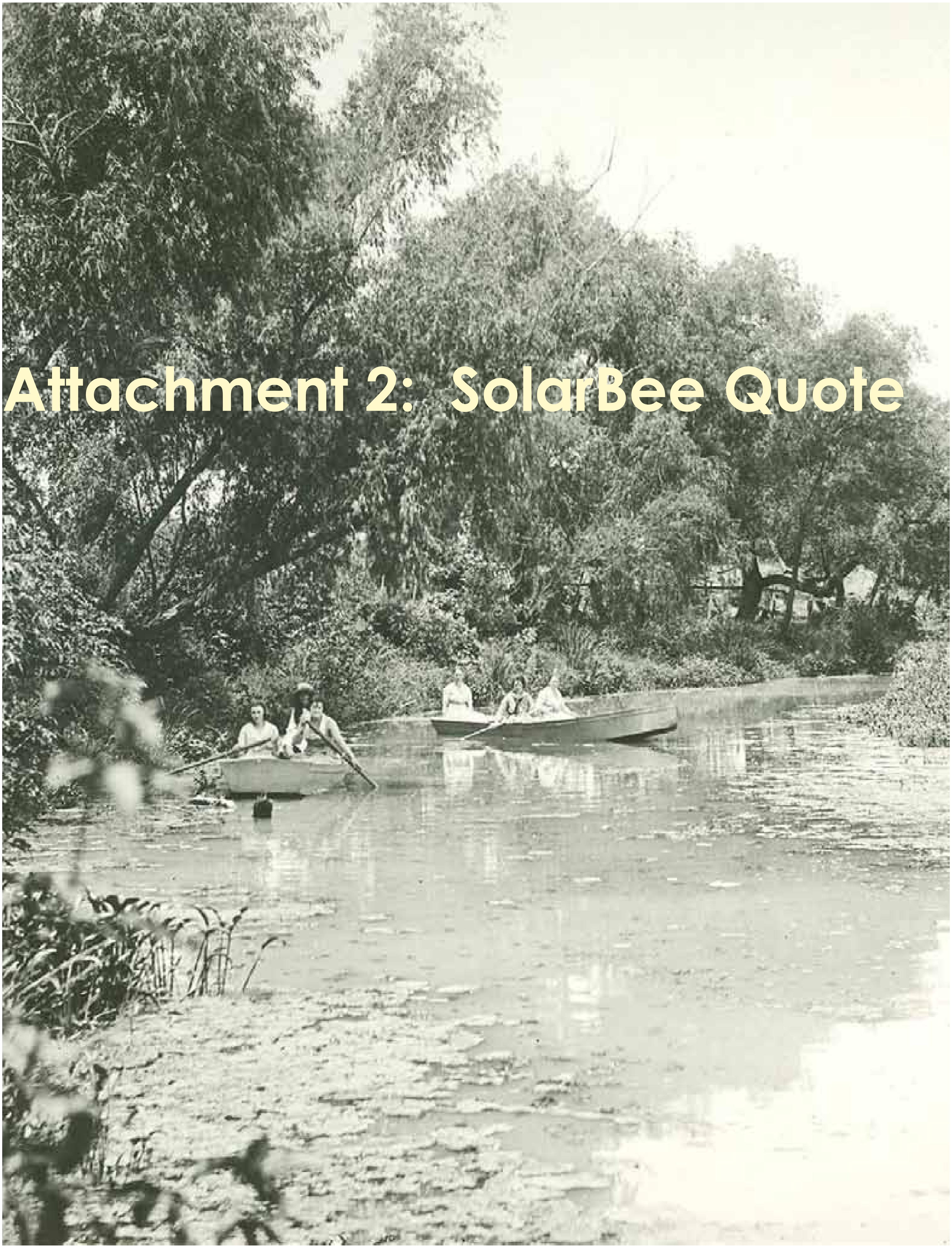
Profile Comparison

INDIVIDUAL CROSS SECTION PROFILE



DEPARTMENT OF WATERSHED MANAGEMENT
GIS DIVISION
AUTHOR: JOHN REFOLO
PUBLISHED: FEBRUARY 2010

Attachment 2: SolarBee Quote



SolarBee®
Circulating the World's Water

Harvey Hibl - West U.S. Manager
303-469-4001 • Harvey@SolarBee.com

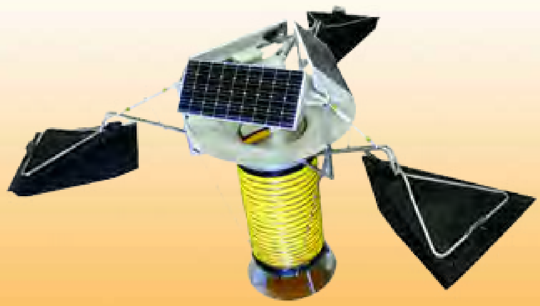
Represented Locally by Moody Bros. Inc.
Kenneth Moody • 713-462-8544

Proposal for:

San Antonio Water System

San Antonio, Texas

c/o Malcolm Pirnie Arcadis



September 29, 2011

Photo of Elmendorf Lake provided by Google Earth

3225 Highway 22 • Dickinson, ND 58601
Tel: (701) 225-4495 • Toll Free: (866) 437-8076 • Fax: (701) 225-0002
www.SolarBee.com

1.0 PROJECT DESCRIPTION

1.1 Name and Location of the Reservoir:

San Antonio, Texas (GPS Coordinates: 29.426393, -98.538286)

1.2 Description of the Reservoir:

Elmendorf Lake was formed by a dam, has a 32-acre surface area, and is 16-feet at it's deepest depth.

1.3 SolarBee Objectives, the Problems to Solve:

Epilimnetic deployment - Primary Objectives: To provide long-distance circulation in order to control harmful cyanobacteria blooms, improve dissolved oxygen levels, fish habitats, and overall water quality.

1.4 SolarBee's Recommendation:

To meet the above objectives, we recommend an incremental approach.

Incremental Phase 1: Installation of three (3) SB10000 v18 machines set for Epilimnetic circulation. These machines should prevent surface water stagnation and associated harmful cyanobacteria blooms, and in turn reduce the amount of algal biomass (and biochemical oxygen demand) going to the bottom. By controlling cyanobacteria blooms and enhancing the distribution of dissolved oxygen in the water column, the lake should be healthier with improved water clarity and fish habitats.

Incremental Phase 2: Due to the shape of the lake and long island, additional units may be required as some marginal areas may not receive sufficient circulation for good cyanobacteria bloom control. Nevertheless, we recommend three initial units because they likely would be adequate, but note here the possible need of a 4th or 5th SB10000 v18 unit set for hypolimnetic oxygenation if the bottom waters continue to be anoxic with good cyanobacterial bloom control in the surface waters.

1.5 Proposed Layout:

Photo Source: Google Earth

Machines are not drawn to scale, and final placement will be determined prior to delivery and installation.

2.0 INVESTMENT OPTIONS

2.1 Budget Estimate for Incremental Phase 1

Equipment Purchase (See Appendix D for details)

Quantity	Description	Purchase Cost Each	Purchase Cost Total
3	SB10000 v18 machines per above:	$45,500	$136,500
	Total Equipment Cost:		$136,500
	Applicable Taxes:		to be determined
3	Factory Delivery, Installation and Startup:	$7,500	$22,500
	Multiple Unit Delivery Discount:	15%	($3,375)
	Total Delivery, Installation, and Startup Cost:		$19,125
	Total Investment (excluding taxes):		$155,625
	Beekeeper cost of $3,891 per year for years 1 & 2 (see Appendix C):		- Optional -
	Beekeeper cost of $9,338 per year for years 3, 4 & 5 (see Appendix C):		- Optional -

5-Year Lease Purchase (See Appendix E for details):

Cost for recommended machines per above:	- Included -
Factory Delivery, Installation and Startup:	- Included -
Beekeeper cost for years 1 & 2 (see Appendix C):	- Included -
Beekeeper cost for years 3, 4 & 5 (see Appendix C):	- Included -
Total Monthly Lease Purchase Cost (excluding taxes):	$3,700

12-Month Rental (See Appendix F for details):

Monthly rental cost for recommended machines per above:	$3,540
Monthly Beekeeper cost during the term of the rental:	- Included -
Factory Delivery, Installation and Startup:	$19,125

2.2 Budget Estimate for Incremental Phase 2

Equipment Purchase (See Appendix D for details)

Quantity	Description	Purchase Cost Each	Purchase Cost Total
2	SB10000 v18 machines per above:	$45,500	$91,000
	Total Equipment Cost:		$91,000
	Applicable Taxes:		to be determined
2	Factory Delivery, Installation and Startup:	$7,500	$15,000
	Multiple Unit Delivery Discount:	$0.10	($1,500)
	Total Delivery, Installation, and Startup Cost:		$13,500
	Total Investment (excluding taxes):		$104,500
	Beekeeper cost of $2,613 per year for years 1 & 2 (see Appendix C):		- Optional -
	Beekeeper cost of $6,270 per year for years 3, 4 & 5 (see Appendix C):		- Optional -

5-Year Lease Purchase (See Appendix E for details):

Cost for recommended machines per above:	- Included -
Factory Delivery, Installation and Startup:	- Included -
Beekeeper cost for years 1 & 2 (see Appendix C):	- Included -
Beekeeper cost for years 3, 4 & 5 (see Appendix C):	- Included -
Total Monthly Lease Purchase Cost (excluding taxes):	$2,430

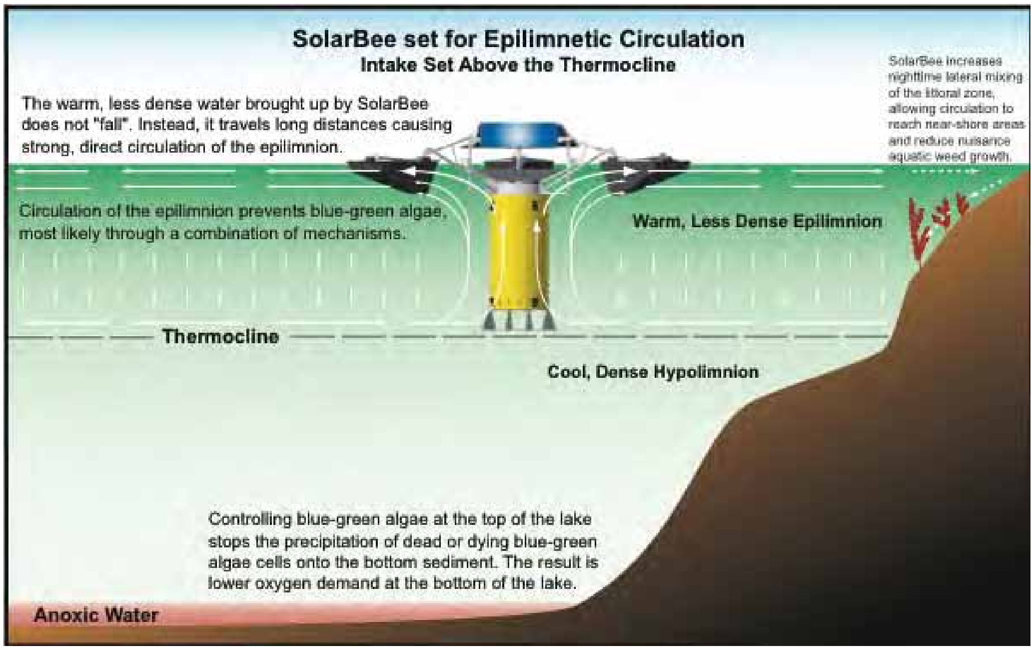
12-Month Rental (See Appendix F for details):

Monthly rental cost for recommended machines per above:	$2,360
Monthly Beekeeper cost during the term of the rental:	- Included -
Factory Delivery, Installation and Startup:	$13,500

Appendix A: Equipment

SB10000 v18 (Epilimnetic Circulation):

The SB10000 v18 features a 10,000 gpm (14.4 MGD) total flow leaving the machine, near laminar flow output for long distance circulation, 316 stainless steel and non-corrosion polymer construction, 25-year life high efficiency brushless electric motor design that provides day and night operation with a solar-charged battery power system, digital control system for intelligent power management with factory programmed reverse functions and anti-jam routines specific to this application, SCADA outputs, three (3) 80-watt solar panels, 36" diameter intake hose, anchoring system, and bird deterrent. See Appendix D - SolarBee Limited Replacement Warranty for information on the most extensive warranty in the industry.



Appendix B: Factory Delivery and Field Services

SolarBee, Inc. sends a factory trained Delivery & Field Services Team with specialized equipment to deliver, assemble, place, and start up your SolarBee machines. A training session on operation and maintenance is also provided for your personnel. Each Team member undergoes training such as Fall Protection, Confined Space Entry, Working Over Water, and Water Quality Testing.

As part of our standard operating procedures, the factory trained Delivery & Field Services Team will conduct vertical profiles with a YSI multi-parameter submersible probe, and at each test point measure dissolved oxygen, pH, temperature and specific conductance at every foot from the surface down to a depth of 25 feet, and at 5-foot intervals thereafter. A Secchi depth measurement will also be made at each test location. GPS coordinates are recorded for each machine and test point location.

Your water quality is our highest priority. Our commitment continues long after the Delivery & Field Services Team leaves your location and we strive to maintain contact with all our customers. Our Customer Service, Application Engineering, and Science Departments are available for any questions regarding machine operation and water quality.

Appendix C: Beekeeper Service Program

The Beekeeper is a program that utilizes Factory Crews to service and maintain proprietary designed equipment. The Beekeeper provides for more than just maintenance and service:
• It extends the warranty during the term of the Beekeeper
• It covers damage from Acts of God and vandalism
• It provides for power system upgrades and updates
• It provides hardware, firmware, and software for computer upgrades
• It provides scientific and technical support
• It provides for scheduled and unscheduled field service calls
• and much more, please request the Beekeeper brochure for more details

Appendix D: General Provisions

This is a Budget Estimate, please call for a firm Quotation:

This budget estimate replaces all prior budget estimates for this project. It is valid until replaced by a subsequent budget estimate, or for 60 days, whichever occurs first.

Purchase of the SolarBee circulation equipment in this quotation is an "Equipment Purchase," not a "Construction Project":

SolarBee circulation equipment is portable, and can be easily relocated or removed entirely from the premises at any time. They do not become an integral part of any building or other structure, and never become part of "real estate". Therefore, to purchase SolarBee circulation equipment, the city or other organization purchasing SolarBees should use the same procedure as for purchasing other portable equipment, such as a forklift, a drill press, or an office desk. SolarBee reserves the right not to accept an order if the purchase is incorrectly characterized as a "construction" project. SolarBee, Inc. has not found any state or other jurisdiction where construction or contractor statutes apply to portable equipment that is sold by a factory, with on-site final assembly and startup performed by factory personnel.

Assumptions:

This quotation may be based on worksheets and calculations that have been provided to the customer, either previously or else attached to this quotation. The customer should bring to our attention any discrepancies in data used for these calculations.

SolarBee Limited Replacement Warranty:

All new and factory-refurbished SolarBee equipment is warranted to be free of defective parts, materials, and workmanship for a period of 2 years from the date of installation. In addition, the SolarBee brushless motor is warranted for a period of 10 years from the date of installation. Photovoltaic modules (solar panels) carry manufacturer warranties, some ranging up to 25 years (see manufacturers' warranty for details). This warranty is valid only for SolarBee equipment used in accordance with the owner's manual, and consistent with any initial and ongoing factory recommendations. This warranty is limited to the repair or replacement of defective components, at SolarBee's discretion. The first 2 years the warranty also includes both parts and labor. In lieu of sending a factory service crew to the site for minor repairs, SolarBee, Inc. may choose to send the replacement parts to the owner postage-paid and, in some cases, may pay the owner a reasonable labor allowance to install the parts.

Except as stated above, SolarBee and its affiliates expressly disclaim any and all express or implied conditions, representations and warranties on products furnished hereunder, including without limitation all implied warranties of merchantability or fitness for a particular purpose.

Please consult your state law regarding this warranty as certain states may have legal provisions affecting the scope of this warranty.

Appendix E: Lease Provisions

Standard Agreement:

Pricing in the above quotation is based on 5 years, 60 monthly payments, and a $0 down payment. For a quotation based on other terms, please call SolarBee, Inc., at 1-866-437-8076.

Non-Appropriation Provision:

Lessee's (borrower's) payment obligation will terminate if the lessee fails to appropriate in future budgets the funds needed to make the lease payments. Because of this non-appropriation provision, neither the lease nor the lease payments are considered debt, and payments can be made from the savings in your operating budget.

Maintenance of the Equipment:

Lessee is to provide minor routine care and maintenance of the Equipment as described in the owners manual. The Beekeeper Service Program is required, and is included in the cost shown above for the term of the lease. See above Appendix C for description of the Beekeeper program.

Additional Lease Provisions:

If the lease option is selected, a master equipment lease/purchase agreement will be sent to lessee, that shall cover all terms and conditions of the lease.

Appendix F: Rental Provisions

Rental payment terms:

The installation day of the month is the anniversary day for determining when a new rental month begins. There are no partial months; if the equipment is in place on the first day of the rental month, a whole month of rental is due. Rental invoices will be provided each month and payment is due 30 days from the invoice date. The installation charge mentioned above will be added to the first month's rental invoice.

Rental period, month-to-month:

The rental period shall be for one month, beginning on the installation date, and shall continue automatically, for one month at a time beginning on each monthly anniversary of the installation date, until the longer of (a) 12 months, or (b) 90 days after written notice is received by SolarBee, Inc. from the renter to terminate the rental. Furthermore, SolarBee, Inc. has the right to terminate the rental agreement and re-possess the equipment at any time, without notice to the renter, if the renter becomes delinquent in rent payments.

Periodic rental cost adjustment:

The rental cost may be adjusted periodically by SolarBee, Inc. upon 90 day written advance notice to the renter, after the minimum rental period mentioned above. SolarBee, Inc. expects, but does not promise, to make such adjustments only once per year on the annual anniversary of the installation, and expects that adjustments will be limited to reflect (a) a general inflationary adjustment equal to the Consumer Price Index, and (b) any additional costs by the factory associated with keeping the rental equipment functioning properly and meeting the renter's goals for the project. The renter, at its option as mentioned above, may cancel the rental agreement with 90 day notice if the proposed new rental costs are ever not acceptable.

Rental conversion to purchase:

The renter may convert this rental to a purchase, at the price shown in the Equipment Purchase section above. To convert this rental to a purchase, the renter should request SolarBee Inc, at least 60 days before the desired purchase date, to supply a firm quotation to convert the rental to a purchase. When conversion to a purchase is made, 50% of prior rents paid will be applied to the purchase price, up to a maximum of 50% of the equipment purchase price. Title to the rental equipment does not pass to the renter unless and until payment of all outstanding rental invoices, and the conversion purchase price for the equipment, is received by the SolarBee, Inc.

Rental Equipment Availability:

SolarBee, Inc. has a limited supply of rental machines available; either new or slightly used or "demonstrator" equipment may be installed at the factory's option. If the equipment installed for a rental is slightly used, then the factory warrants that: (1) the equipment is clean, current, and in like-new condition with a full new-equipment warranty, and (2) the equipment is equivalent to new equipment with the very latest technology and improvements. Also note that SCADA or other remote monitoring options may have been included in the purchase cost in Section 2 above, but these components are not included with rental equipment. If a rental is desired, the SCADA remote monitoring equipment would be installed only after the equipment had been converted to a purchase, unless other provisions have been made.

Maintenance of the Equipment.

Renter is to provide minor routine care and maintenance of the Equipment as described in the owners manual. The Beekeeper Service Program is required and is included in the cost shown above for the term of the rental. See above Appendix C for description of the Beekeeper.

Appendix A: Public Meeting - June 19, 2012 Memorandum

ARCADIS U.S., Inc
70 NE Loop 410
Suite 1150
San Antonio
Texas 78216
Tel 512-584-4242

MEMO

To:
Rudy Farias (SARA)

Copies:
Pirnie Team Members

From:
Fred M. Blumberg, Project Manager

Date:
June 20, 2012

ARCADIS Project No.:
06353020.0000

Subject:
Public Meeting on Elmendorf Lake Improvements—June 19, 2012

On June 19, 2012 Bexar County, the City of San Antonio (COSA) and the San Antonio River Authority (SARA) hosted a public meeting to provide an update on the coordinated projects to improve Elmendorf Lake through the Westside Creeks Restoration Project and the 2012 COSA Bond Program. The public meeting was held at Our Lady of the Lake University (OLLU). The agenda and presentation are attached. The purpose of this memo is to document the public comments that were received after the presentation.

Overall Reaction to the Proposed Vision

The majority of the comments were very supportive and complimentary to the Vision and the proposed improvements to Elmendorf Lake Park. Several people said they “loved what they were hearing,” that “it is a great plan” and that it was a “beautiful plan for the neighborhood.” There was a very positive reaction to the ideas related to environmental education and use of the area by schools. It was suggested that the plan should be kept as simple as possible.

Comments and Suggestions

The comments, suggestions and concerns that were expressed included the following major areas:

ARCADIS

1. Habitat and Ecosystems. The plan should continue to support habitat for the birds, ducks and other aquatic life. More trees should be included in the park; it may be possible to mark the trees with the names of veterans.

2. Private Entities and Private Property. There were questions about the amount of control "private entities" would have in the development of the improvements. There were also concerns expressed about the purchasing of private property for improvements to the park, specifically for the possible relocation of Buena Vista Street. The commenters asked to be kept informed.

3. Hispanic Veterans Monument. Several people spoke in favor of having space in the park for the proposed Hispanic Veterans Monument. It was emphasized that private funding is being solicited for the monument and that COSA and County funds were not being used. The COSA also addressed questions about how artists are chosen for public art that is associated with city projects.

4. Neighborhood Park and Lake. There were several comments related to keeping a balance between Elmendorf Lake and Elmendorf Lake Park as neighborhood/community resources and. making them a destination for the city and a wider area. There was also general support bringing school children from a wider area to use the environmental education opportunities and the recreation facilities.

5. Safety and Security. There were a significant number of questions, comments and suggestions related to the importance of improving safety and security in the park and around the lake. The suggestions included safety monitors and call boxes; trying to reduce or eliminate the number of surrounding businesses that promoted bad behavior such as drug use and drinking; making the lake safer from a water safety/drowning standpoint; solving the traffic safety issues along Commerce Street; lighting trails and areas within the park; and putting trails under the Commerce and 24th St bridges to eliminate crossing the streets. One person also discussed the need to clean up the area around the lake to reduce the number of raccoons and other animals.

6. Water Quality. Is the lake large enough to allow boating without interfering with the restoration? Will the water quality be improved enough to allow swimming at some time in the future? Trash coming from Zarzamora Creek (under Gen. McMullen Road), Bandera Branch, and Apache Creek are major problems.

7. Implementation and Operation. How long will it take to construct the improvements? How will the improvements to Elmendorf Lake Park fit in the schedule for improvements to other Westside Creeks? There will not be enough money to do all of the improvements at one time, so choices must be made. It is important to maintain the facilities after they are constructed.

8. Specific Comments and Suggestions. The more specific comments and suggestions included the following:

   - Senior citizens that live in the complex at 26th Street and Martin Street need to be able to walk on trails along the lake;
   - Senior citizens need an auditorium and an indoor Olympic-size swimming pool;
   - This area of the city is not getting any of the venue tax;
   - Graffiti needs to be reduced;
   - Street lights are out along 19th Street; and
   - Walking trails for the handicapped are needed.