City of San Marcos

630 East Hopkins
San Marcos, TX 78666

Work Session - Final-Amended

City Council

Tuesday, January 7, 2020 | **3:00 PM** | **City Council Chambers**

630 E. Hopkins - Work Session

I. Call To Order

II. Roll Call

PRESENTATIONS

1. Receive a Staff update and hold discussion regarding Cape's Dam, and provide direction to the City Manager.

EXECUTIVE SESSION

2. Executive Session in accordance with the following Government Code Sections:
A. Section § 551.072 - Real Property: to receive a staff briefing and deliberation regarding acquisition of property in Downtown San Marcos for Public Use.
B. Section § 551.071 - Consultation with Attorney: to receive a staff briefing and deliberation regarding Martindale ETJ Matters.

III. Adjournment.

POSTED ON THURSDAY, DECEMBER 26, 2019 @ 12:00PM

TAMMY K. COOK, INTERIM CITY CLERK

IV. ADDENDUM

The following items has been added to the agenda since it was posted on December 26, 2019:
Item #2:
Executive Session in accordance with the following Government Code Section(s):
B. Section § 551.071 - Consultation with Attorney: to receive a staff briefing and deliberate regarding Martindale ETJ Matters.

ADDENDUM POSTED ON TUESDAY, DECEMBER 31, 2019 @ 12:00PM

TAMMY K. COOK, INTERIM CITY CLERK

Notice of Assistance at the Public Meetings

The City of San Marcos does not discriminate on the basis of disability in the admission or access to its services, programs, or activities. Individuals who require auxiliary aids and services for this meeting should contact the City of San Marcos ADA Coordinator at 512-393-8000 (voice) or call Texas Relay Service (TRS) by dialing 7-1-1. Requests can also be faxed to 855-461-6674 or sent by e-mail to ADArequest@sanmarcostx.gov

File #: ID#19-825, **Version:** 1

AGENDA CAPTION:
Receive a Staff update and hold discussion regarding Cape's Dam, and provide direction to the City Manager.
Meeting date: January 7, 2020

Department: Parks and Recreation Department

Amount & Source of Funding
Funds Required: Click or tap here to enter text.
Account Number: Click or tap here to enter text.
Funds Available: Click or tap here to enter text.
Account Name: Click or tap here to enter text.

Fiscal Note:

Prior Council Action: Click or tap here to enter text.

City Council Strategic Initiative: [Please select from the dropdown menu below]

N/A

Choose an item.

Choose an item.

Comprehensive Plan Element (s): [Please select the Plan element(s) and Goal # from dropdown menu below]

☐ Economic Development - Choose an item.

☐ Environment & Resource Protection - Choose an item.

☐ Land Use - Choose an item.

☐ Neighborhoods & Housing - Choose an item.

☐ Parks, Public Spaces & Facilities - Choose an item.

☐ Transportation - Choose an item.

☐ Not Applicable

Master Plan: *[Please select the corresponding Master Plan from the dropdown menu below (if applicable)]*

Choose an item.

Background Information:

February 22, 2016: Capes Dam Workshop

- Presentation by Dr. Thomas Hardy
- Effects of changing height of Cape's Dam on recreation, Texas wild rice and fountain darter habitat (Hardy Report - 10/12/15)

March 15, 2016: Council voted to approve the removal of Cape's Dam.

August 16, 2016: Capes Dam Council Presentation

- Presentation by Mike Montagne, U.S. Fish and Wildlife Service
- Cape's Dam Removal Analysis (Hydraulic Hardy Report - 3/27/2017)
- Supplement Cape's Dam and Mill Race Assessment (Supplemental Assessment-Hardy Report - 5/23/17)

October 4, 2018: Historic Preservation Commission

- Recommended approval of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark (4-2)

November 27, 2018: Planning and Zoning Commission

- Recommended denial of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark (5-4)

January 11, 2019: Capes Dam Memo Staff Update

January 15, 2019: City Council briefed in executive session to discuss possible partnership opportunities with Hays County and the Hays County Historical Commission.

January 29, 2019: City Council considered an item designating Cape's Dam as a historic landmark. This action was postponed for up to 6 months while staff gathered more information related to the project.

June 18, 2019: City Council briefed in Work Session on status of possible partnership opportunities with Hays County and the Hays County Historical Commission. Presentation from County on proposed project anticipated in fall 2019.

October 15, 2019: City Council received a presentation from Vista Planning & Design on behalf of Hays County and the Hays County Historical Commission regarding a visioning study for Cape's Dam, the Mill Race, Thompson's Island & San Marcos River. Council provided consensus for staff to seek what permissions and permits would be needed from State and Federal agencies to remove or repair the dam.

Council Committee, Board/Commission Action:

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Click or tap here to enter text.

Alternatives:

Click or tap here to enter text.

Recommendation:

Provide direction to Staff.

CITY COUNCIL WORK SESSION

Cape's Dam Update

Tuesday, January 7, 2020

PURPOSE & AGENDA

- To provide an update since the October 15, 2019 Work Session regarding Cape's Dam.

- Today we will review the following:
  - Timeline
  - Progress since October 15
  - The possible permitting process
  - Options for Council's discussion and direction

Mill Race & Machinery

Cape's Dam Timeline

JAN, 2013

The Woodlands of SM Approved

- Received 20 Ac. dedicated parkland
- Includes Cape's Dam and the Mill Race

SEPT, 2014

Presentation - Dr. Thom Hardy

- Parks and Recreation Advisory Board receives presentation
- Evaluation of safety and environmental issues
- Recommendation for Dam removal and filling in the Mill Race.

FEB, 2016

City Council Workshop

- Presentation from Dr. Hardy
- Direction to bring back an action item for Dam removal

MAR, 2016

City Council Approval

- Motion approved to remove Cape's Dam and fill in Mill Race

JUN, 2016

Stakeholder Mtg.

- US Fish and Wildlife Service (USFWS)
- Texas Historical Commission (THC)
- US Army Corps of Engineers (USACE)
- Hays County Historical Commission
- City
- THC - "Sufficient historic integrity for National Register"
- USFWS - "Dam must be fully removed to receive funding"

AUG, 2016

USFWS Presentation

- Presentation to Council about Planning and Permitting Process
- Dam "Acts as a barrier to fish and aquatic species"
- Dam "Is in severe disrepair and a safety hazard to recreation"
- Conflicting positions between USFWS and THC
- City suspends USFWS permit due to multiple competing interests

JAN, 2019

Partnership Opportunities

- Executive Session briefing on potential partnership
- Hays County, Hays County Historical Commission, City

JAN, 2019

Historic Landmark Designation

- 10/18 - HPC Recommends designation of Cape's Dam
- 11/18 - P&Z recommends denial of the designation
- 1/19 - City Council postpones for 6 months to gather more info.

JUNE, 2019

City Council Work Session

- Status of partnership opportunities
- Presentation from County on proposed project in Fall 2019

OCT, 2019

Visioning Study

- Presentation from Vista Planning and Design
- Council asked Staff to explore required State or Federal permits

UPDATE

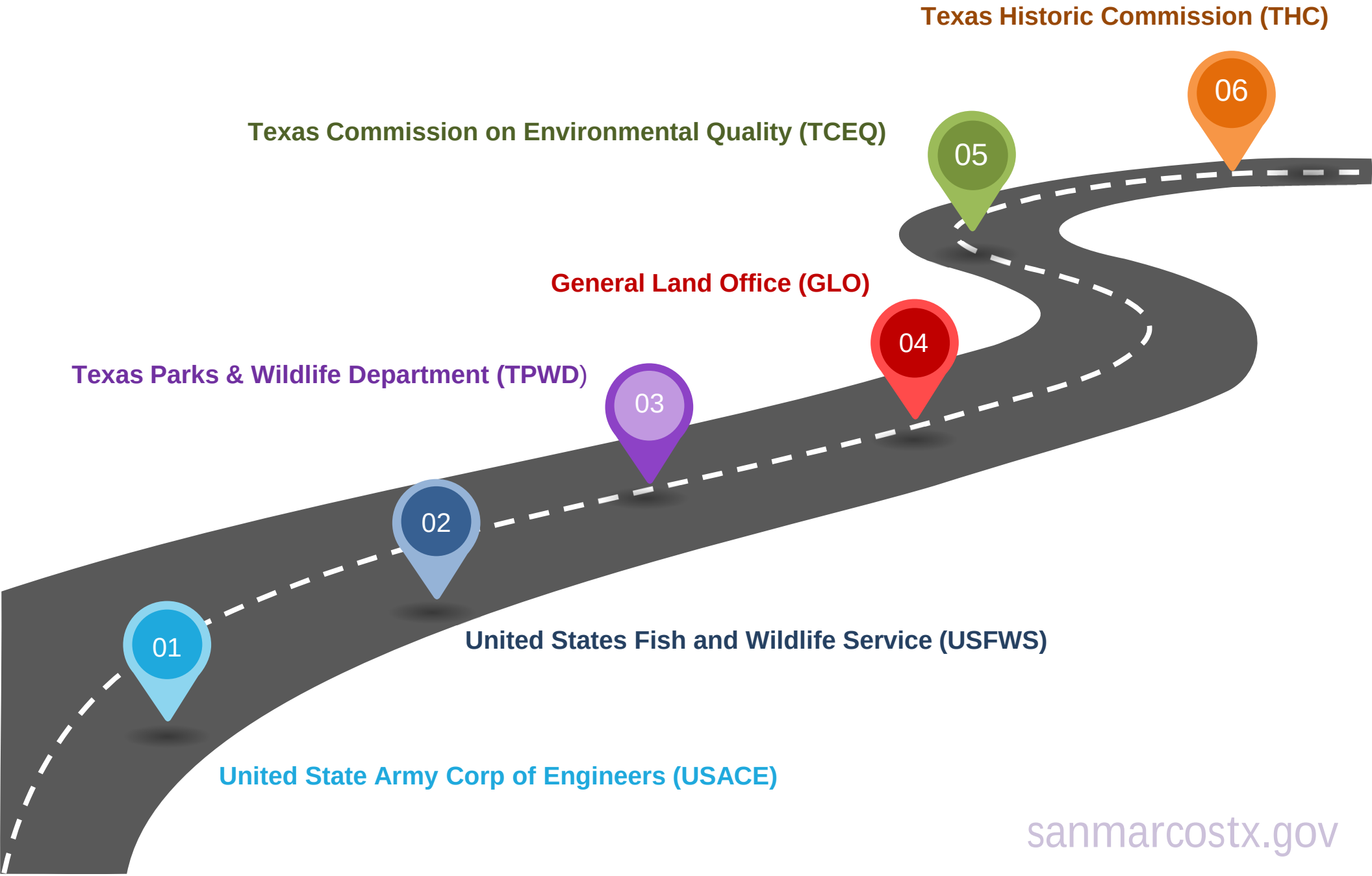
- Staff has met with representatives of Hays County and the Hays County Historical Commission.
- Discussed possible Interlocal Agreement to cost share in some aspects of the project, dependent upon direction Council wishes to take.
- A memo dated December 2, 2019 was provided to the City Council reporting on safety measures at Cape's Camp/Thompson Island area.
- City Council provided consensus on October 15 for staff to seek what permissions and permits would be needed from state and federal agencies to remove or repair the dam.

PERMITTING

What would the process potentially look like?

- The permitting requirements could vary depending on what direction the City Council would like to go in.
- The following slide is a general overview of all agencies that could be involved

Potential Permitting Process Roadmap



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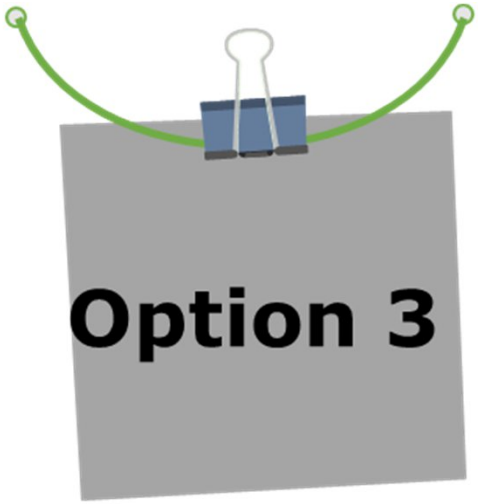
COUNCIL DIRECTION

Removal of the Dam

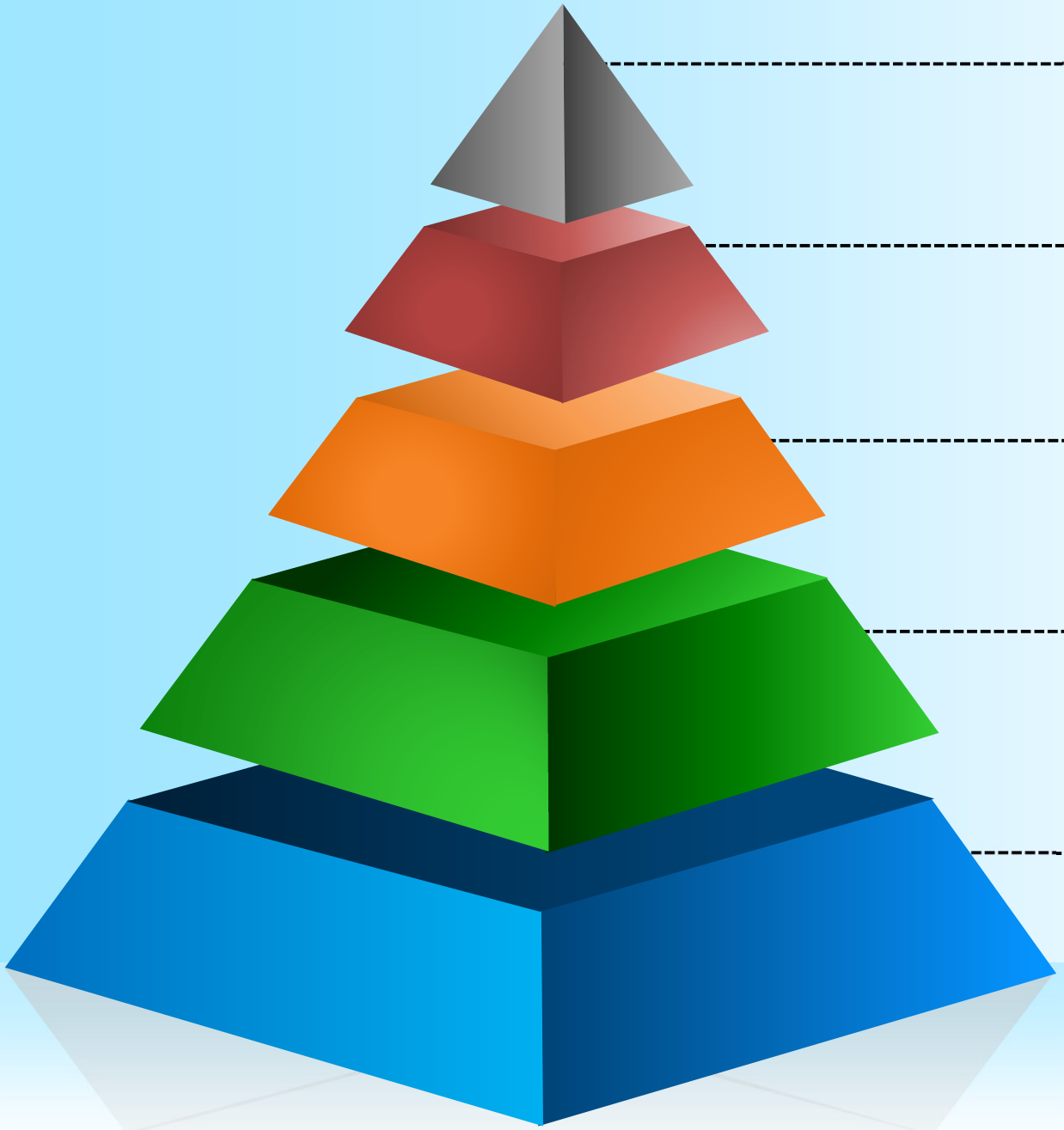
Redesign & Rebuild



Restoration

Conduct Another Study

OPTION 1: REMOVAL



REMOVAL

- The demolition process will begin.

CONTRACTS/FUNDING

- Staff will bring back any necessary items for consideration, if needed.

STATE AGENCIES CONTACTED

- Staff will contact all necessary state agencies to begin permitting.

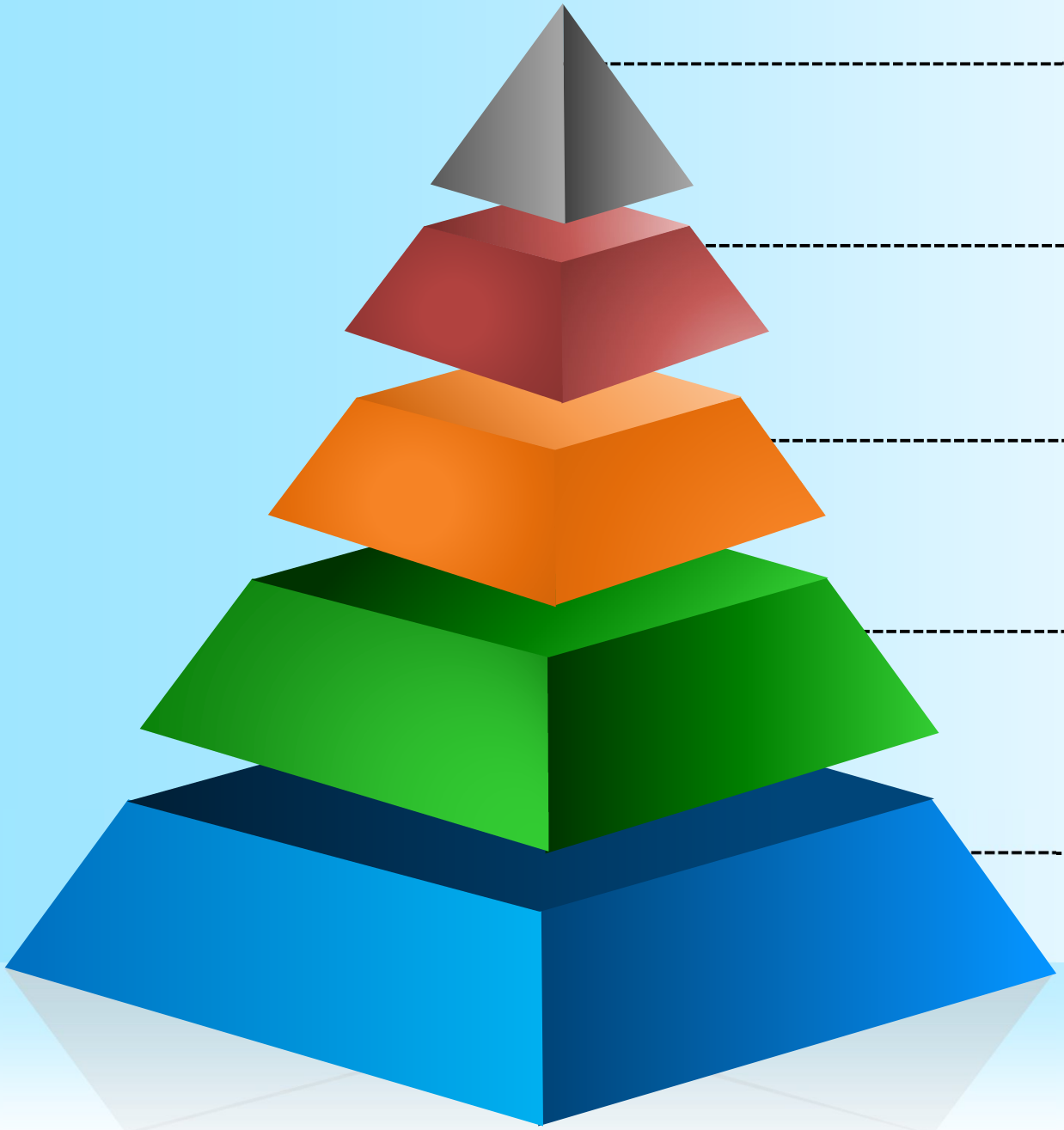
STAFF INITIATES PERMITTING

- Staff will contact the US Army Corp of Engineers

COUNCIL DIRECTION

- Council direction to move forward with removal.

OPTION 2: REDESIGN & REBUILD



REBUILDING

- The rebuilding process would begin.

STAFF INITIATES PERMITTING

- Staff will contact US Army Corp of Engineers and all necessary state agencies.

COUNCIL CONSIDERATION

- Staff will bring forward any Interlocal Agreements, contracts, or designs.

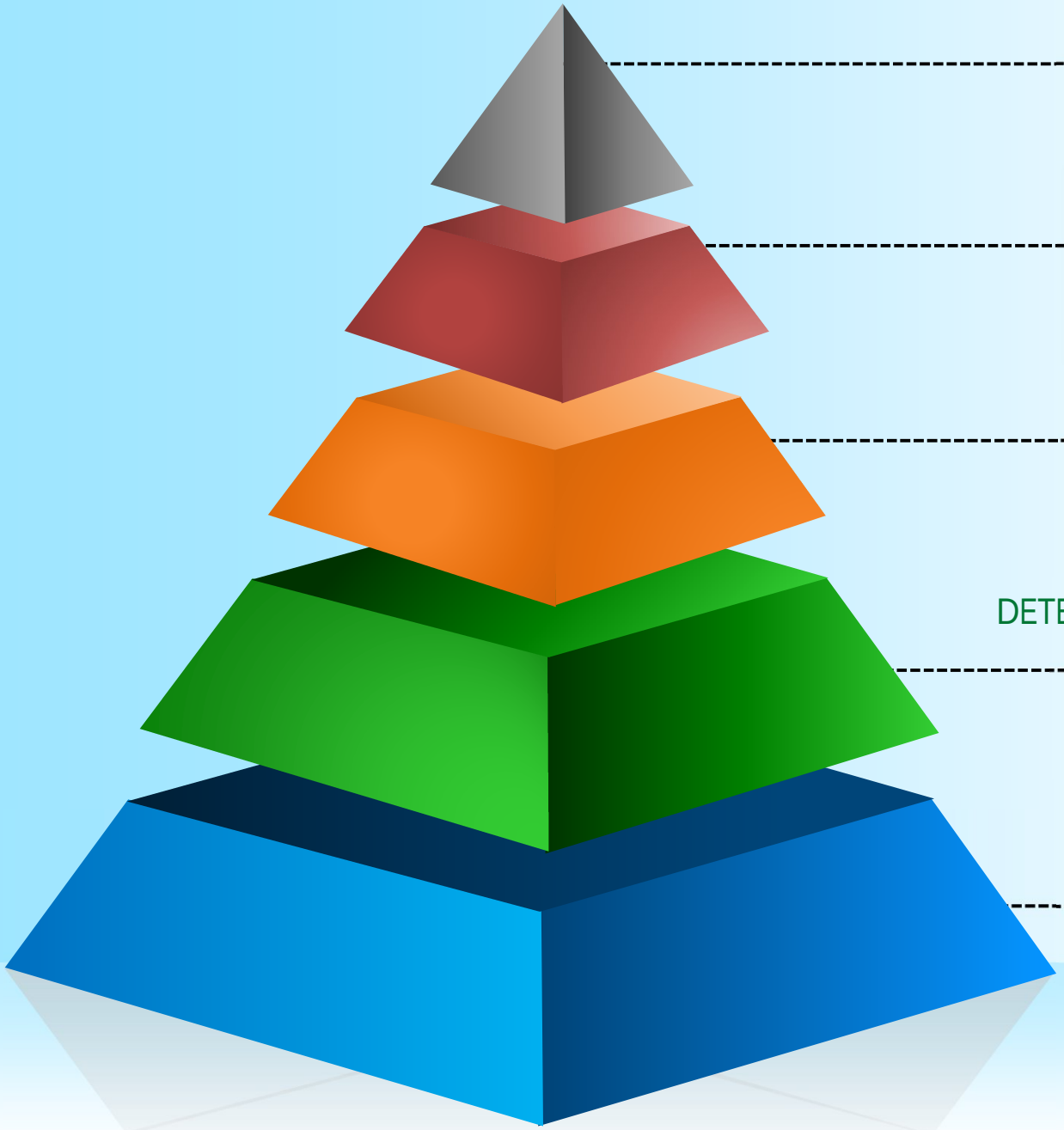
INTERLOCAL AGREEMENT

- Staff will work with Hays County and the Hays Co. Historical Commission.

COUNCIL DIRECTION

- Council direction to redesign & rebuild.

OPTION 3: RESTORATION



PERMITTING & RESTORATION

- The permitting and restoration process would begin.

FUNDING/CONTRACTS

- Council will need to consider funding & contracts for project

COUNCIL UPDATE

- Update on what will be allowed under today's federal & state regulations

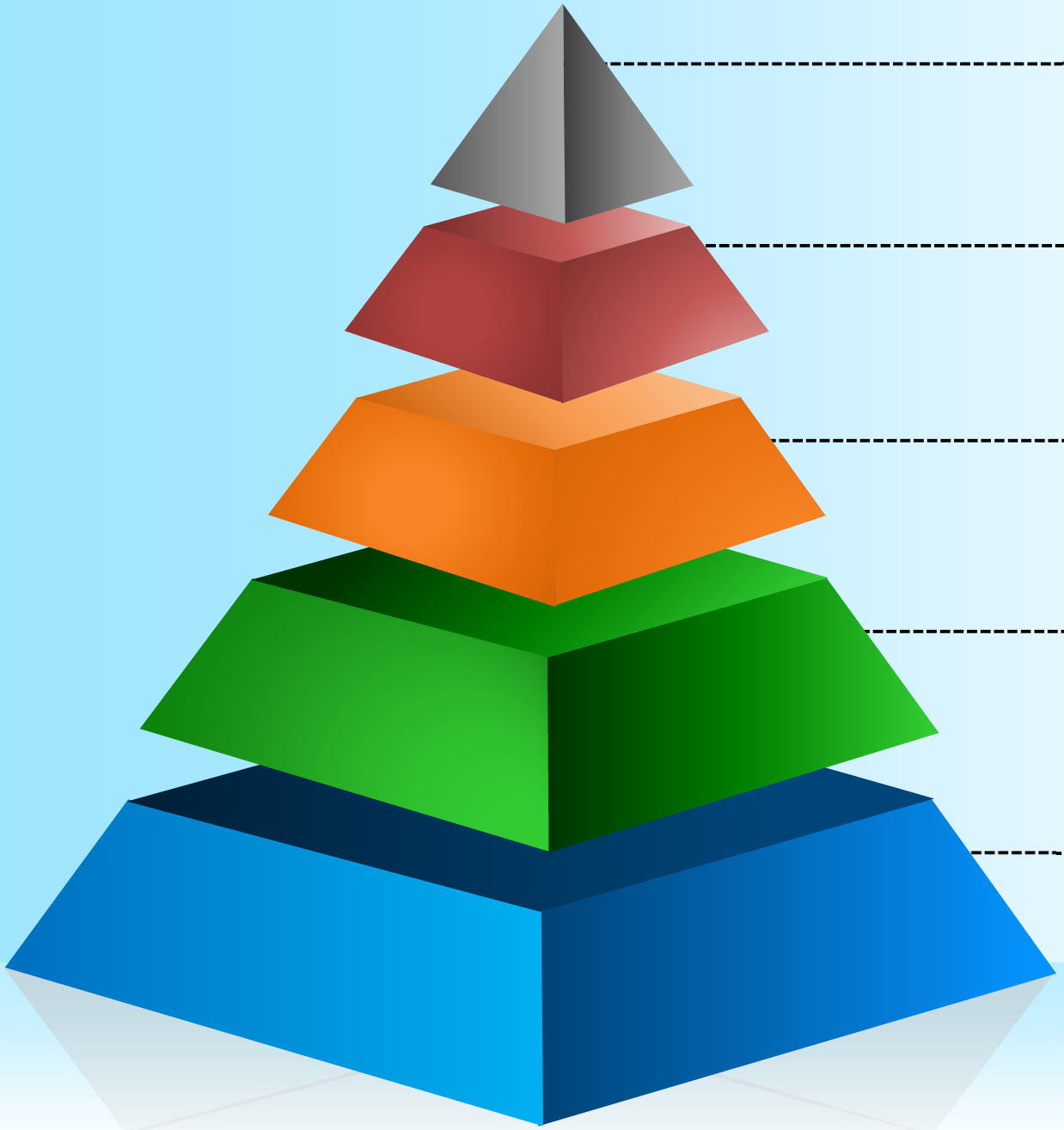
DETERMINE FEASIBILITY/INTERLOCAL AGREEMENT

- Staff will work with Texas Historical Commission, US Fish and Wildlife & Hays County.

COUNCIL DIRECTION

- Council direction to restore the dam.

OPTION 4: ANOTHER STUDY



COUNCIL DIRECTION

- Council will provide direction to staff on how to proceed.

RESULTS OF STUDY

- Council will receive results of the study.

COUNCIL UPDATE/CONTRACT

- Update on progress and potential approval of contract for study.

POSSIBLE RFP PROCESS

- Staff will put out an RFP and go through the selection process.

COUNCIL DIRECTION

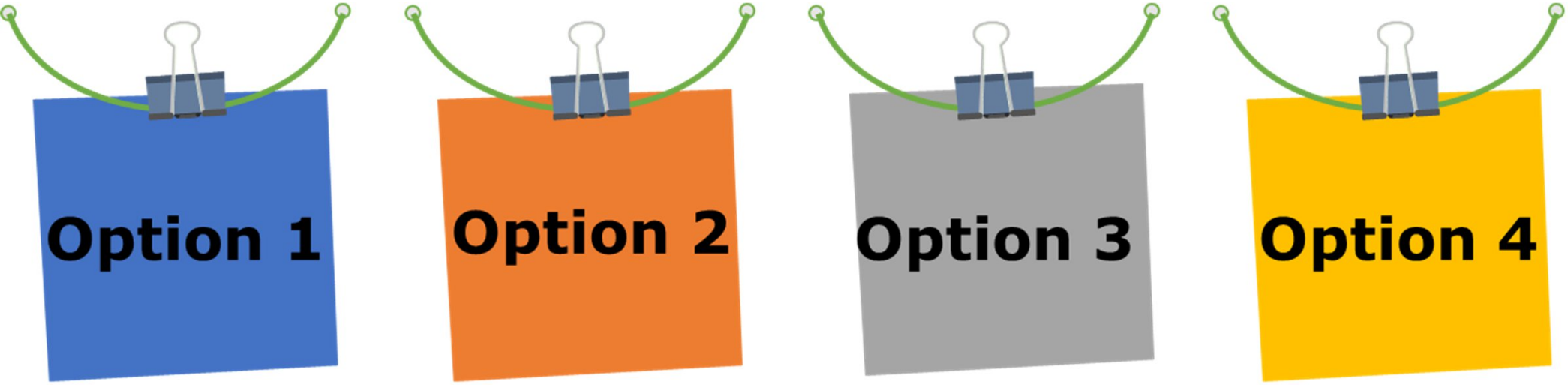
- Council direction to conduct another study

FUNDING AVAILABLE

- Currently there is $174,628 remaining of the $250,000 that was originally funded for the Cape's Camp Improvement and Dam Project.

- To date $75,372 of the funds have been used to fund previous studies on Cape's Dam and the Mill Race.

COUNCIL DIRECTION REQUESTED RECAP



Removal of the Dam

Redesign & Rebuild

Restoration

Conduct Another Study

QUESTIONS?

PARKS AND RECREATION

MEMO

TO: **Stephanie Reyes, Assistant City Manager**
FROM: Drew Wells, Director of Parks and Recreation
DATE: December 23, 2019
RE: **Cape's Dam**

SUMMARY
The purpose of this memorandum is to provide further detail regarding the timeline and permitting process related to Cape's Dam. Hyperlinks are including within the information below.

Background

January 15, 2013, City Council approved Planned Development District (PDD) zoning for The Woodlands of San Marcos development project, and received 20 acres of dedicated parkland along the San Marcos River, which includes Cape's Dam and the Mill Race.

September 23, 2014, the Parks and Recreation Advisory Board received a presentation from Dr. Thom Hardy regarding work done by the Meadows Center in regards to a study of the safety and environmental issues associated with Cape's Dam. Scientific evaluation was completed which recommended the removal of Cape's Dam and filling of the Mill Race.

February 22, 2016, City Council held a Cape's Dam Workshop where they received a presentation from Dr. Thom Hardy, and provided direction to Staff to bring back an action item that would approve the removal of the dam and the filling of the mill race. Click to read minutes here.

March 15, 2016, City Council approved a motion to remove Cape's Dam. Click here. to read minutes.

June 21, 2016, a stakeholder meeting was held at fish hatchery, including US Fish and Wildlife Service (USFWS), Texas Historical Commission (THC), US Army Corps of Engineers (USACE), Hays County Historical Commission, and the City. THC stated that the dam, mill race and associated structures retain sufficient historic integrity to remain eligible for listing in the National Register. USFWS stated that leaving the dam in place, in whole or in part, would make the City ineligible for USFWS funding for the project.

August 16, 2016, Council received a presentation from USFWS regarding the Cape's Dam removal planning and permitting process. The USFWS report states that the dam, "acts as a barrier to fish and other aquatic species" and "is in severe disrepair and poses a safety hazard to recreational users." Due to the conflicting positions of USFWS and THC, and the

competing interests of other interested stakeholders, the City determines that the best course of action is to suspend the UFWS permit process and further investigate removal, repair and replacement options. Click here to read minutes.

October 4, 2018: Historic Preservation Commission recommended approval of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark (4-2). Click here to read minutes.

November 27, 2018: Planning and Zoning Commission recommended denial of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark (5-4). Click here to read minutes.

January 15, 2019: City Council briefed in executive session to discuss possible partnership opportunities with Hays County and the Hays County Historical Commission.

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June 18, 2019: City Council briefed in Work Session on status of possible partnership opportunities with Hays County and the Hays County Historical Commission. Presentation from County on proposed project anticipated in fall 2019. Click here.to read minutes

October 15, 2019: City Council received a presentation from Vista Planning & Design on behalf of Hays County and the Hays County Historical Commission regarding a visioning study for Cape's Dam, the Mill Race, Thompson's Island & San Marcos River. Council provided consensus for staff to seek what permissions and permits would be needed from State and Federal agencies to remove or repair the dam. Click here.to read minutes.

Permitting

The permitting requirements could vary depending on what direction the City Council would like to go in, but the following is a general overview of all agencies that could be involved.

Federal Agencies

United States Army Corp of Engineers (USACE): The United States Army Corps of Engineers is a federal agency under the Department of Defense that primarily oversees dams, canals and flood protection in the United States, as well as a wide range of public works throughout the world. The permitting process would begin with the submission of the project, whether that is rehabilitation or removal. They would be the lead federal agency and would coordinate with the United States Fish and Wildlife Service (USFWS) for permitting.

United States Fish and Wildlife Service (USFWS): The United States Fish and Wildlife Service is an agency within the US Department of the Interior dedicated to the management of fish, wildlife, and natural habitats. They would provide the permits required related to the endangered species within the project area.

State Agencies

Texas Parks and Wildlife Department (TPWD): The Texas Parks & Wildlife Department is a state agency that oversees and protects wildlife and their habitats. In addition, the agency is responsible for managing the state's parks and historical areas. They would provide the permits required for excavation of state-owned substrate (soil/river bottom).

General Land Office (GLO): The Texas General Land Office is responsible for managing lands and mineral rights properties that are owned by the state. They would provide the permits required for activities on state-owned substrate (soil/river bottom).

Texas Commission on Environmental Quality(TCEQ): The Texas Commission on Environmental Quality is the environmental agency for the state. They would provide the permits and certifications needed to ensure compliance with state water quality standards. One of the requirements for obtaining USACE permitting is certification from TCEQ.

Texas Historic Commission (THC): The Texas Historic Commission is the state agency for historic preservation. Due to the historic nature of the structure Historic Building and Structure Permits may be issued for preservation, rehabilitation, restoration, reconstruction, architectural investigation, hazard abatement, new construction, and in rare cases, relocation or demolition.

Options to Consider

Option 1: Removal.

Next steps: Staff would begin the permitting process with the US Army Corp of Engineers and state agencies to begin demolition.

Option 2: Redesign & Rebuild.

Next steps: Staff would begin working on an Interlocal Agreement partnering with Hays County on the rehabilitation efforts that would be brought back to the City Council for consideration. An Interlocal Agreement could include things such as cost sharing of an impact study, agreement on vision & design and other cost participation commitments.

Option 3: Restoration.

Next steps: Staff would begin working with the Texas Historical Commission and the US Army Corp of Engineers to determine exactly what restoration would potentially look like. There is a strong possibility that the steps needed to fully restore the dam would not be allowed under today's federal and state statutes and the project would not be permitted.

Option 4: Have another study conducted on Cape's Dam and the Mill Race

Next steps: Staff would need direction on if the study is to be comprehensive or have a specific focus. Staff would reach out to Hays County and the Hays County Historical

Commission to determine if they would be willing to cost participate. Staff would then move forward with identifying an unbiased third party to conduct the analysis and would bring the completed report back to the City Council and Hays County.

Redesign & Rebuild (Rehabilitation) vs. Restoration

Rehabilitation acknowledges the need to alter or add to a historic property to meet continuing or changing uses while retaining the property's historic character.

Restoration depicts a property at a particular period of time in its history, while removing evidence of other periods.

Funding Currently Available

Currently there is $174,628 remaining of the $250,000 that was originally funded for the Cape's Camp Improvement and Dam Project. To date $75,372 of the funds allocated have been used to fund previous studies on Cape's Dam and the Mill Race.

END

PARKS AND RECREATION

MEMO

TO: Stephanie Reyes, Interim Assistant City Manager
FROM: Drew Wells, Director of Parks and Recreation
DATE: December 2, 2019
RE: **Report on safety measures at Cape's Camp/Thompson Island area**

SUMMARY
The purpose of this memorandum is to provide a report requested by Mayor Hughson concerning safety measures effected by city staff and/or resources in the immediate area of Cape's Dam.

Safety Measures taken at Thompson's Island, Cape's Camp, Cape's Dam and Stokes Park since 2014

- Barbed wire fencing removed
- Sink Hole covered and caution tape installed around area
- Mowed Thompson Island and Cape's Camp area for visibility and safety
- Installed limestone blocks to prevent parking on Thompson Island
- Installed gates along trails and park rules signage

After floods of 2015

- Installed Fencing and signage closing the area of Thompson's Island and cape's Camp
- Removed flood debris from area
- Removed downed trees in river channel and mill race
- Removed trash dumpsters and other debris from river channel and mill race
- Removed Concrete chunks from mill race and below mill race falls
- Removed collapsed bridge connecting Cape's Camp and Thompson Island
- Quit mowing Thompson Island to discourage movement in the closed park of people on the Island
- Reinstalled PVC pipe over railroad rails on Cape's Dam that was previously installed by citizens
- Removed hazardous fallen tree on Cape's Dam
- Installed safety rope with floats from Cape's Dam to river bank upstream to designate a safe line of travel around the dam
- Worked with HCP and River foundation to remove hazardous trees along river banks in the area
- Enforced trespassing in Thompson Island and Cape's Camp
- Worked with code enforcement to deal with code and safety issues on adjacent properties

We believe all practical items have been addressed and do not see any additional measures at this point that can be implemented.

Parks staff is onsite once a week to gather trash and during our collection efforts, staff performs a cursory check of the area for safety measures. The Park Rangers are out there on a more regular basis, sometimes multiple times a week and also review the area and report issues as necessary. I will advise the Parks staff to make an inspection visit at least weekly with the sole purpose of the visit for safety-related matters. This will begin this week and if anything substantial is addressed, I'll be sure to inform you.

Thompson/Cape Dam & Ditch Engineering Structure FAQ

June 12, 2019

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1. How did we get here?

- In 2014, City Council approved Planned Development District (PDD) zoning for the Woodlands development project, and received 20 acres of dedicated parkland along the San Marcos River, which includes Capes Dam and the Mill Race.
- In October 2014, the Parks and Recreation Advisory Board requested a study of safety and environmental issues associated with the Dam. Watershed Systems Group, Inc. (Dr. Thom Hardy), was contracted to conduct a scientific evaluation.
- On February 22, 2016, Council held a Workshop and received a presentation from Dr. Thom Hardy. Council provided direction to the City Manager to prepare an item for Council consideration and possible action for removal of Cape's Dam and filling of the Mill Race.
- On March 15, 2016, City Council approved a motion to remove Cape's Dam.
- On June 21, 2016, a stakeholder meeting was held at fish hatchery, including US Fish and Wildlife Service (USFWS), Texas Historical Commission (THC), US Army Corps of Engineers (USACE), Hays County Historical Commission, and the City. At this meeting, THC stated that the dam, mill race and associated structures retain sufficient historic integrity to remain eligible for listing in the National Register. USFWS stated that leaving the dam in place, in whole or in part, would make the City ineligible for USFWS funding for the project.
- On August 16, 2016, Council received a presentation from USFWS regarding the Cape's Dam removal planning and permitting process. The USFWS report states that the dam, "acts as a barrier to fish and other aquatic species" and "is in severe disrepair and poses a safety hazard to recreational users."
- Due to the conflicting positions of USFWS and THC, and the competing interests of other interested stakeholders, the City determines that the best course of action is to suspend the UFWS permit process and further investigate removal, repair and replacement options.
- On September 6, 2018, the Historic Preservation Commission initiated a petition to designate Cape's Dam and the Mill Race as a Local Historic Landmark.
- On October 4, 2018, the Historic Preservation Commission voted to recommend designation of Cape's Dam and the Mill Race as a Local Historic Landmark.
- On November 27, 2018, the Planning & Zoning Commission voted to deny designation of Cape's Dam and the Mill Race as a Local Historic Landmark.
- On January 29, 2019, City Council held a public hearing regarding Ordinance 2019-04, and postponed the vote to designate Cape's Dam and the Mill Race as a Local Historic Landmark.

2. The property has a trinomial attached to it 41HY164. What does this mean for the property?

- An archeological site has officially been recorded with the state. What is listed under the trinomial is smaller than the 17 acres noted in the 1985 National Register nomination form for Thompson/Cape Dam & Ditch Engineering Structure. The exact boundaries of the archeological

site may be bigger than boundary shown on the National Register nomination form; an archeological survey would be required to determine this boundary.

- Since the site is located on state land administered by the City, removal of or repairs to the dam and associated elements would fall under the Antiquities Code of Texas. Any work taking place in this area must be coordinated with the THC. Archeological work would be required in advance of most projects
- The City or Texas Parks and Wildlife Department (TPWD) would take the lead in negotiating with the Texas Historical Commission (THC) on what level of effort would be necessary to mitigate the impacts to the site if removal or repair is undertaken.
- Designation does not require the City to do historic preservation activities to maintain the dam or associated structure(s).

3. How does being eligible for listing in the National Register of Historic Places (NRHP) affect the property?

- Property is not listed in the NRHP but has been deemed eligible.
- If listed, there are no restrictions on what a non-federal owner may do with the property, including demolition, unless the property is involved in a project that receives Federal assistance, usually funding or licensing.
- In addition to honorific recognition, NRHP listing has the following effect:
- Consideration in planning for Federal, Federally licensed, and Federally assisted projects;
- Eligibility for certain tax provisions; and
- Qualification for Federal grants for historic preservation, when funds are available.
- NRHP listing does not require the City to do historic preservation related activities to maintain the dam.

4. How will designation of this property as a local historic landmark affect the property?

- Local Historic Landmark designation does not require the City to do anything to the dam or the associated structure(s).
- Ordinary repair and maintenance do not require a Certificate of Appropriateness.
- Exterior changes in material or design, including demolition, must be approved through a Certificate of Appropriateness (COA) by the Historic Preservation Commission (HPC).

5. Can Certificates of Appropriateness for City-owned property designated as historic landmarks or located in local historic districts be appealed to City Council?

- Section 2.5.5.5 of the San Marcos Development Code requires that appeals of Certificates of Appropriateness are heard by the Zoning Board of Adjustments (ZBOA).
- City Council discussed amending this Section to allow the City Council to be appellate body of Certificates of Appropriateness when City-owned property is involved. This Section can be amended with the upcoming annual update to the Code.

6. How does the location of the dam on a navigable body of water affect the property?

- The US Army Corps of Engineers (USACE) would likely need to be involved if the dam is removed or water flow is affected. US Fish and Wildlife Service (USFWS) may also be involved.
- Section 106 of the National Historic Preservation Act and its implementing regulations at 36 CFR Part 800 would be triggered.
- If the federal agencies are involved, they would take the lead in negotiating with the City and THC about an appropriate level of effort for mitigating the effects of the project (removal, refurbishment, restoration, etc.) on the dam.

7. What cost estimates do we currently have for dam removal, repair and/or replacement?

- Our original estimates to remove the dam ranged between $50k and $75k to remove the structure. These numbers have not been updated at this point. The original funding was going to be funded through USFW. The original cost estimate to restore the dam was a range starting at approximately $500k up to 6 figures. This had a wide variation because the type of structure and the amenities associated with the development. These numbers will all be updated at the next presentation.

8. What is the status of negotiations with Hays County and the Hays County Historical Commission?

- Hays County, in partnership with the Hays County Historical Commission, has stated their preference to assume responsibility for operation and maintenance of the dam and mill race structures, and surrounding areas of City-owned park land, under agreement with the City.
- Hays County Historical Commission has stated their intent to secure funding for restoration of the dam structure, and ongoing operations and maintenance.
- Discussions with Hays County are ongoing, and include other parks-related topics. Specifically, the County has proposed transferring ownership of the Five Mile Dam Soccer Complex, Randy Vetter Park, and Dudley Johnson Park to the City. The City currently operates and maintains the Five Mile Dam Soccer Complex under (an expired) agreement with Hays County. Vetter and Johnson Parks are County-owned and maintained.

9. What is the status of Rio Vista Falls?

- City staff and consulting engineer (Gary Lacy, Recreation Engineering & Planning) have evaluated Rio Vista Falls and identified structural deficiencies. Specifically, undercutting along the man-made south bank, below the second and third falls.
- Staff, with the concurrence of our consulting engineer, has concluded that emergency repairs are warranted.
- City staff provided the consulting engineer's report to the US Army Corp of Engineers (USACE), which is the lead agency for all matters related to the bed and banks of the San Marcos River.
- City staff contacted USACE in early March and requested an inspection of the structural deficiencies identified by Recreation Engineering & Planning. In response to our request, USACE stated that the identified structural deficiencies do not warrant emergency repairs.

- USACE will conduct a visual inspection of Rio Vista Falls; however, no timeframe for that inspection has been identified. Upon visual inspection, USACE may determine that emergency repairs are warranted.
- Notification was also provided to US Fish & Wildlife, Texas Parks & Wildlife, Texas Commission on Environmental Quality (TCEQ), and the Texas Historical Commission.
- In coordination with US Fish & Wildlife, USACE must issue a permit for any modifications or repairs to the main-made structures at Rio Vista Falls.

Effects of changing height of Cape's Dam on recreation, Texas wild rice and fountain darter habitat in the San Marcos River, Texas

Prepared for:

City of San Marcos

Prepared by:

Dr. Thomas B. Hardy, Ph.D.
Dr. Nolan Raphelt, Ph.D.

Watershed Systems Group, INC
San Marcos, Texas

October 12, 2015

EXECUTIVE SUMMARY

Modeling of aquatic habitats and water based recreation in the San Marcos River associated with Cape's Dam simulated at full height, half height or complete removal was completed using advanced hydraulic modeling which allowed the river bed to adjust due to sediment transport under these three assumed conditions. The results demonstrate that with full dam removal, the San Marcos River in the vicinity of Cape's Dam will revert to normal flow depths similar to existing free flowing sections below Rio Vista and downstream of Thompsons Island. Deep pool areas (e.g., just downstream of the IH35 access road, the plunge pools below the location of Cape's Dam and the outfall pool below the Mill Race will remain

over 3-6 feet deep even when river flows are 45 cfs which is a flow rate that was observed for one day during the drought of record. These areas will retain even greater depths at 100 cfs which is a daily flow rate that is equaled or exceeded 90 percent of the time.

Full height or half height Cape's Dam scenarios provide no demonstrable environmental benefits to the native aquatic or riparian species within the San Marcos River. Rebuilding Cape's Dam will continue to impact native aquatic species due to habitat fragmentation, reduction in habitat quality and continue to maintain a passage barrier. These negative impacts are associated with loss of native species diversity. Diversion of water into the Mill Race under half height or full height dam conditions will continue to result in reduced flows within the main channel of the San Marcos River and contribute to reductions in habitat conditions for the native aquatic species especially under low flow conditions.

Results clearly demonstrate that habitat conditions for aquatic macrophytes including the endangered Texas wild rice show the greatest benefits with full dam removal at all simulated flow rates. Full dam removal is expected to result in increased aquatic macrophyte growth due to better light penetration to the stream bottom with removal of the backwater conditions upstream from Cape's Dam. Dam removal will also result in an increase in the distribution of higher velocities within this section of river that are beneficial to Texas wild rice. Texas wild rice shows diminished growth and survival in low and no velocity areas reflective of backwater conditions upstream of Cape's Dam.

Dam removal results in improved fountain darter habitat over all simulated flows. The improvements in fountain darter habitat conditions under removal of Cape's Dam are underestimated since they do not reflect the habitat gains that will occur due to increased stream coverage from aquatic macrophytes in this section of the river.

Dam removal and subsequent changes in river characteristics (i.e., depth and velocities) will result in a sustainable safe recreation corridor over all simulated flow rates. River characteristics in the Cape's Dam reach without Cape's Dam will be similar to existing free flowing river sections not impacted by backwater effects (e.g., Sewell Park, City Park and downstream of Rio Vista above IH35). Hourly recreation counts conducted daily over the past three years show that these free flowing sections support swimming, tubing, canoeing, kayaking, and paddle boards.

Rebuilding Cape's Dam at full height or half height will require substantial restoration work on the Mill Race given its current deteriorated state with multiple areas of structural failure.

INTRODUCTION

The City of San Marcos is evaluating the implications in terms of the impacts/benefits to recreation and the habitats for the endangered Texas wild rice (TWR) and fountain darters in the San Marcos River if Cape's Dam is rebuilt to full height, modified to half of full dam height, or is removed. The assessment presented here relied upon existing data on river topography, empirical hydraulic and river sediment properties in conjunction with supplemental field data, and habitat models developed at Texas State University (Hardy et al., 2012). Advanced hydrodynamic modeling was utilized to evaluate expected changes in river bed topography due to sediment transport and river bed evolution under full height, half height, and full dam removal that was not considered in the previous modeling evaluations (Hardy et al., 2012). In this report, "full height" refers to Cape's Dam based on topography measured after dam repairs by the USFWS. The resulting evolved river bed topography and associated hydraulic properties were utilized to model TWR and fountain darter habitat, as well as for modeling water depths available for

water-based recreation under all three Cape's Dam scenarios. Habitat modeling for TWR and fountain darters followed the general procedures developed by Hardy et al. (2012) that were used in the development of the Edwards Aquifer Habitat Conservation Plan.

METHODS

Study Area

Figure 1 shows the spatial extent of the assessment conducted in the San Marcos River. The study area begins downstream from Rio Vista Dam and extends downstream to the TPWD State Hatchery outflow. This reach of the river encompasses the spatial extent most likely to be affected by the proposed Cape's Dam scenarios and is occupied habitat for the endangered TWR and fountain darters. Empirical data show that the effects of Cape's Dam does not extend far enough upstream to reach Rio Vista Dam, therefore the section of the river between Rio Vista Dam and the upstream extent of the model is not included in this study.

Figure 1. San Marcos River study area.

Figure 2 documents the distribution of the endangered Texas wild rice both above and below Cape's Dam based on historical survey data. This stretch of river (and downstream) also contains the endangered fountain darter. The Edwards Aquifer Habitat Conservation Plan has identified specific long term biological goals for Texas wild rice in this section of river as illustrated in Table 1.

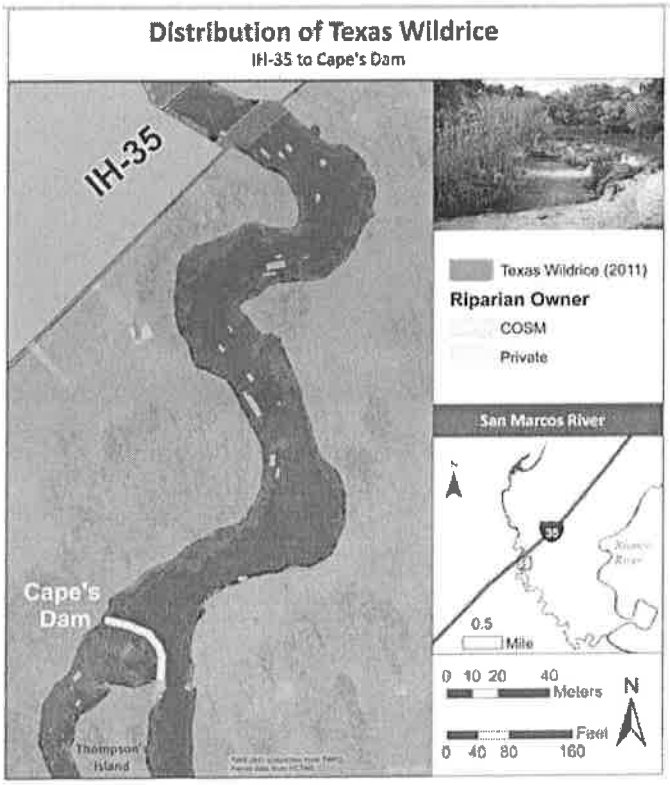


Figure 2. Spatial location of Texas wild rice above and below Cape's Dam in the San Marcos River.

Table 1. Edwards Aquifer Habitat Conservation Plan long term biological goals within the San Marcos River.

LONG-TERM BIOLOGICAL GOAL FOR TEXAS WILD-RICE

River Segment	Areal Coverage (m^2)	Reach Percentage of Total Areal Coverage
Spring Lake	1,000 – 1,500	n/a
Spring Lake Dam to Rio Vista Dam	5,810 – 9,245	83 – 66
Rio Vista Dam to IH-35	910 – 1,650	13 – 12
Downstream of IH-35	280 – 3,055	4 – 22
TOTAL	8000 – 15,450	100

River Channel Topography, Hydraulic and Substrate/Vegetation Data

Topography (i.e., elevation), substrate, vegetation, and surface water elevation data were collected from September 2009 – April 2010. Standard survey equipment and GPS Trimble XH units were used to measure topography within the wetted portion of the stream using a systematic irregular sampling strategy that targets capturing all available heterogeneity within the stream channel topography. Data density was

approximately 3000 data points per 100 meters of stream length. Latitude (x), longitude (y), depth, and substrate type were recorded at each point. Vegetation within the stream was delineated with polygons and the corresponding percentages of each vegetation or substrate type were recorded for each polygon. Vegetation polygons were spatially joined with the hydrodynamic modeling grids to assign roughness values and vegetation class attributes for habitat modeling of fountain darters and Texas wild rice. Discharge and water surface elevation (WSE) longitudinal profiles were recorded each day during field measurements of channel topography. In addition, substrate data collected by Dr. Paul Hudson from the University of Texas as part of the original modeling efforts in 2012 were utilized and consisted of penetrometer and substrate grab samples at 100 locations upstream of Cape's Dam to estimate particle size distribution and depth of sediments. Lateral scour and bed evolution data were also obtained at fixed cross section locations associated with points where channel changes were monitored after channel dredging occurred in reaches below Cape's Dam (Hudson, 2012). Initial water surface elevations were obtained from the calibrated two-dimensional hydrodynamic models developed at Texas State University (Hardy et al., 2010).

Computational Mesh from River Topography

The process of using river bed topography to generate the computational mesh for use in the hydraulic modeling was accomplished using triangular irregular networks as illustrated graphically in Figure 3.

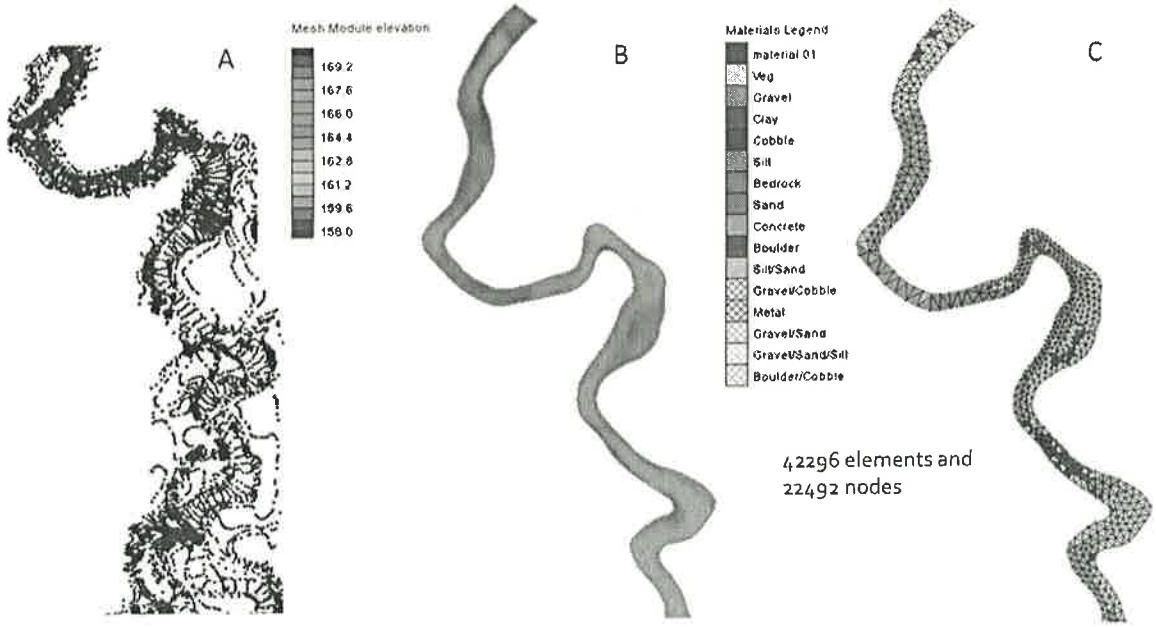


Figure 3. Example of field measured topography points (A) and computational mesh mapped onto elevation contours (B) and substrate (C).

Assumed Cape's Dam Configurations for Full Height, Half Height and Complete Removal

The elevation of Cape's Dam associated with full height conditions was derived from actual historical survey data (Figure 4). These data were used to construct the full height computational mesh to reflect

this topography, as shown in Figure 5. The full height computational mesh shown in Figure 5 was lowered by 50 percent and then 100 percent to approximate the starting conditions for the hydrodynamic modeling under the different dam removal scenarios and is illustrated in Figures 6 and 7.

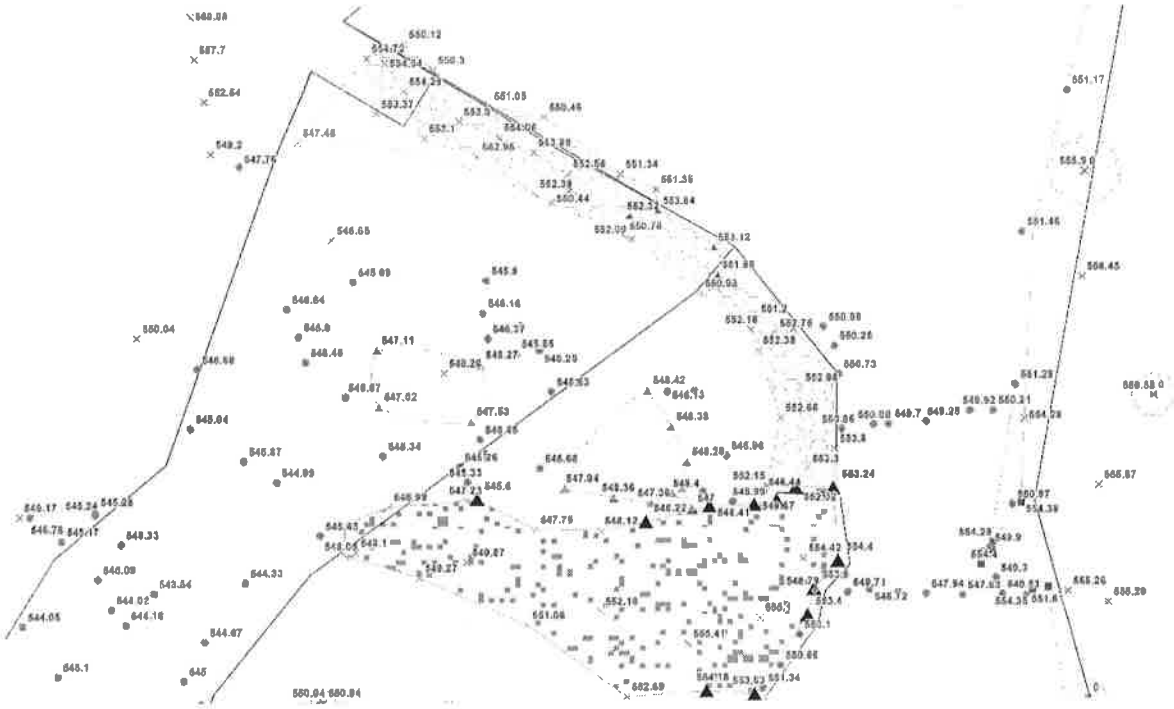


Figure 4. Survey data for full height Cape's Dam.

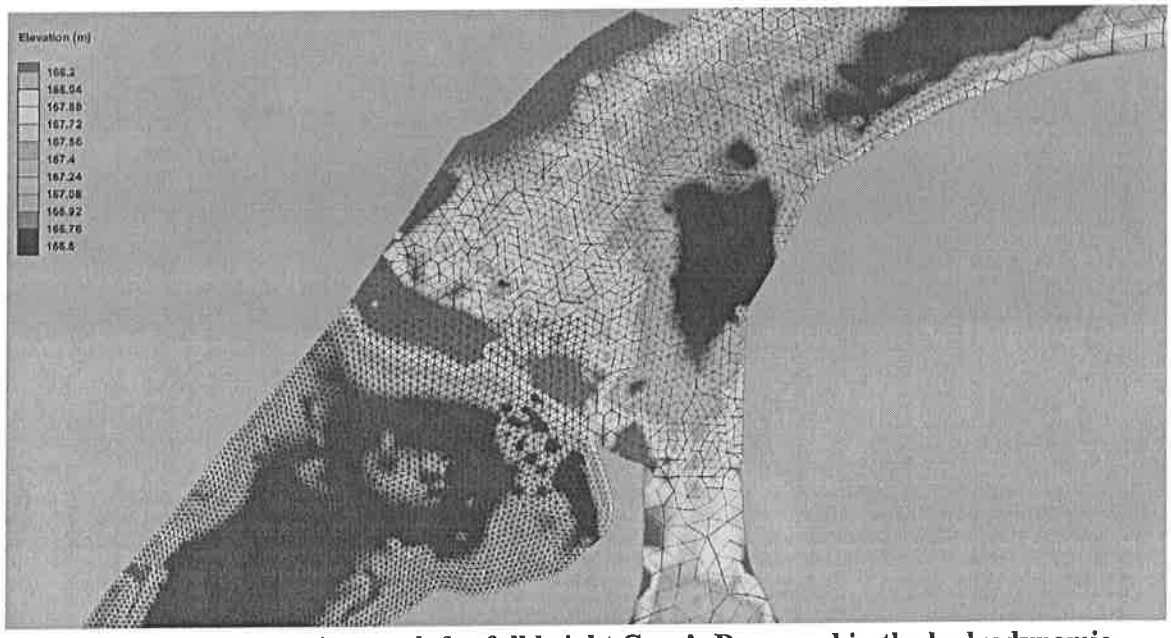


Figure 5. Assumed computation mesh for full height Cape's Dam used in the hydrodynamic modeling.

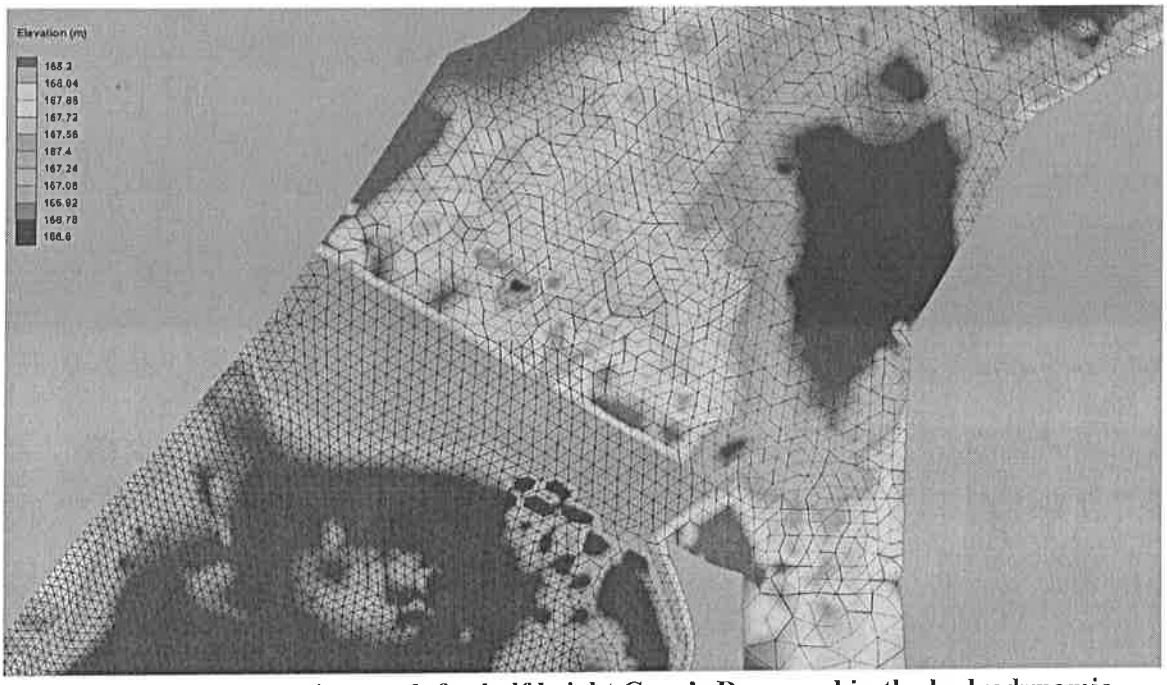


Figure 6. Assumed computation mesh for half height Cape's Dam used in the hydrodynamic modeling.

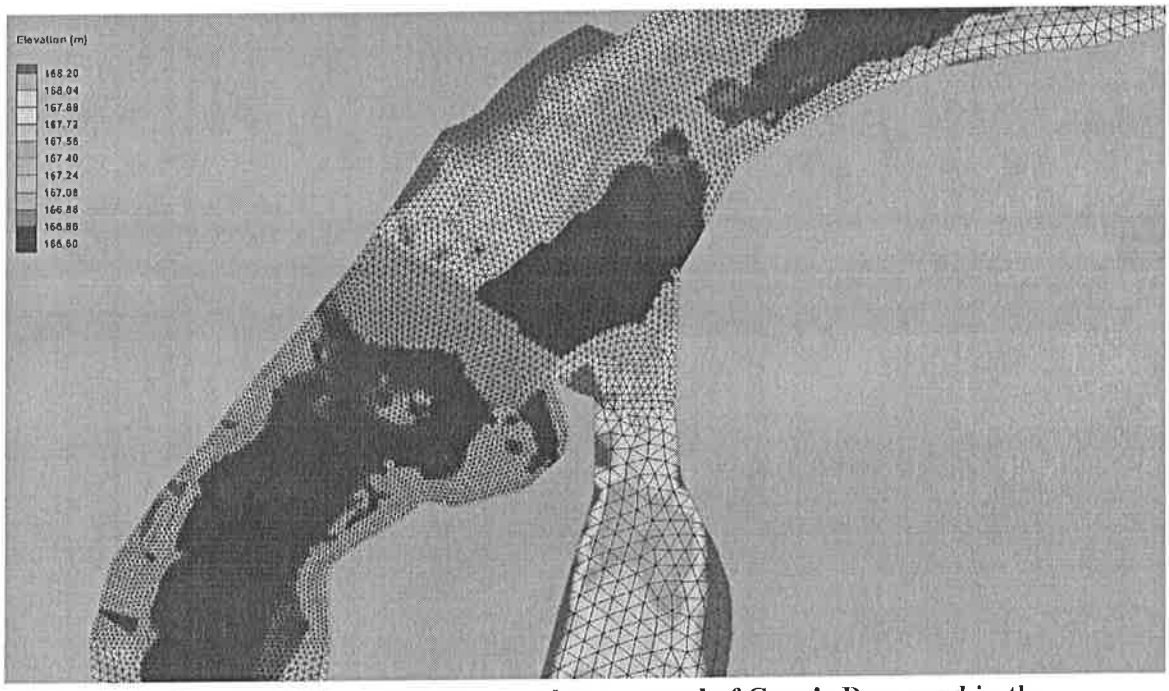


Figure 7. Assumed computation mesh for complete removal of Cape's Dam used in the hydrodynamic modeling.

Note that the half height and full removal topographies are approximations to evaluate channel characteristics after expected sediment transport and river bed evolution and are not meant to represent as-

built construction drawings for full height or half height dam scenarios, or the pre-dam natural channel topography under the full removal scenario.

Sediment Characteristics

Channel-bottom sediment polygons over the study area were mapped using GPS and spatially joined with the computational mesh using GIS, as noted previously. However, to support the bed evolution modeling under full height, half height, and complete removal, data from Hudson (2012) was used to characterize the particle size distribution behind Cape's Dam (Table 2) and then spatially interpolate sediment characteristics and sediment depth profiles as illustrated in Figures 8 and 9. Based on these data, Hudson (2012) estimated that ~ 6,700+ cubic meters of fine sediment are trapped behind Cape's Dam. Furthermore as shown in Figures 8 and 9 upward of 3 m (10 feet) of accumulated fine sediments are trapped behind Cape's Dam under existing conditions.

Table 2. Sediment particle size distributions behind Cape's Dam (adapted from Hudson, 2012).

Reservoir bottom sediment samples of Capes Dam							
G=grab sample at bed with sediment sampler; Sh=shallow core sample (0-10 cm); Dp=deep core sample (20-30 cm)							
			Sediment size (mm)				
			D10	D50	D90	Sample type	Location
Sample ID #	X	Y	(10 % finer by weight)	(50% finer by weight, median size)	(90% finer by weight)		
SM-1	-	-	-	-	-	N/A	Thalweg
SM-2-G	N29° 52' 27.9	W097° 55' 52.2	<0.001	0.7	>1	Grab	Inside bend
SM-3-Sh	N29° 52' 27.3	W097° 55' 51.4	<0.001	0.0035	0.4	Core (Shallow)	Outside bend
SM-3-Dp			<0.001	0.005	>1	Core (Deep)	
SM-4-Sh	N29° 52' 27.3	W097° 55' 52.1	<0.001	0.15	>1	Core (Shallow)	Inside bend
SM-5-G	N29° 52' 27.1	W097° 55' 52.3	<0.001	0.26	0.7	Grab	Riffle
SM-6-G	N29° 52' 26.7	W097° 55' 52.8	<0.001	0.16	0.5	Grab	Pool
SM-7-Sh	N29° 52' 27.2	W097° 55' 53.5	<0.001	0.0140	0.19	Core (Shallow)	Outside bend
SM-7-Dp			<0.001	0.0085	0.14	Core (Deep)	
SM-8-Sh	N29° 52' 26.0	W097° 55' 53.4	<0.001	0.0140	0.13	Core (Shallow)	Outside bend
SM-8-Dp			<0.001	0.0013	0.13	Core (Deep)	
SM-9-Sh	N29° 52' 25.8	W097° 55' 52.6	<0.001	0.0020	0.20	Core (Shallow)	Inside bend
SM-9-Dp			<0.001	0.0022	0.30	Core (Deep)	
SM-10-G	N29° 52' 25.2	W097° 55' 53.1	-	-	-	Grab	Thalweg
SM-11-Sh	N29° 52' 24.9	W097° 55' 52.3	<0.001	0.0042	0.18	Core (Shallow)	Left bank
SM-11-Dp			<0.001	0.0090	0.26	Core (Deep)	
SM-12-G	N29° 52' 24.6	W097° 55' 52.5	<0.001	0.31	>1	Grab	Riffle
SM-13-Sh	N29° 52' 24.1	W097° 55' 52.7	<0.001	0.0350	0.51	Core (Shallow)	Inside bend
SM-13-Dp			<0.001	0.0169	0.30	Core (Deep)	
SM-14-Sh	N29° 52' 23.0	W097° 55' 53.5	<0.001*	>1	>1	Core (Shallow)	Right bank
SM-14-Dp			<0.001	0.2200	0.45	Core (Deep)	

SM-15-Sh	N29° 52' 23.2	W097° 55' 53.3	**<0.002**	**0.0040**	**0.80**	Core (Shallow)	Left bank
SM-15-Dp			**<0.003**	**0.0035**	**1.00**	Core (Deep)	
SM-16-Sh	N29° 52' 23.3	W097° 55' 52.0	**<0.001**	**0.0025**	**0.11**	Core (Shallow)	Outside bend
SM-16-Dp			**<0.001**	**0.0029**	**0.13**	Core (Deep)	
SM-17-G	N29° 52' 23.1	W097° 55' 53.8	**<0.001**	**0.1300**	**0.45**	Grab	Thalweg
SM-18-G	N29° 52' 27.0	W097° 55' 53.0	**<0.001**	**0.2700**	**0.90**	Grab	Thalweg
SM-19-G	N29° 52' 28.0	W097° 55' 51.7	**<0.001**	**0.1700**	**0.99**	Grab	Thalweg
SM-20-Sh	N29° 52' 28.5	W097° 55' 52.1	**<0.001**	**0.0600**	**0.40**	Core (Shallow)	Left bank
SM-20-Dp			**<0.001**	**0.0300**	**0.33**	Core (Deep)	

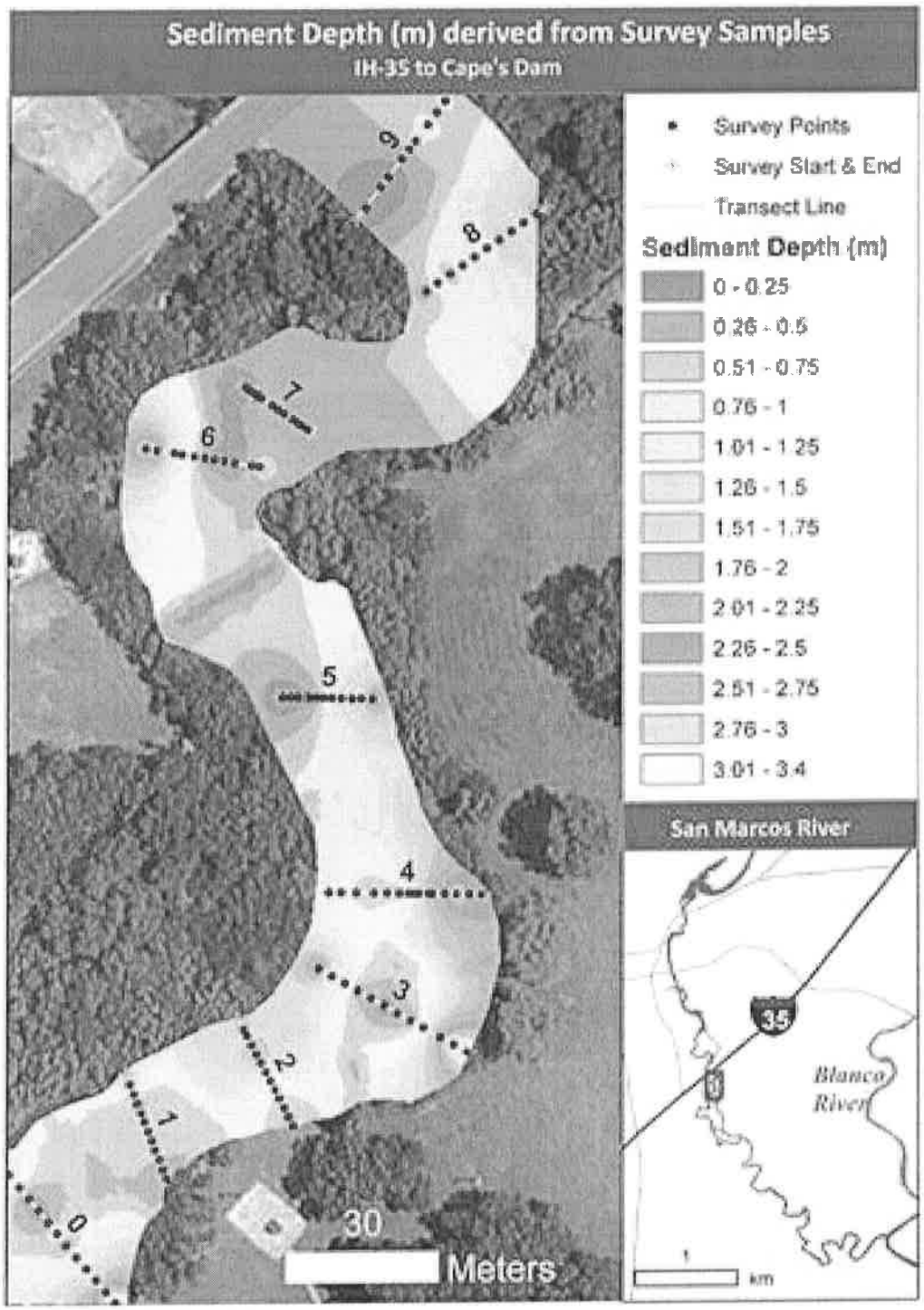


Figure 8. Location of field measurements of sediment cross-sections behind Cape's Dam and interpolated spatial distribution used in hydrodynamic modeling (adapted from Hudson 2012).

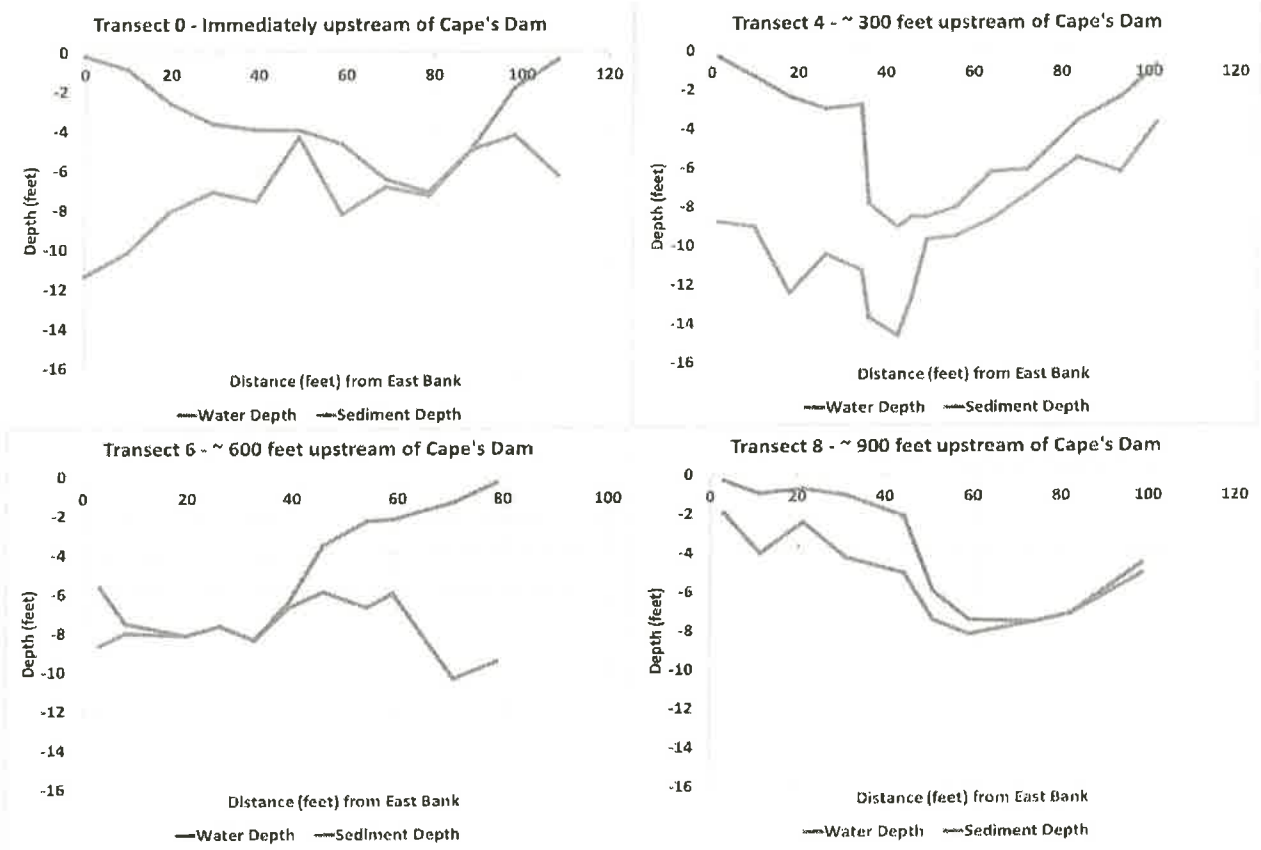


Figure 9. Sediment depth profiles for selection cross sections (XS numbers correspond to crosssection locations in Figure 8) behind Cape's Dam (adapted from Hudson 2012). The difference between the water depth and sediment depth lines represent the depth of accumulated sediment.

Simulated Flows

Four different steady state flows were modeled for this study; ranging from 45 to 300 cfs, (Table 3). The 45 cfs flow represents the expected minimum flow under the proposed Edwards Aquifer Habitat Conservation Plan during a repeat of the drought of record. The purpose of modeling this flow was to evaluate the expected distribution of depths within the channel to potentially guide aquatic vegetation restoration in this section of the river. This flow rate represents the lowest observed daily flow during the drought of record. The 100 cfs flow was chosen because it is equaled or exceeded ~90 percent of the time for the period of recorded flows within the San Marcos River (October 1, 1994 to October 23, 2015). This was also approximately the lowest summer and fall flow observed during the drought period in 2009. The 173 cfs flow was chosen as it is approximately the long-term median discharge for the period of recorded flows within the San Marcos River. The median flow represents the flow rate where half of all observed flows are higher and half of all observed flows are lower. The 300 cfs discharge was utilized to evolve the river bed topography under sediment transport conditions (high flow periods) and is equaled or exceeded approximately 10 percent of the time.

Table 3. Modeled discharge and percent of time exceeded for the San Marcos River.

Discharge Cfs[1]	Discharge Cms[2]	Percentage of time flow equaled or exceed * (1995-2011)
45	1.27	Not Determined
100	2.83	90
173	4.9	50
300	8.5	10

* Flows Measured at USGS Gage 08170500 San Marcos River at San Marcos, Texas
1 = cubic feet per second
2 = cubic meters per second

Hydraulic Modeling

Adaptive Hydraulics (ADH) is an unstructured finite element computer software package capable of modeling 2-dimensional and 3-dimensional shallow water equations, 3-dimensional Navier Stokes equations, groundwater equations and groundwater-surface water interaction. ADH solves the hydraulic and sediment transport equations while dynamically adapting the mesh so that a coarse mesh can give results as accurate as a mesh with finer resolution. (Berger et al., 2011) (See Figure 10).

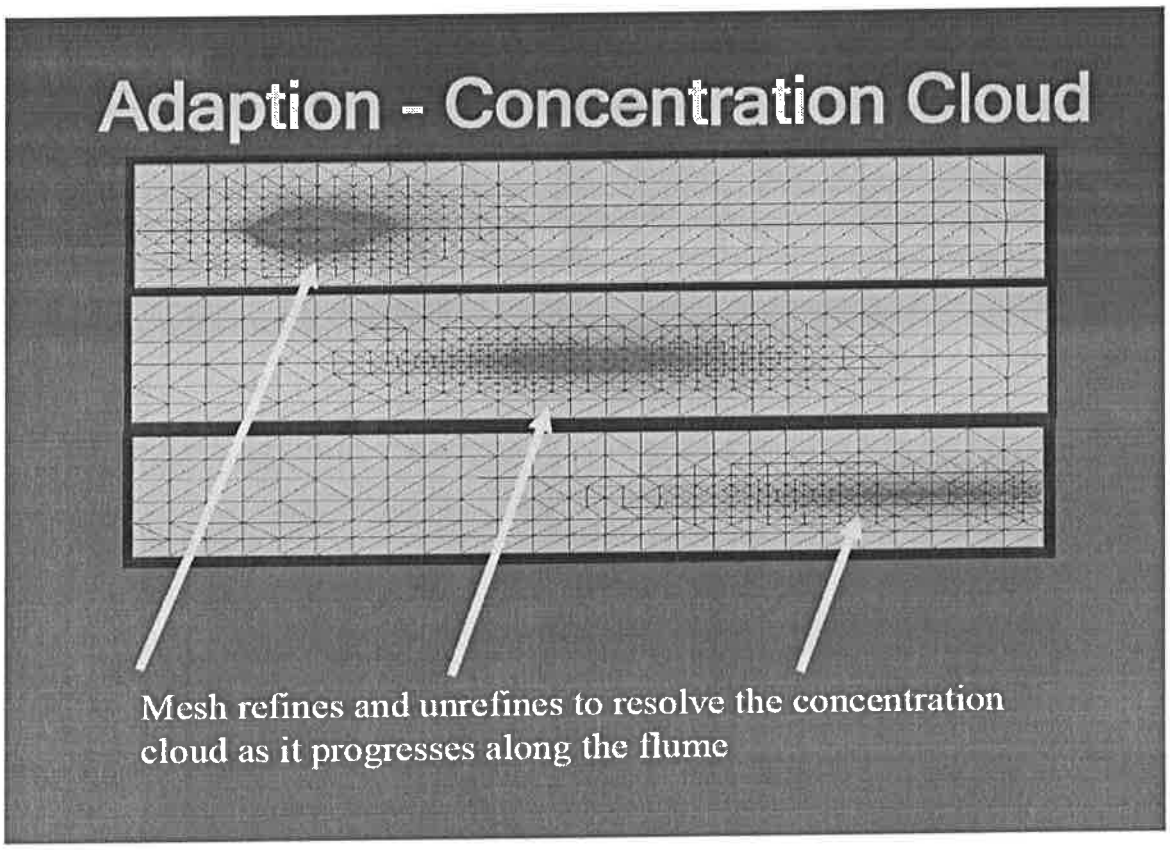


Figure 10. Example of dynamically adaptive mesh of ADH for refinement of sediment transport. The three panels show how the mesh characteristics change over time (top, middle, bottom panels) as the sediment plume moves downstream (left to right).

ADH contains other essential features such as wetting and drying, and completely coupled cohesive and non-cohesive sediment transport. One of the major benefits of ADH is it also allows for the rapid convergence of flows to steady state solutions using parallel processing architecture. ADH contains other essential features such as completely coupled sediment transport. The User's Manual for Adaptive Hydraulics Modeling system provides additional information on the hydrodynamic modeling capabilities of ADH (Berger et al., 2011).

The 300 cfs flow was modeled for 30 days to approximate bed evolution under high flow conditions where sediment transport and scouring are known to occur. This is a pragmatic modeling approach used in standard engineering practice to approximate expected long-term channel adjustments associated with intermittent 'storm events' by using a shorter simulation period with a sustained high flow given the intensive computational burden of the model. However, this is also representative of naturally occurring conditions in the San Marcos River. For example, in 2015, between May 28 and August 3, discharge in the river continuously exceeded 300 cfs for 68 days, and peak storm discharges during a single day exceed 1000 cfs every few years. Simulations were carried out on a 64 node parallel processing architecture and each 30-day simulation required approximately 23 hours of computational time to reach convergence of modeling results. Hydraulic model calibrations followed standard engineering practice by changing model parameters such as roughness and viscosity until convergence in the simulations were achieved to derive the expected bed topography and expected water surface elevation profiles for each dam scenario.

Modeling Texas wild rice, Fountain Darters and Recreation

Both Texas wild rice and fountain darters were modeled by computing physical habitat based on habitat suitability curves for depth, velocity, and substrate/vegetation cover using the approach in Hardy et al. (2012). At each computational node, given the simulated depth (d), velocity (cv), and substrate/vegetation type (sub), the suitability (S) of the 'cell' was computed by the following equations:

Texas Wild Rice and Fountain Darters

The combined suitability for Texas wild rice (TWR) was derived as the geometric mean of the component suitability's for depth and current velocity as follows:

$$\text{TWR Combined Suitability} = (\text{TWRdS} * \text{TWRcvS})^{1/2}$$

The combined suitability for fountain darters (FD) was derived as the geometric mean of the component suitability's for depth, velocity and substrate/vegetation as follows:

$$\text{Fountain Darter Combined Suitability} = (\text{FDdS} * \text{FDcvS} * \text{FDsubS})^{1/3}$$

The suitable area of the computational cell is then derived by multiplying the combined suitability by the area of the computational cell. The total suitable area for the reach at a given discharge is the sum of all computational cells weighted by the corresponding combined suitability in each cell. For example, if the combined suitability for depth and velocity in all computational cells for TWR were 1.0 then the amount

of habitat for TWR would be equal to the surface area of the stream at that simulated discharge. For a given flow rate and dam scenario (i.e., full height, half height, or full removal), the total available habitat area for TWR or fountain darters were normalized by the total wetted surface area in the river at that simulated flow. The impacts to aquatic vegetation growth potential (including TWR) due to light attenuation from suspended sediments and other factors were incorporated into the assessment by adjusting the suitability of depths under full height, half height and full dam removal as discussed below.

Recreation

Based on a review of the recreational literature (e.g., Mosley 1983; Shelby et al., 1992) and empirical experience, a simple 2 foot minimum depth was set as the criteria to permit water borne recreation in terms of kayaks, canoes, paddle boards, and tubing. Specifically, all locations that were over two feet deep were considered suitable for recreation. Therefore, the total area suitable for recreation is the total surface area of the stream at a given flow rate and dam scenario that is over two feet deep. As was the case for TWR and fountain darters, the recreational area was normalized by the total surface area at the specific flow rate/dam scenario evaluated.

Results and Discussion

Channel Changes

Removal of Cape's Dam will result in reestablishment of normal depths equivalent to depths currently observed upstream of the backwater section and the channel below the confluence with the Mill Race return flows.

Figure 11 shows the estimated bed elevation differences between full height conditions (~ existing conditions) and the channel after bed evolution with dam removal. As noted in the figure, areas in which the bed evolution were computed to be less than 0.1 meters (~ 4 inches) are not shown as this amount of change is considered within the computational noise of the hydrodynamic model. Clearly, scour of the main thalweg (deepest part of the channel) will occur through sections with increased gradient due to removal of the backwater effect of Cape's Dam in conjunction with movement of fine sediment downstream (compare with Figures 8 and 9). Also, as expected, there is very little area in the modeled reach where sediment deposition occurs because sediments are transported downriver due to increased velocity and stream gradient with dam removal. Furthermore, increased velocity fields under half height and no dam scenarios would favor removal of existing sediments and promote reduction in the accumulation of fine sediments directly attributed to the backwater effects of the dam (Stanley and Doyle 2003).

Figures 12, 13, and 14 show the expected depth of water at flow rates of 45, 100 and 173 cfs in the San Marcos River under full height, half height and full removal conditions. A careful examination of the depths just downstream of IH-35 (very top of figures) show there is essentially no change in depth between any of the three scenarios at any of the flow rates, as would be expected, because this section of the river is not impacted by backwater effects from Cape's Dam, even under full height conditions. It is also evident in examination of Figure 12 that, even at the exceptional low flow of 45 cfs, the river maintains an active water course under all three dam height scenarios and as expected, deeper sections (holes or pools) retain over 1-2 meters of depth (3-6 feet). It should be noted that this extremely low flow

rate (45 cfs) is not expected to occur except under a repeat of the drought of record and under pumping restrictions imposed on the Edward Aquifer by the EA Habitat Conservation Plan.

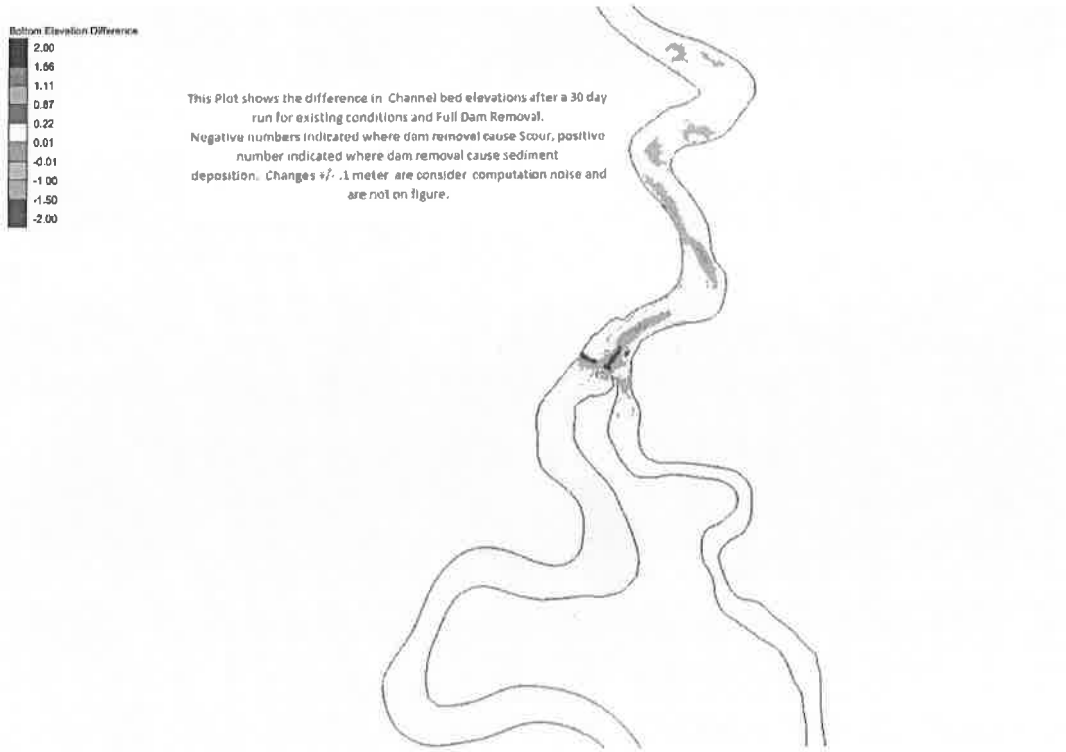


Figure 11. Changes in bed elevation difference (meters) between existing (full height) and full dam removal after bed evolution. Changes are the result of sediment being mobilized and transported downstream as velocities increase.

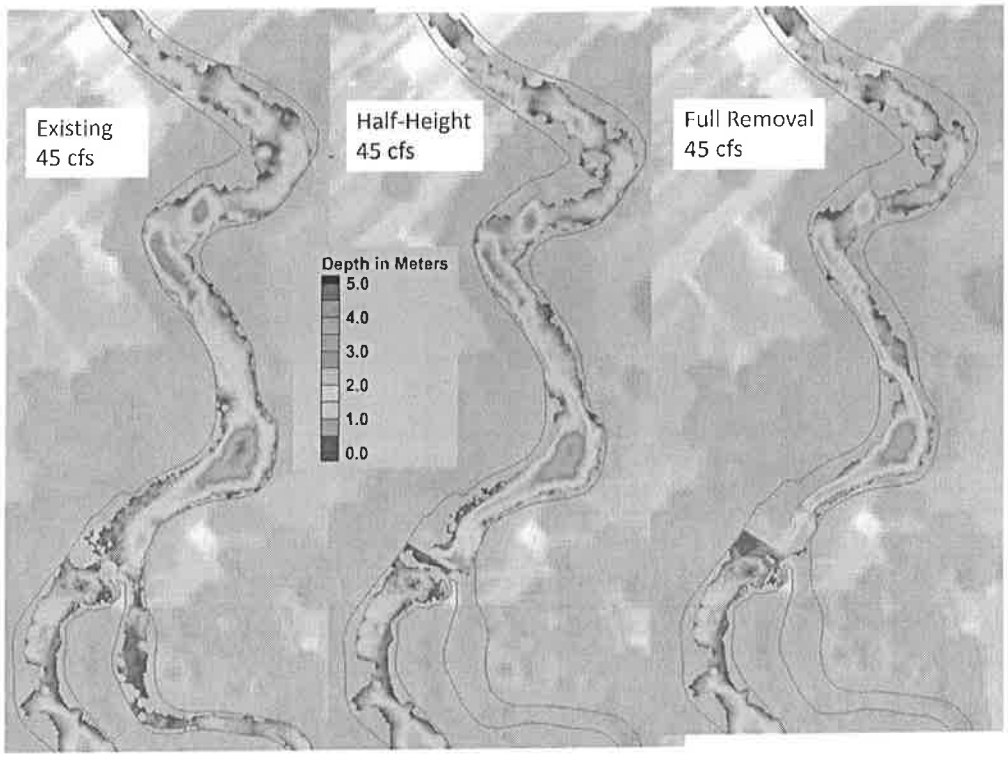


Figure 12. San Marcos River depth with full height, half height, and full Cape's Dam removal at 45 cfs (approximately the lowest single observed daily flow during the drought of record).

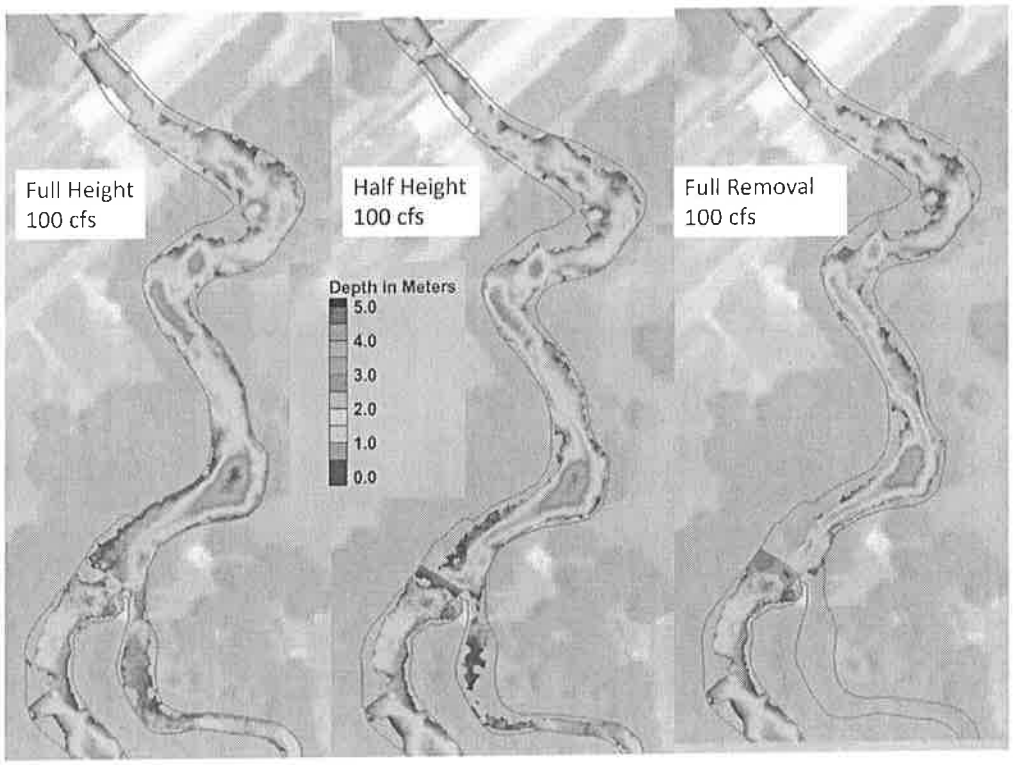


Figure 13. San Marcos River depths with full height, half height, and full Cape's Dam removal at 100 cfs (a flow equaled or exceeded approximately 90 percent of the time on a daily basis).

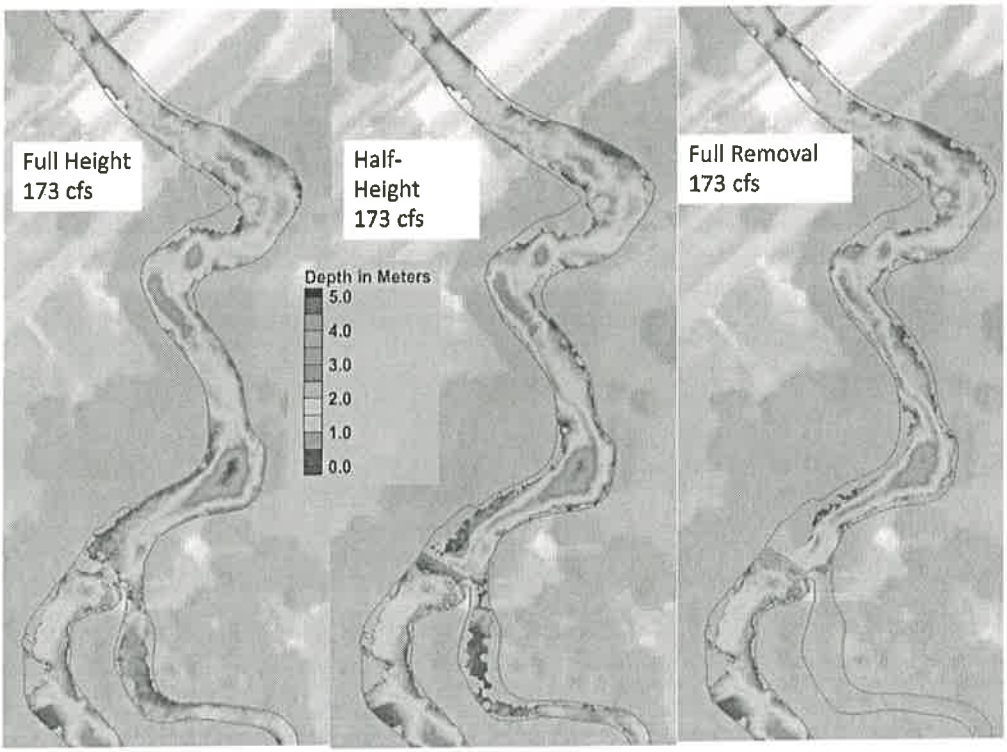


Figure 14. San Marcos River depths with full height, half height, and full Cape's Dam removal at 173 cfs (approximately the median daily flow).

The modeling results at 100 and 173 cfs clearly show that an active stream course is maintained under the dam removal scenario and even at daily flow rates equaled or exceeded over 90 percent of the time (100 cfs) that the deep pools at the bend downstream of IH-35 and above Cape's Dam maintain depth in excess of ~ 2-3 -meters (6 to 9 feet) and the remaining sections of the river are at or over a meter of depth (3.2 feet) and resemble channel depths upstream of the backwater effects of Cape's Dam. This is clearly understood from examination of Figure 15.

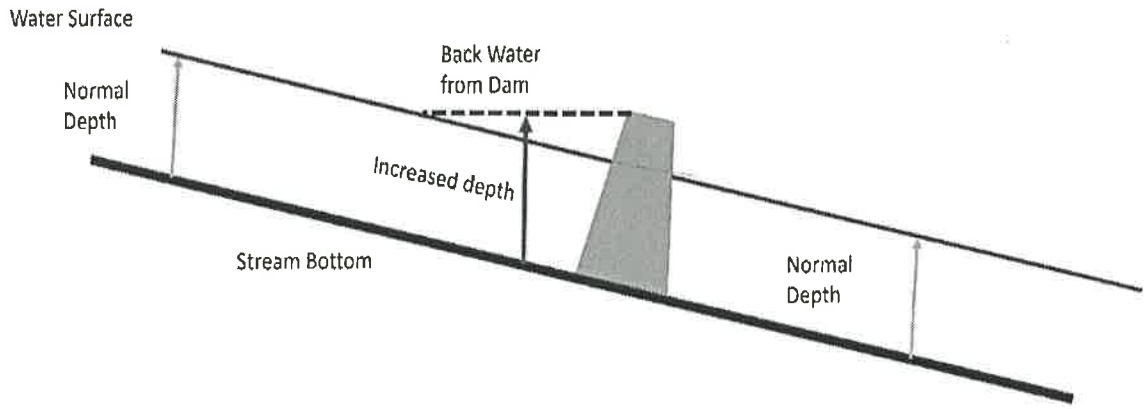


Figure 15. Normal depths upstream, backwater effects of a dam, and normal depths downstream in an idealized channel.

Upstream of any backwater effects from a dam, the water surface elevation assume normal depth (left side of figure). Normal depth also occurs downstream past the short influence of the flow over the dam (right side of figure). Placement of a dam creates a backwater effect where the water surface is flat in the upstream direction until it intersects with the slope of the natural stream surface at the elevation of the dam upstream (middle of figure). Obviously, the higher the dam, the greater the distance in the upstream direction of the backwater effect. Removing the dam results in reconnecting the energy grade line and the section of the river where the dam produced the backwater effect reverts to the normal depth. This is precisely the results illustrated in Figures 12, 13 and 14 under any range of flow rates in the river in the reach impacted by the backwater from Cape's Dam. Compare depths at the upper left of these figures with the sections of river under the backwater section with the dam (middle sections), and areas downstream of the dam location (bottom). Without the dam, the channel will revert to depths and morphologies that are very similar to those found in the existing un-dammed sections of the San Marcos River.

The results for both 100 and 173 cfs clearly show that reductions in stream width associated with dam removal are primarily localized to the section immediately above Cape's Dam (i.e., the backwater section). This is expected because the current widths are partly the result of impoundment, and the impounded area will not exist with dam removal. The total reduction in stream area with half height and full Removal is 15 and 17 percent, and are primarily a result of reduced or elimination of flows in the Mill Race. A careful comparison of the channel widths between the different dam removal scenarios and flow rates illustrate that dam removal will not result in extensive areas of exposed banks or result in the river corridor becoming a mud pit. Reduction in stream width at 45 cfs will be extensive under any dam

scenario. The reader is reminded that 45 cfs is an extremely low flow that has been recorded only for a single day during the entire period of hydrologic record.

Hudson (2012) monitored geomorphic adjustments of the San Marcos River downstream of Cape's Dam after channel dredging to remove the invasive aquatic plant *Cryptocoryne beckettii*. Study results showed that the river channel remained stable with no evidence to support either head cutting, lateral channel migration, or significant back sloughing. This is due to the cohesive nature of the natural bank materials. These results are applicable to the section of river impacted by Cape's Dam and similar results are expected (i.e., lack of bank erosion or lateral scour) with dam removal.

Implications on Flows in the Mill Race

Reduction in Cape's Dam to half height will result in a reduction of the amount of time that flows will enter the Mill Race. Under full removal flows will only occur at flow rates equaled or exceeded about 10-15 percent of the time.

The simulation results for half height and full removal shown in Figures 12 through 14 clearly demonstrate that reduction in the height of Cape's Dam or its removal will impact how often water will flow into the Mill Race. As a validation check on the physical representation of the model, the actual bed elevations in the river immediately upstream from Cape's Dam and the entrance to the Mill Race were surveyed on Tuesday July 21st, 2015. The cross section profiles of the San Marcos River and the Mill Race showing the observed water surface elevation and depth of the their respective channel bottoms are shown in Figure 16. These cross sections were obtained using a common bench mark so the elevations are shown to same absolute scale. These data show that under existing (or full height) conditions, the difference in the elevation at the bottom entrance of the Mill Race and the San Marcos River is approximately 3.9 feet and in excellent agreement with the physical representation of the computational mesh used in the Cape's Dam modeling scenarios.

This difference in elevation between the river and elevation of the bottom entrance to the Mill Race dictates when and to what extent water will flow between the San Marcos River and Mill Race as a function of total flow in the San Marcos River under the various dam configurations. This is easily illustrated by the relationship between stage (height of the water or depth of river flow) and discharge under full height, half-height, and full Cape's Dam removal (Figure 17). Full height conditions in Figure 17 were derived from empirical measurements used in the initial calibration of the hydrodynamic model while the relationships between water surface elevation and discharge for the half height and full dam removal are derived from the simulation results after bed evolution.

Figure 17 illustrates clearly that, under full height conditions, Cape's Dam increases the water surface elevation above the dam and flows enter the Mill Race over a wide range of discharges (this was the original intent of constructing the dam and mill race). This is reflected in the simulation results presented in Figures 12 through 14. Under half heightconditions, where the height of the water backed up behind Cape's Dam would be lower, water would not enter the Mill Race until the San Marcos River discharge was approximately 130 cfs. This flow rate is equaled or exceeded approximately 53 percent of the time based on the daily flow record in the San Marcos River. Conversely, flows would not enter the Mill Race approximately 47 percent of the time, or when flows were less than about 130 cfs. Under full dam

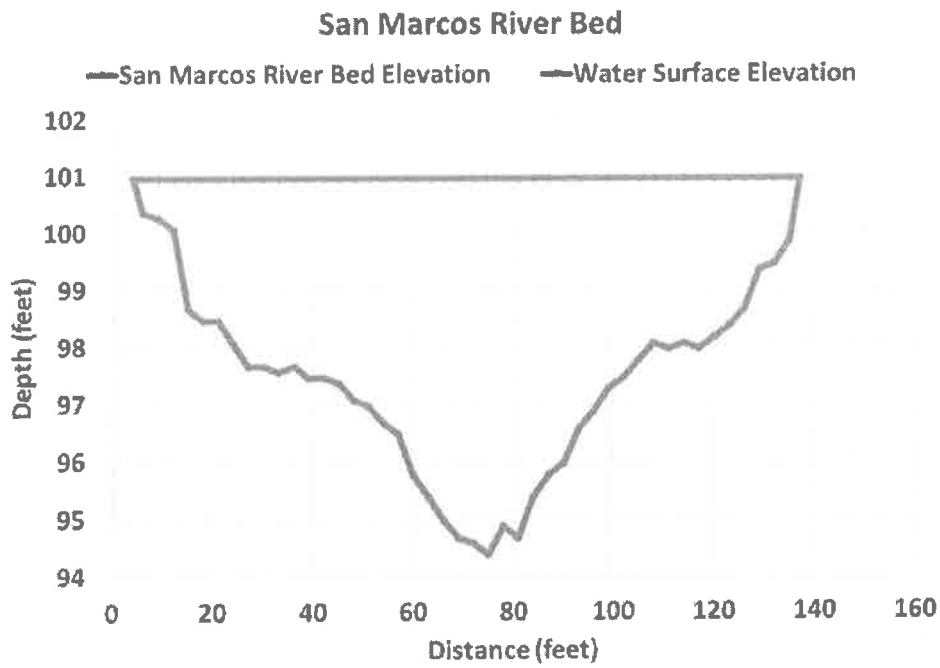
removal, water would enter the Mill Race when San Marcos flows are approximately equal to or higher than 280 cfs. This average daily flow rate is equaled or exceeded only about ~10-12 percent of the time. It should be noted that daily flows of this magnitude and greater are rarely sustained over long periods but are generally associated with short-term flood events.

These results suggest that if Cape's Dam is rebuilt at half height or fully removed, the Mill Race will remain dry or contain stagnant water for extended periods of time between short duration flood events. Even at higher discharges under full height (existing) conditions (e.g., > 250 cfs), water quality impacts due to the backwater effects and flow into the Mill Race are observable. For example, empirical data collected on September 28, 2015 in mid-morning (9:30 – 10:15) prior to extensive recreation use in upstream river reaches showed increasing turbidity (suspended sediment) between Cheatham Street (0.18 FTUs), immediately above Cape's Dam (0.51 FTUs) and at the end of the Mill Race (2.28 FTUs). Dissolved oxygen in the Mill Race was also lower (7.0 ppm) compared to 8.0 in the main river.

Diversion of flows into the Mill Race will continue to reduce the quantity and quality of aquatic habitats in the main stem San Marcos River which are already stressed during low-flow periods.

It is intuitive that, as the total flow of the San Marcos River decreases, splitting the flow (i.e., diversion of flow into the Mill Race) will result in increasingly lower depths per unit discharge in the main steam San Marcos River below the Cape's Dam under half height or full removal. The greatest ecological protection for the aquatic community, especially for the listed species in this section of the river is to retain all the flow of the San Marcos River within its historic natural channel.

The presence of the Mill Race does not offered any added protection against flooding within the San Marcos River in this section of the river, as the height of the water surface elevation is artificially raised by the presence of Cape's Dam. With dam removal, the channel capacity of the San Marcos River will be increased with resulting lower water surface elevations.



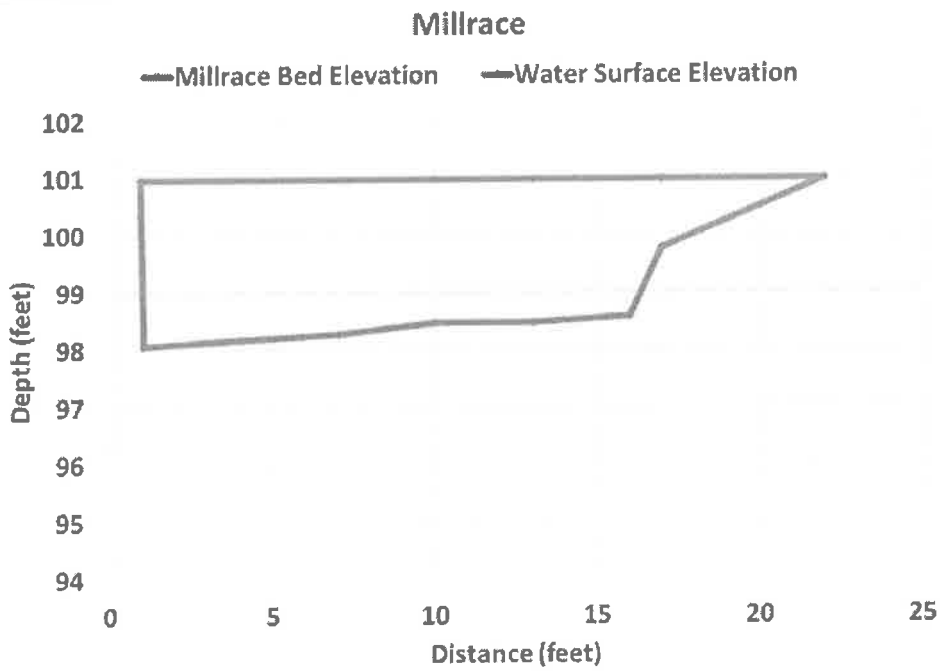


Figure 16. Computational mesh (upper left), location of physical measurements (upper right), cross section profile of the San Marcos River above Cape's Dam (lower left) and cross section profile of the Mill Race (lower right).

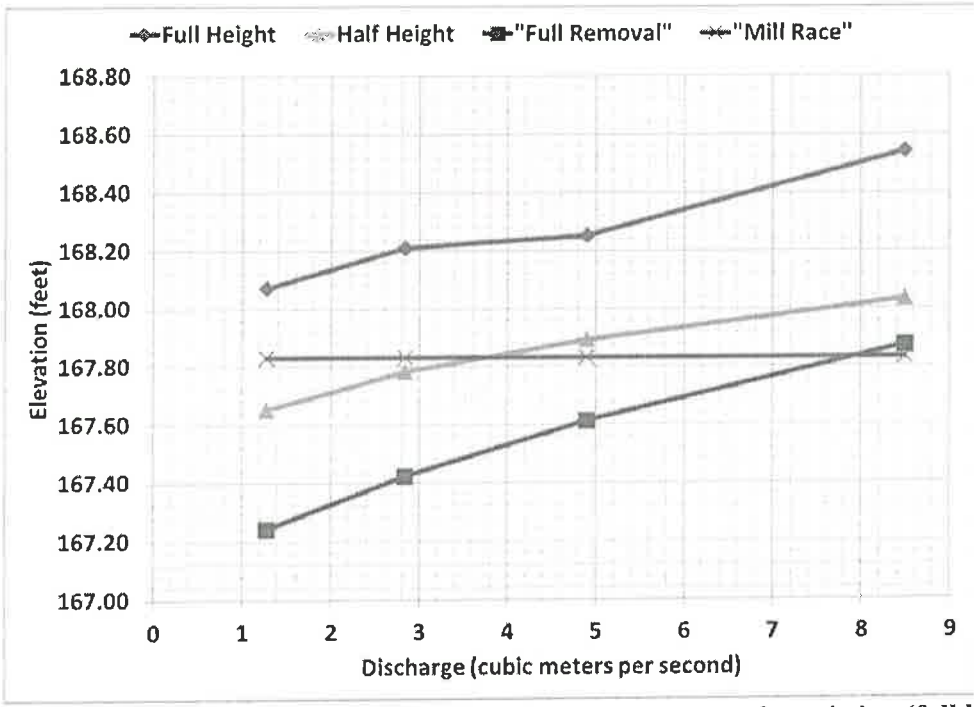


Figure 17. Relationship between water surface elevation and discharge for existing (full height), half height and full Cape's Dam removal and the bed elevation of the inlet to the Mill Race. Whenever points are above the 'Mill Race' line, this indicates that some amount of flow from the San Marcos River will be diverted into the Mill Race channel

Texas Wild Rice

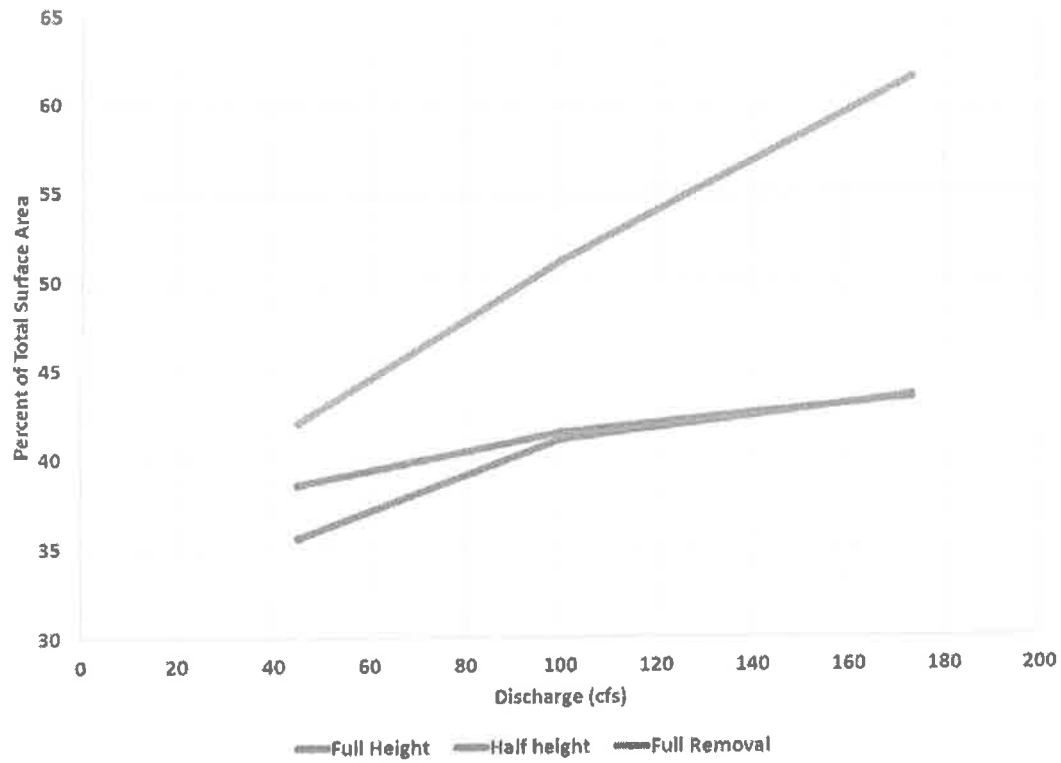
Removal of Cape's Dam represents the best ecological benefits to improving habitat for Texas wild rice.

Figure 18 (top half) shows the amount of Texas wild rice habitat as a percent of the total stream area under full height, half height and full removal and the associated percent change compared to full height conditions (bottom half) for each simulated flow. It is clear that removal of Cape's Dam provides the greatest potential benefit to TWR compared to any with dam scenario over any simulated flow rate. This increase in TWR habitat is also indicative of expected benefits to other native aquatic vegetation. These results likely underestimate the actual increase in habitat quantity and quality with dam removal due to a variety of physical and life history factors of aquatic vegetation not incorporated into the modeling as discussed below. The expected improvement to habitat conditions with dam removal is also based on multiple years of TWR restoration efforts within the San Marcos River by the Meadows Center for Water and the Environment in which applied research and restoration actions have significantly increased the aerial coverage of TWR.

Photosynthetically Active Radiation (PAR)

The decrease in depths within the existing backwater section of the river with removal of Cape's Dam will result in an increase in available PAR reaching the stream bottom which will promote increased TWR and other aquatic macrophyte growth in this section of the river.

Given no nutrient or CO_2 limitations, aquatic macrophyte growth is directly dependent on light availability in terms of Photosynthetically Active Radiation (PAR) reaching the stream bottom. PAR naturally attenuates with water depth, however, PAR reductions due to suspended sediments or other particulate and dissolved matter greatly increases light attenuation and therefore inhibits aquatic plant growth (e.g., Pedersen et al., 2013; Middleboe and Markager 1997; Kemp et al., 2004). Figure 19 shows PAR readings as a function of water depth taken in Spring Lake and immediately upstream of Cape's Dam during a low-recreation weekday morning (9:30-10:15) in September of 2015. The data clearly demonstrate that, relative to Spring Lake, there is a reduction in PAR at each depth upstream of Cape's.. Current research from the San Marcos River clearly shows a strong relationship between increasing reductions in PAR with water depth longitudinally downstream from Spring Lake Dam (Bryne 2015). Under non-stormwater conditions, the reduction in PAR and increased turbidity above Cape's Dam is directly attributed to suspended sediment due to water recreation density. These findings are based on 15 minute turbidity readings at three longitudinal locations between Sewell Park and upstream of Cape's Dam with concurrent hourly recreation counts in Sewell Park, City Park, and Rio Vista since 2012 (Hardy, unpublished data). This reduction in PAR is in part contributing to the observed reduction in the amount of stream bed coverage by aquatic macrophytes in the backwater reaches above Rio Vista and Cape's Dam (San Marcos Observing System and Meadows Center for Water and Environment vegetation monitoring data since 2009). Ongoing research with TWR to quantitatively document the response of plant growth in terms of above- and below-ground biomass relative to suspended sediment and PAR in the San Marcos River supports these relationships (Crawford 2016).



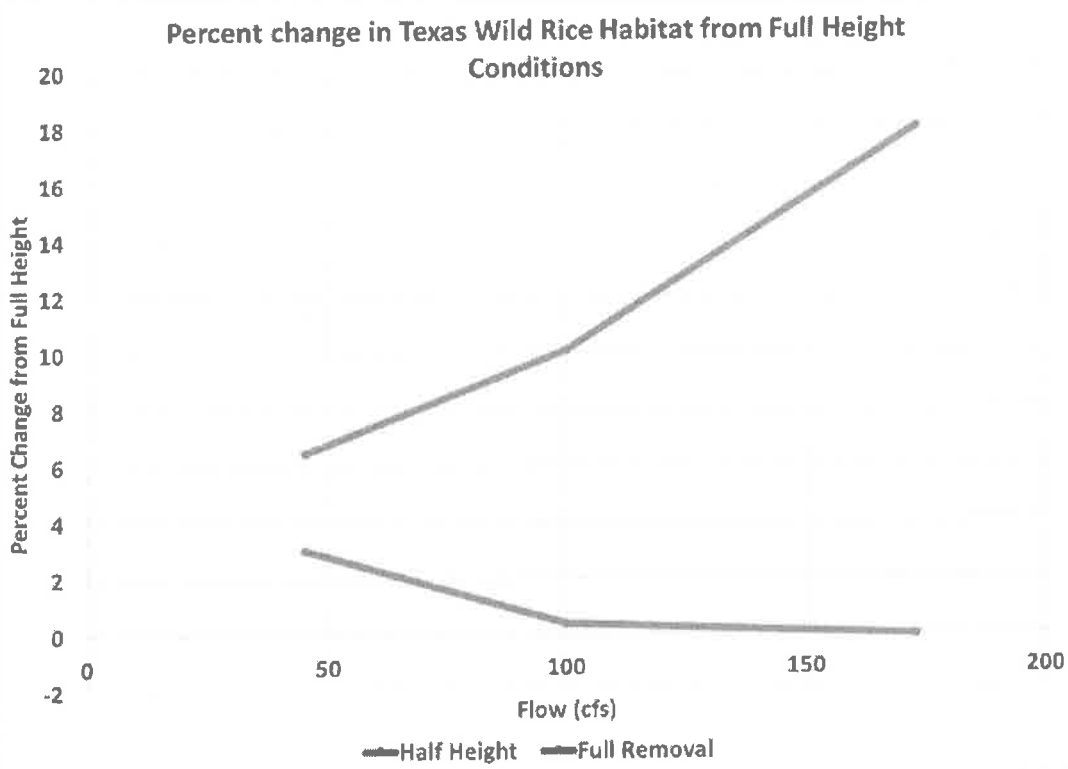


Figure 18. Percent of total surface area and percent change in Texas wild rice habitat compared to full height conditions.

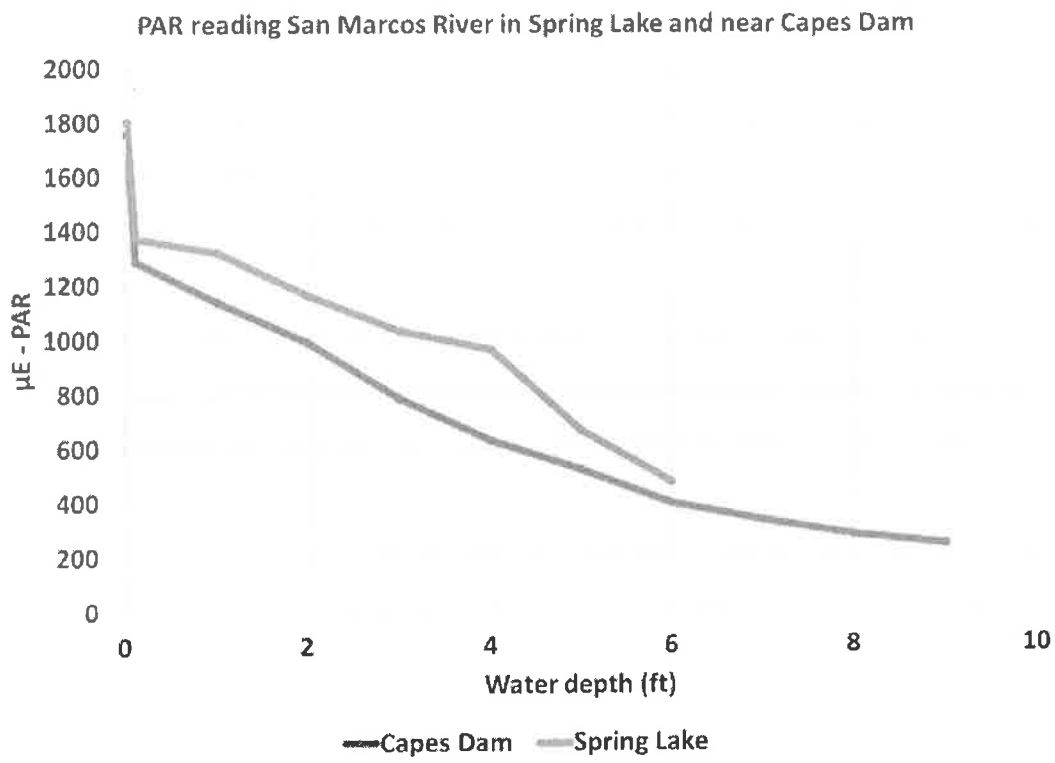


Figure 19. PAR reduction with depth in Spring Lake compared to upstream of Cape's Dam.

Velocity and Gas Exchange Dynamics in Aquatic Plants

Increased distribution of higher velocities in the backwater section of the river with dam removal will promote higher growth rates of TWR and other aquatic macrophytes.

The following is taken from Pedersen et al. (2013):

The 10^4-fold lower diffusion coefficient of gases in water, compared with in air, presents a major challenge to submerged plants (Armstrong, 1979; Maberly and Madsen, 2002). Diffusive boundary layers (DBL) develop on all surfaces and their thickness adjacent to leaves in water is of the same order of magnitude as those for leaves in air (Vogel, 1994; Raven and Hurd, 2012). Although the transport distance for gases across the DBL is similar, the much lower diffusion coefficient in water results in a 10^4-fold lower flux for the same concentration gradient and thus the DBL constitutes a much larger proportion of the total resistance to gas exchange for leaves under water than in air (Maberly and Madsen, 2002). The "bottleneck effect" of the DBL on underwater gas exchange was demonstrated in a study of four submerged aquatic species, where the DBL accounted for 90% of the total resistance to carbon fixation (Black et al., 1981).

Basically this means that exchange of gases and nutrients between the water and the leaf is more difficult for aquatic plants due the mechanics of the diffusion process in water. Aquatic plants, such as Texas wild rice have adapted strategies however to overcome these limitations. Increased water velocities at the leaf

surface have been shown to increase the photosynthetic rates in several aquatic macrophytes due to reduction in the thickness of the DBL (Black et al., 1981). Powers (1996) demonstrated that for TWR the stem density was greater in fast flowing water (0.40-0.49 m/s) than in either moderate (0.12-0.24 m/s) or slow flowing (0.05-0.12 m/s) water. Hardy et al. (2015) harvested thousands of free floating TWR tillers from the San Marcos River and showed > 90% success rate for propagation of TWR exposed to moderate velocities. This research also showed increased mortality of TWR when raised in still water conditions. Hardy et al. (2015) utilized hydraulic and habitat modeling imposing suitable depth and moderate velocities to identify targeted areas for removal of nonnative aquatic plant species and replacementplanting of TWR in the San Marcos River. Utilization of hydraulic and habitat modeling to identify suitable areas for TWR was shown to be highly successful. All treatment areas in which the non-native species *Hydrilla* or *Hygrophila* were removed, and TWR was planted in suitable velocity conditions, showed net gains for TWR. System-wide increases in TWR was on the order of greater than 300 m^2. Modeling results based on suitable depth and velocities to guide removal of nonnative aquatic species and planting of other native aquatic species (i.e., *Sagittaria* sp., *Ludwidia* sp., and *Potamogeton* sp.) was also highly successful.

Implications on Reproduction and Genetic Integrity

Reduction of depths with removal of Cape's Dam will provide an increase in areas suitable for sexual reproduction of TWR important for maintenance of genetic integrity of the population.

TWR propagates by both sexual and asexual means. Asexual propagation occurs from the production of tillers that represent a clone of the host plant that expands or detaches and becomes established in new locations. Sexual reproduction occurs when the plant reaches the surface and relies on wind based pollination to produce seeds that subsequently disperse. Depths over approximately 2 meters (~6 feet) result in TWR rarely reaching the surface and using the sexual reproduction strategy.
Both types of reproduction are important to the long term genetic viability of the species in the San Marcos River. The San Marcos Aquatic Resource Center (USFWS) has developed reintroduction guidelines for the use of tillers versus seed based propagation for plantings of TWR by river sections to ensure long term genetic integrity of the species. Reduction in depths in the backwater section of Cape's Dam with dam removal provides increased diversity of depth conditions that will support both tiller based expansion as well as sexual reproduction by allowing proportionally greater access by TWR to suitable habitats.

Fountain Darters

Habitat Quantity

Removal of Cape's Dam will provide an increase in the area of fountain darter habitat due to both improved hydraulic conditions (i.e., depth and velocity) as well as aquatic macrophyte expansion.

The amount of fountain darter habitat based only on depth and velocity for each flow rate and dam scenario is provided in Figure 20 as a function of total stream area. As noted previously, the total surface area is reduced by ~ 15-17 percent due to small losses along the stream margins in the backwater section of the channel above Cape's Dam and primarily from lack of flows in the Mill Race. The results however, indicate that the quantity of darter habitat as a function of total stream area is highest under dam removal for all stream flows. It should be noted that the increases in habitat for both half height and full dam removal are underestimated since these results do not reflect expected increases in darter habitat due to increases in the density and distribution of aquatic macrophytes.

Long term monitoring has clearly shown that darter densities are higher in aquatic vegetation compared to open substrates (Biowest 210a, b). As noted above, the reduction of depths and increased PAR reaching the stream bottom with dam removal is expected to increase the distribution and abundance of aquatic macrophytes in this section of river, hence improving overall fountain darter habitat. Modeling the expansion of aquatic vegetation under either half height or full dam removal was beyond the scope of this work.

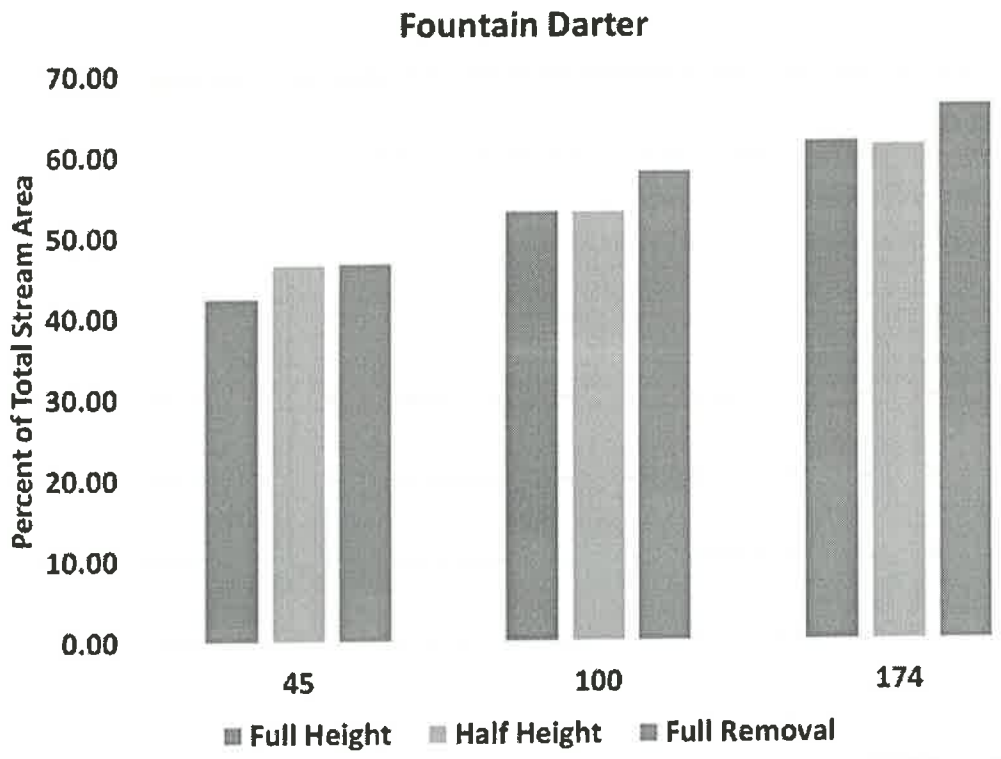


Figure 20. Percent of total stream area suitable for fountain darters under full height, half height and full dam removal.

Habitat Quality

Removal of Cape's Dam will provide an increase in the quality of fountain darter habitat over all flow ranges compared to full height or half height dam scenarios.

Figures 21 through 23 show the number of computational cells containing combined suitability values between 0.1 and 1.0, where a combined suitability of 0.1 is considered 'poor' habitat while a combined suitability of 1.0 is considered 'ideal'. These combined suitability values reflect the individual suitability associated with depth and velocity at each location (computational cell) and provide an objective comparison of potential habitat quality across difference flow ranges under full height, half height and full dam removal.

These results clearly show that stream conditions under dam removal provides a significant increase in the overall number of spatial locations (i.e., computational cells) containing higher suitability values compared to full height or half height conditions.

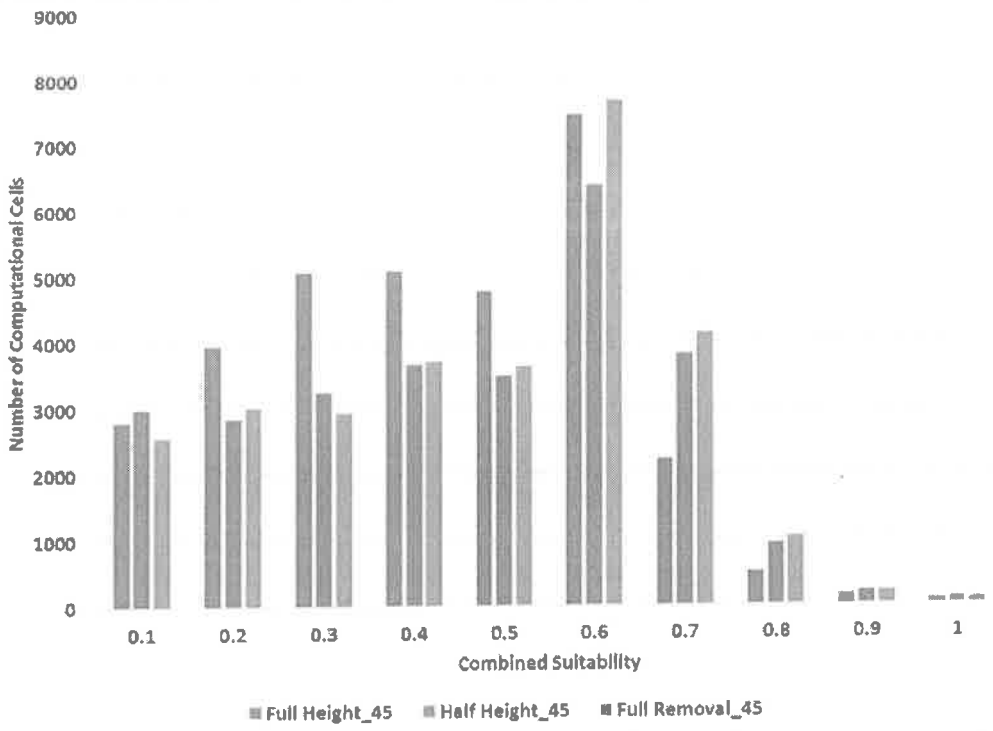


Figure 21. Fountain darter habitat quality under full height, half height and full dam removal at 45 cfs.

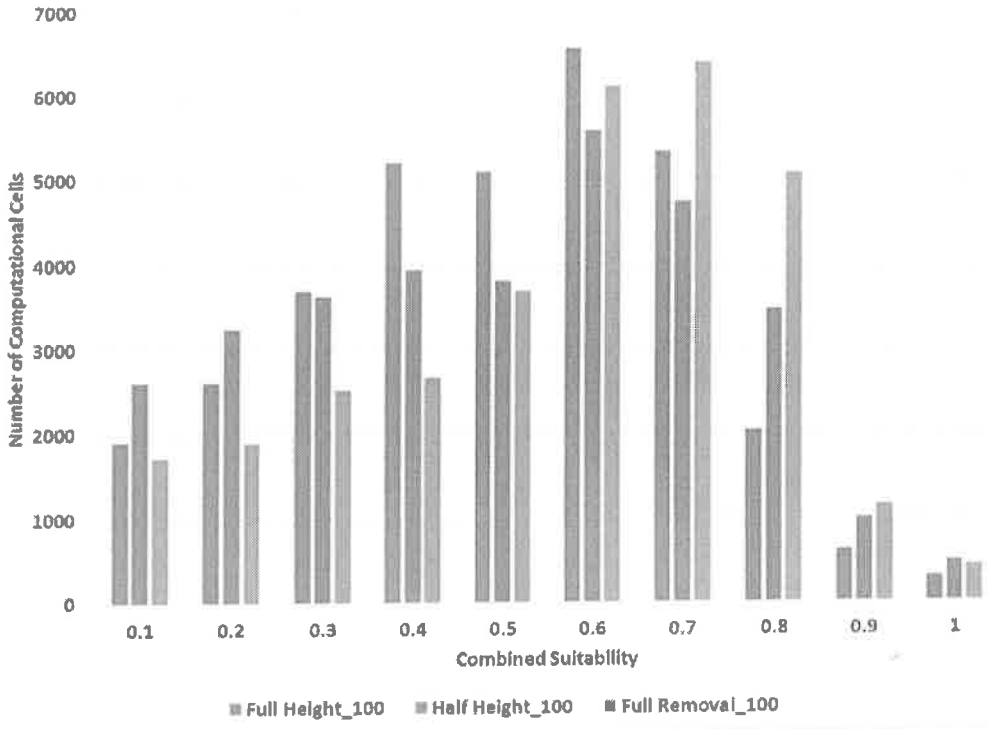


Figure 22. Fountain darter habitat quality under full height, half height and full dam removal at 100 cfs.

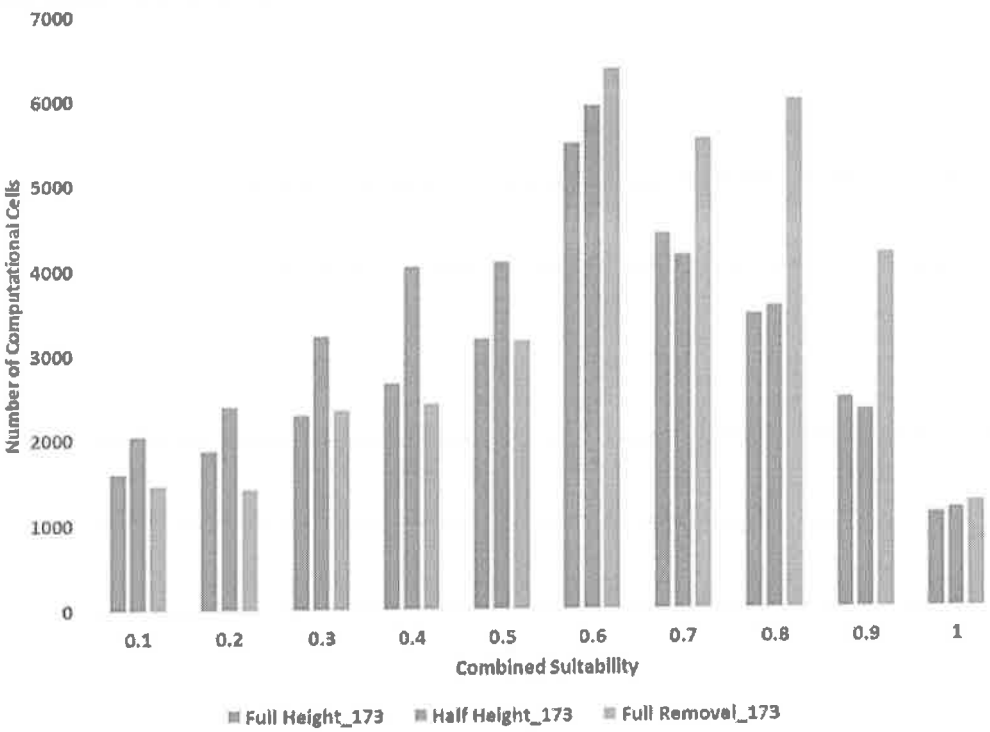


Figure 23. Fountain darter habitat quality under full height, half height and full dam removal at 173 cfs.

Impacts of Low Head Dams

Removal of Cape's Dam will eliminate known ecological impacts associated with low head dams such as adversely affecting warmwater stream fish, aquatic macroinvertebrates, and aquatic/riparian plants by blocking migration pathways, degrading habitat and water quality, and fragmenting the river landscape, which results in a loss of native species diversity.

Low head dams, such as Cape's Dam, are known to contribute to habitat fragmentation, lower aquatic diversity and disrupt migration pathways for fish and aquatic/riparian species. Research suggests that the effects of low head dams on fishes, aquatic macroinvertebrates, aquatic and riparian plant species and their habitats are similar to those reported for larger dams (Anderson et al., 2000; Santucci et al., 2005; Tiemann et al., 2004). Behen (2013) documented that the fish community below Cape's Dam is most closely allied with the stream fish community in the Brazos River rather than the spring fish assemblage in the upper San Marcos River. This was attributed to the impact of Cape's Dam on upstream movement of fishes. Furthermore, research has shown that fish species richness and diversity generally increase in reconnected areas after dam removal (Burroughs et al. 2010; Catalano et al. 2007; Bednarek 2001).

Recreation

Removal of Cape's Dam will provide a safe and sustainable recreation corridor that will accommodate, swimming, tubing, canoeing, kayaking and paddle boarding without a demonstrable negative impact relative to full height or half height dam scenarios for these water based recreation activities.

Figure 24 shows a comparison of changes in normalized habitat area for recreation at different simulated flow rates under each of the dam scenarios evaluated.

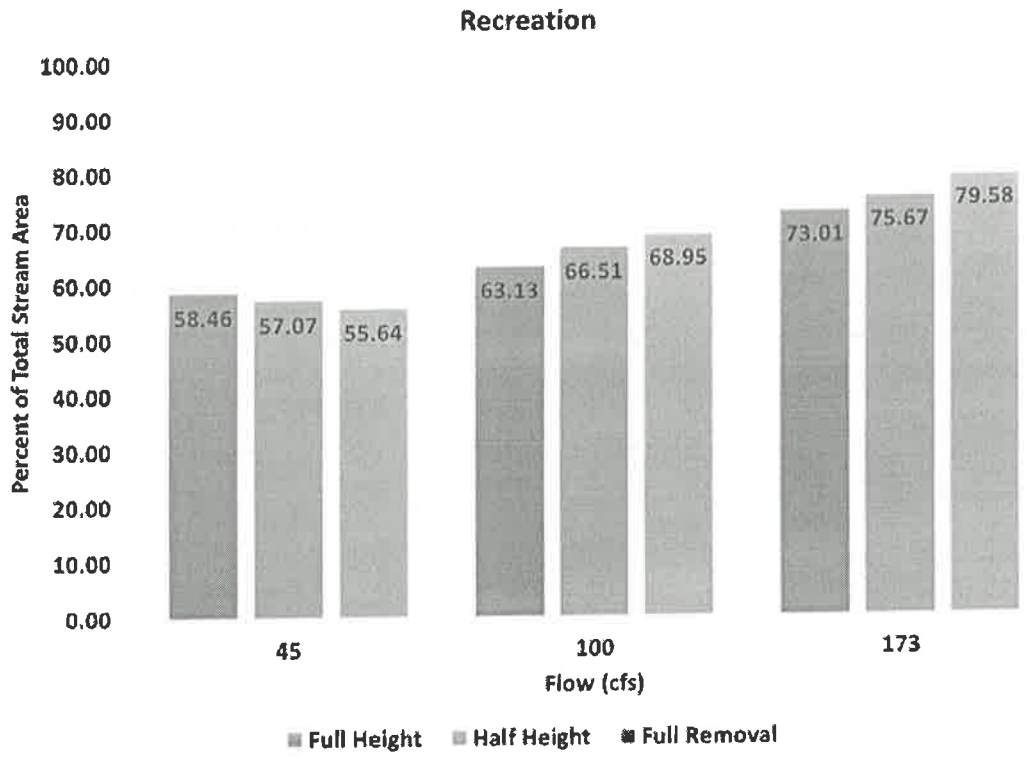


Figure 24. Area of normalized available habitat as a percent of the stream area for recreation for different flow rates and dam scenarios.

As noted previously, a careful examination of Figures 12, 13, and 14 show the expected depths of water at flow rates of 45, 100 and 173 cfs in the San Marcos River under full height, half height and full removal conditions maintain adequate areas with sufficient depths (> 2 feet) to support all forms of contact recreation throughout the river channel. The results are also clear in that with dam removal, existing deep water areas (downstream of IH35, upstream of Cape's Dam, the plunge pool below Cape's Dam and the plunge pool at the end of the Mill Race) will still exist and retain depths in excess of 4-6 feet even under flows of 100 cfs, which are equaled or exceeded 90 percent of the time on a daily basis. Removal of Cape's Dam will result in the maintenance of a safe sustainable recreation corridor with sufficient depths to support all forms of contact water recreation. **Conclusions**

The modeling results and supporting science-based literature clearly demonstrate that the most ecologically beneficial conditions for the San Marcos River is removal of Cape's Dam. There are demonstrably no ecological benefits to the native aquatic or riparian fauna within the San Marcos River to reconstruct Cape's Dam at either half height or full height. The results also clearly demonstrate that Dam Removal will result in a safe and sustainable recreation corridor for all forms of contact recreation over daily flow rates that are equaled or exceeded 90 percent of the time. Dam removal will maintain river conditions similar to free flowing sections above IH35 and downstream of the Thompson Island. Under half height or full removal options, the Mill Race will have substantially less flowing water and/or reductions in the amount of time that water will flow into the Mill Race. Empirical data collected from the Mill Race shows that it currently results in degraded water quality even at flow rates that are above the long term median daily flows.

The assessment also shows that removal of Cape's Dam will result in improved conditions for restoration of aquatic macrophytes including the endangered Texas wild rice. Increased aquatic macrophytes will increase the available habitat for the endangered fountain darter in this reach of the San Marcos River. Dam removal will result in river conditions that are more favorable for meeting long term Biological Goals identified for this reach of river in the Edwards Aquifer Habitat Conservation Plan.

Rebuilding Cape's Dam to either full or half height will continue to cause fragmentation of the habitat within the San Marcos River, impede or stop migration pathways for aquatic and riparian species, and will continue to result in abnormal accumulation of fine sediments behind the dam that negatively alter fish and aquatic macroinvertebrate habitats and result in loss of native species diversity.

Literature Cited

Andersson, E., Nilsson, C. and Johansson, M. E. (2000), Effects of river fragmentation on plant dispersal and riparian flora. Regul. Rivers: Res. Mgmt., 16: 83–89. doi: 10.1002/(SICI)1099-1646(200001/02)16:1<83::AID-RRR567>3.0.CO;2-T

Bednarek, A. T. 2001. Undamming rivers: a review of the ecological impacts of dam removal. Environmental Management 27: 803-814.

Behen, K. 2013. Influence of connectivity and habitat heterogeneity on fishes in the Upper San Marcos River, Texas. 2013. MS Thesis, Department of Biology, Texas State University.

Berger, R.C., J.N. Tate, G.L. Brown, G. Savant. 2011. Adaptive Hydraulics Users manual. Guidelines for solving two-dimensional shallow water problems with the adaptive hydraulics modeling system. Coastal and Hydraulics Laboratory Engineer Research and Development Center. 90pp

BioWest. 2010a. Comprehensive and critical period monitoring program to evaluate the effects of variable flow on biological resources in the Comal Springs/River aquatic ecosystem. Final 2009 annual report. Edward Aquifer Authority. 82pp. + appendices.

BioWest. 2010b. Comprehensive and critical period monitoring program to evaluate the effects of variable flow on biological resources in the San Marcos/River Aquatic Ecosystem. Final 2009 Annual Report. 66pp + appendices.

Black M. A., Maberly S. C., Spence D. H. N. (1981). Resistances to carbon dioxide fixation in four submerged freshwater macrophytes. New Phytol. 89, 557–56810.1111/j.14698137.1981.tb02335.x

Bryne, R.E. 2015 (expected). Influence of Recreation on Spatial and Temporal Patterns in Water Quality and Periphyton Growth and their Effect on Texas wild-rice (*Zizania texana*). MS. Thesis, University of Houston-Clear Lake.

Burroughs, B. A., D. B. Hayes, K D. Klomp, J. F. Hansen, and J. Mistak. 2010. The effects of the Stronach Dam removal on fish in the Pine River, Manistee County, Michigan. Transactions of the American Fisheries Society 139: 1595-1613.

Catalano, M. J., M. A. Bozek, and T.D. Pellett. 2007. Effects of dam removal on fish assemblage structure and spatial distributions in the Baraboo River, Wisconsin. North American Journal of Fisheries Management 27: 519-530.

Crawford, M. 2016 (expected). An analysis of the effects of suspended sediment and photosynthetically active radiation (PAR) on the vegetative growth of Texas wild rice (*Zizania texana*). PhD dissertation, Department of Biology, Texas State University.

Hardy, T.B., K.A. Kollaus, and K. Tower. 2010. Evaluation of the proposed Edwards Aquifer Recovery Implementation Program drought of record minimum flow regimes in the Comal and

San Marcos River systems. River Systems Institute, Texas State University, San Marcos Texas. 81pp + appendices.

Hardy, T.B., K.A. Kollaus, K. Tolman, T. Heard and M. Howard. 2015. Ecohydraulics in applied river restoration: a case study in the San Marcos River, Texas, USA. Journal of Applied Water Engineering and Research, 2015. http://dx.doi.org/10.1080/23249676.2015.1090352

Hudson, P. 2012. Geomorphic Adjustment of the San Marcos River, Texas to Environmental Management for Removal of an Invasive Water Plant, *Cryptocoryne beckettii*. Final Report, Texas Parks and Wildlife and US Fish and Wildlife.

Kemp, M. W., R. Batiuk, R. Bartleson, P. Bergstrom, V. Carter, C. L. Gallegos, W. Hunley, L. Karrh, E. W. Koch, J. M. Landwehr, K. A. Moore, L. Murray, M. Naylor, N. B. Rybicki, J. C. Stevenson, and D.J. Wilcox. 2004. Habitat requirements for submerged aquatic vegetation in Chesapeake Bay: water quality, light regime, and physical-chemical factors. Estuaries 27: 363-377.

Middelboe, A.L. and S. Markager. 1997. Depth limits and minimum light requirements of freshwater macrophytes. Freshwater Biology (1997) 37, 553-568.

Pedersen O., Colmer T. D., Sand-Jensen K. (2013) Underwater photosynthesis of submerged plants recent advances and methods. Front. Plant Sci. 4:140 10.3389/fpls.2013.00140

Powers, P. 1996. Effects of current velocity and substrate composition on growth of Texas wildrice (*Zizania texana*). Aquatic Botany, Nov, 1996; 55: 3; 199-204.

Santucci, V.J. Jr., S.R. Gephard, and S.M. Pescitelli. 2005. Effects of multiple low-head dams on fish, macroinvertebrates, habitat, and water quality in the Fox River, Illinois. North American Journal of Fisheries Management 25:975-992.

Saunders, K.S., K.B. Mayes, T.A. Jurgensen, J.F. Trungale, L.J. Kleinsasser, K. Aziz, J.R. Fields, and R.E. Moss. 2001. An Evaluation of Spring Flows to Support the Upper San Marcos River Spring System, Hays County, Texas. Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas. 126 pp.

Stanley E H and M. W. Doyle. 2003. Trading off: the ecological effects of dam removal. Frontiers in Ecology and the Environment 1: 15–22.

Tiemann, J.S., D.P. Gillette, M.L. Wildhaber, and D.R. Edds. 2004. Effects of lowhead dams on riffledwelling fishes and macroinvertebrates in Midwestern river. Transactions of the American Fisheries Society 133:705-171.

Appendix A – Author Biographies

Dr. Hardy – Short Biography

Dr. Thomas Hardy holds a Ph.D. in Civil and Environmental Engineering, M.S. and B.S. degrees in Biology and a B.S. in Secondary Education. He is a tenured Full Professor in the Department of Biology at Texas State University and holds the Meadows Center for Water and the Environment (MCWE) Endowed Professorship for Environmental Flows and is the Chief Science Officer at MCWE. Dr. Hardy was a tenured Full Professor in the Department of Civil and Environmental Engineering at Utah State University where he was the Director of the Institute for Natural Systems Engineering for 21 years and the Associate Director of the Utah Water Research Laboratory for 10 years. He is a founding member and Past-President of the Ecohydraulics Section of the International Association for Hydro-Environment Engineering and Research and served on the National Academy of Science Committee on review of the Texas Instream Flow Program. Dr. Hardy's career has spanned a wide array of fundamental and applied

multidisciplinary research including the development, testing, validation, and application of assessment methodologies in aquatic systems. His research includes use of unmanned autonomous vehicles for remote sensing and image processing, aquatic ecosystems modeling, aquatic vegetation and macroinvertebrate dynamics, river and reservoir water quantity modeling and distributed watershed modeling. He is also active in the evaluation of fresh water inflows on bay and estuary health and recreation based impacts to fish, aquatic macrophytes and macroinvertebrate communities. He is an internationally recognized expert in instream flow assessments and has collaborated with national instream flow and river restoration programs in the United States, Canada, Mexico, United Kingdom, western European countries, South Korea, and Japan.

Dr. Raphlet – Short Biography

Dr. Nolan Raphelt holds a Ph.D. and ME in Civil Engineering and a BS in Agricultural Engineering. He is also a licensed Professional Engineer with the State of Texas. His research and applied experience includes studies on the hydrologic regimes of Texas' rivers and streams in terms of impacts of flow alterations on stream stability and morphology, and the aquatic and riparian habitats. Dr. Raphelt has extensive experience in sediment modeling, 1-D, 2-D and 3-D hydraulic modeling; riverine erosion and sediment transport; non-cohesive sediment modeling in coastal/estuarine environments; channel sedimentation and restoration modeling; simulation in riverine and coastal flood control and navigation channels; fluvial and geomorphic analysis in riverine/coastal environments; and the effects of flow sediment diversion in riverine and estuarine areas. Dr. Rpahelt spent several decades at the US Army Corps of Engineers Coastal and Hydraulics Laboratory where he performed numerical modeling in a number of water resource areas, including 1, 2 and 3-dimensional numerical modeling of the hydrodynamic and sediment regimes in river and estuarine environments. He was responsible for the development of 2 and 3 dimensional flow and sediment models for the Mississippi River from Pool 18 on the upper Mississippi to the mouth of Mississippi River. This work included 3-D sediment modeling of the Old River Control Complex (ORCC) structures which include three major flood control structures and one hydropower plant. The work on the lower Mississippi River focused on the effects of proposed sediment diversion for wetland restoration in adjacent shallow water bays. Two of the studies, Apalachicola River and Pool 18 study involved the tracking of sediments dredged from the navigation channel and placed on riverbanks. Additional work included the development of procedures for the EPA to use in evaluation of the effects of land use changes and channel modification in urban areas on channel morphology, water quality and biota diversity. Dr. Raphelt also developed the original sediment transport module for the computer program SAM. He has served as Principal Investigator for the Demonstration and Erosion Control Monitoring program that developed a comprehensive design guidance manual that includes techniques for channel stabilization and environmental enhancement. Dr. Raphelt is the author/co-author of 35 Technical Publications, including conference papers, Journal Publications, and ERDC Technical papers, on such topics as: Multidimensional sediment modeling; effects of in channel structures on stream stability, navigation conditions and erosion control; and the effects of flow diversions on sedimentation regimes and stream stability.

Appendix B – Supporting Bibliographic Literature Relied Upon

Thesis and Dissertations (Hardy - major professor or committee member)

Kenneth Behen: Influence of connectivity and habitat heterogeneity on fishes in the Upper San Marcos River, Texas. 2013. MS Thesis, Department of Biology, Texas State University.

Michele Crawford: An analysis of the effects of suspended sediment and photosynthetically active radiation (PAR) on the vegetative growth of Texas wild rice (*Zizania texana*). PhD dissertation, Department of Biology, Texas State University.

Ovie Agarie: Seasonal and longitudinal Investigation of the impacts of recreational activities on aquatic macroinvertebrates community and habitat structure of the San Marcos River. MS thesis, Department of Biology, Texas State University.

Anji Dodd: Two-dimensional mobile bed hydrodynamic model for the transport of mixed sediments. 2006. Dissertation Department of Civil and Environmental Engineering, Utah State University.

Jacob Bilbo: Seasonal impact of recreation based suspension of turbidity on the macroinvertebrate assemblage of the San Marcos River. 2015. MS Thesis, Department of Biology, Texas State University.

Rachel Byrne: Influence of Recreation on Spatial and Temporal Patterns in Water Quality and Periphyton Growth and their Effect on Texas wild-rice (*Zizania texana*). MS Thesis University of Houston – Clear Lake.

Kristina Tolman: Habitat Characterization of *Zizani texana* in the San Marcos River. 2013. MS thesis, Department of Geography, Texas State University.

Kerstin Hoesel: Short term responses of nutrient uptake and release of *Eichhornia crassipes*, *Pistia stratiotes*, and *Ceratophyllum demersum* to nutrient pulses via precipitation events in Spring Lake, San Marcos River, Texas. MS Thesis, Department of Biology, Texas State University, anticipated completion Spring 2016.

Mikhail Bhosle: Estimating uncertainty in fish habitat modeling using two-dimensional hydraulics, MS Thesis, Department of Civil and Environmental Engineering, Utah State University, 2004

Nathan Bartsch: Development and utilization of a physical habitat model for *Etheostoma fonticola* in the Landa Lake and Comal River systems, MS Thesis, Department of Civil and Environmental Engineering, Utah State University, 1996

Karl Tarbet: Evaluation of two-dimensional hydraulic modeling in a natural river and implications in instream flow assessment methods, MS Thesis, Department of Civil and Environmental Engineering, Utah State University, 1996

Michael Chulick: Statistical modeling methodology for the determination of habitat suitability and habitat preferences of the endangered fountain darter, Department of Civil and Environmental Engineering, Utah State University, 1995.

Selected Journal Articles

Hardy, T.B., K. Kollaus, K. Tolman, T. Heard and M. Howard. (2015). Ecohydraulics in applied river restoration: a case study in the San Marcos River, Texas, USA. DOI: 10.1080/23249676.2015.1090352. Once the article has published online, it will be available at the following permanent link: http://dx.doi.org/10.1080/23249676.2015.1090352

Kollaus, K.A., K.P.K. Behen, T.C. Heard, T.B. Hardy, T.H. Bonner. 2014. Influence of urbanization on a karst terrain stream and fish community. Urban Ecosystems, 29 June 2014. ISSN 1083-8155. DOI 10.1007/s11252-014-0384-x

Goodwin, P., and T.B. Hardy. 1999. Integrated simulation of physical, chemical and ecological processes for river management. Journal of Hydroinformatics 1:33-58.

Hardy, T.B. 1998. The future of habitat modeling and instream flow assessment techniques. Regulated Rivers: Research and Management 14:405-420.

Selected Referred Conference Proceedings and Abstracts

Hardy, T.B., K. Kollaus, K. Tolman, T. Heard, and M. Howard. 2014. Ecohydraulics in applied river restoration: A case study in the San Marcos River, Texas, USA. 10th International Symposium on Ecohydralics 2014. Trondheim, Norway, June 23-27th.

Kollaus, K.A., K.M. Tolman, T.C. Heard, N. Raphelt, and T.B. Hardy. 2014. Assessing potential removal of two low-head dams in an urbanized Texas karst stream. 10th International Symposium on Ecohydralics 2014. Trondheim, Norway, June 23-27th.

Tolman, K., K. Kollaus, T. Heard, T. Hardy, J. Jensen, and N. Currit. 2014. Habitat suitability modeling of endangered, *Zizania texana*, within a highly urbanized, artesian ecosystem in San Marcos, Texas. 10th International Symposium on Ecohydralics 2014. Trondheim, Norway, June 23-27th. Hardy, T.B., K.A. Kollaus, T. Heard, J.M. Tennant, and K. Tower. 2012. Incorporating physical habitat and water temperature modeling at high spatial and temporal scales to evaluate required minimum flow regimes during sustained drought. 9th International Symposium on Ecohydraulics 2012. H. Mader, and J. Kraml (Eds). ISBN: 978-3-200-02862-3. http://www.iahr.org/site/cms/contentviewarticle.asp?article=663

Hardy, T.B., W. Nowlin, B. Schwartz, and T. Bonner. 2010. Implementation of the San Marcos River observing system: a spatially explicit delineation of a spring system based on physical, hydrologic, chemical, and biological monitoring. 8th International Symposium on Ecohydraulics, Seoul, Korea, September 12-16, 2010. 1714-1721 pp. http://www.iahr.org/site/cms/contentviewarticle.asp?article=663

Hardy, T.B. 2008. River restoration: Integration of sediment and riparian modeling for assessment of long-term post restoration conditions for aquatic resources. International Symposium on the Stream Corridor Restoration, River Environmental Technology Institute, Seoul, Korea. November 11, 2008. English and Korean papers printed in Symposium Proceedings.

Bartsch, N., C.P. Gubala, and T.B. Hardy. 1996. Determining habitat criteria for the endangered fountain darter through aquatic mapping and hydrologic modeling. In: The 2nd International Symposium on Habitat Hydraulics, Quebec, Canada. pp B251-B262. ISBN 2-89146-381-1: Volume B http://www.iahr.org/site/cms/contentviewarticle.asp?article=663

Tarbet, K., and T.B. Hardy. 1996. Evaluation of one-dimensional and two-dimensional hydraulic modeling in a natural river and implications in instream flow assessment methods. In: The 2nd

International Symposium on Habitat Hydraulics, Quebec, Canada. pp B395-B406. ISBN 289146-381-1: Volume B

Hardy, T.B. 2009. Addressing repeatability, uncertainty, scalability and bias in habitat mapping based approached to instream flow assessments. The 7th International Symposium on Ecohydraulics, Concepcion, Chile. February 12-16, 2009. http://www.iahr.org/site/cms/contentviewarticle.asp?article=663

Hardy, T.B., and E. Saraeva. 2009. A comparative evaluation of habitat mapping versus hydraulic based habitat modeling to assess river restoration actions. The 7th International Symposium on Ecohydraulics, Concepcion, Chile. February 12-16, 2009. http://www.iahr.org/site/cms/contentviewarticle.asp?article=663

Selected Reviewed Reports

Hardy, T.B., K. Kollaus, T.C. Heard, and J.M. Tennant. 2012. Effects of changing height of Cape's dam on critical habitat in the San Marcos River. Report prepared for U.S. Fish and Wildlife Service. Meadows Center for Water and the Environment, Texas State University. 16 pp.

Hardy, T.B., K. Kollaus, T.C. Heard, and J.M. Tennant. 2012. Management strategies for Cumming's Dam to enhance fish habitat in the San Marcos River, Texas. Report prepared for U.S. Fish and Wildlife Service. Meadows Center for Water and the Environment, Texas State University. 17 pp.

Hardy, T.B. 2010. Technical assessments in support of the Edwards Aquifer science committee "J Charge" flow regime evaluation for the Comal and San Marcos River systems. River Systems Institute, Texas State University. 159 pp

Hardy, T.B., K. Kollaus, and K. Tower, 2010. Evaluation of the proposed Edwards Aquifer recovery implementation program drought of record minimum flow regimes in the Comal and San Marcos River systems. River Systems Institute, Texas State University. 81 pp.

Shoemaker, J., and T.B. Hardy. 2004. Development and application of an instream flow assessment framework for the Fountain Darter (*Etheostoma fonticola*) and Texas Wild Rice (*Zizania texana*) in Spring Lake and the San Marcos River system. Institute for Natural Systems Engineering, Utah Water Research Laboratory, Utah State University, Logan, Utah.

Bartsch, N., T.B. Hardy, J. Shoemaker, and P. Connor. 1999. Development and application of an instream flow assessment framework for the Fountain Darter (*Etheostoma fonticola*) and Wild Rice (*Zizania texana*) in Landa Lake and the Comal River System. Institute for Natural Systems Engineering Utah Water Research Laboratory, Utah State University, Logan, Utah, and U.S. Fish and Wildlife Service, Ecological Services Field Office Austin, Texas.

Selected Non-Reviewed Reports

Gleason, J., P. Hartigan, B. Reese, T.B. Hardy, and K. Tolman. 2013. San Marcos water quality protection plan. 166 pp.

Tolman, K., C. Clary, and T.B. Hardy. 2013. Assessing water quality changes under existing and future build-out scenarios in the upper San Marcos watershed. Meadows Center for Water and the Environment. Final Report to the City of San Marcos. 33 pp.

Kollaus, K., T. Heard, J. Tennant, and T.B. Hardy. 2013. Fountain darter management at Cape Road Bridge, San Marcos River, San Marcos, Texas. Meadows Center for Water and the Environment. Final Report to Texas Department of Transportation. 3 pp.

Hardy, T.B., N. Raphelt, K. Kollaus, T. Heard, and J. Tennant. 2012. Management strategies for Cumming's dam to enhance fish habitat in the San Marcos River, Texas. Report prepared for U. S. Fish and Wildlife Service, San Marcos, TX.

Hardy, T.B., N. Raphelt, K. Kollaus, T. Heard, and J. Tennant. 2012. Effects of changing height of Cape's Dam on critical habitat in the San Marcos River, Texas. Report prepared for U. S. Fish and Wildlife Service, San Marcos, TX.

Hardy, T.B. 2002. Update of the San Marcos hydraulic and habitat analysis system. Prepared for U.S. Fish and Wildlife Service. Department of Civil and Environmental Engineering, Utah State University, Logan, Utah.

Hardy, T.B. 1982. Ecological interactions of the introduced and native fishes in the outflow of Ash Springs, Lincoln County, Nevada. Department of Biological Sciences, University of Nevada at Las Vegas, Las Vegas, Nevada. 110 pp.

Dr. Thomas Hardy
Dr. Rolan Raphelt

Evaluation of Capes Dam

A bit of Ecology

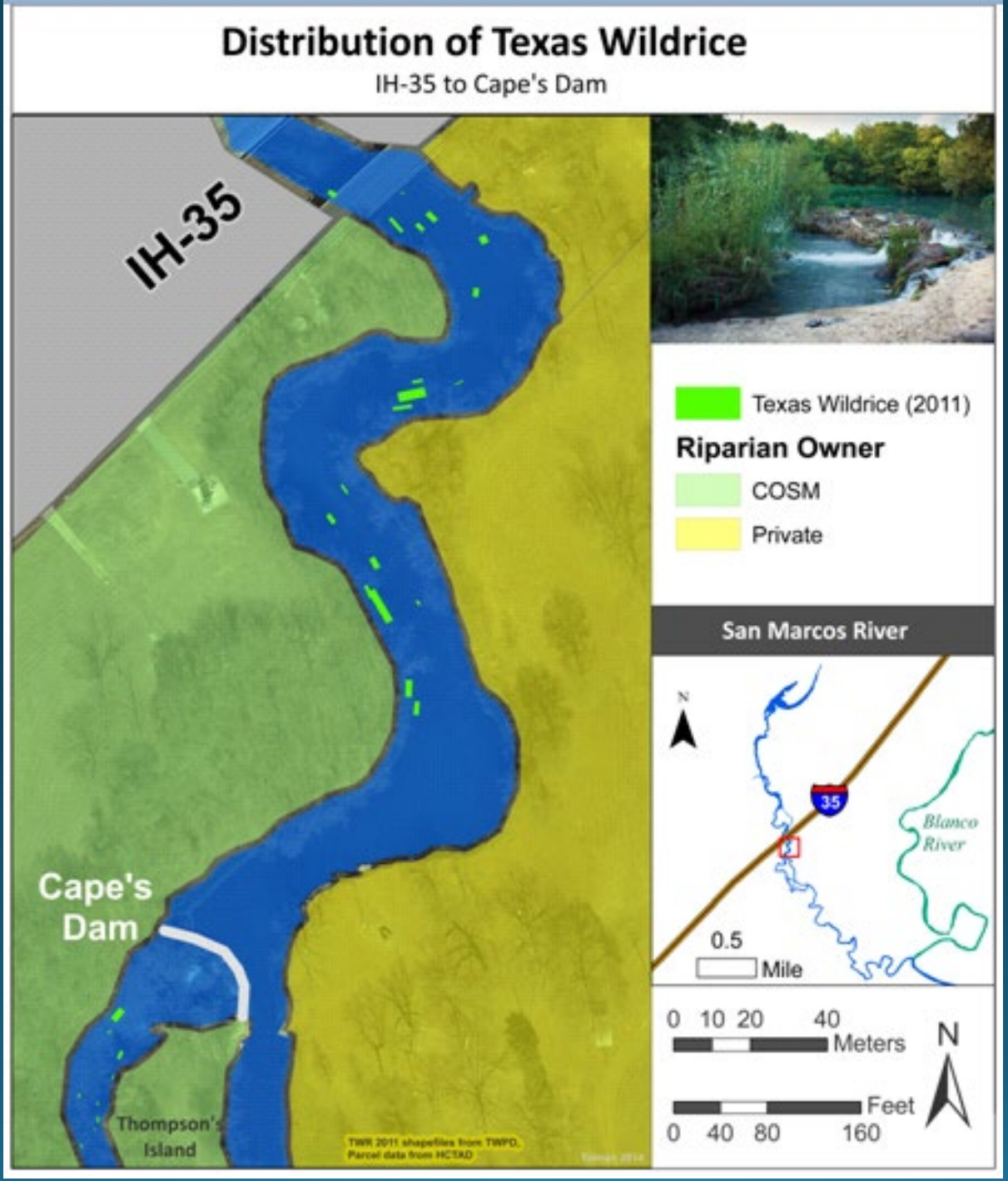


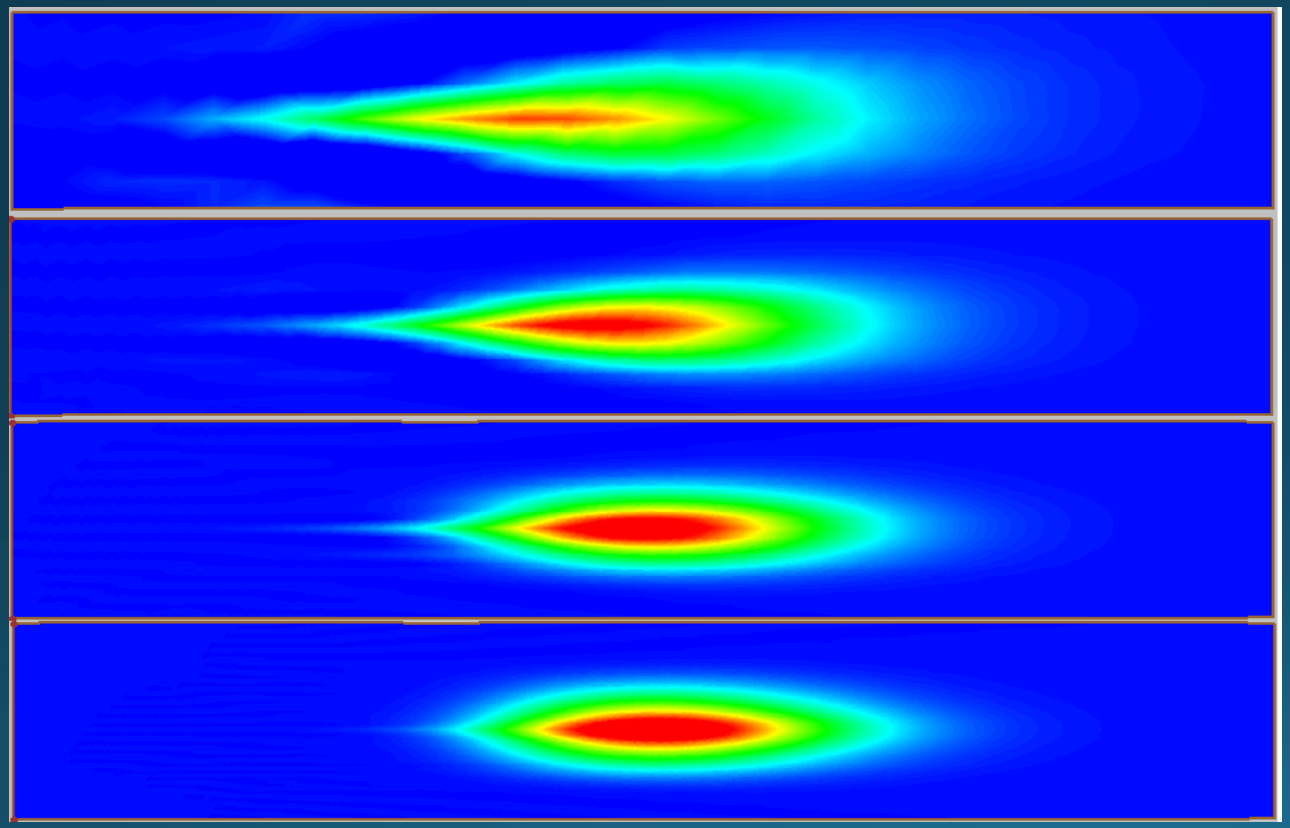
TABLE 4-10
LONG-TERM BIOLOGICAL GOAL FOR TEXAS WILD-RICE

River Segment	Areal Coverage (m^2)	Reach Percentage of Total Areal Coverage
Spring Lake	1,000 – 1,500	n/a
Spring Lake Dam to Rio Vista Dam	5,810 – 9,245	83 – 66
Rio Vista Dam to IH-35	910 – 1,650	13 – 12
Downstream of IH-35	280 – 3,055	4 – 22
TOTAL	8000 – 15,450	100

Adaptive Hydraulics Modeling

- ADH is a state-of-the-art Adaptive Hydraulics Modeling system developed by the Coastal and Hydraulics Laboratory, ERDC (ENGINEER RESEARCH AND DEVELOPMENT CENTER), USACE
- Capable of handling three-dimensional Navier-Stokes flow, and two- or three-dimensional shallow water problems.
- One of the major benefits of ADH is its use of adaptive numerical meshes that can be employed to improve model accuracy without sacrificing efficiency.
- ADH contains other essential features such as completely coupled sediment transport.

Grid Resolution Results…



Coarse

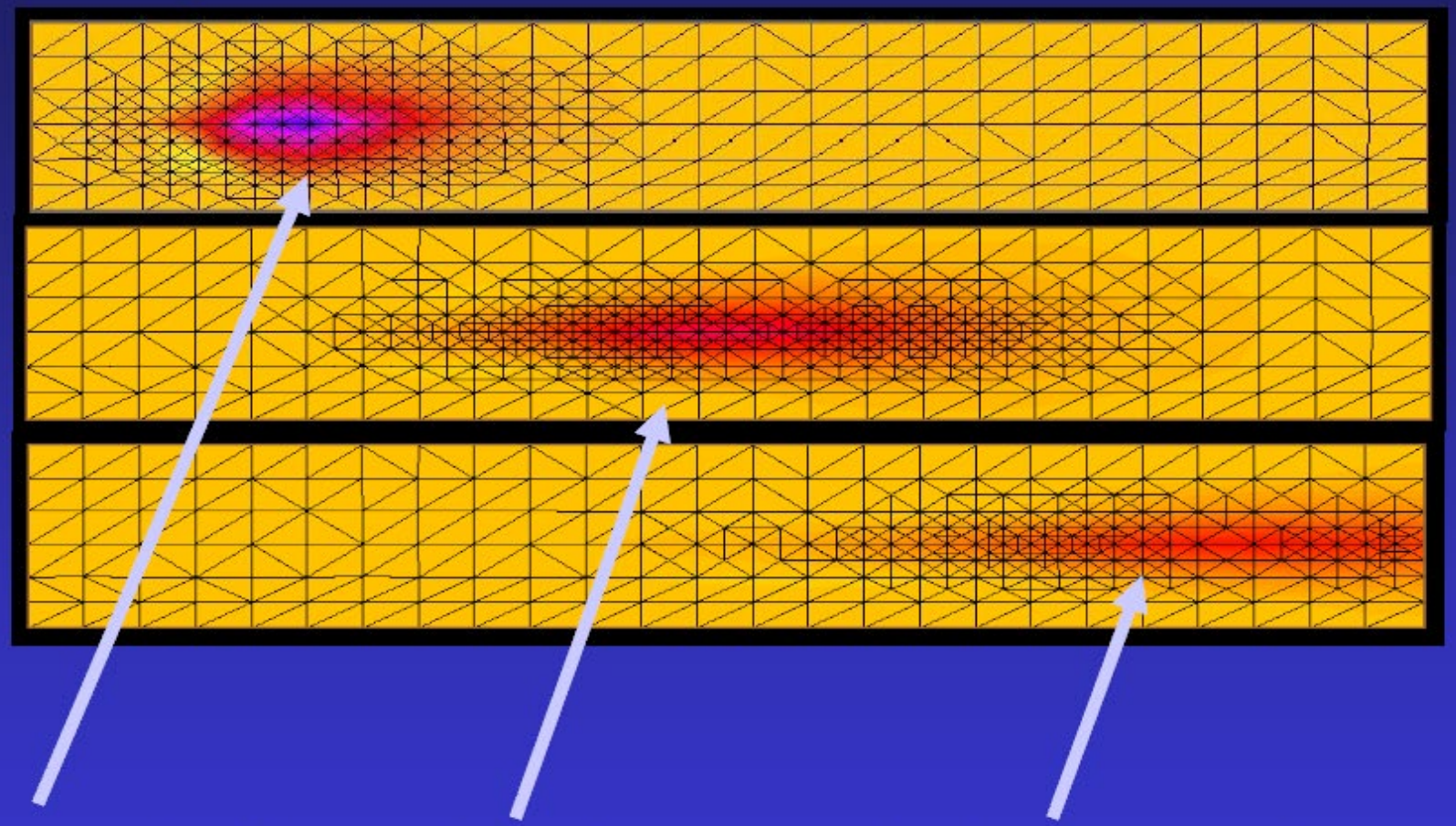
Refined #1

Refined #2

Refined #3

at timestep = 380 seconds

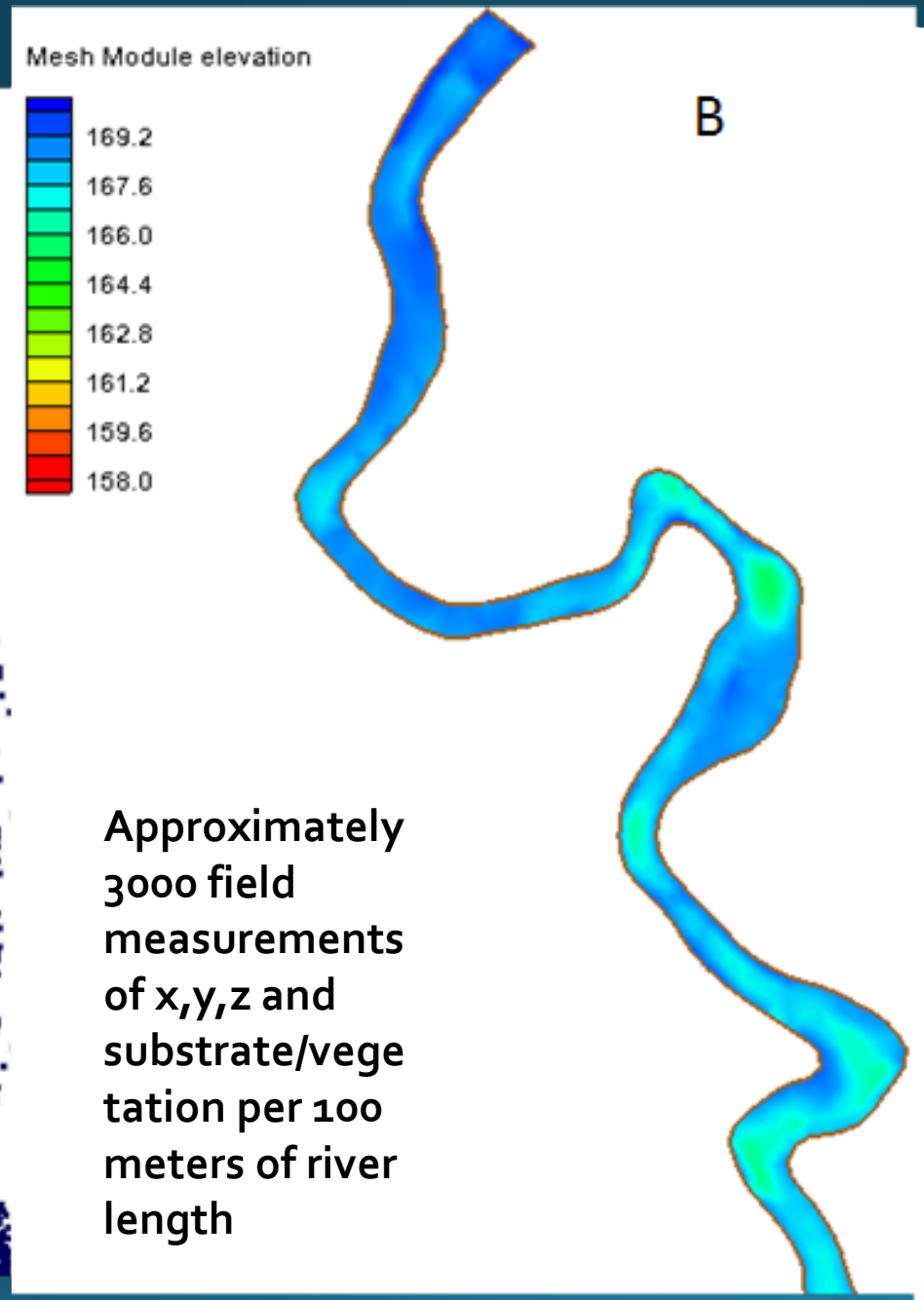
Adaption - Concentration Cloud



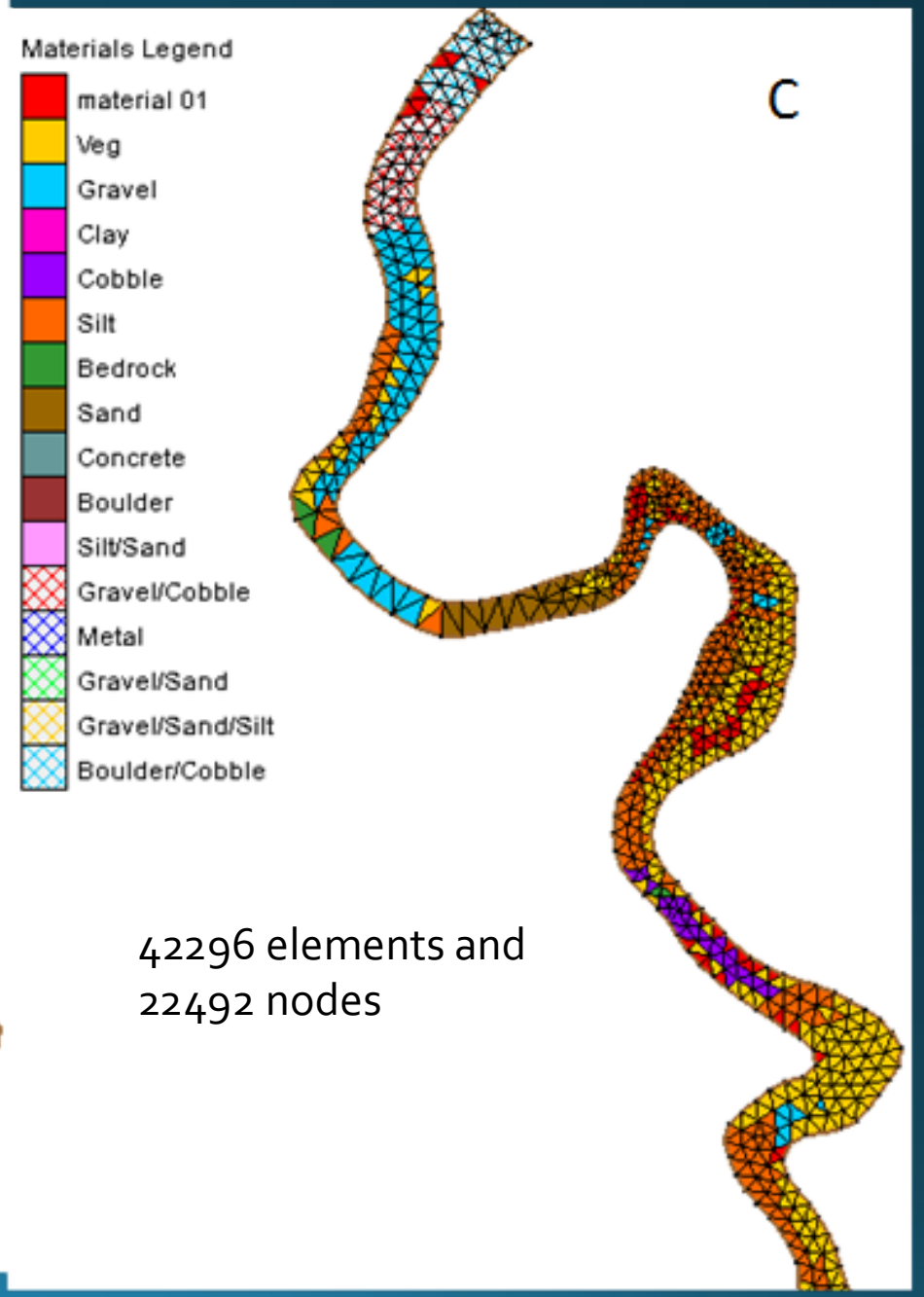
Mesh refines and unrefines to resolve the concentration cloud as it progresses along the flume

Modeled Stretch of River

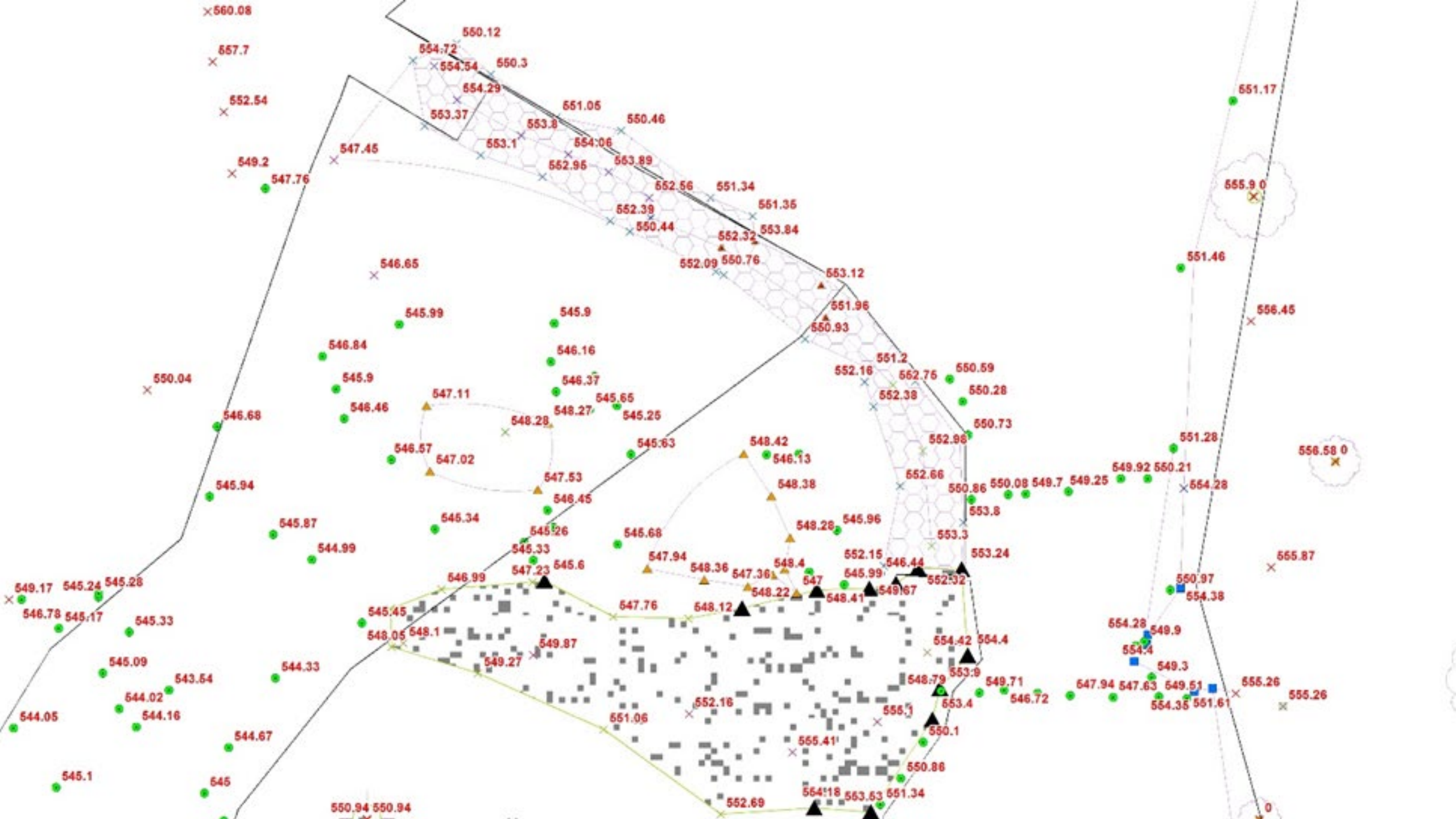
Rio Vista was not included because under most flow regimes the backwater affects from Cape's Dam stop downstream



Approximately 3000 field measurements of x,y,z and substrate/vegetation per 100 meters of river length



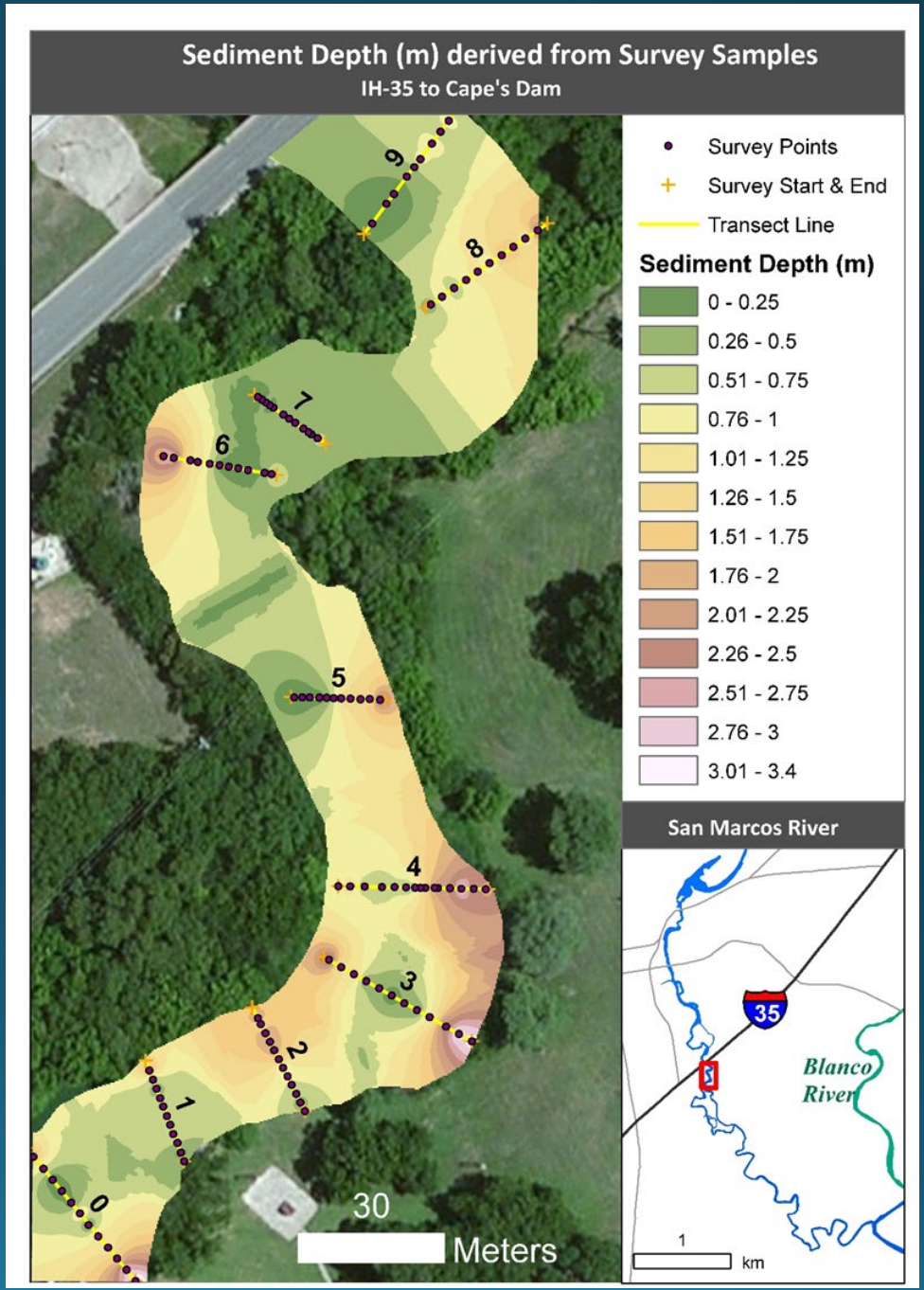
42296 elements and 22492 nodes

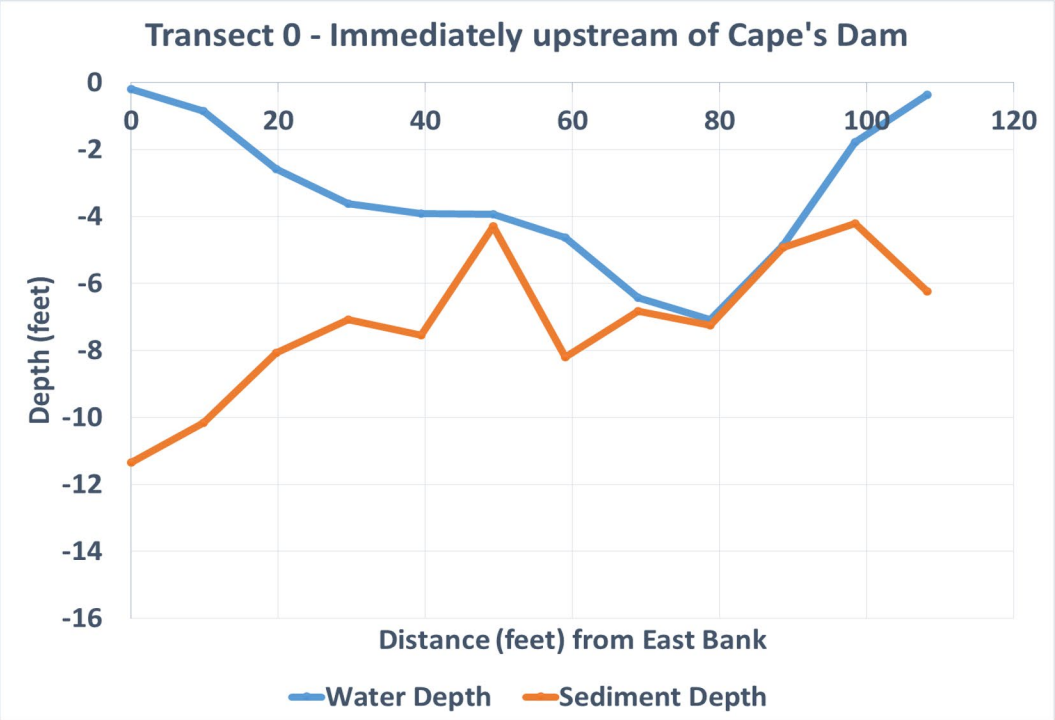


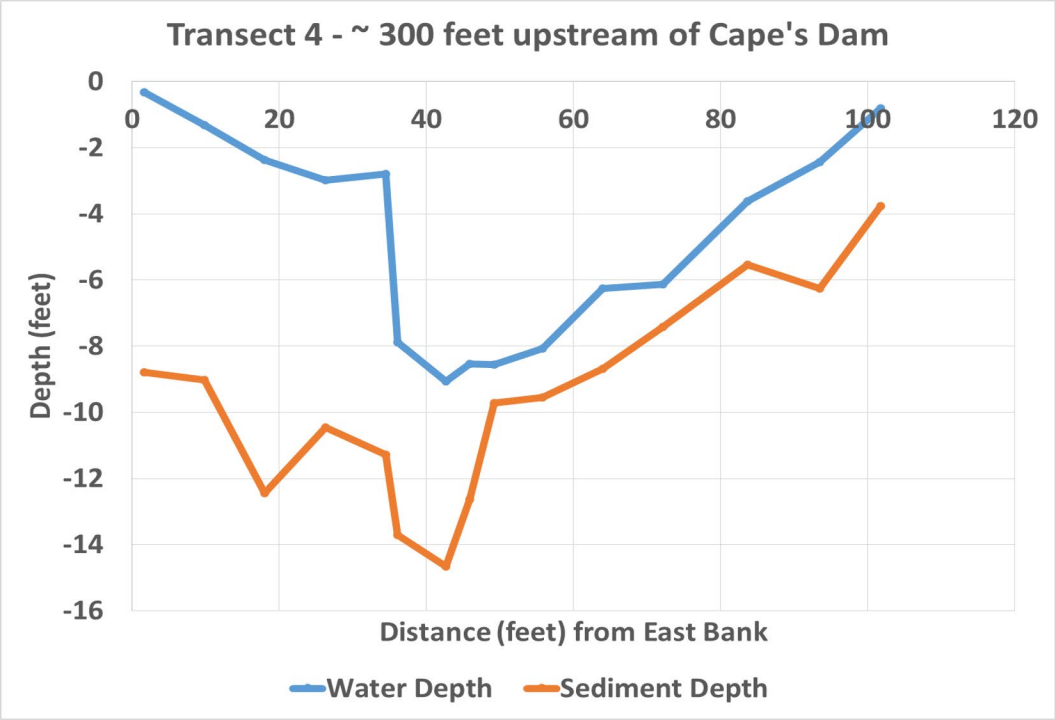
Depth of Sediment

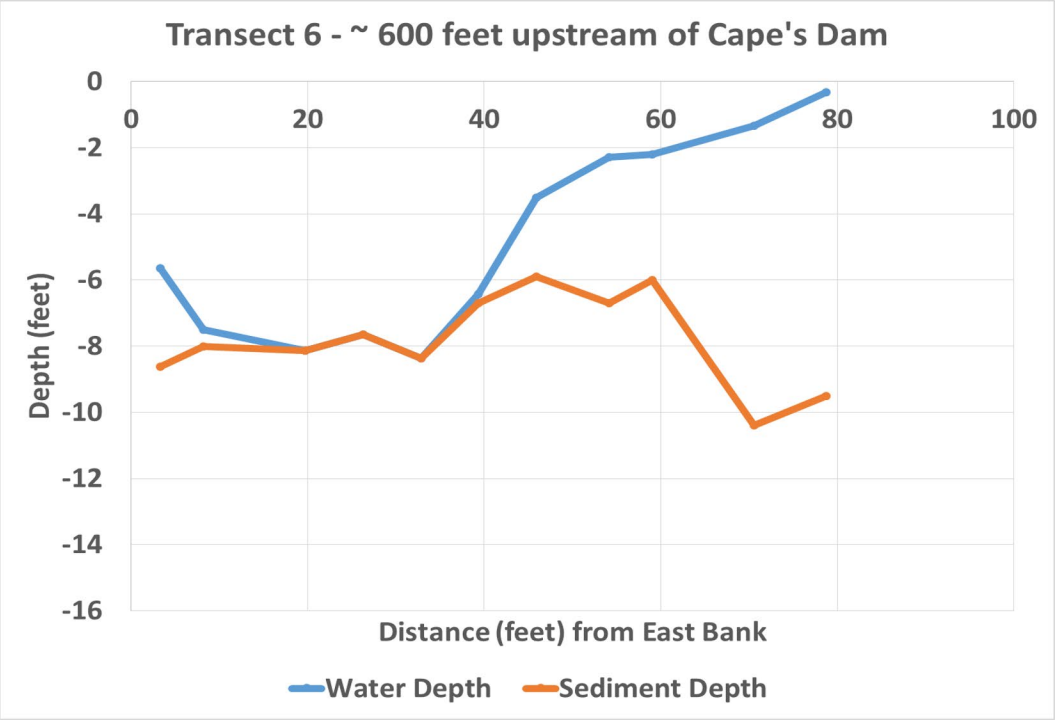
The reservoir deposits were probed at 100 locations along 10 transects to assess potential sediment storage behind Capes Dam, which would be available for mobilization following dam removal.

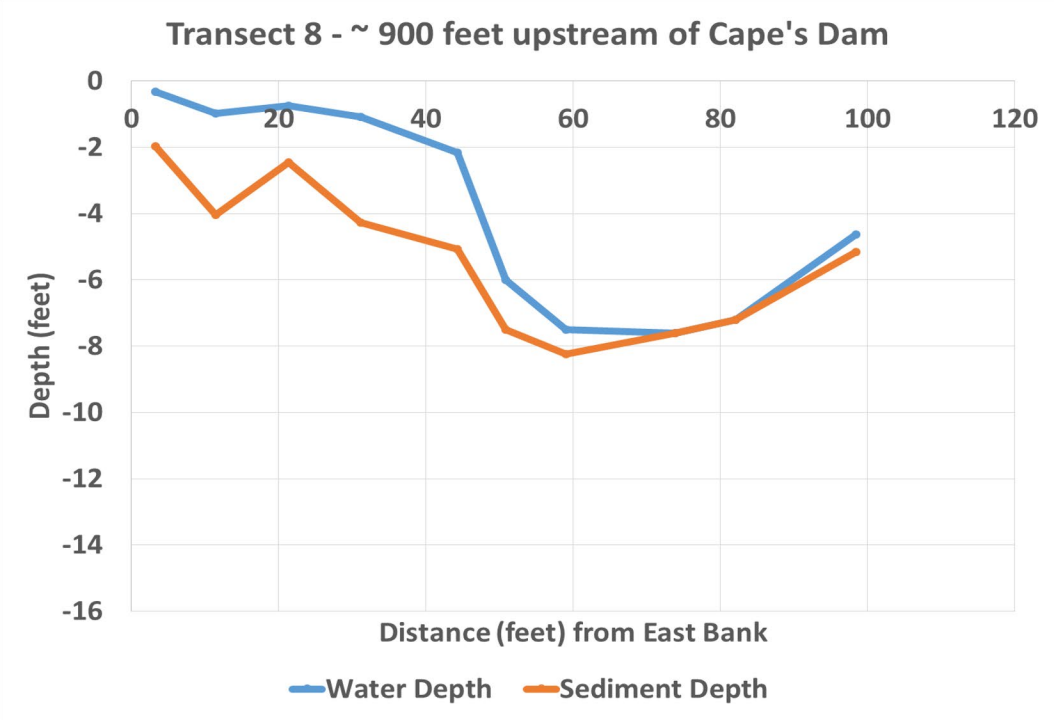
The volume of soft sediment stored that could potentially be mobilized in Capes reservoir is estimated at 6,762 m^3. This is considered a minimum estimate. (Paul Hudson, UofT.)




Transect 0 - Immediately upstream of Cape's Dam
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth


Transect 4 - ~ 300 feet upstream of Cape's Dam
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth


Transect 6 - ~ 600 feet upstream of Cape's Dam
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth


Transect 8 - ~ 900 feet upstream of Cape's Dam
Depth (feet)
Distance (feet) from East Bank
Water Depth
Sediment Depth

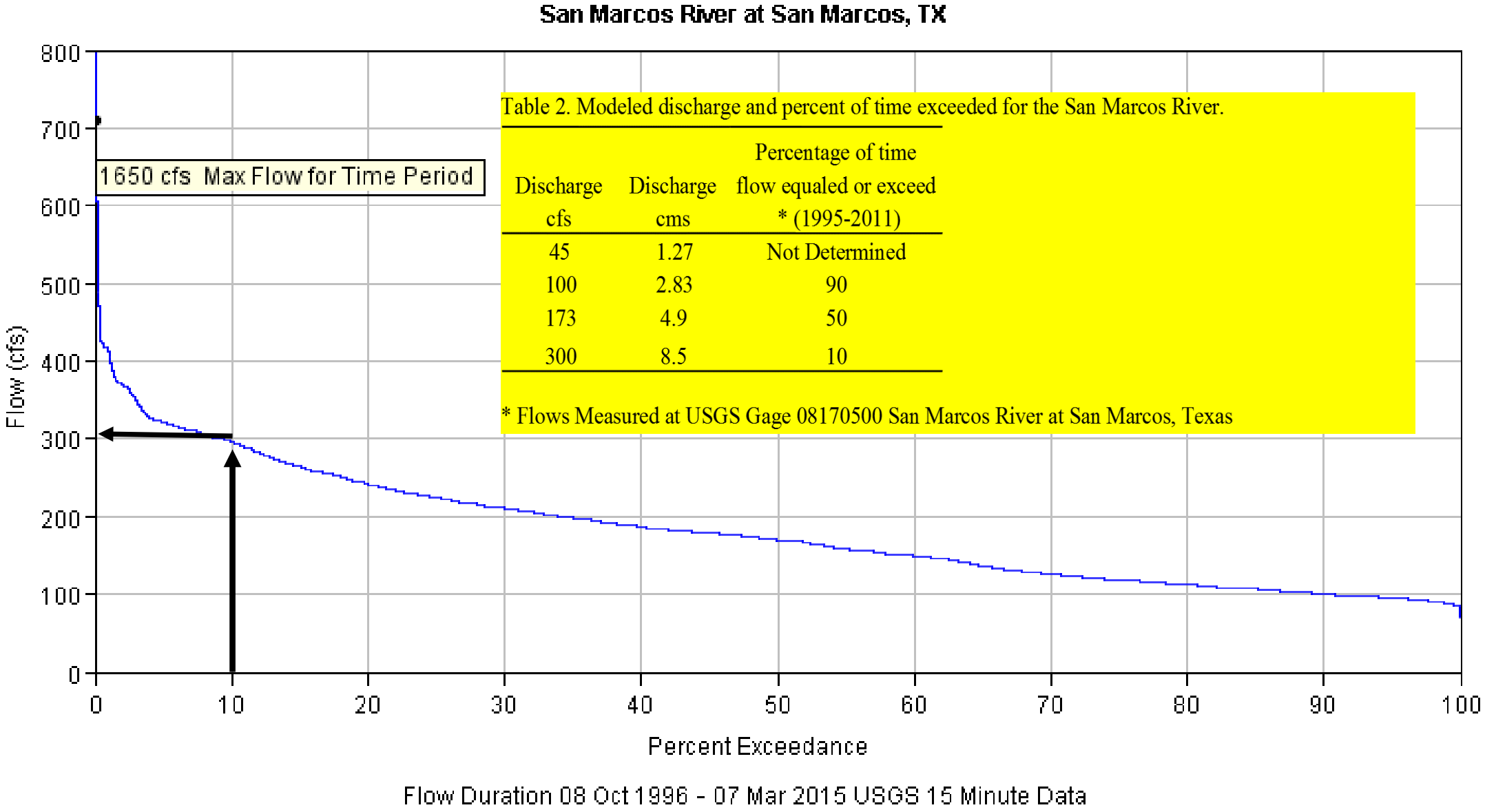


Table 2. Modeled discharge and percent of time exceeded for the San Marcos River.

Discharge cfs	Discharge cms	Percentage of time flow equaled or exceed * (1995-2011)
45	1.27	Not Determined
100	2.83	90
173	4.9	50
300	8.5	10

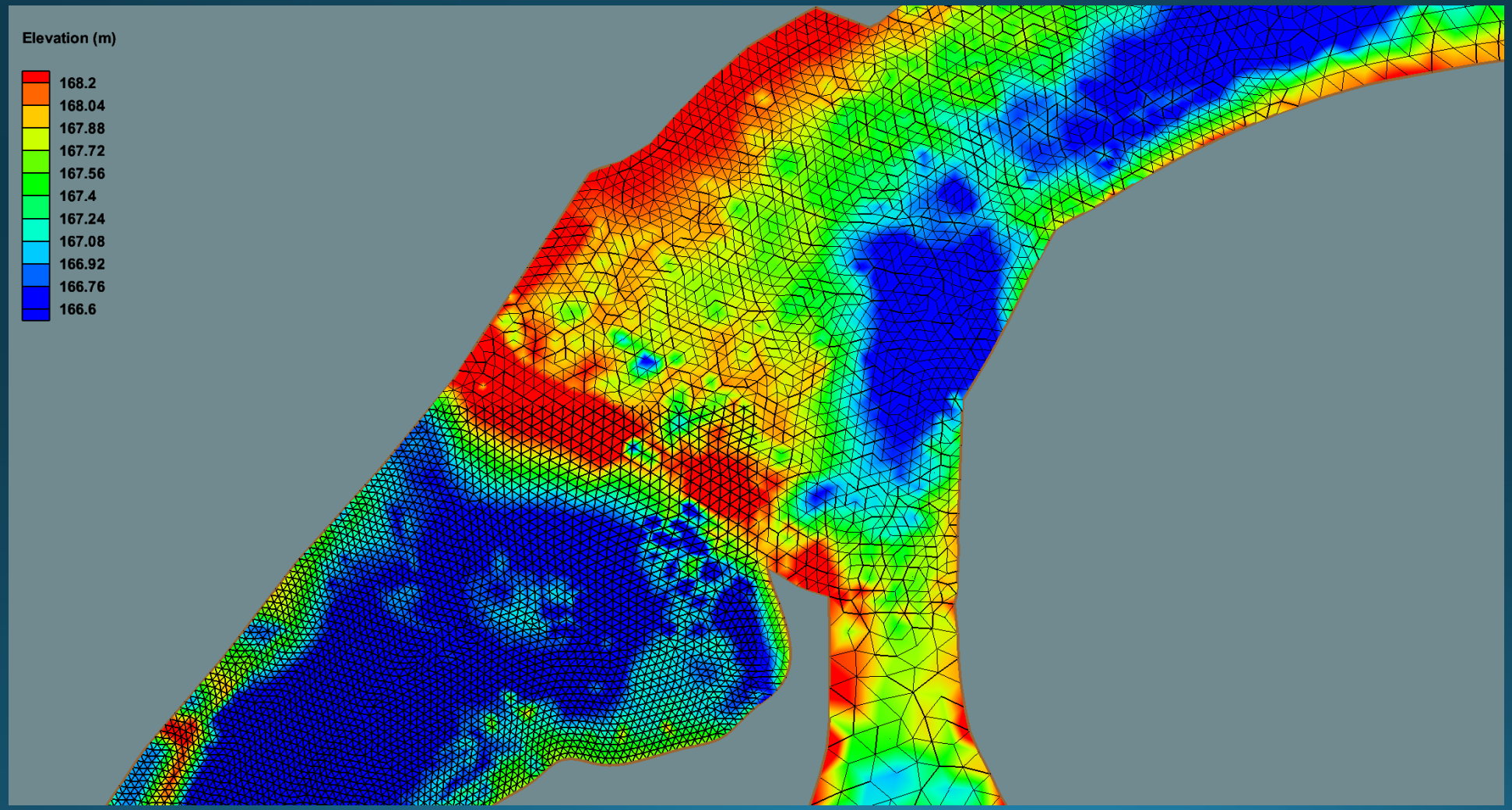
* Flows Measured at USGS Gage 08170500 San Marcos River at San Marcos, Texas

ADH Modeling

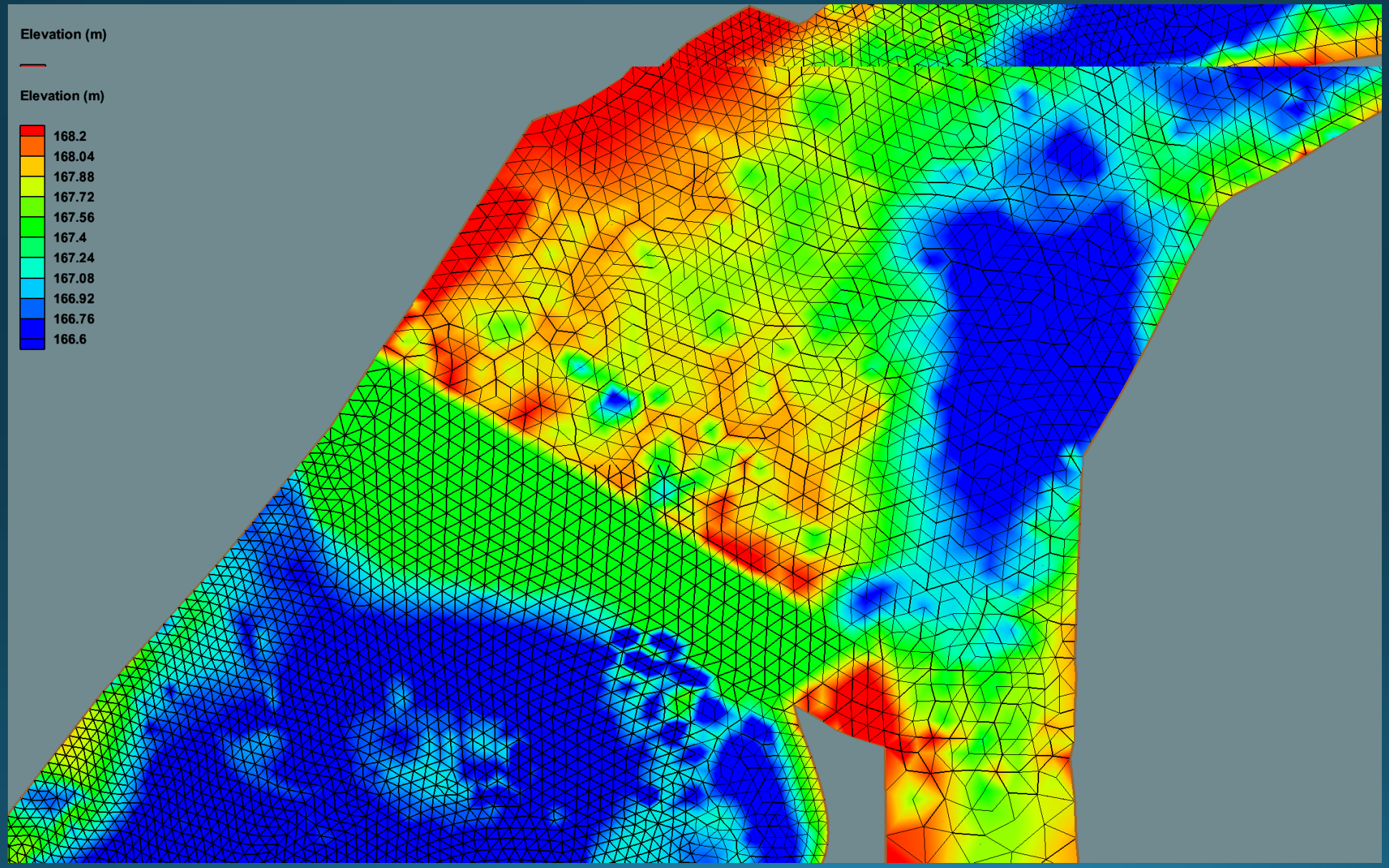
Bed Evolution was evaluated by running 300 cfs for 30 days

Runs were completed on a 64 node parallel processor and execution times were approximately 23 hours per simulation run to reach convergence at a given discharge

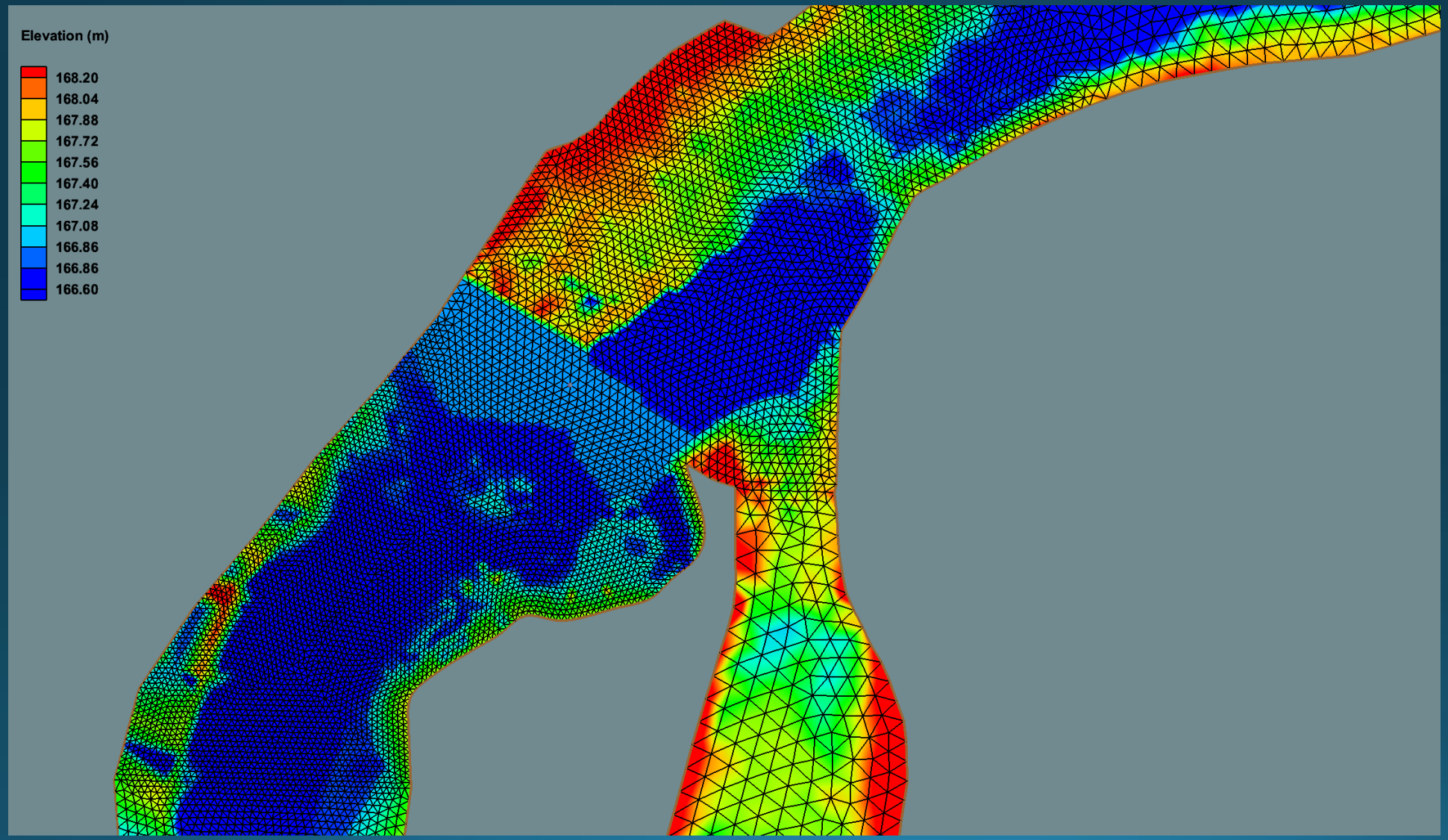
Existing (~full height) Bed Elevation Conditions



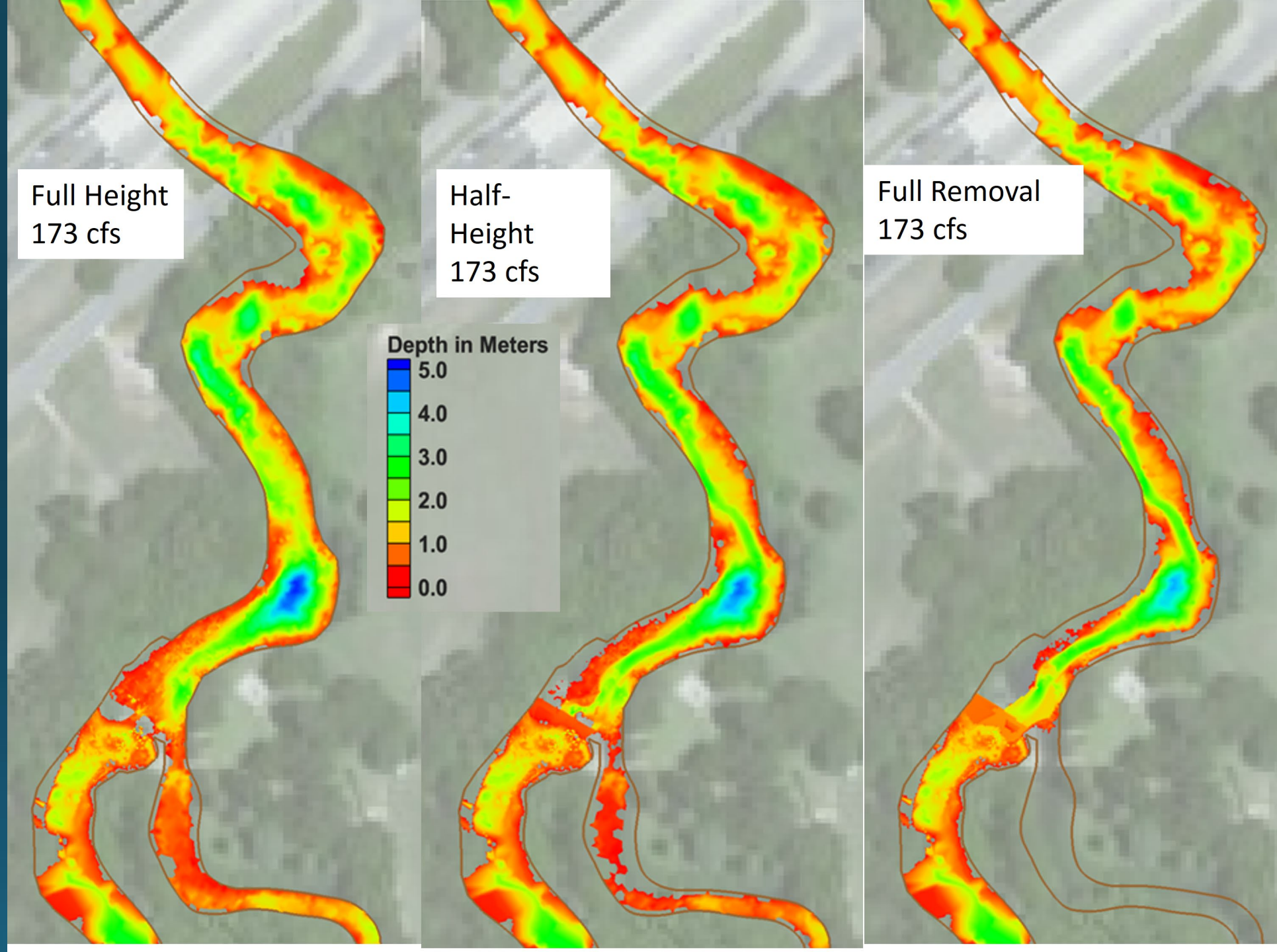
Assumed Half Height Elevations



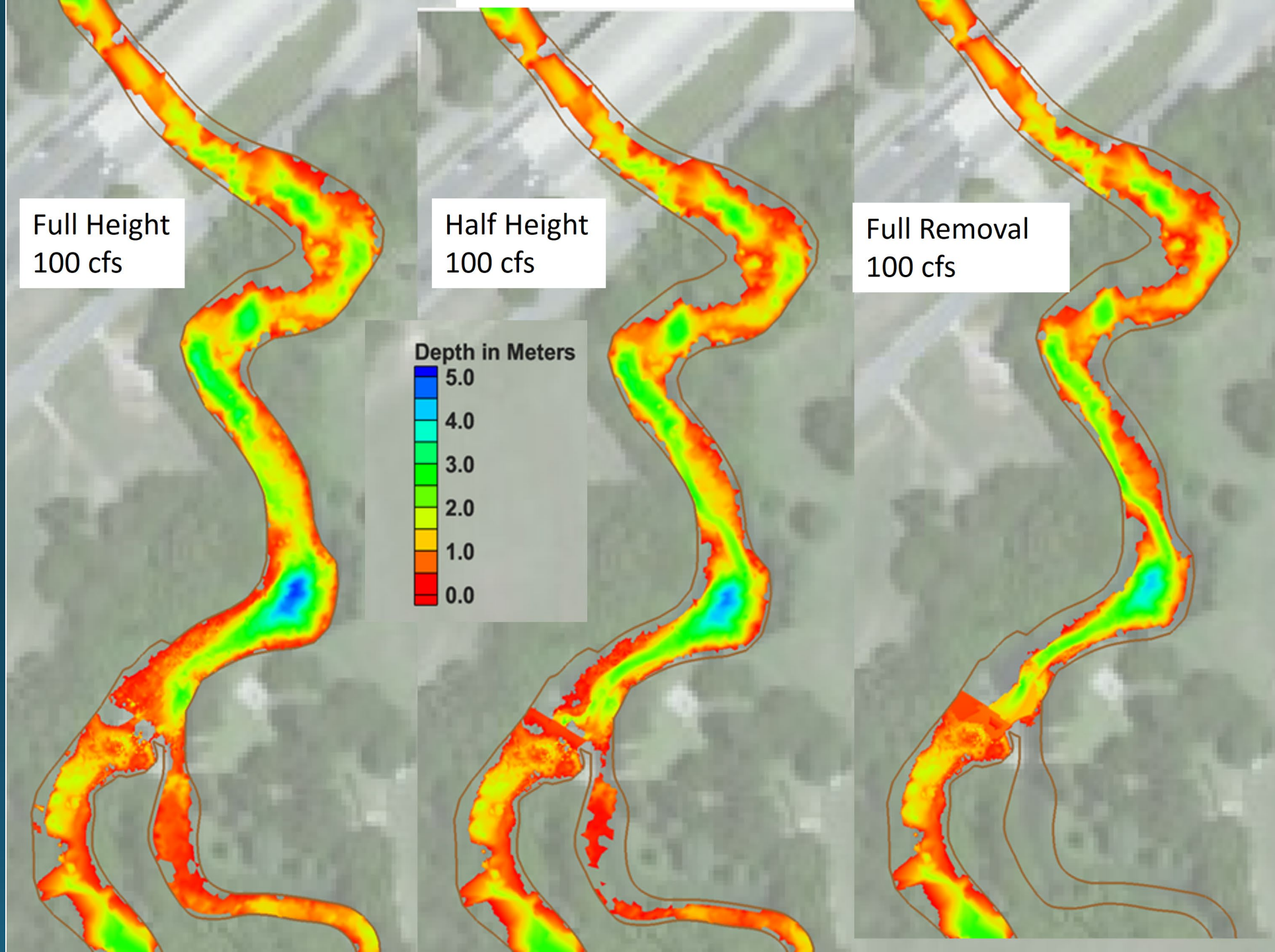
Assumed Full Dam Removal Elevations



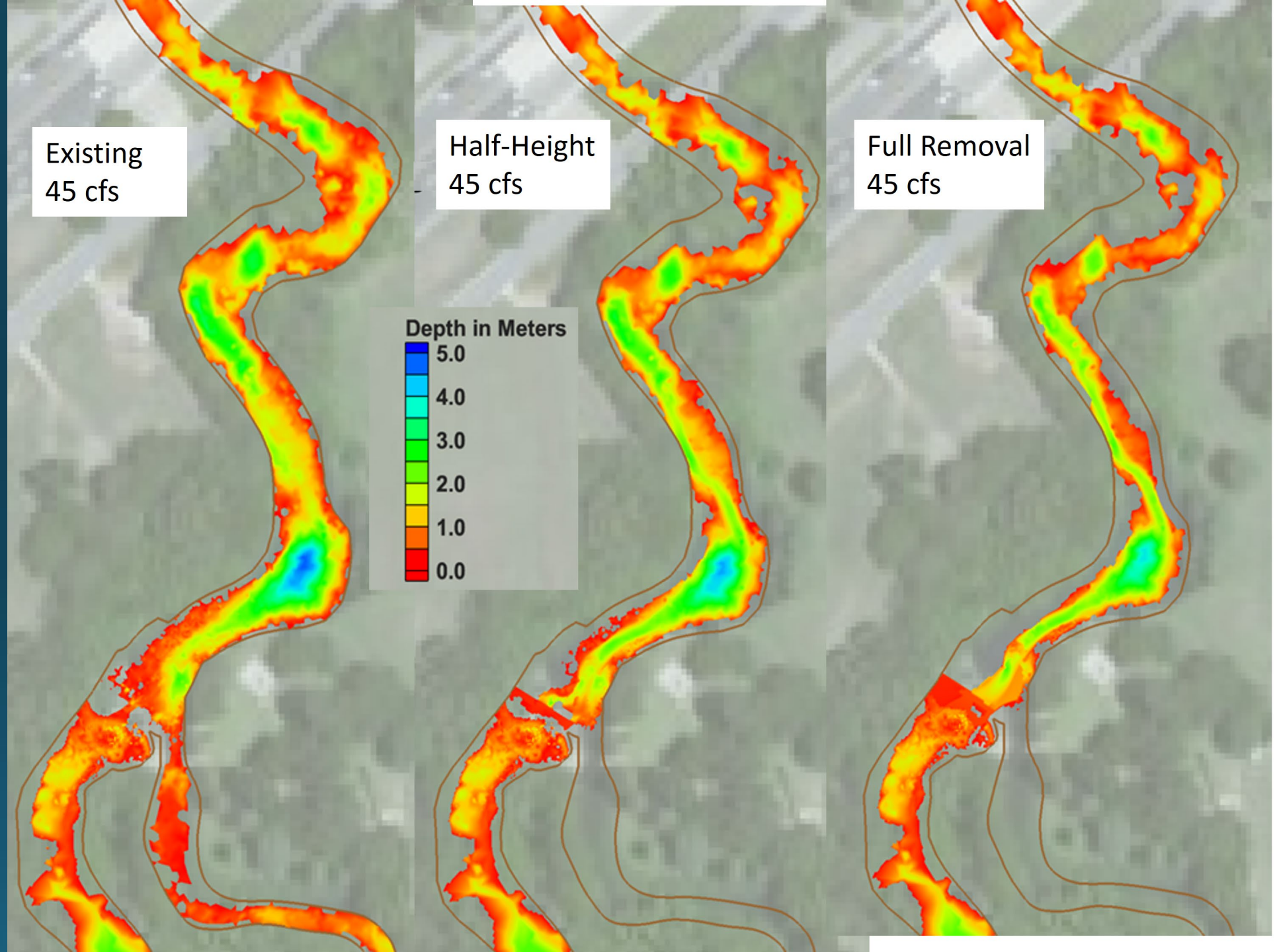
DEPTH


Full Height
173 cfs
Half-
Height
173 cfs
Full Removal
173 cfs
Depth in Meters
5.0
4.0
3.0
2.0
1.0
0.0

DEPTH

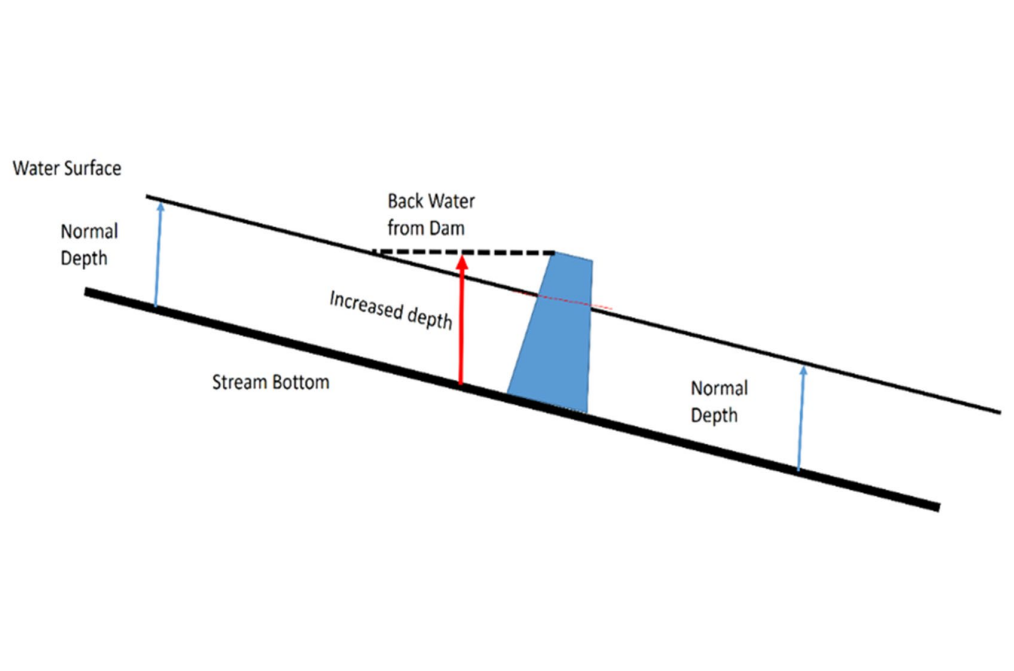

Full Height
100 cfs
Half Height
100 cfs
Full Removal
100 cfs
Depth in Meters
5.0
4.0
3.0
2.0
1.0
0.0

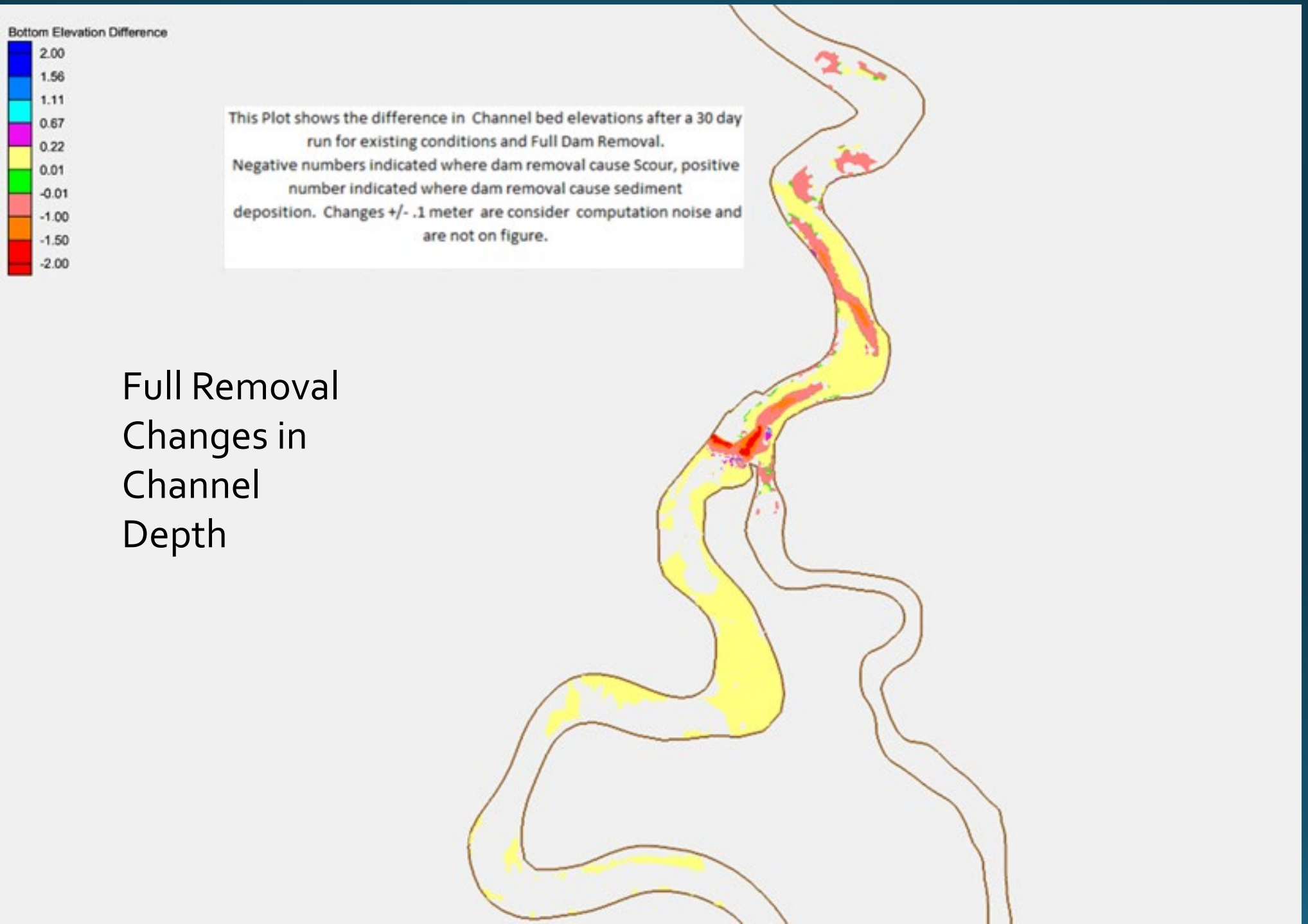
DEPTH


Existing
45 cfs
Half-Height
45 cfs
Full Removal
45 cfs
Depth in Meters
5.0
4.0
3.0
2.0
1.0
0.0

Key Conclusions

- *Channel Changes*
- **Removal of Cape's Dam will result in reestablishment of normal depths equivalent to depths currently observed upstream of the backwater section and the channel below the confluence with the Mill Race return flows.**
- **Removal of Capes Dam will restore natural fish and other aquatic organism passage.**



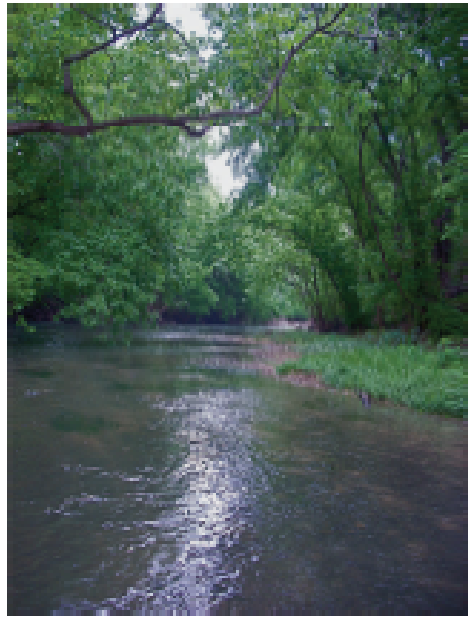


Full Removal Changes in Channel Depth

GEOMORPHIC MONITORING OF THE UPPER SAN MARCOS RIVER, TEXAS TO ASSESS CHANNEL ADJUSTMENT IN RESPONSE TO REMOVAL OF AN INVASIVE EXOTIC WATER PLANT, *CRYPTOCORYNE BECKETTII*

CONTRACT NO. 05-222-GM

FINAL REPORT



Submitted to Texas Parks and Wildlife

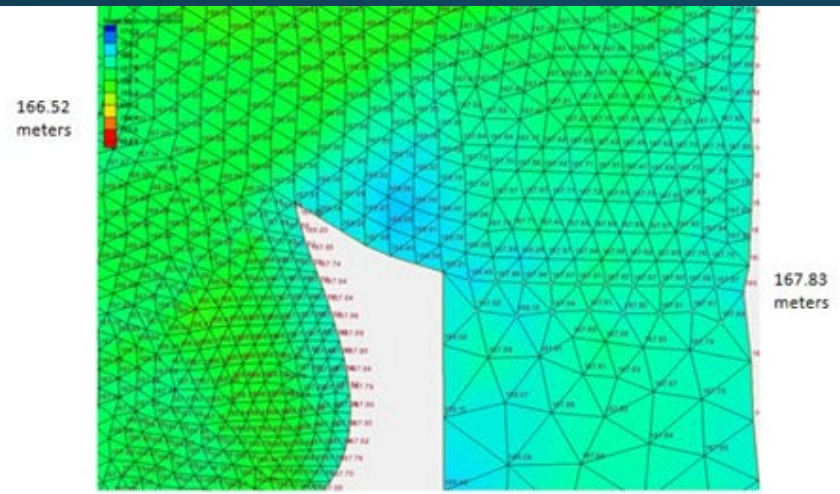
March 12, 2012

Paul F. Hudson, Ph.D.
Department of Geography and the Environment

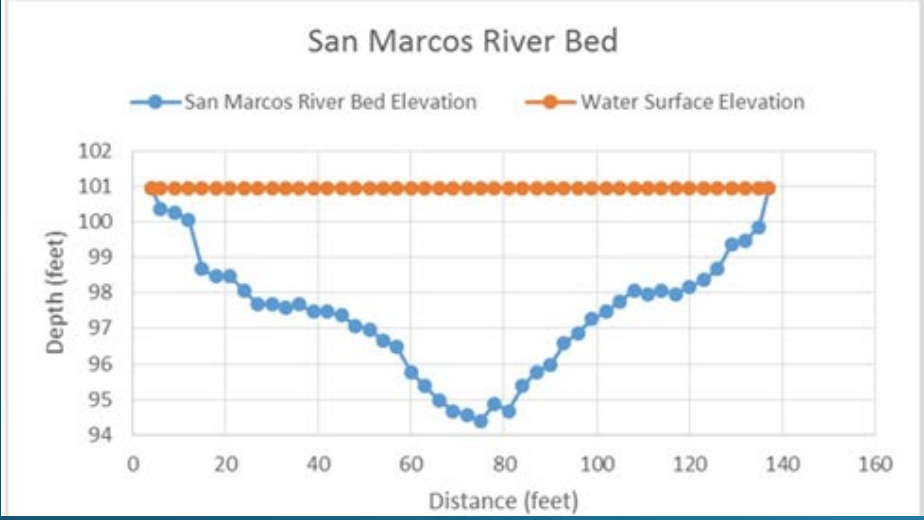
University of Texas at Austin

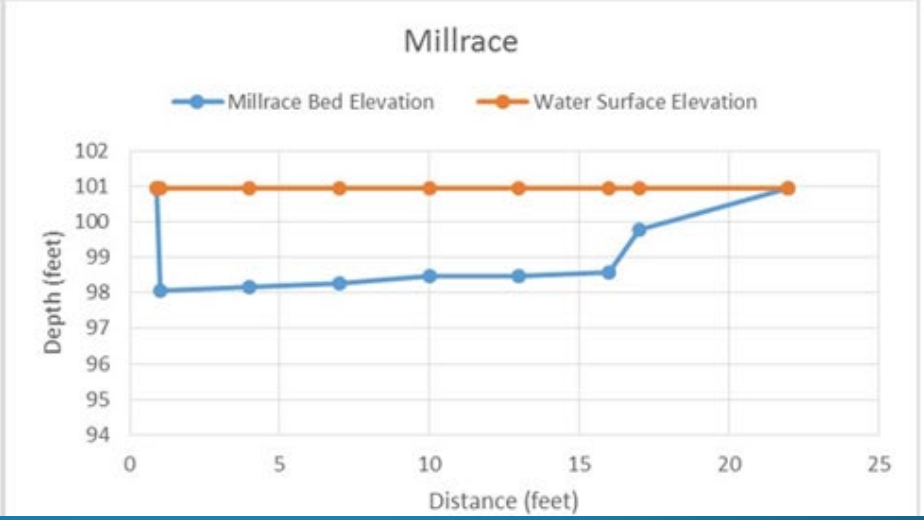
Additionally, bank erosion rates were 1.8 inches per year along the channel, and did not spatially vary. The cohesive (clayey) bank material likely represents an inherent geomorphic buffer along the San Marcos River, thereby reducing the rivers sensitivity to erosion.

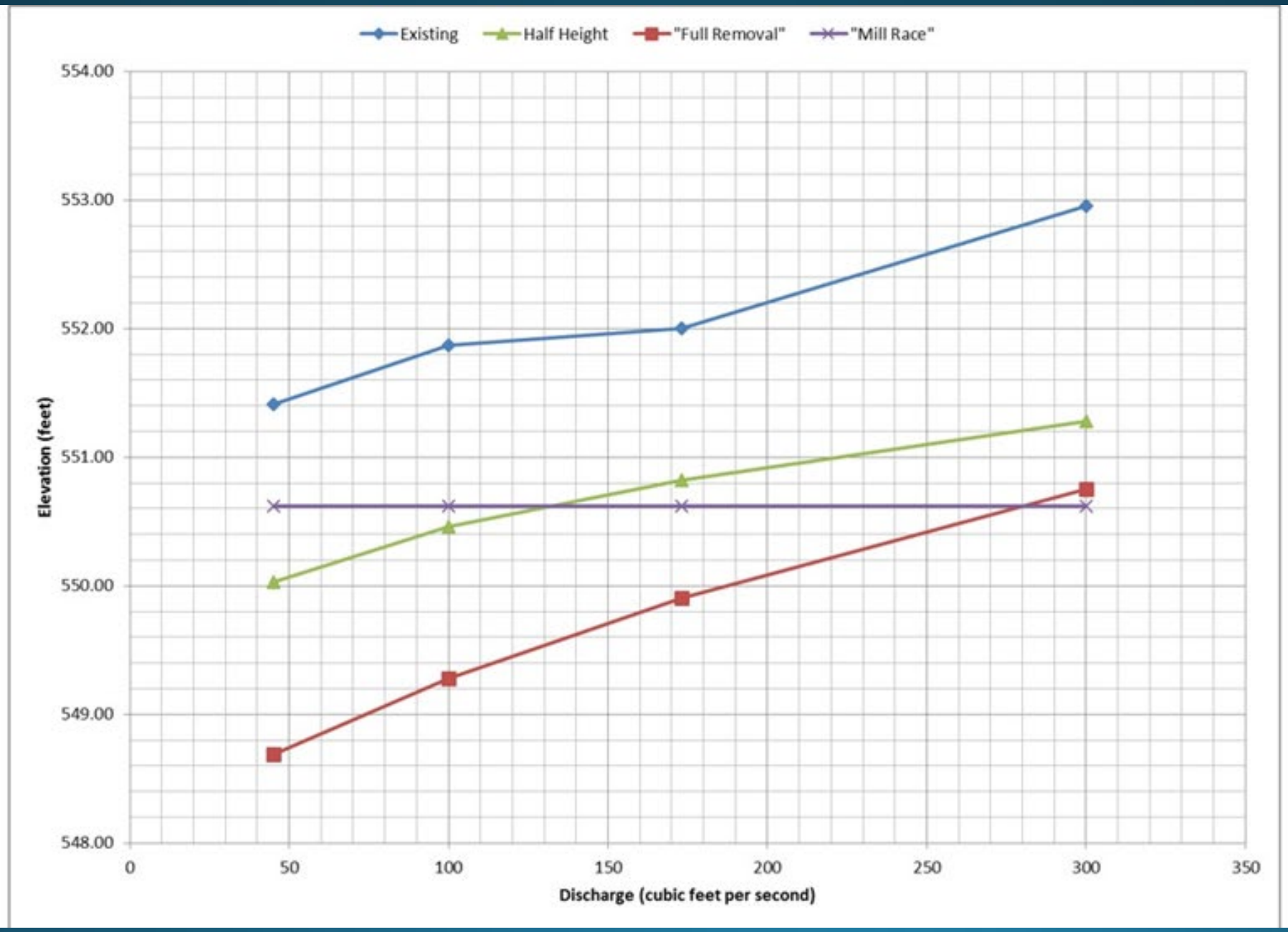
Mill Race


166.52
meters
167.83
meters

Google earth


San Marcos River Bed
San Marcos River Bed Elevation
Water Surface Elevation
Depth (feet)
102
101
100
99
98
97
96
95
94
0
20
40
60
80
100
120
140
160
Distance (feet)


Millrace
Millrace Bed Elevation
Water Surface Elevation
Depth (feet)
102
101
100
99
98
97
96
95
94
0
5
10
15
20
25
Distance (feet)

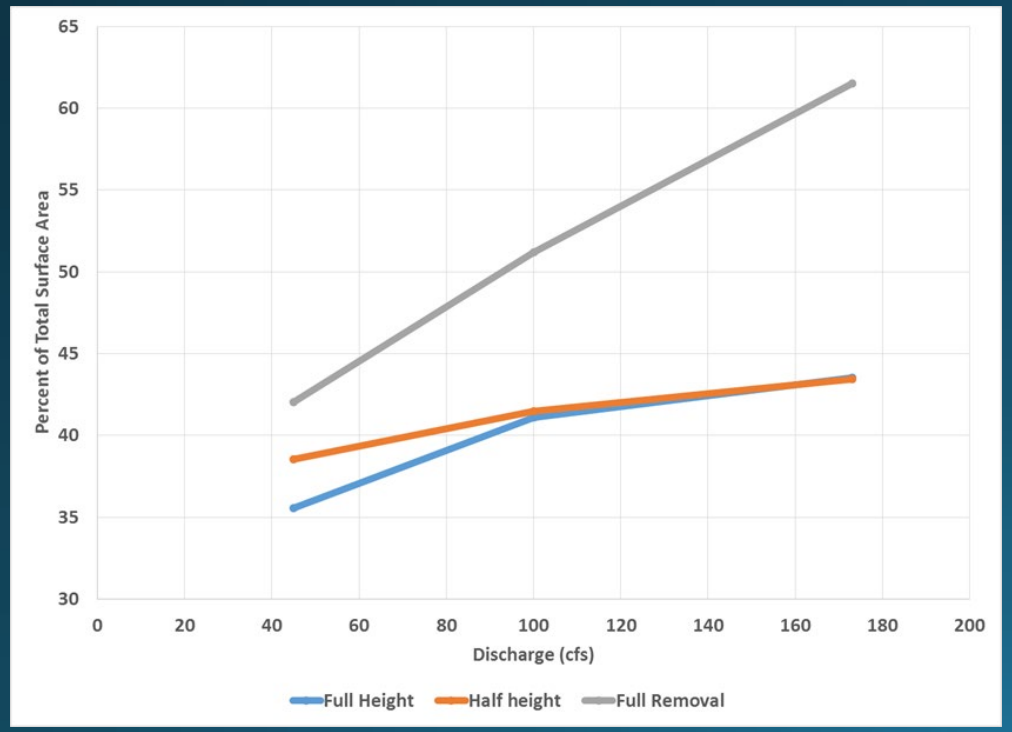

Existing
Half Height
"Full Removal"
"Mill Race"
554.00
553.00
552.00
551.00
550.00
549.00
548.00
Elevation (feet)
0
50
100
150
200
250
300
350
Discharge (cubic feet per second)

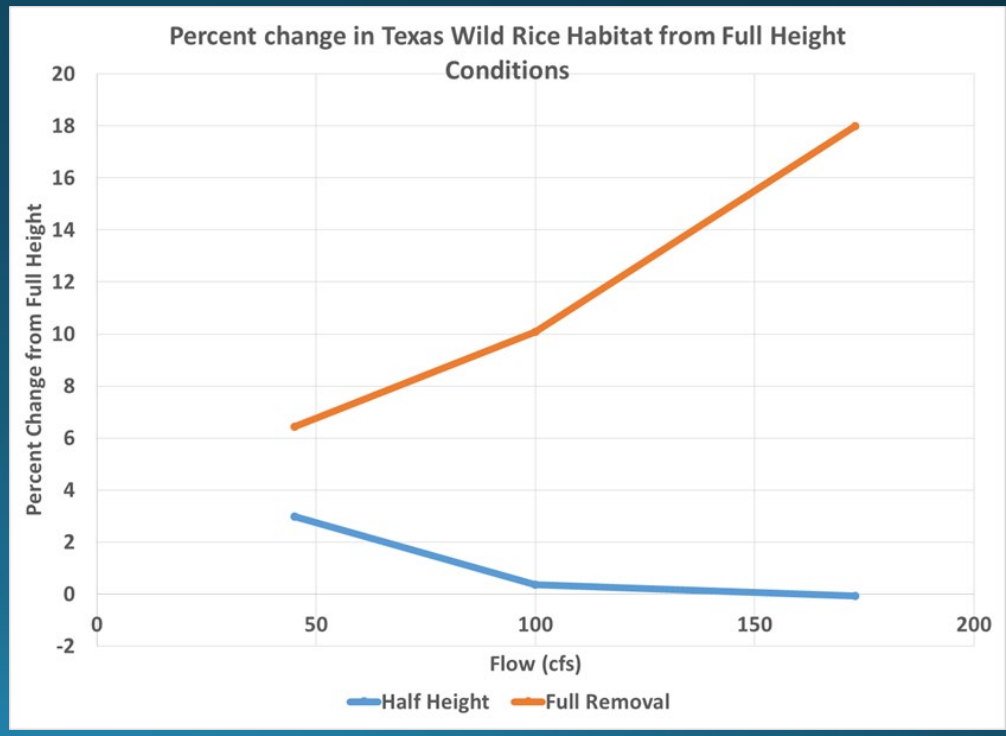
Key Conclusions

- ***Implications on Flows in the Mill Race***
-
- **Reduction in Cape's Dam to half height will result in a reduction of the amount of time that flows will enter the Mill Race. Under full removal flows will only occur at flow rates equaled or exceeded about 10-15 percent of the time.**
- **Diversion of flows into the Mill Race will continue to reduce the quantity and quality of aquatic habitats in the main stem San Marcos River which are already stressed during low-flow periods.**

Key Conclusions

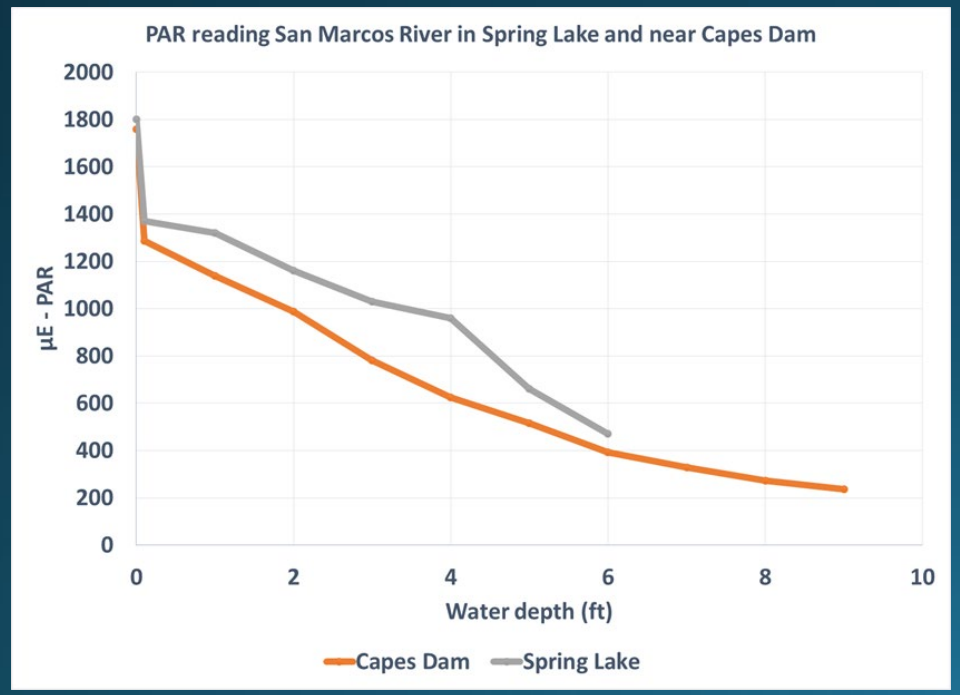
- *Texas Wild Rice*
- **Removal of Cape's Dam represents the best ecological benefits to improving habitat for Texas wild rice.**





Key Conclusions

- ***Photosynthetically Active Radiation (PAR)***
  - **The decrease in depths within the existing backwater section of the river with removal of Cape's Dam will result in an increase in available PAR reaching the stream bottom which will promote increased TWR and other aquatic macrophyte growth in this section of the river.**



Species	San Marcos River Reach					
	Sewell Park	Above City Park	City Park	Purgatory Creek	Cypress Island-Rio vista	Total
Ludwigia repens	2,657	2,393	6,461	-	768	12,279
Heteranthera dubia	622	475	2,169	-	2,544	5,810
Zizania texana	1,886	4,269	16,140	384	7,752	30,431
Sagittaria	673	1,560	1,121	133	305	3,792
Potamogeton	55	124	54	-	-	233
Hydrocotyle	-	42	-	-	-	42

Key Conclusions

- ***Velocity and Gas Exchange Dynamics in Aquatic Plants***
  - **Increased distribution of higher velocities in the backwater section of the river with dam removal will promote higher growth rates of TWR and other aquatic macrophytes.**

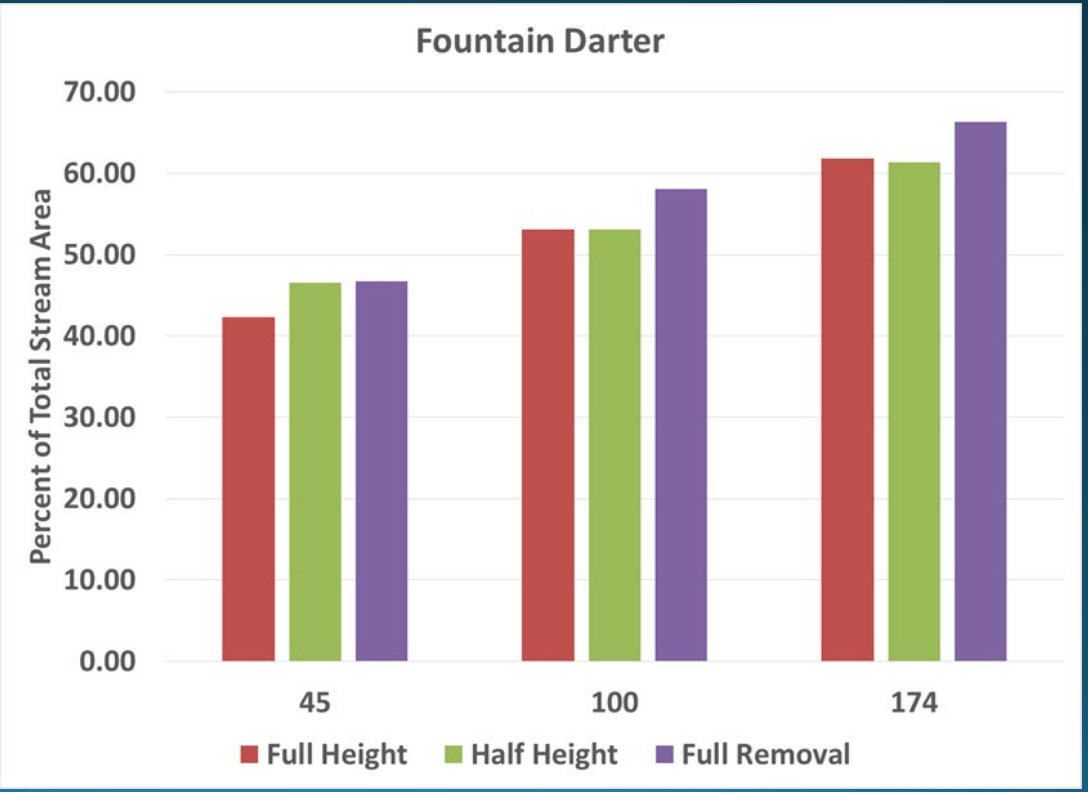
Increased water velocities at the leaf surface have been shown to increase the photosynthetic rates in several aquatic macrophytes due to reduction in the thickness of the DBL (Black et al., 1981). Powers (1996) demonstrated that for TWR the stem density was greater in fast flowing water (0.40-0.49 m/s) than in either moderate (0.12-0.24 m/s) or slow flowing (0.05-0.12 m/s) water. Hardy et al. (2015) harvested thousands of free floating TWR tillers from the San Marcos River and showed > 90% success rate for propagation of TWR exposed to moderate velocities.

Key Conclusions

- ***Implications on Reproduction and Genetic Integrity***
  - **Reduction of depths with removal of Cape's Dam will provide an increase in areas suitable for sexual reproduction of TWR important for maintenance of genetic integrity of the population.**

Key Conclusions

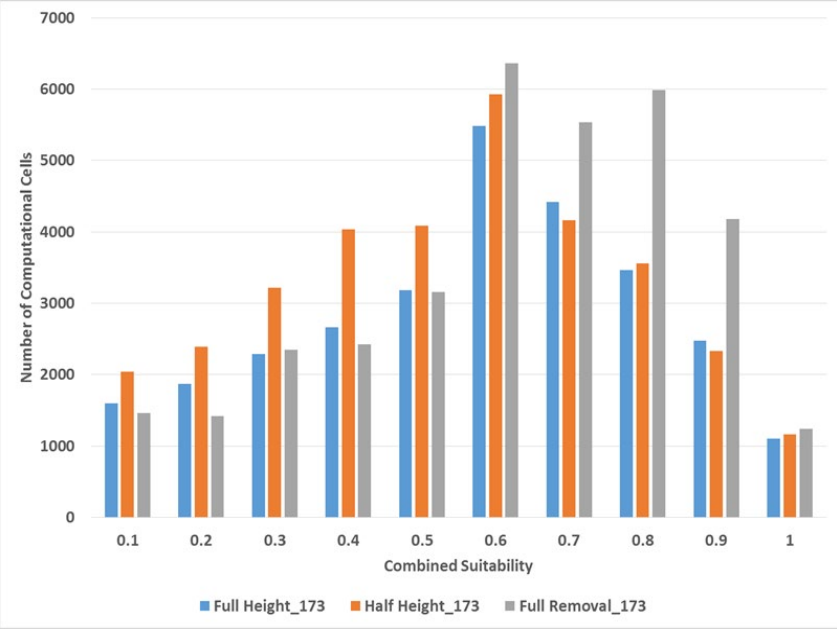
- ***Habitat Quantity***
  - **Removal of Cape's Dam will provide an increase in the area of fountain darter habitat due to both improved hydraulic conditions (i.e., depth and velocity) as well as aquatic macrophyte expansion.**



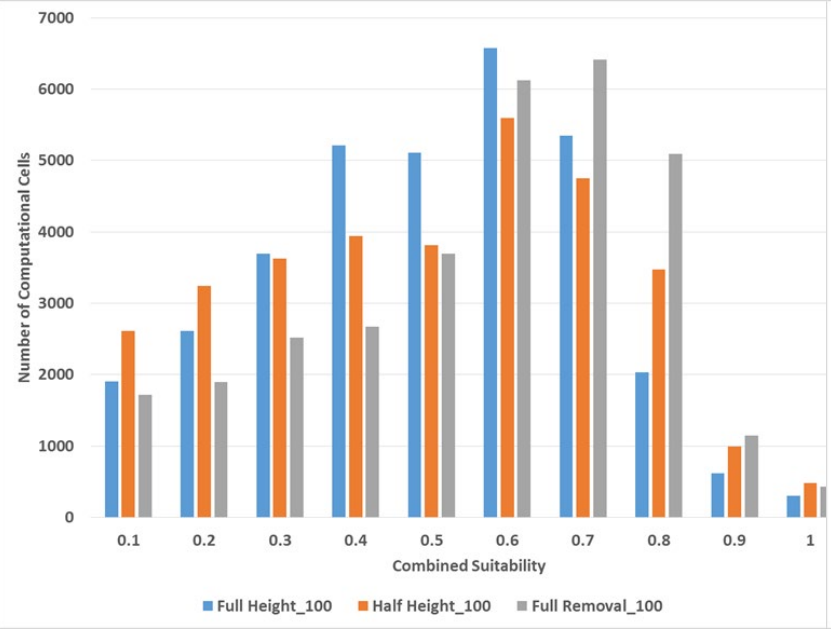
Key Conclusions

- ***Habitat Quality***
  - **Removal of Cape's Dam will provide an increase in the quality of fountain darter habitat over all flow ranges compared to full height or half height dam scenarios.**

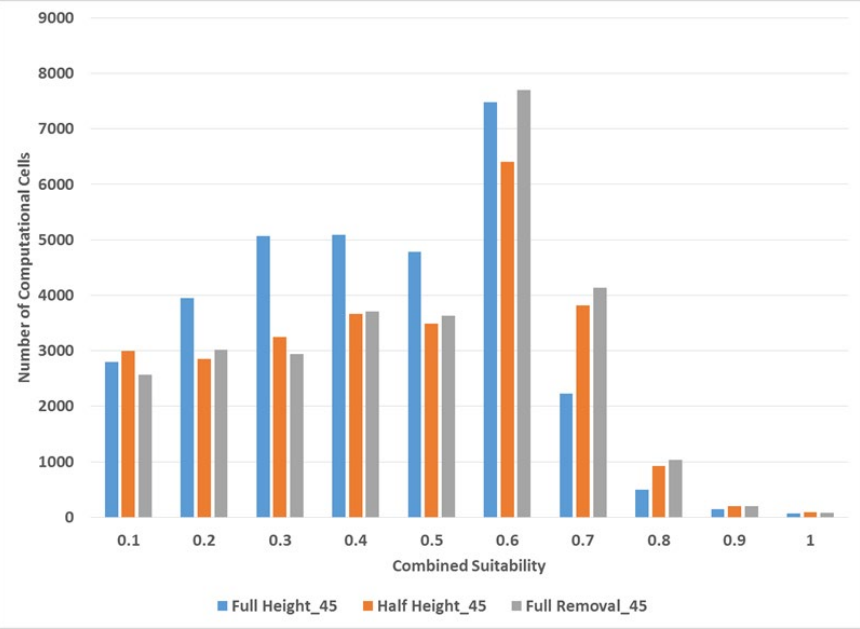
173 cfs



100 cfs



45 cfs

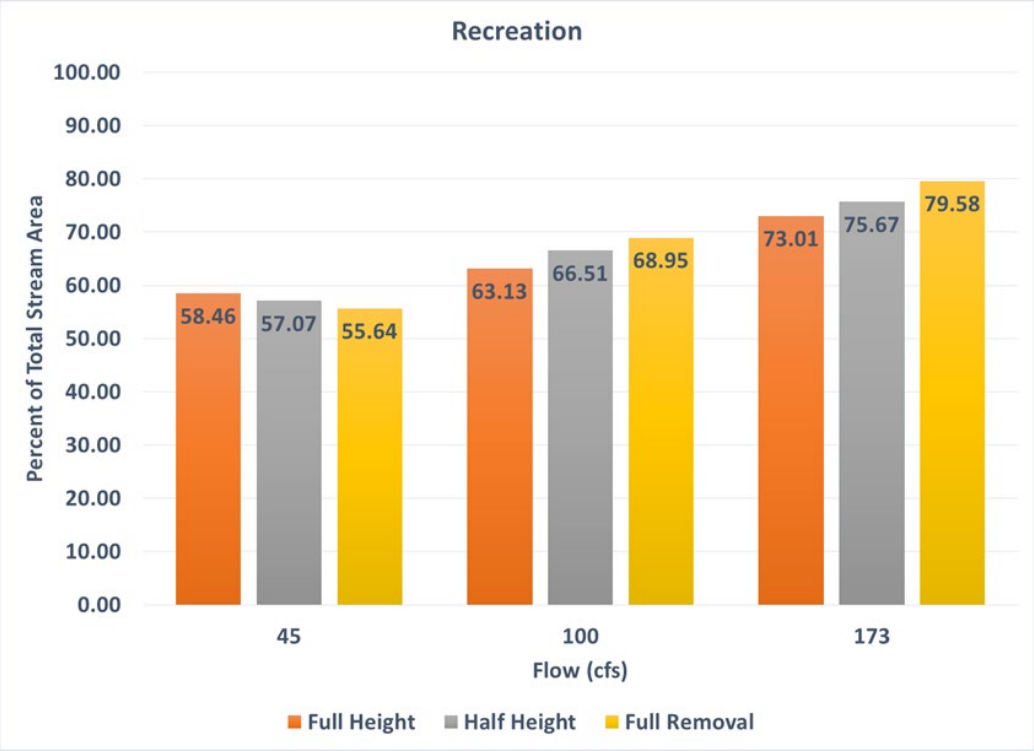


Key Conclusions

- ***Impacts of Low Head Dams***
  - **Removal of Cape's Dam will eliminate known ecological impacts associated with low head dams such as adversely affecting warmwater stream fish, aquatic macroinvertebrates, and aquatic/riparian plants by blocking migration pathways, degrading habitat and water quality, and fragmenting the river landscape, which results in a loss of native species diversity.**
  - **Backwaters from Low Head Dams are known to encourage the proliferation of introduced aquatic plant and fish species which are detrimental to the native flora and fauna within the San Marcos River. Introduced fish directly compete for space and food resources and are known predators or many native larval fish.**
  - **Low head dams can impact the height of flood waters**

Key Conclusions

- ***Recreation***
  - **Removal of Cape's Dam will provide a safe and sustainable recreation corridor that will accommodate, swimming, tubing, canoeing, kayaking and paddle boarding without a demonstrable negative impact relative to full height or half height dam scenarios for these water based recreation activities.**



Summary

- Dam removal represents the best "cost/benefit" environmentally
- Removal results in increases in both fountain darter and Texas wild rice habitat and does not negatively impact opportunities for contact recreation
- Dam removal will not functionally impact recreation at flow levels that are equaled or exceeded over 90 percent of the time
- Simulations support that dam removal will result in improved aquatic vegetation production with concomitant increases in the endangered fountain darter (and other aquatic organisms) habitat
- Existing empirical data from this section of river clearly shows very little potential for bank erosion or lateral migration if the dam were removed
- Multi-Year monitoring of channel changes after dredging in this reach showed no evidence of head-cuts

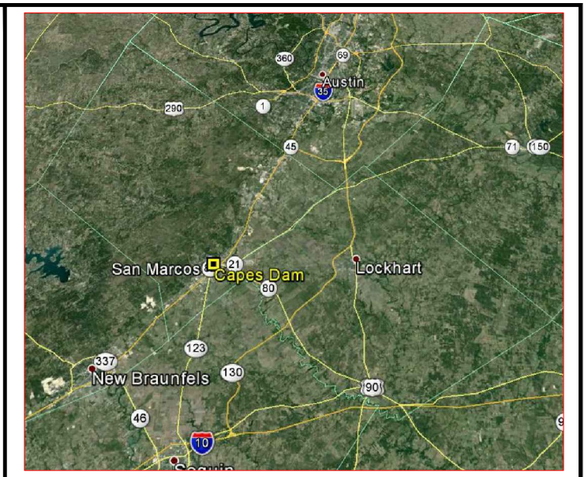
Summary

- Under existing conditions that Capes Dam backs up the water surface elevation and flows enter the Mill Race over a wide range of discharges.
- Under half-height conditions, where the height of the water backed up behind Capes Dam would be lower, that water would enter the Mill Race when the San Marcos River discharge is approximately 130 cfs. This flow rate is equaled or exceeded approximately 53 percent of the time.
- Under full dam removal, water would enter the Mill Race when San Marcos flows are greater than about 280 cfs. This average daily flow rate is equaled or exceeded only about 10-13 percent of the time over the indicated period of record.

U.S. FISH & WILDLIFE SERVICE

SAN MARCOS, TEXAS

CAPES DAM-BREACH & CHANNEL RESTORATION



VICINITY MAP
NO SCALE

DRAWING INDEX

SHEET NO.	DRAWING TITLE
1 OF 12	VICINITY MAP, SITE PLAN AND DRAWING INDEX
2 OF 12	EXISTING SITE, ALIGNMENT & SECTION LINE SAMPLING LOCATIONS
3 OF 12	EXISTING SITE PHOTOS
4 OF 12	EXISTING & PROPOSED ALIGNMENT PROFILE DETAILS
5 OF 12	EXISTING SITE SECTION LINE DETAILS
6 OF 12	PROPOSED SITE SECTION LINE DETAILS AT DAM
7 OF 12	MILL RACE GRADE CONTROL & EROSION CONTROL DETAILS
8 OF 12	LOCATION OF ADDITIONAL STRUCTURES SCHEDULED FOR REMOVAL
9 OF 12	PHOTOS OF ADDITIONAL STRUCTURES SCHEDULED FOR REMOVAL
10 OF 12	NEW ACCESS POINT LOCATIONS
11 OF 12	NEW ACCESS POINT PHOTOS
12 OF 12	STAGING AREA LOCATION
13 OF X	PLAN DETAILS
14 OF X	PLAN DETAILS

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 6 ENGINEERING - DENVER, COLORADO

REGIONAL ENGINEER DATE	SAN MARCOS, TEXAS SAN MARCOS, RIVER HAYS TEXAS
PROGRAM SUPERVISOR DATE	
ASS'T. REGIONAL DIR. DATE	CAPES DAM-BREACH & CHANNEL RESTORATION VICINITY MAP, SITE PLAN AND DRAWING INDEX
DIVISION / INITIALS / DATE	
SAFETY	
INDUSTRIAL HYGIENIST	DESIGNED : W.STANCILL / DRAWN : W.STANCILL / CHECKED : W. RICE
CULTURAL RESOURCES	DATE : 8/5/2016 / PROJECT NO. : 6R-TX-2016-002 / SHEET 1 OF 12

EXISTING SITE
NO SCALE

NOTES

ALL ELEVATIONS ARE REPORTED AS FEET TIED TO NGVD 88 DATUM.

DAM

1. DAM ELEVATION ~ 552.0 +/- 1' WITH PARTIAL BREACHES EVIDENT DUE TO PARTIAL FAILURE DURING FLOOD.

MILLRACE

1. MILLRACE WIDTH AT CONCRETE HEADWORKS ~ 20'
2. MILLRACE SILL-ELEVATION: 549.0 +/- 1'.

BENCH MARK

1. SEE EXISTING SITE PHOTOS
2. BM ELEVATION: 554.4' VD88

ALIGNMENT

1.ALIGNMENT ORIENTATED AT THE APPROXIMATE CHANNEL CENTERLINE LOCATION.
2.ALIGNMENT RUNS FROM STATION 0 + 00 (UPSTREAM LOCATION) TO 1 + 20 (DOWNSTREAM LOCATION).
3.ALIGNMENT SAMPLE POINTS ARE LOCATED AT P.I. POINTS AND DISPLAYED ON SHEET 4.

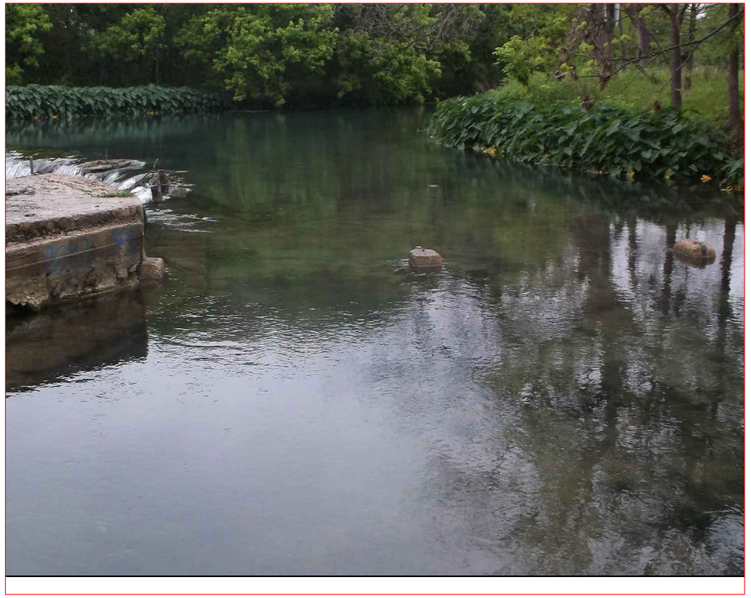
SECTION SAMPLE LINES

1.SECTION LINES WERE SAMPLED AT THREE LOCATIONS ALONG THE ALIGNMENT: UPSTREAM (0 + 12.30), CAPES DAM (0 + 73.38) AND DOWNSTREAM (1 + 17.38).
2. SECTION LINES ARE DISPLAYED ON SHEETS 5 & 6.

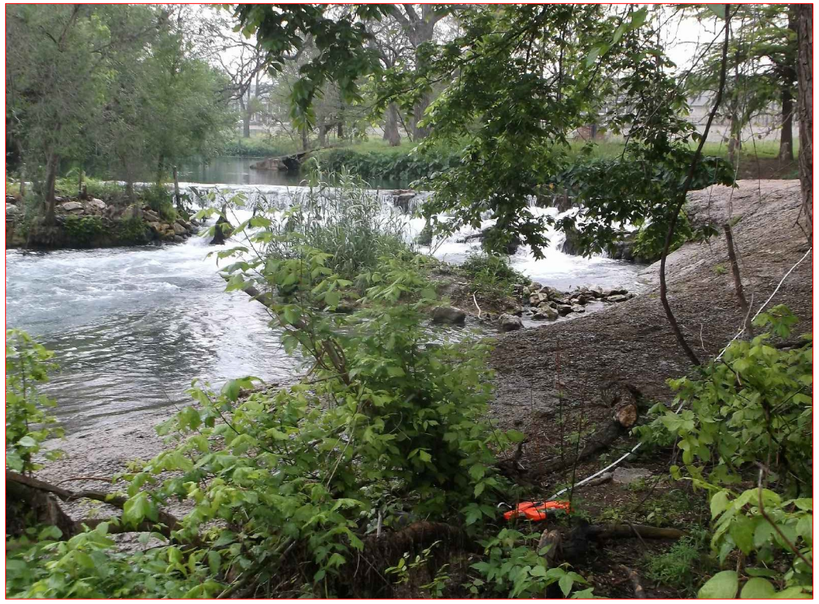
SAN MARCOS, TEXAS CAPES DAM–BREACH & CHANNEL RESTORATION	EXISTING SITE ALIGNMENT & SECTION LINE SAMPLING LOCATIONS				SUB–SHEET 2
DESIGNED W. STANCILL	DRAWN W. STANCILL	CHECKED W. RICE	DATE 8/2016	DRAWING NO. GR–TX–2016–002	SHEET 2 OF 12

CAPES DAM, ~ 300 CFS, VIEW ACROSS DAM FROM MILLRACE INLET

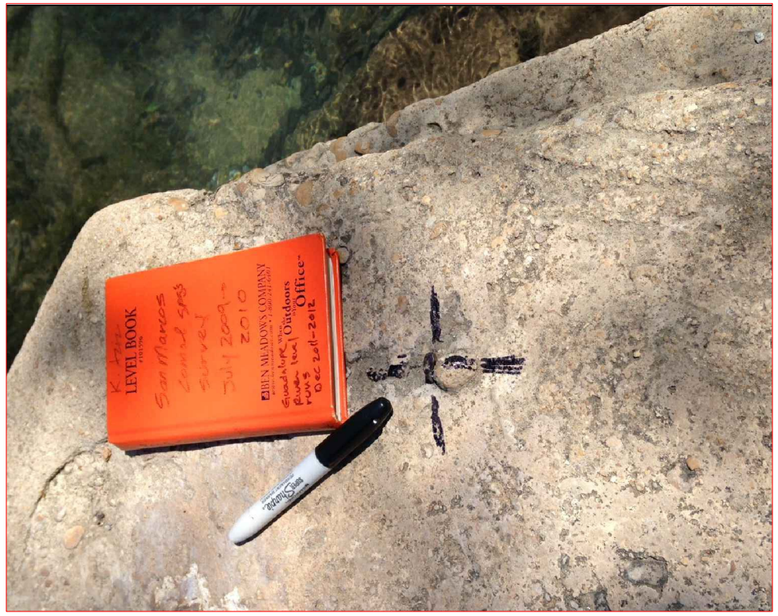
CAPES DAM, ~ 600 CFS, VIEW ACROSS DAM FROM MILLRACE INLET



MILLRACE INLET, VIEW DOWNSTREAM TO UPSTREAM



CAPES DAM, ~ 600 CFS, VIEW DOWNSTREAM TO UPSTREAM

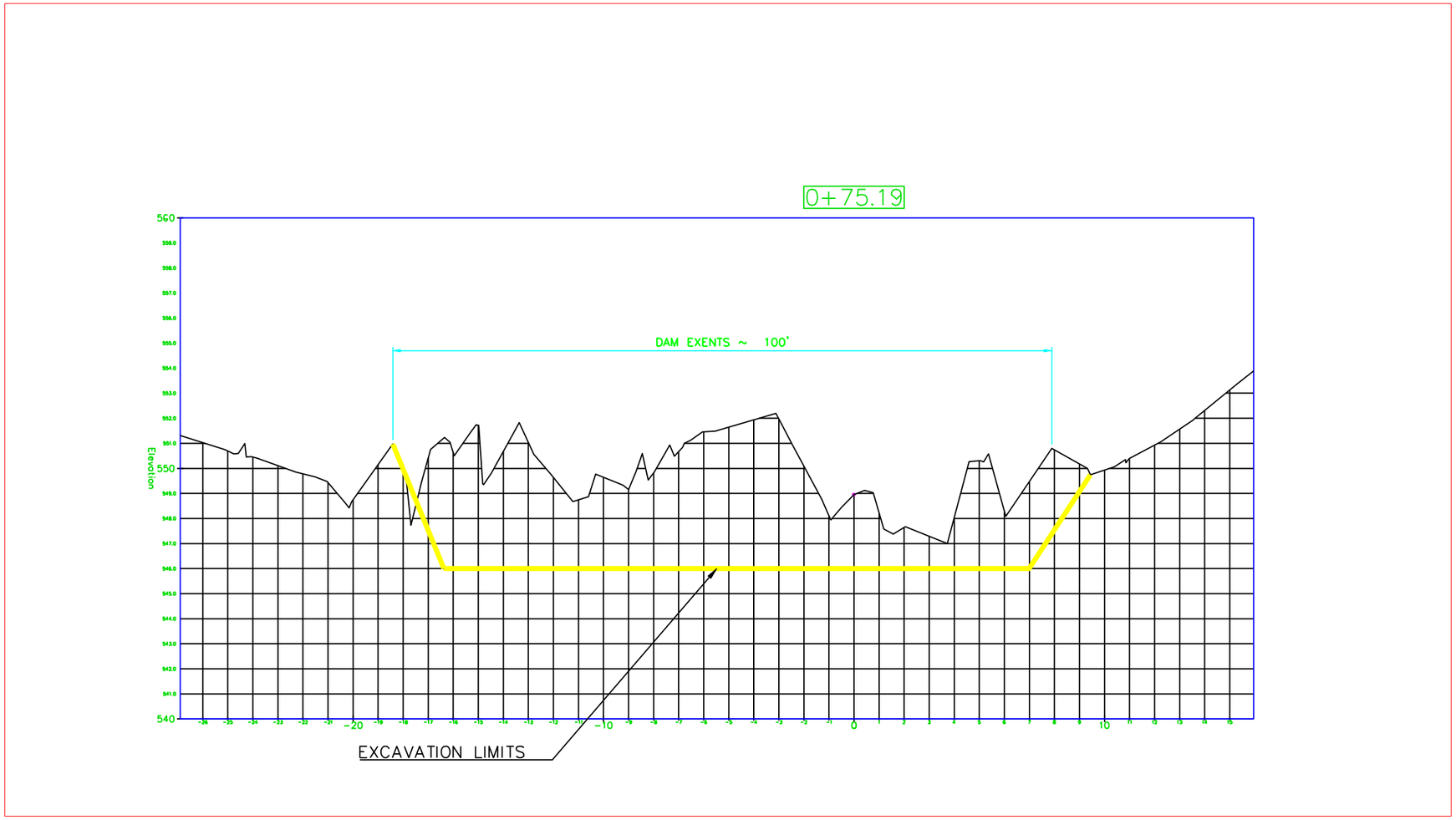


MILLRACE BENCH MARK CLOSEUP

MILLRACE ENTRANCE, VIEW LEFT BANK TO RIGHT BANK

EXISTING SITE
NO SCALE

SAN MARCOS, TEXAS CAPES DAM–BREACH & CHANNEL RESTORATION	EXISTING SITE PHOTOS				SUB-SHEET 3
DESIGNED W STANCILL	DRAWN W STANCILL	CHECKED W RICE	DATE 8/2016	DRAWING NO CR-TX-2016-002	SHEET 3 OF 12



EXISTING AND PROPOSED CROSS SECTION PROFILE PARALLEL WITHLONG AXIS OF DAM CENTERLINE

NOTES:

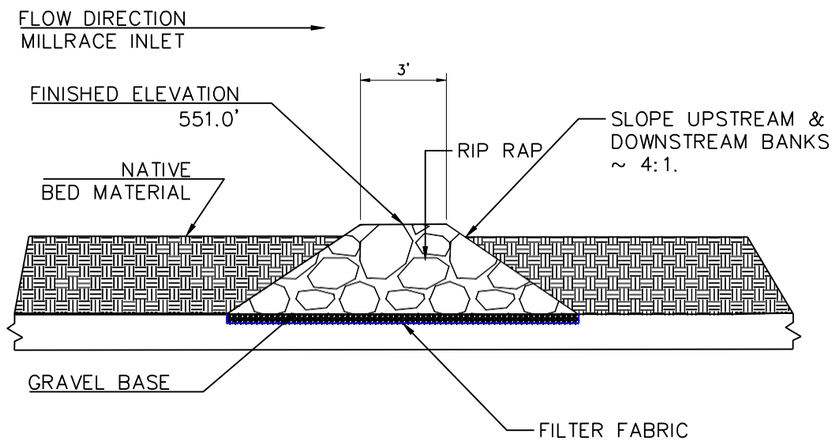
ELEVATIONS ARE REPORTED AS NGVD-88 AND TIED TO THE BENCHMARK LOCATED ON THE RIGHT BANK OF THE MILL RACE RIGHT BANK CONCRETE WALL. SEE SHEET 3 (EXISTING SITE PHOTOS).

DAM REMOVAL & CHANNEL EXCAVATION

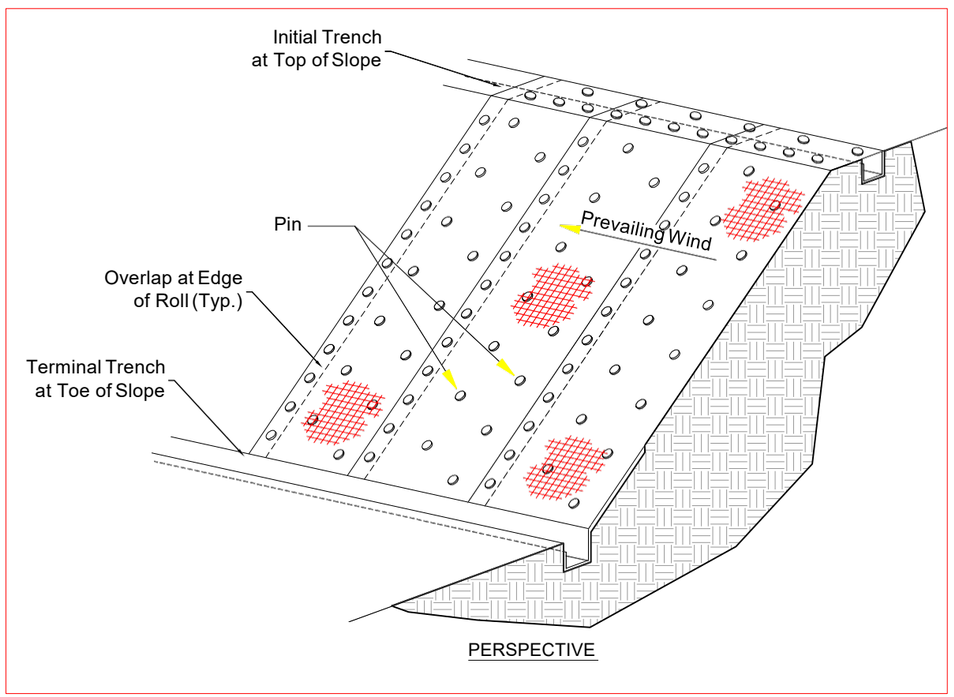
1. DAM WILL BE EXCAVATED FROM BANKLINE TO BANKLINE TO AN ELEVATION OF 546.0' OR REFUSAL.
2. EXCAVATED BANKLINES WILL BE SLOPED TO ~ 2:1 BUT FOLLOW THE EXISTING BANKLINE CONDITIONS WHERE POSSIBLE.
3. ALL EXCESS EXCAVATED MATERIAL WILL BE REMOVED FROM THE CHANNEL AND TRANSPORTED OFF SITE.
4. EXCAVATED MATERIAL TRANSPORTED OFF SITE WILL BE NO LARGER THAN 8 CUBIC FT.
5. REBAR WILL NOT BE REMOVED FROM EXCAVATED MATERIAL.
6. SILT AND OTHER DEPOSITIONAL MATERIAL STORED IN THE RESERVOIR AREA (UPSTREAM OF DAM) WILL NOT BE EXCAVATED.
7. THE LEFT BANK CHANNEL REQUIRES RESTORATION. THIS WORK WILL NOT COMMENCE UNTIL THE EXCAVATED CHANNEL HAS REACHED ITS NEW EQUILIBRIUM (NATURAL GRADE AND PLAN-FORM) AS DETERMINED BY THE US FISH & WILDLIFE SERVICE'S FIELD STAFF.
8. **IF AND WHEN NEEDED, INSTALL ROCK GRADE CONTROL STRUCTURE AT MILLRACE INLET TO CONTROL HEAD CUTTING AS DEPICTED ON SHEET 7 (BANK STAB & EROSION CONT).**

PROPOSED SITE
NO SCALE

SAN MARCOS, TEXAS CAPES DAM-BREACH & CHANNEL RESTORATION	PROPOSED SITE SECTION LINE DETAILS AT DAM				SUB-SHEET 6
DESIGNED W. STANCILL	DRAWN W. STANCILL	CHECKED W. RICE	DATE 8/2016	DRAWING NO. GR-TX-2016-002	SHEET 6 OF 12



CENTERLINE PROFILE VIEW: RIP RAP GRADE CONTROL STRUCTURE



PLAN VIEW: INSTALLATION OF JUTE BANK STABILIZATION MATERIAL

PROPOSED SITE
NO SCALE

CAPES DAM AREA: EROSION CONTROL INSTALLATION LOCATIONS

NOTES:

RIGHT BANK REFERS TO RIGHT SIDE OF RIVER LOOKING IN THE DOWNSTREAM DIRECTION.

RIGHT BANK EROSION CONTROL.

1. COVER SECTION OF RIGHT BANK EXPOSED DURING DAM REMOVAL WITH JUTE FIBER ROLL.
2. JUTE FIBER ROLL MATERIAL EXTENDS LATERALLY ALONG THE BANK FOR ~ 60' AS DEPICTED IN THE ATTACHED PHOTO.

MILL RACE ENTRANCE (ONLY IF NEEDED TO AVOID HEAD CUTTING)
(INSTALL ROCK GRADE CONTROL STRUCTURE, ONLY IF AND/WHEN NEEDED, TO CONTROL HEAD CUTTING INTO THE MILLRACE.

1. EXCAVATE MILL RACE ENTRANCE TO ELEVATION 545.0' AND BACKFILL WITH RIP RAP TO ELEVATION 551.0.
2. INSTALL 6" OF GRAVEL OVER GEOTEXTILE FILTER FABRIC BEFORE BACKFILLING EXCAVATED AREA WITH RIP RAP.
3. RIP RAP EXTENDS HORIZONTALLY ~ 40' FROM BANKLINE TO BANKLINE AS DEPICTED IN THE ATTACHED PHOTO.
4. KEY RIP RAP INTO LEFT BANK 5'.
5. RIP RAP SHALL BE TIED INTO THE RIGHT BANK (CONCRETE LINED SIDE) TO MAXIMUM POSSIBLE EXTENT WITHOUT EXCAVATING THE CONCRETE.
6. ENGINEER WILL STAKE GRADE CONTROL STRUCTURE EXTENTS PRIOR TO CONSTRUCTION.

SAN MARCOS, TEXAS CAPES DAM–BREACH & CHANNEL RESTORATION	MILL RACE GRADE CONTROL & EROSION CONTROL DETAILS				SUB-SHEET 7
DESIGNED W. STANCILL	DRAWN W. STANCILL	CHECKED W. RICE	DATE 8/2016	DRAWING NO. GR-TX-2016-002	SHEET 7 OF 12

NOTES

LOCATIONS DEPICTED ON IMAGE ARE APPROXIMATE. SEE GPS COORDINATES AND PICTURES ON SHEET 9 FOR DETAILED LOCATIONS.

ACCESS TO STRUCTURES 1, 2, AND 3 ARE GAINED FROM THE STAGING AREA DEPICTED ON SHEET 12.

ACCESS TO STRUCTURE 4 IS GAINED FROM CAPE STREET AS DEPICTED ON SHEET 12.

DEFICIENT STRUCTURE 1
1. LOCATION: -97.931534; 29.872978.
2. STRUCTURE IS A CONCRETE-SLAB COMPROMISED BY BANK EROSION.
3. NO INFORMATION EXISTS ON THE SLABS CONDITION OR EMBEDMENT DEPTH.
4. THE CONCRETE-SLAB SHALL BE BROKEN INTO PIECES NO LARGER THAN 8 CUBIC FEET AND EXPORTED OFF SITE.

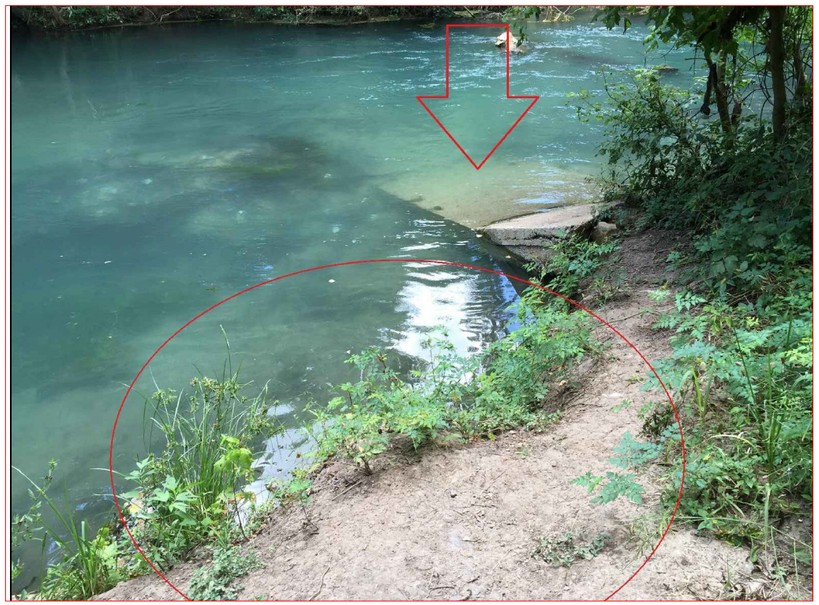
DEFICIENT STRUCTURE 2
1. LOCATION: -97.931794; 29.872696.
2. STRUCTURE IS A CONCRETE-SLAB COMPROMISED BY BANK EROSION.
3. NO INFORMATION EXISTS ON THE SLABS CONDITION OR EMBEDMENT DEPTH.
4. THE CONCRETE-SLAB SHALL BE BROKEN INTO PIECES NO LARGER THAN 8 CUBIC FEET AND EXPORTED OFF SITE.

DEFICIENT STRUCTURE 3
1. LOCATION: -97.931934; 29.870159.
2. STRUCTURES INCLUDE A CONCRETE BRIDGE AND CONCRETE RUBBLE PLACED ON THE BANK FOR EROSION PROTECTION.
3. NO INFORMATION EXISTS ON THE SLABS CONDITION OR EMBEDMENT DEPTH.
4. THE CONCRETE-SLAB SHALL BE BROKEN INTO PIECES NO LARGER THAN 8 CUBIC FEET AND EXPORTED OFF SITE.

DEFICIENT STRUCTURE 4
1. LOCATION: -97.931456; 29.869921.
2. STRUCTURE INCLUDES A DIVERSION STRUCTURE CONSTRUCTED OF CONCRETE.
3. NO INFORMATION EXISTS ON THE STRUCTURES CONDITION OR EMBEDMENT DEPTH.
4. THE STRUCTURE SHALL BE BROKEN INTO PIECES NO LARGER THAN 8 CUBIC FEET AND TRANSPORTED OFF SITE.

DEFICIENT STRUCTURE 1. CONCRETE BANK-STABILIZAION STRUCTURE

DEFICIENT STRUCTURE 2. CONCRETE BANK-STABILIZATION STRUCTURE



DEFICIENT STRUCTURE 3. COMPROMISED BRIDGE & BANK-STABILIZATION

DEFICIENT STRUCTURE 4. COMPROMISED WATER CONTROL STRUCTURE

EXISTING SITE
NO SCALE

SAN MARCOS, TEXAS CAPES DAM-BREACH & CHANNEL RESTORATION	EXISTING INFRASTRUCTURE SITE PHOTOS				SUB-SHEET 9
DESIGNED W STANCILL	DRAWN W STANCILL	CHECKED W RICE	DATE 8/2016	DRAWING NO CR-TX-2016-002	SHEET 9 OF 12

NOTES

LOCATIONS DEPICTED ON IMAGE ARE APPROXIMATE. SEE GPS COORDINATES AND PICTURES ON SHEET 11 FOR DETAILED LOCATIONS. ACCESS POINT DEVELOPMENT STYLES AND METHODS DEPICTED ON SHEET 11 ARE TYPICAL. ACCESS POINTS WILL BE CONSTRUCTED AS DETERMINED BY THE CITY OF SAN MARCOS.

ACCESS TO POINTS 1, 2, AND 3 WILL GAINED FROM THE STAGING AREA DEPICTED ON SHEET 12.

ACCESS TO POINTS 4 AND 5 ARE GAINED FROM CAPE STREET AS DEPICTED.

NEW ACCESS POINT 1
1. LOCATION: -97.931534; 29.872978.
2. SEE SITE PHOTO ON SHEET 11.

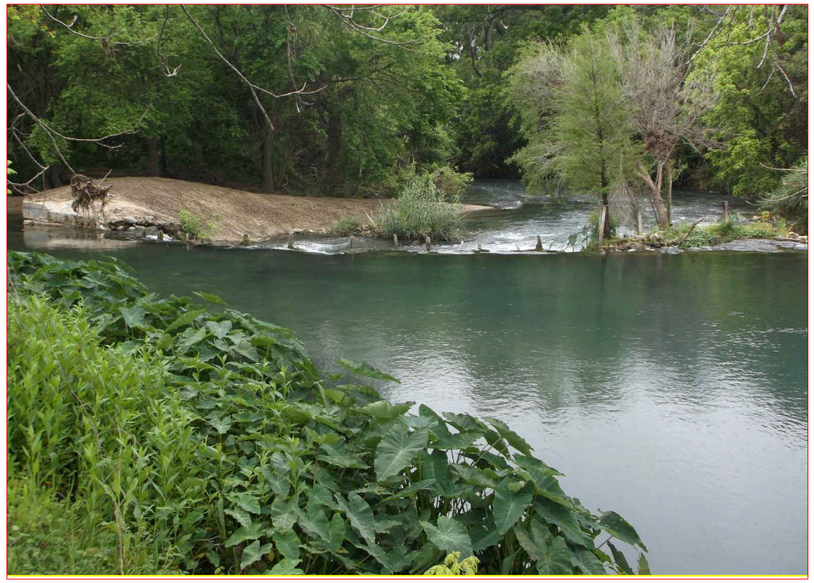
NEW ACCESS POINT 2
1. LOCATION: -97.931794; 29.872696.
2. SEE SITE PHOTO ON SHEET 11.

NEW ACCESS POINT 3
1. LOCATION: -97.931914; 29.872242.
2. SEE SITE PHOTO ON SHEET 11.

NEW ACCESS POINT 4
1. LOCATION: -97.931456; 29.869921.
2. SEE SITE PHOTO ON SHEET 11.

NEW ACCESS POINT 5
1. LOCATION: -97.930576; 29.869486.
2. SEE SITE PHOTO ON SHEET 11.

SAN MARCOS, TEXAS CAPES DAM–BREACH & CHANNEL RESTORATION	NEW ACCESS POINT LOCATIONS FUTURE CONSTRUCTION				SUB–SHEET 10
DESIGNED W STANCILL	DRAWN W STANCILL	CHECKED W RICE	DATE 8/2016	DRAWING NO GR–TX–2016–002	SHEET 10 OF 12



NEW ACCESS POINT 1, UPSTREAM OF MILLRACE INLET

NEW ACCESS POINT 2; DOWNSTREAM OF MILLRACE INLET

NEW ACCESS POINT 3

NEW ACCESS POINT 4

NEW ACCESS POINT 5

NEW ACCESS POINT DESIGN (TYPICAL)

EXISTING SITE
NO SCALE

SAN MARCOS, TEXAS CAPES DAM-BREACH & CHANNEL RESTORATION	NEW ACCESS POINTS SITE PHOTOS				SUB-SHEET 11
DESIGNED W STANCILL	DRAWN W STANCILL	CHECKED W RICE	DATE 8/2016	DRAWING NO CR-TX-2016-002	SHEET 11 OF 12

NOTES

LOCATIONS DEPICTED ON IMAGE ARE APPROXIMATE. SEE GPS COORDINATES AND PICTURES FOR DETAILED LOCATIONS. STAGING AREA IS APPROXIMATELY 0.5 ACRES. EQUIPMENT AND MATERIALS WILL BE STORED AT STAGING AREA.

STAGING AREA

1. LOCATION: -97.931534; 29.872978.
2. ACCESS TO STAGING AREA WILL BE GAINED FROM EXISTING TRAIL UNDER THE JURISDICTION OF THE CITY OF SAN MARCOS, TEXAS.
3. STAGING AREA WILL BE REHABILITATED AFTER DECONSTRUCTION IS COMPLETED.

SAN MARCOS, TEXAS CAPES DAM-BREACH & CHANNEL RESTORATION	NEW ACCESS POINT LOCATIONS FUTURE CONSTRUCTION				SUB-SHEET 12
DESIGNED W STANCILL	DRAWN W STANCILL	CHECKED W RICE	DATE 8/2016	DRAWING NO GR-TX-2016-002	SHEET 12 OF 12

Capes Dam Removal

Project Performance Tracking and Reporting

Product	Start	Finish	Actual work	Actual duration	Explanations
Design, Engineer	03/30/16	08/05/16	128	128	Turned in latest plans to USACE and Historical Commission.
Complete USACE Application	05/02/16	05/06/16	4	132	Completed.
Army Corps 404 Nationwide Permit	05/09/16	06/24/16	46	178	Submitted. Waiting for SHPO approval of MOA.
TPWD Sand and Gravel Permit	05/09/16	06/24/16	0	178	In progress. On track.
TCEQ Dam Removal Information Sheet	05/09/16	06/24/16	0	178	Completed.
SHPO Consultation	05/09/16	06/24/16	0	178	In progress. Development of MOA with THC, SM, USFWS
NEPA Catogorical Exclusion	05/09/16	06/24/16	0	178	In progress. On track.
GLO Notification	05/09/16	06/24/16	0	178	Completed.
Section 7 Consultation	05/09/16	09/23/16	137	315	Request submitted 05/03/2016. In progress. On track.
Dam Removal/ Temporary Bank Stabilization	09/26/16	12/31/16	96	411	Will only take about a week to do the work, but must be scheduled first
Temporary Restoration of Disturbed Area	01/01/17	03/31/17	5	416	Revegetate with native plans to avoid non-native intrusion
Natural Sediment Removal and River Adjustment			?		Dependant upon river flows/flooding events
Rebuild Riverbank in Proper Place			?		Dependant upon river flows/flooding events
Restoration of work area			5 years		Dependant upon river flows/flooding events

Capes Dam Removal Analysis DRAFT

PREPARED FOR: The City of San Marcos
PREPARED BY: Recreation Engineering & Planning Inc.
DATE: March, 27 2017

Recreation Engineering and Planning
485 Arapahoe Ave.
Boulder, CO 80302

303-545-5883 (office)
gary@boaterparks.com
www.boaterparks.com

TBPE Firm Number: 13981

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Introduction

This report describes the hydraulic analysis conducted for Capes Dam located within the City of San Marcos, Texas. This analysis focuses on dam removal impacts to the San Marcos River and the existing Mill Race channel created by the dam.

Capes Dam is currently in a state of disrepair. It was built in the 1800's to create head and divert water for a mill located downstream. The dam failed during floods in 1998 and a weir structure was constructed immediately upstream to maintain water depths. Further damage was sustained during flooding in 2015 and again in 2016. Today, the dam continues to divert water into the Mill Race channel, but the condition of the dam poses a hazard to any navigation in the San Marcos River and threatens endangered species in the area.

The City of San Marcos contracted Recreation Engineering and Planning (REP) to complete a site feasibility study and propose a solution to the failing and dangerous Capes Dam that not only eliminates the hazard, but also makes for an attractive area that the community can enjoy.

Location

Figure 1 shows the location of Capes Dam. It is located on the San Marcos River just downstream of the I35 bridge, and very near the University campus. The dam diverts water from the river into the Mill Race channel. The Mill Race channel flows parallel to the San Marcos River, passes under Cape Street, and then rejoins the river at the old mill site.

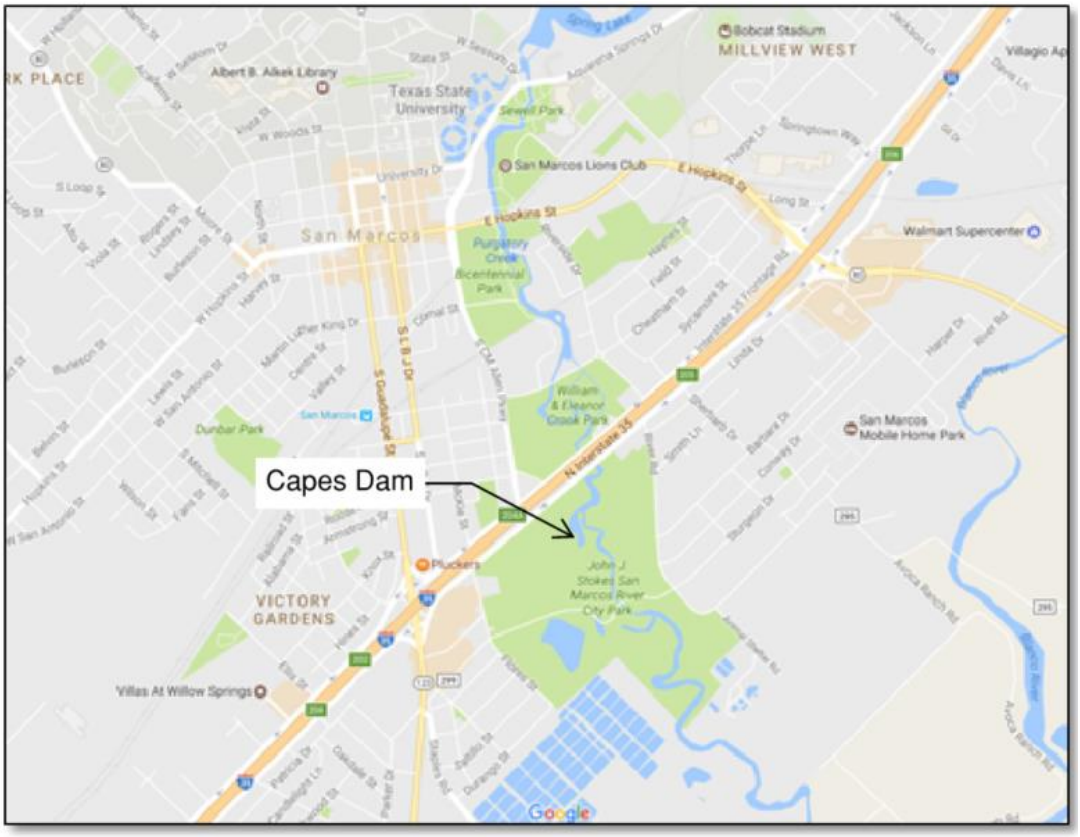


Figure 1: Project Location Map

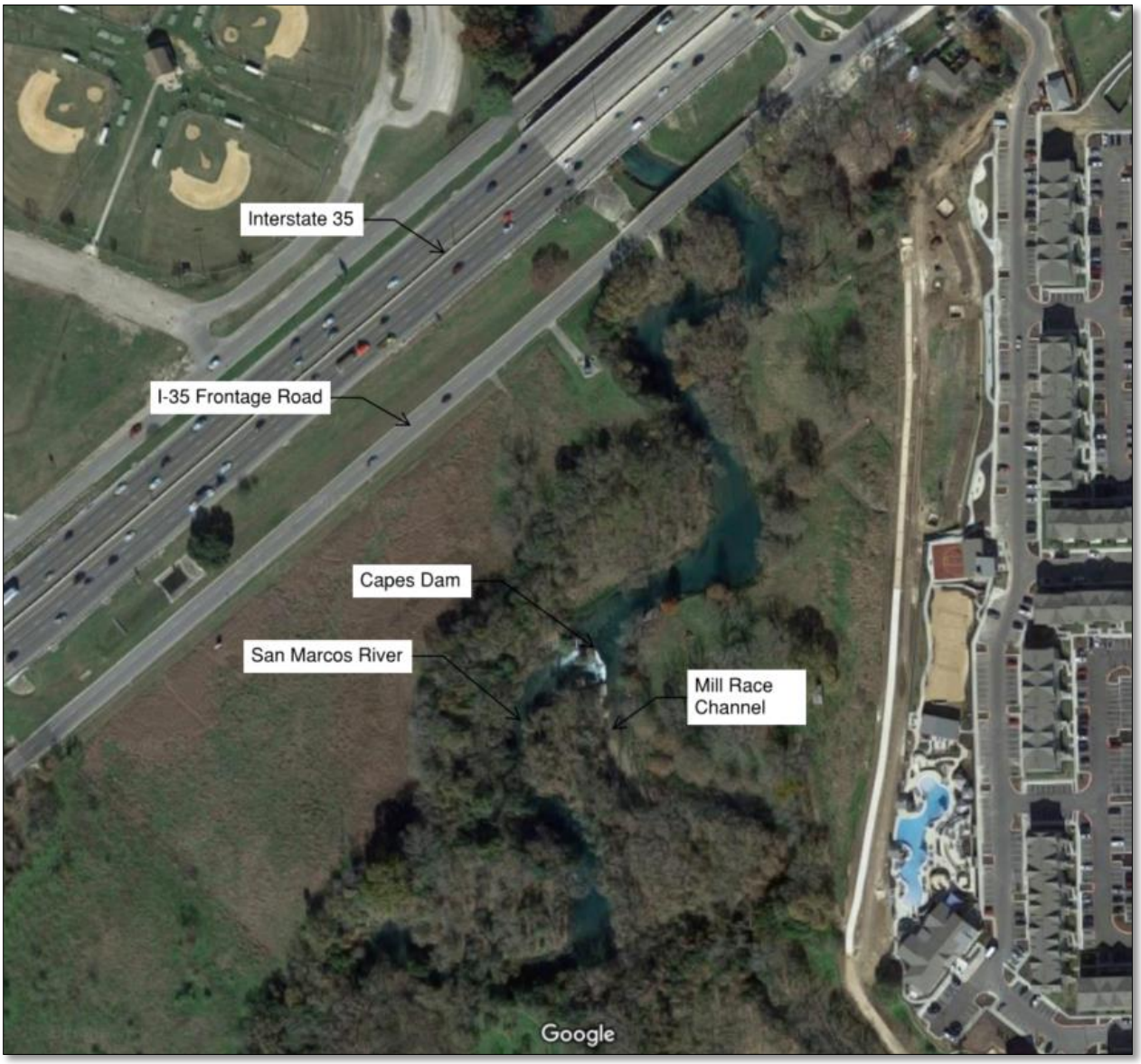


Figure 2: Capes Dam Location Map

Existing Conditions

Capes Dam continues to divert water into the Mill Race channel, however the current configuration of the dam is a hazard to navigation. There is considerable woody debris that creates entrapment hazards and the crest of the dam is uneven with protruding steel bars and broken concrete. Many users recreate in this area, yet any attempt to navigate Capes Dam is ill advised in its current condition. See the photos below.

The channel in this area is highly sinusoidal and braided. Apart from the dam, this section of the San Marcos River is very calm and flat, meandering through a heavily vegetated area. Backwater flooding from the Rio Blanco is a common occurrence during major floods.

The Mill Race channel is well established with conditions similar to the main stem of the San Marcos River in that it is very flat and vegetated. The channel drops only slightly as it meanders parallel to the San Marcos River. It passes under Cape Street with the water surface elevation reaching almost to the low chord of the bridge (Figure 4). At the end of the Mill Race channel, the water drops over a small weir creating a waterfall feature shown in Figure 5.

Figure 3: Existing Conditions, Capes Dam

Figure 4: Mill Race passing under Cape Street

Figure 5: Old Mill Site. Confluence with the San Marcos River

HYDROLOGY

Discharge information for the modeled reach containing the project location was obtained from USGS gauge 08170500 San Marcos River at San Marcos, TX. Flow rates in the San Marcos River are relatively stable, rarely varying outside the 150-200 cubic feet per second (cfs) range except during short high intensity rainfall events. The average flows are shown in the figures below.

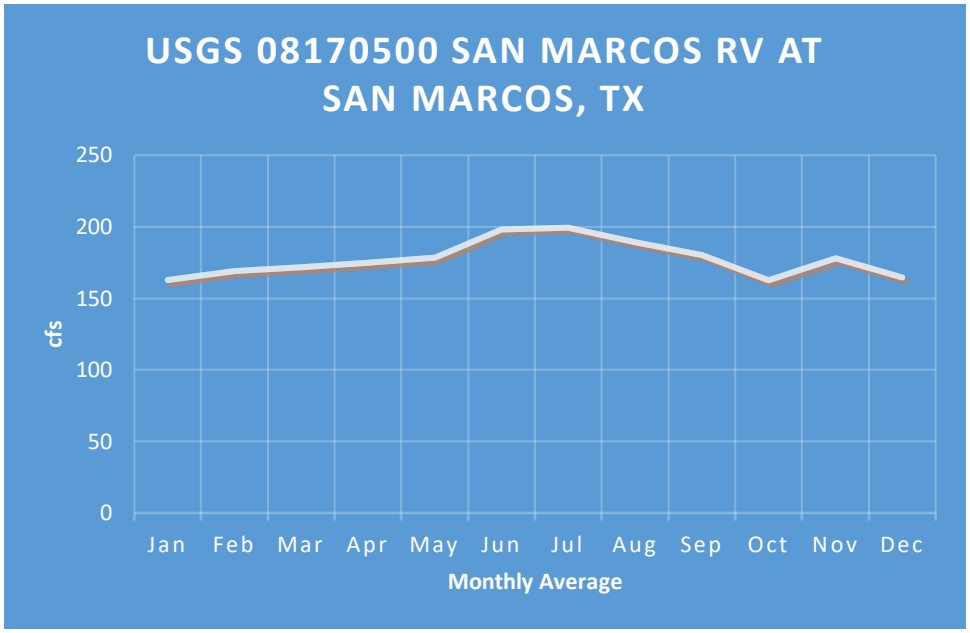


Figure 6: San Marcos River Average Flow by Month

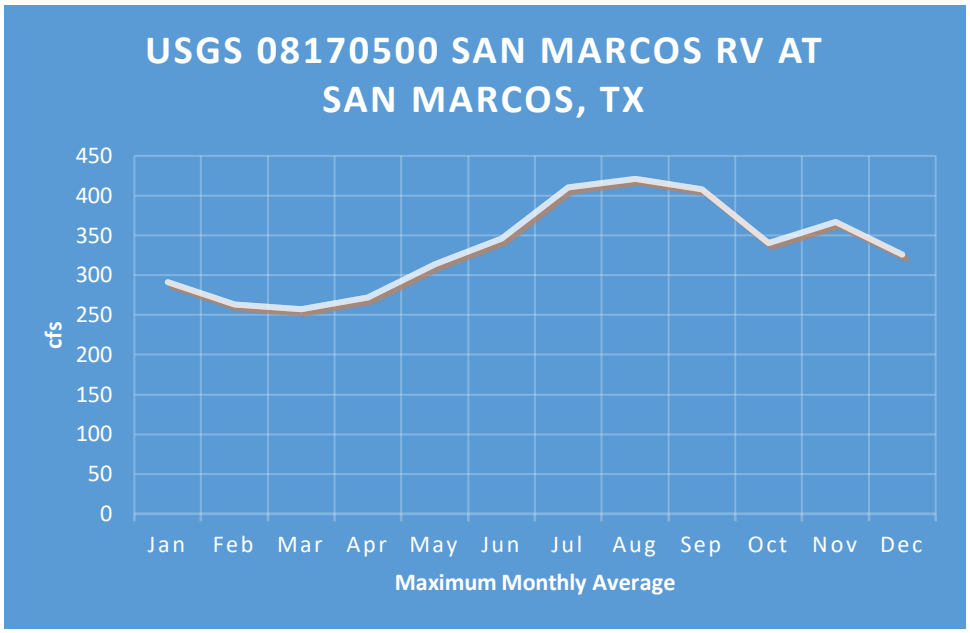


Figure 7 San Marcos River Average Maximum Flow by Month

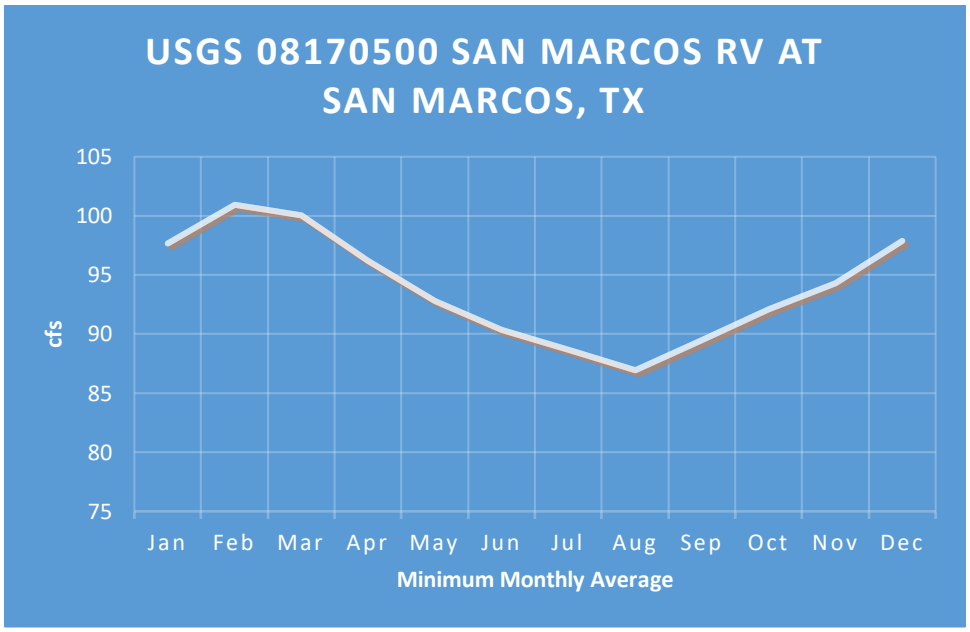


Figure 8 San Marcos River Average Minimum Flow by Month

Proposed Design

The area in which Capes Dam is located attracts all forms of recreation, is near a university campus, and home to various endangered species. This contributes to the need to make the San Marcos river safely navigable by all in this location. The primary goal of this dam removal is to eliminate a safety hazard, but simultaneously create an amenity for the community and an environmental improvement.

The proposed design will not only remove the dam, but also continue to divert water into the Mill Race channel. This is desirable because the Mill Race channel meanders through an attractive area and can be used to navigate back upstream. The proposed design removes the dam and leaves a grade control riffle with a specified crest elevation. The removal of the dam eliminates the hazard to navigation and benefits the habitats for the endangered Texas wild rice and fountain darters in the San Marcos River. In addition to the removal of the dam, the proposed design includes lowering the elevation of the Mill Race channel inlet invert and dredging the channel bed between 1 and 3 feet along the length of the Mill Race. The crest of the waterfall/weir at the exit of the Mill Race channel will be lowered by approximately 2 feet as well. Lowering the elevation of the Mill Race channel allows for continued flow through the channel after removal of the dam and also allows for safe passage under the existing Cape Street Bridge. The design is optimized for the various flows in the river. Even at low flows, just enough water enters the Mill Race channel to make it navigable and attractive while the vast majority of the water at all flows remains in the main channel of the San Marcos River. See the Results section.

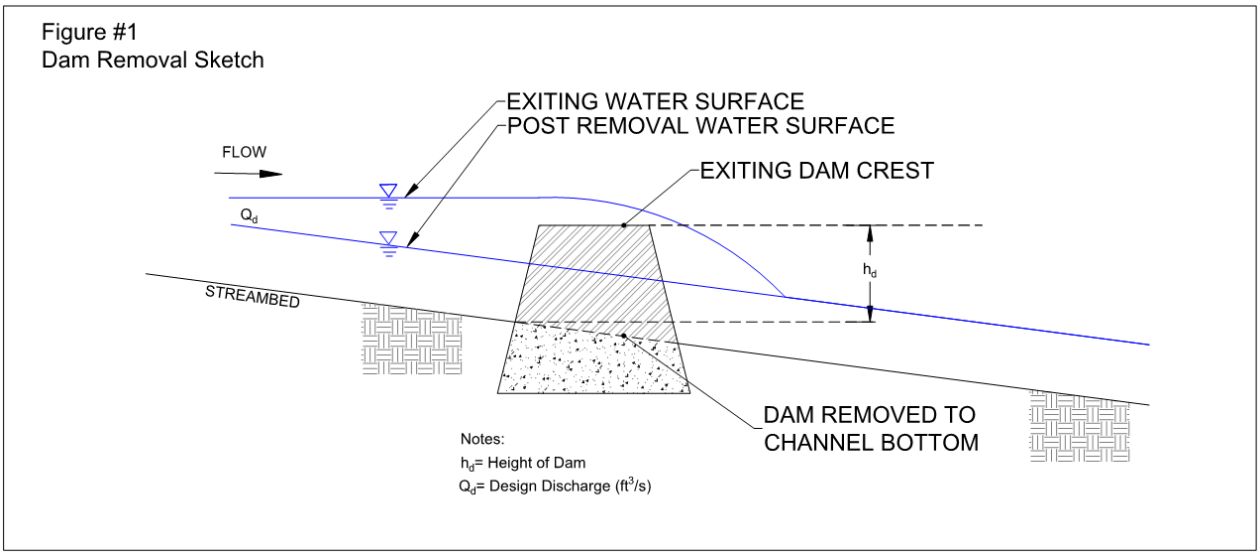


Figure 9: Conceptual Profile Sketch of the Proposed Dam Removal (not to scale)

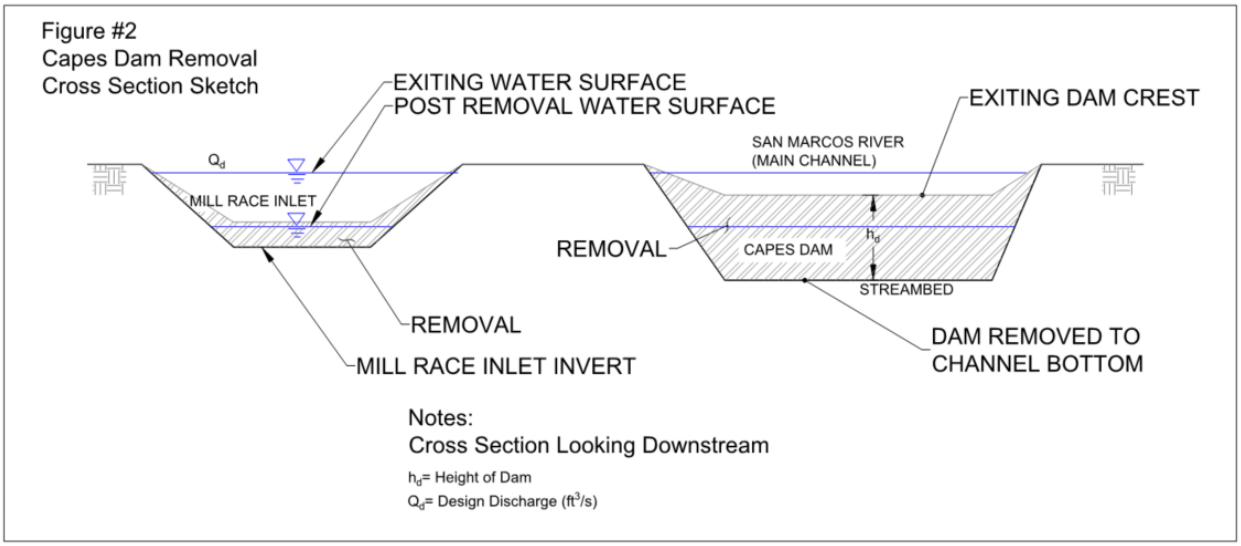


Figure 10: Conceptual Cross Section Sketch of the Proposed Dam Removal (not to scale)

Hydraulic and Sediment Transport Modeling

Modeling Methodology

Hydraulic and sediment transport modeling was performed to determine the effects of the proposed dam removal on the surrounding river system and Mill Race. Two types of models were developed, a one-dimensional hydraulic model using HEC-RAS and a two-dimensional morphodynamic using iRIC.

The one-dimensional hydraulic model was developed to determine preliminary design elevations and perform a flow split analysis between the mill race and the main channel of the San Marcos River. The one-dimensional model allows for quick run times for multiple design iterations, while producing accurate results.

A two-dimensional morphodynamic model was developed for the project reach in order to investigate the upstream channel bed evolution after removal of Capes Dam. The upstream backwater created by the dam is used by recreationalists, and there is a desire to maintain flow depth in this area.

1D HEC-RAS Hydraulic Model

HEC-RAS (Hydraulic Engineering Center – River Analysis System) is a one-dimensional step backwater program created by the U.S. Army Corps of Engineers. The program is applicable for analysis of floodplain impacts and is the standard program used by FEMA to create FISs and FIRMs. The program has the ability to perform split flow analysis on branching channels, such as the Mill Race split from the San Marcos River.

Discharges for analysis in HEC-RAS were chosen to represent a range of low to high flows expected in the San Marcos River, and for consistency with the flows analyzed by Hardy and Raphelt[1].

Table 1. Steady State San Marcos River Discharges Data Used in HEC-RAS model

Flow (cfs)	% Exceedance
45	"Drought of Record"
100	90
173	50
300	10

EXISTING CONDITIONS & CALIBRATION

Halff Associates, Inc. developed an unsteady HEC-RAS version 4.1.0 model for the USACE (United States Army Corp of Engineers) for the San Marcos and Blanco Rivers dated July 23, 2015 and provided to REP on May 12, 2016. This model presents time varied water surfaces referencing the NAVD 88 datum.

The model was developed for floodplain analysis of large flow events. To accurately model the project reach for low flow events, REP created a new reach for the Mill Race, added new cross sections to the San Marcos and the Mill Race, and updated existing cross section elevation data. Topography and river bathymetry data was provided to REP by Watershed Systems Group.

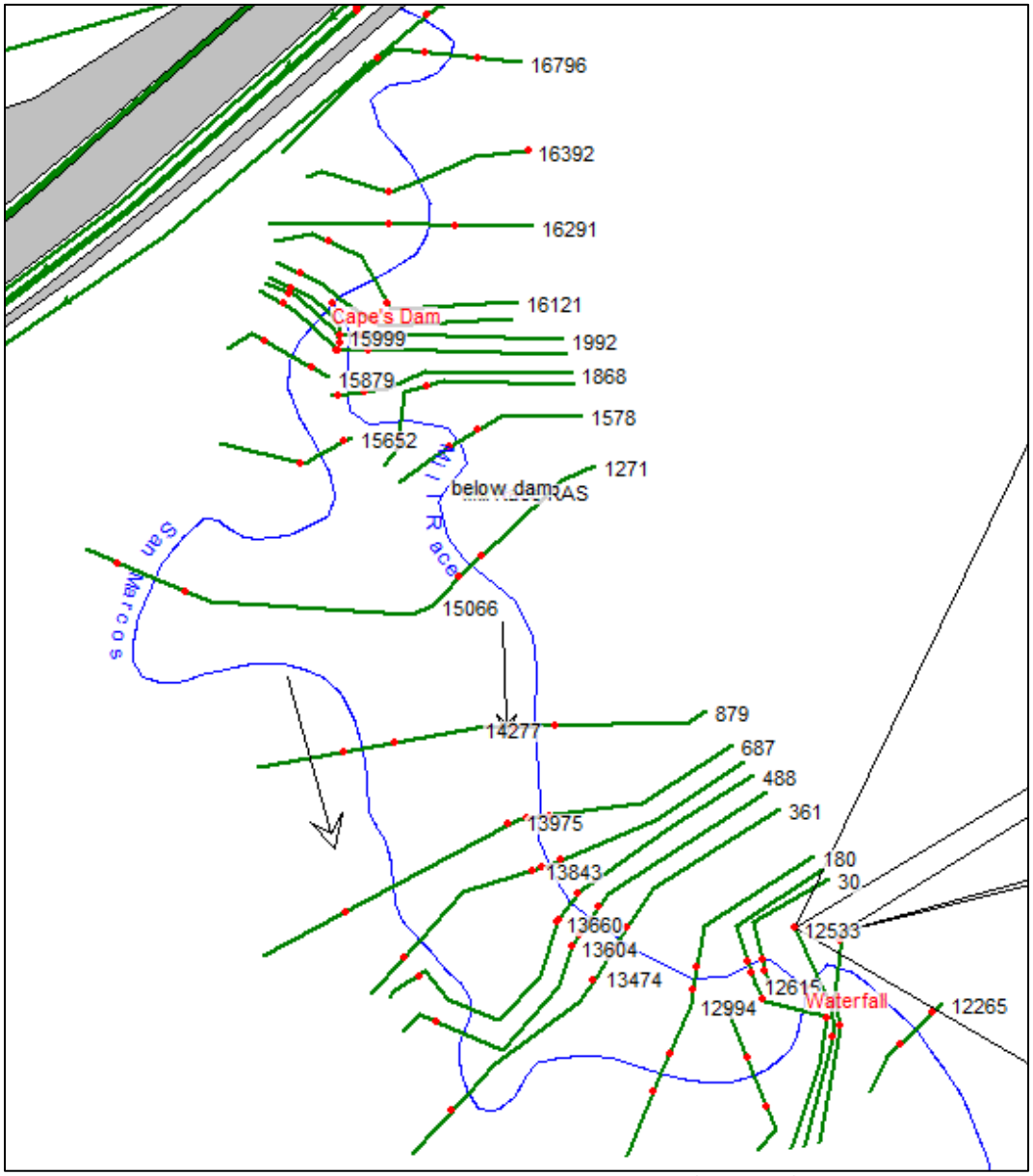


Figure 11: HEC-RAS XS and reaches in the project area. Flow is from top of image to bottom.

The Existing Conditions model was calibrated to water surface elevations in the Mill Race and the San Marcos River upstream of Capes Dam provided in the "Cape Dam and Mill Race Assessment" by Hardy[2]. The flow measurements were taken in the Mill Race on 8/19/2016 at a discharge in the San Marcos River of 283cfs, and in the San Marcos River upstream of the dam on 12/16/2016 at a discharge of 245cfs.

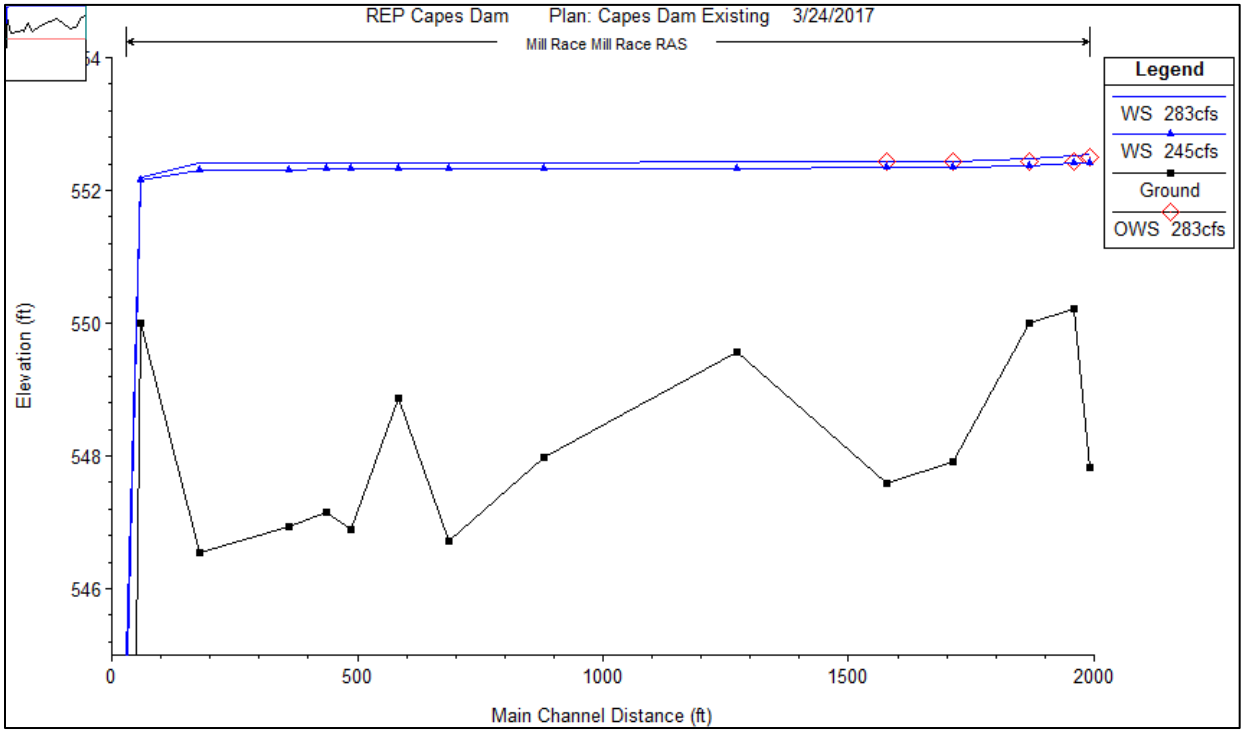


Figure 12: Existing conditions Mill Race reach profile with calibrated water surface elevations and observations.

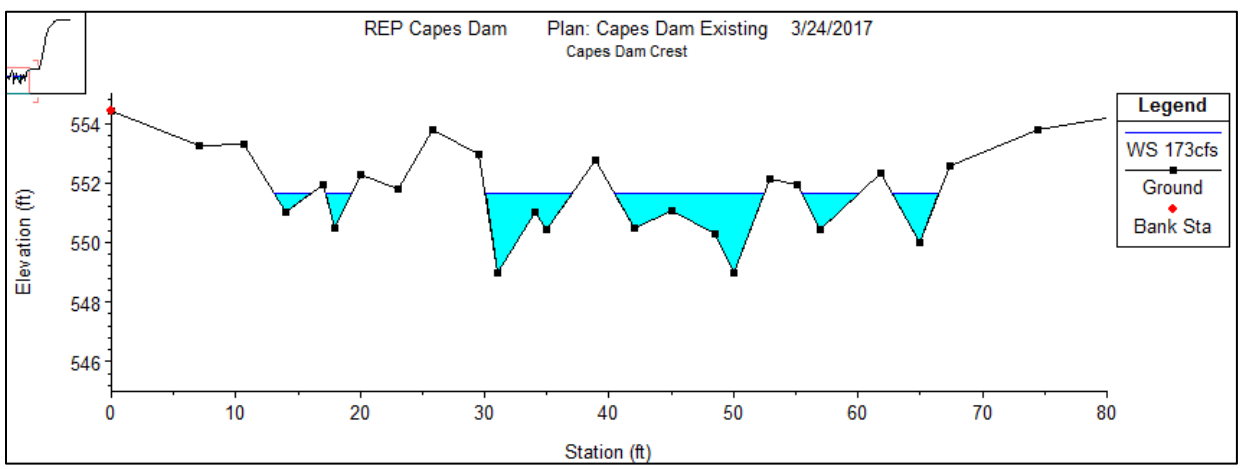


Figure 13: Existing Capes Dam crest cross section at median flow.

PROPOSED CONDITIONS MODEL

The proposed dam removal design geometry was input into the model and the flow split and water surface elevations analyzed.

The proposed geometry includes dredging of the Mill Race, lowering the "waterfall" weir crest at the downstream end of the Mill Race, and replacing the Capes Dam crest with the grade control riffle crest.

All elevations are NAVD88. The crest of the weir at the downstream end of the Mill Race was set to EL 548.2. The Mill Race cross-sections were modified to represent dredging of the Mill Race to EL 547.0. See Figure 14. The invert of the new Capes Dam crest (grade control riffle) cross section is EL 546.5 as shown in Figure 15 below.

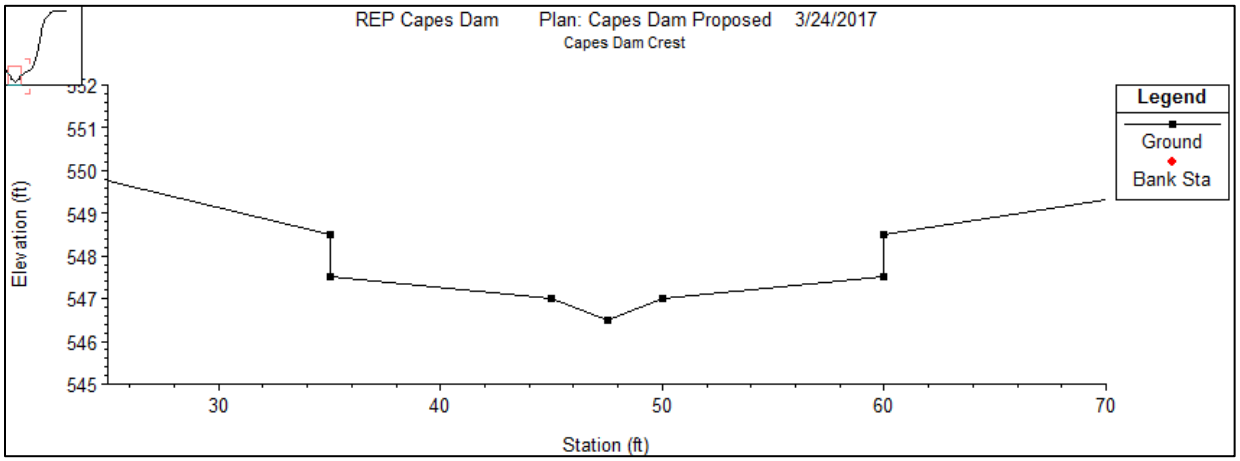


Figure 164: Proposed Capes Dam crest cross-section.

RESULTS

The model was run under mixed flow conditions with split flow optimization at the Mill Race. Water surface elevations (WSEL) and discharge outputs were compared for the flows analyzed and evaluated the project objectives. Results of the split flow analysis are shown below in Table 2. At flows of 100cfs and below, nearly all of the discharge flows into the main San Marcos River channel rather than the Mill Race. However, depths in the Mill Race are maintained due to backwater effect of the "waterfall" weir crest even at minimal discharges, allowing passage for small watercraft. WSEL along the Mill Race profile at various flows is shown in Figure 18.

Table 2. Split flow results for Proposed Geometry

Flow (cfs)	Discharge in Mill Race (cfs)	Discharge in River Channel (cfs)
45	0	45
100	1.6	98.4
173	8.4	164.6
300	22.3	277.7

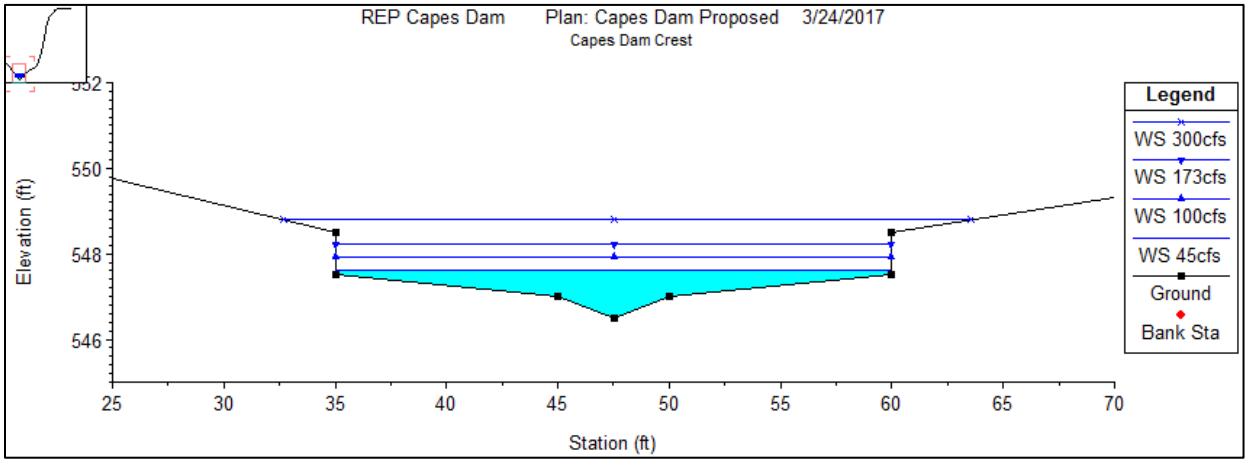


Figure 15: Proposed Capes Dam cross section at all flows.

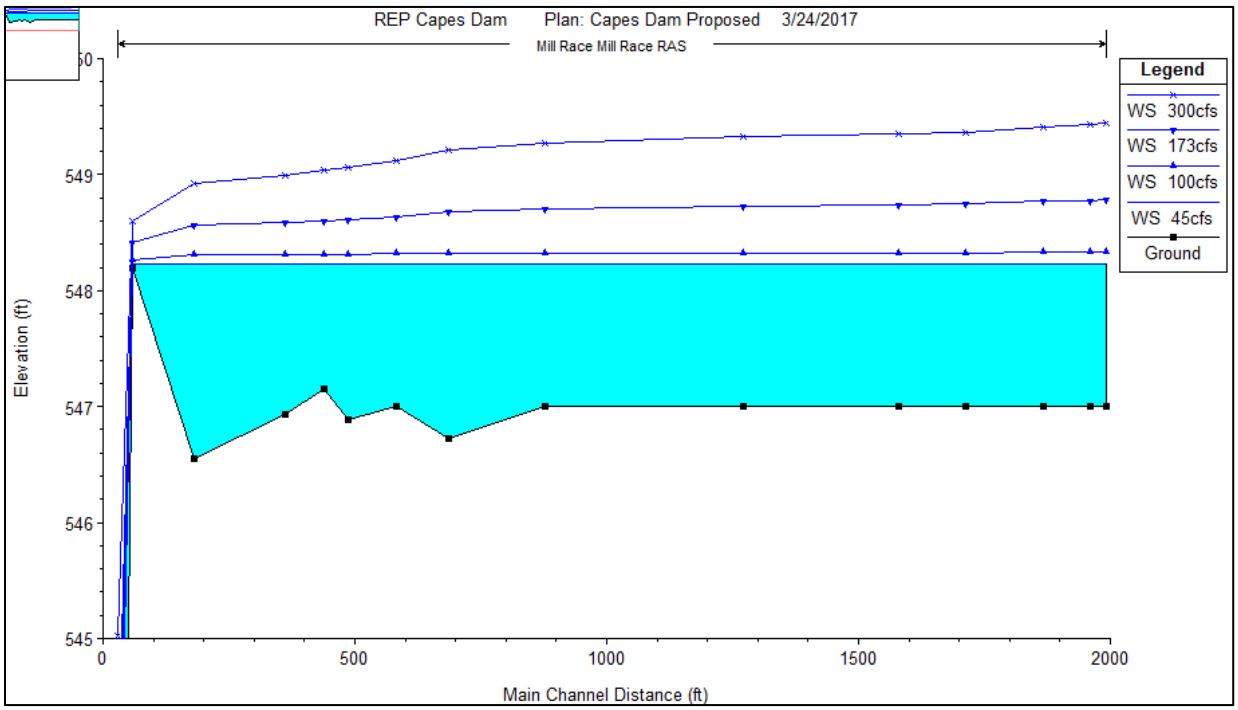


Figure 16: Proposed conditions profile of Mill Race channel

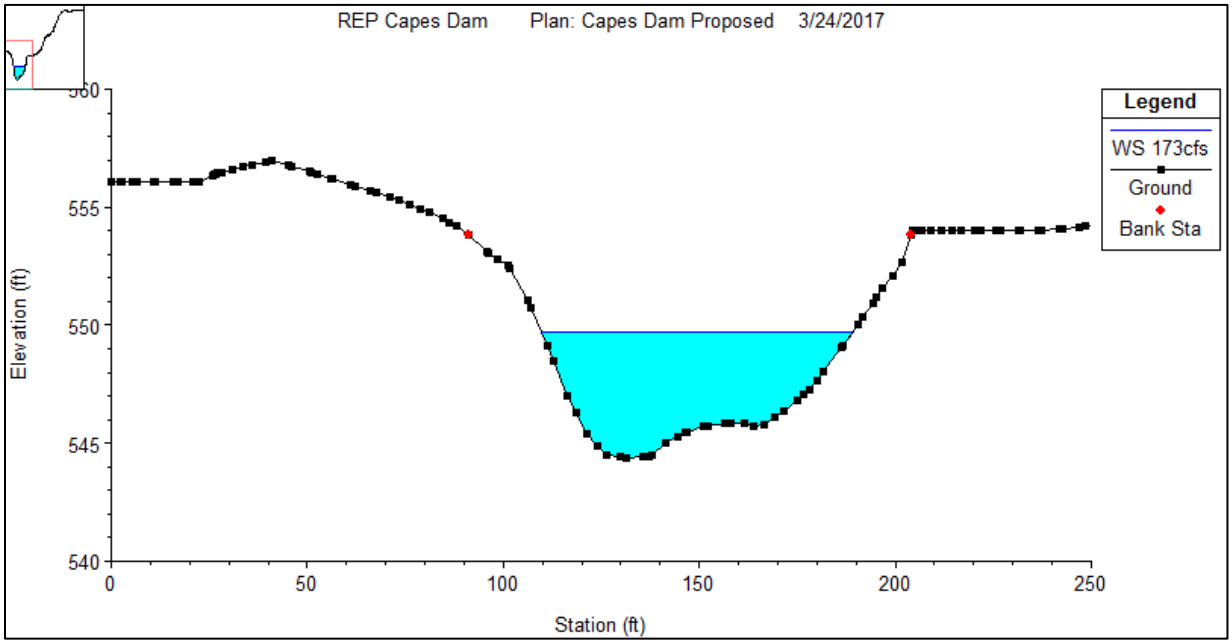


Figure 177:HEC-RAS RS 16796, Proposed Median Flow Conditions 170ft DS of I35

2D iRIC Morphodynamic Model

The purpose of the two-dimensional morphodynamic model was to investigate the upstream effects on the San Marcos River after removal of Capes Dam. The upstream backwater created by the dam is used by recreationalists, and there is a desire to maintain flow depth in this area.

The analysis was performed using the International River Interface Cooperative (iRIC) software. iRIC is a public-domain river flow and riverbed variation analysis software package which combines the functionality of hydraulic modeling software developed by the U.S. Geological Survey (USGS) and the Foundation of Hokkaido River Disaster Prevention Research Center, among others. The iRIC software includes many different solvers, capable of modeling complex 2D and quaisi-3D hydraulics, as well as riverbed morphology change.

Model Development

The Nays2DH solver within iRIC (version 2.3) was chosen for its robust two-dimensional unsteady flow solver, and capability to model sediment transport and riverbed change. Topography and river bathymetry data was provided to REP by Watershed Systems Group. From this data, a 2D mesh was created in iRIC with nodes generated on a curvilinear grid with 3 meter spacing.

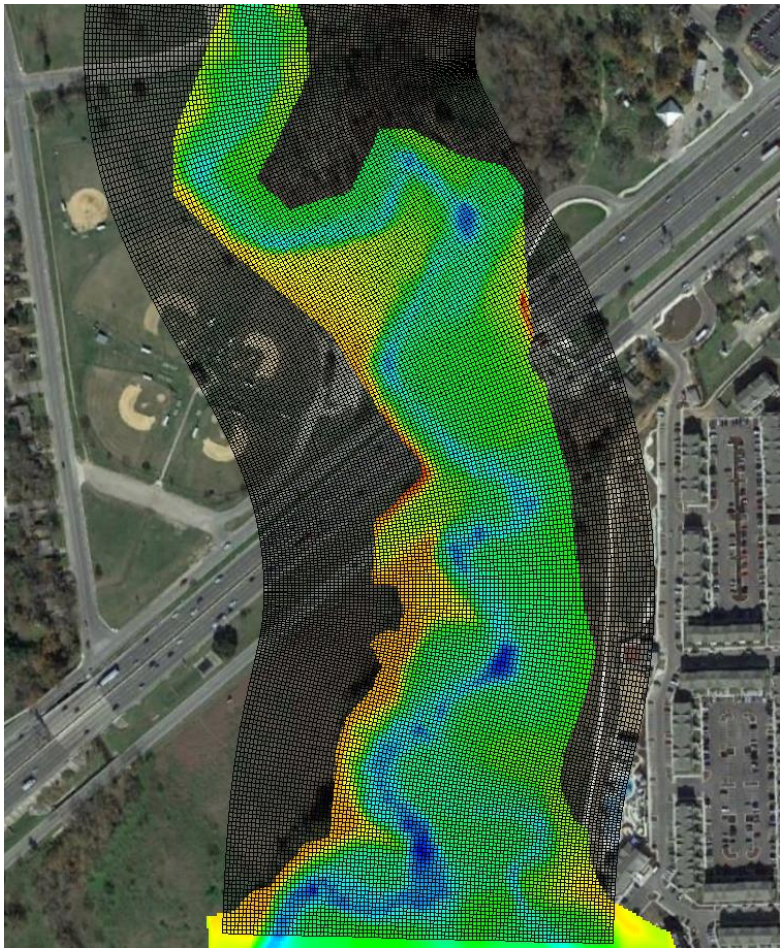


Figure 18: 2D Mesh and Base Topography Data.

Boundary conditions for the two-dimensional analysis were developed based on the one-dimensional HEC-RAS model for the reach. An existing "Dam In" model was built from the base topography data, and a proposed "Dam Out" model was built with the removed Capes Dam. Dredging of the Mill Race was not included in this model run.

RESULTS

Both the existing and proposed models were run with flows of 100cfs, representing low flow conditions, and 173cfs, the median flow for the reach. The water surface extents and depths were compared, as shown in Figure 19 and 20.

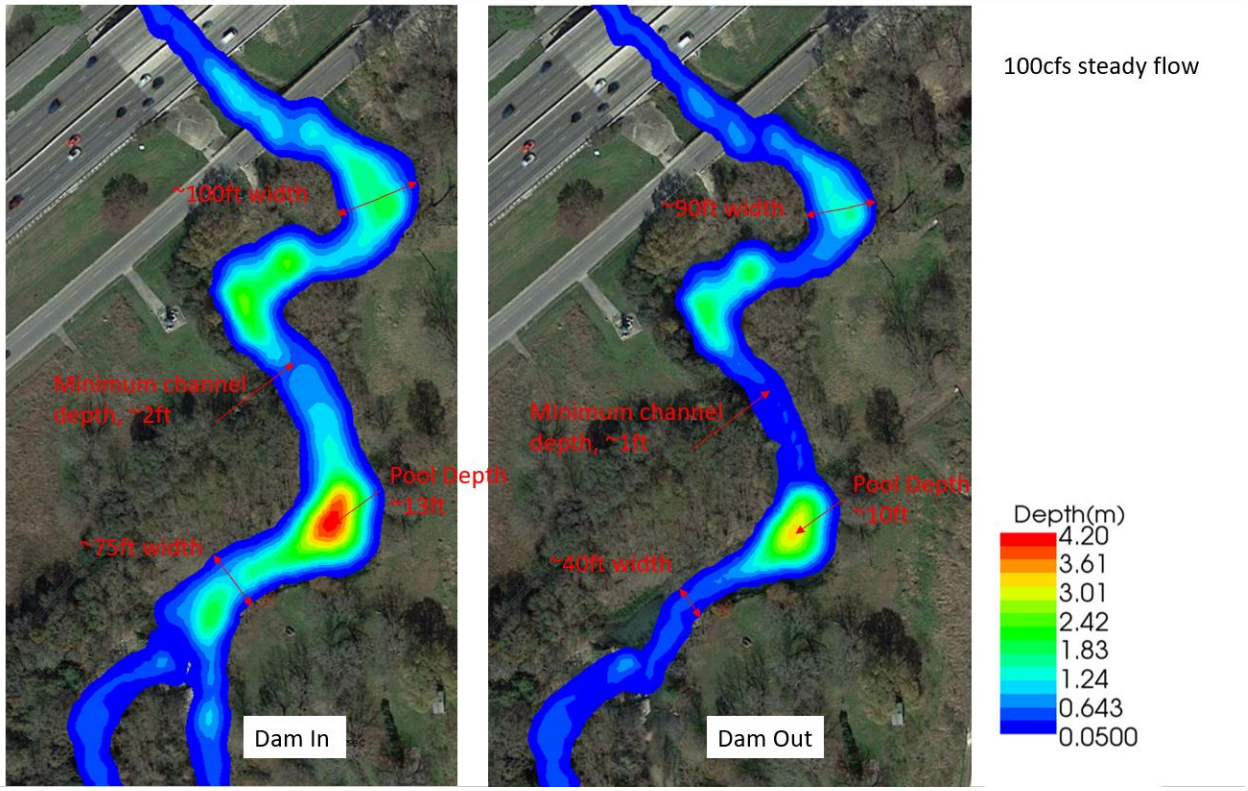


Figure 19. Existing and Proposed Conditions models with a discharge of 100cfs

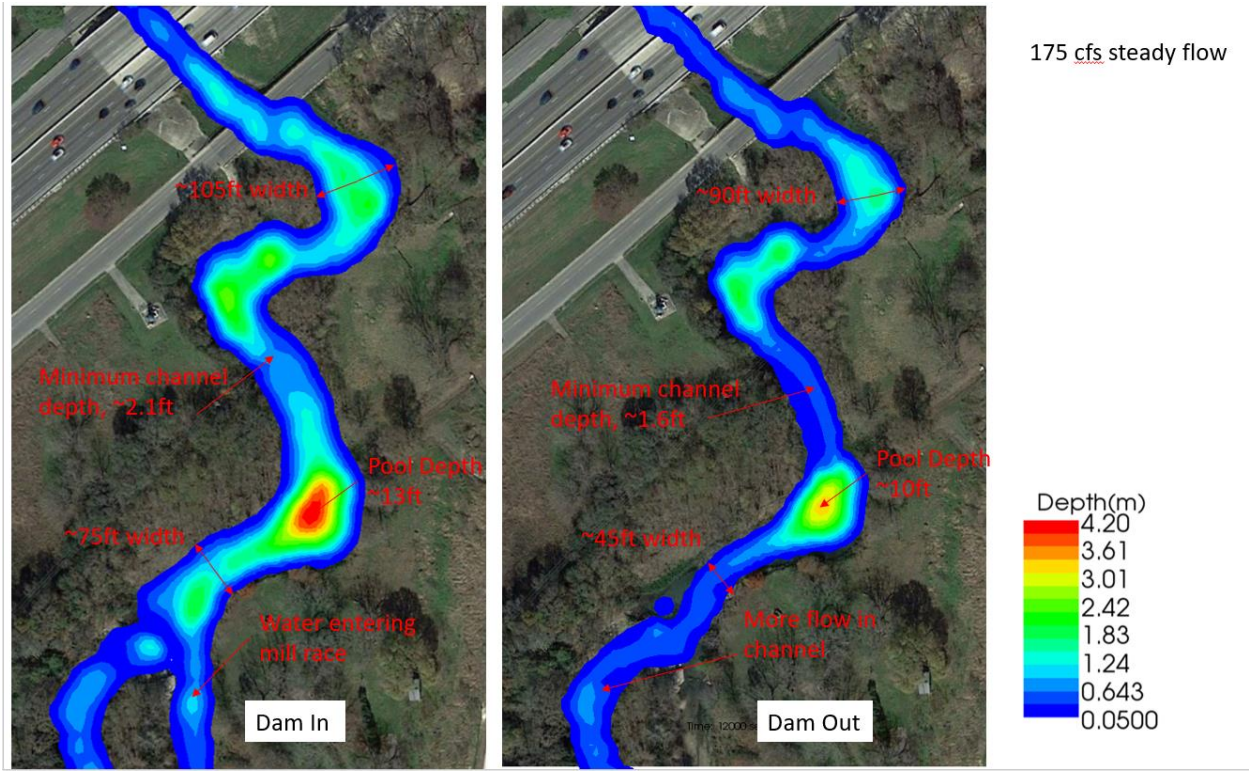


Figure 20 Existing and Proposed Conditions model with a discharge of 175cfs.

HIGH FLOW EVENT

Sediment accumulated upstream of the dam will mobilize as a result of increased channel slope from removal of Capes Dam. Channel forming flows or "bank full" discharges are generally assumed by fluvial geomorphologists to be 1.5yr to 2yr flow events. In order to investigate sediment transport and resulting river bed morphology change during such an event, the hydrograph of the high flow event that occurred on September 26, 2016 (Figure) was routed through the modeled reach with "Dam Out" topography.

For this analysis, a uniform grain diameter of 0.55mm was modeled. The bed morphology change modeled here is based on bed load sediment transport, computed using the Ashida and Michiue formula, and the vector of bedload transport uses the Watanabe formula.

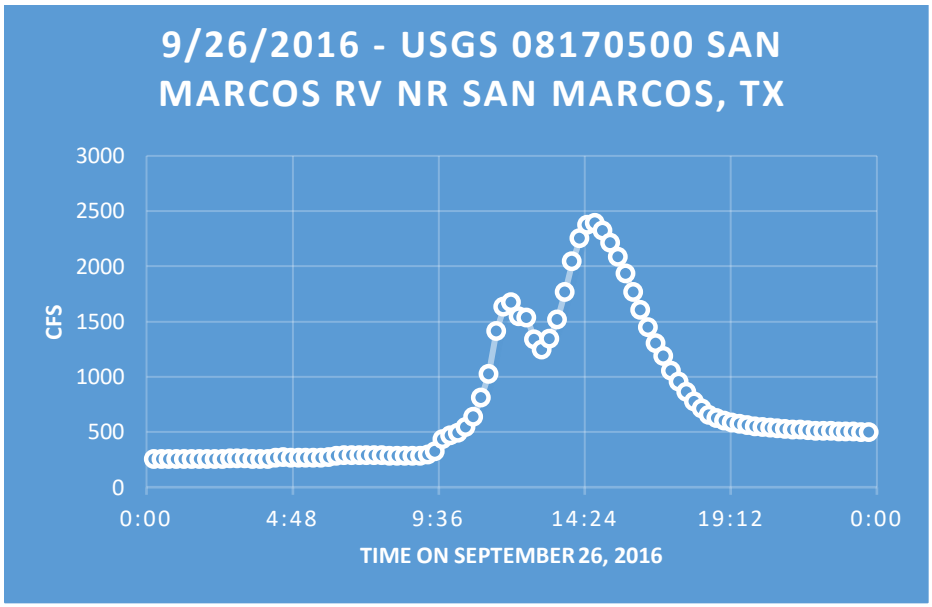


Figure 21 San Marcos River Flow Hydrograph for September 26, 2016

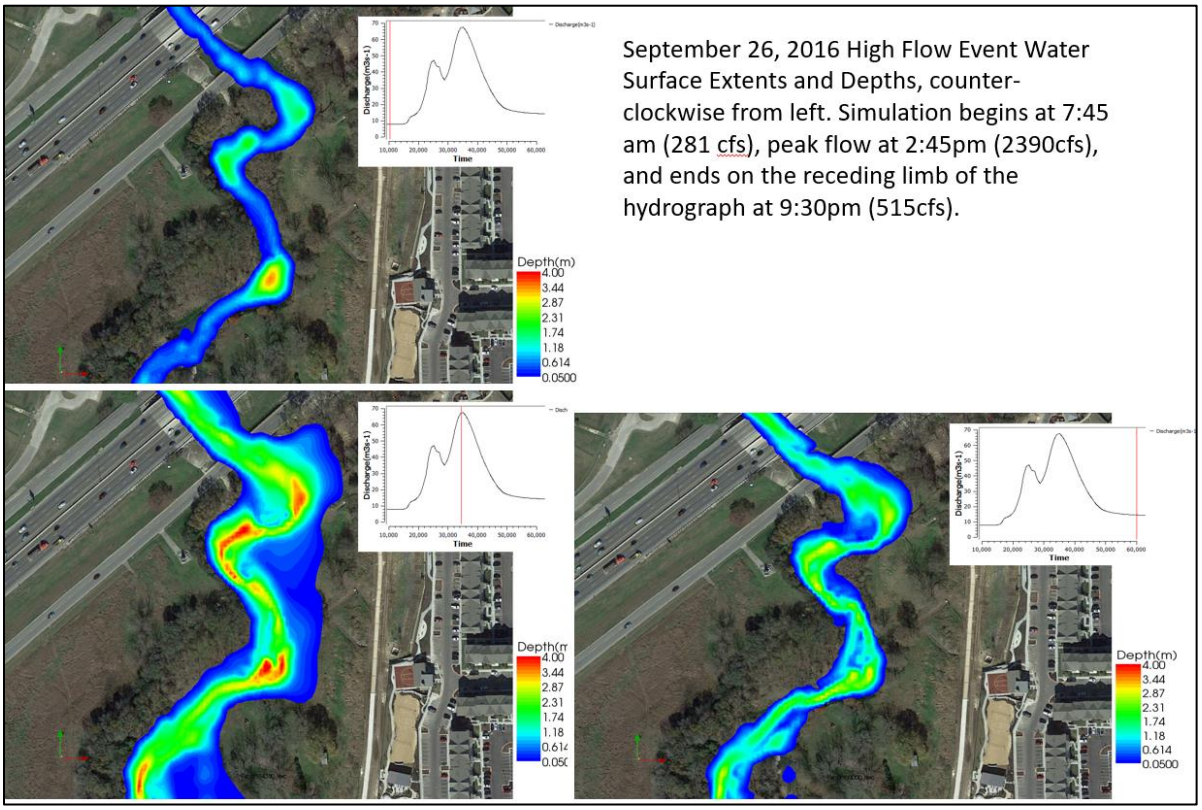


Figure 22. Modeled depths and water surface extents

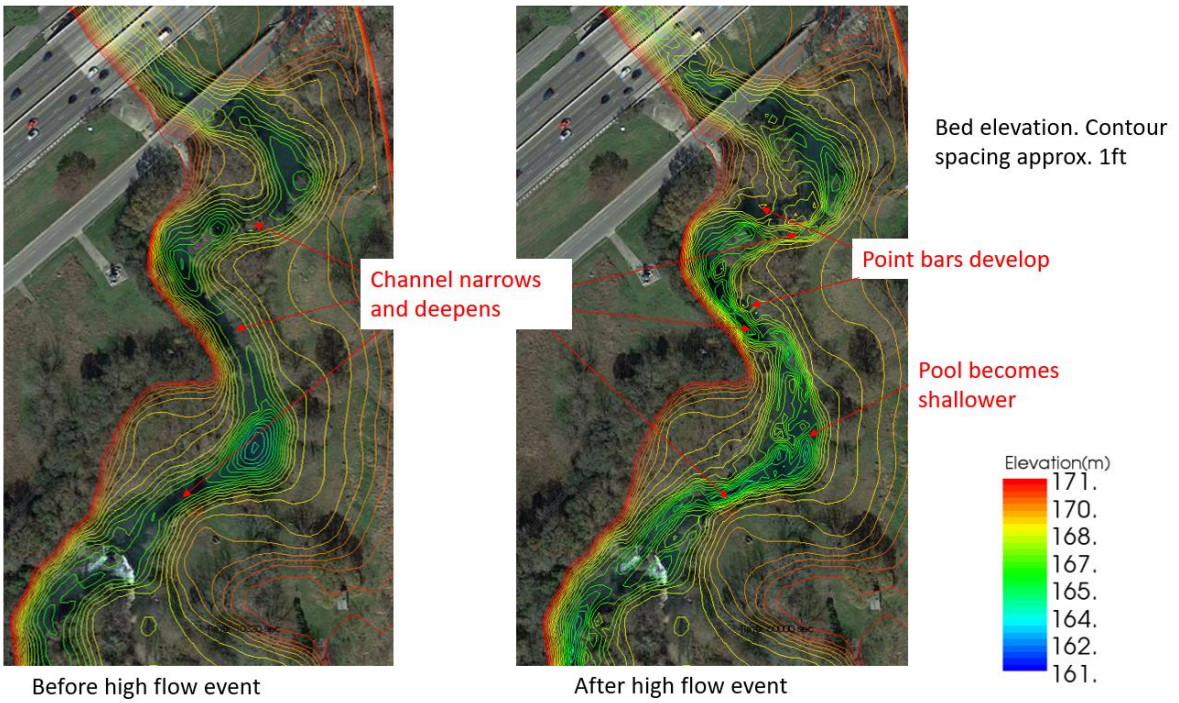


Figure 23. Riverbed morphology change.

With Capes Dam removed, it can be seen that after a channel forming event such as the flow that occurred on September 26, 2016 there will be upstream impacts to the riverbed. As the river erodes the sediment deposited in the existing reservoir, the channel will deepen. The eroded sediment is expected to deposit as point bars on the downstream end of the inside river bends, narrowing the active channel.

Conclusion

The Capes Dam removal proposed in this report accomplishes many desired objectives. The existing public safety hazard that the dam poses will be eliminated as well as many adverse impacts the dam has on natural habitats. During low flow, all discharge will flow through the main San Marcos river channel, which was a specific concern for the endangered species in the project reach. The Mill Race will be retained and enhanced as a recreational amenity even during low flow events. The existing backwater upstream of Capes Dam will become a more natural river channel with adequate flow depths for recreationalists. This dam removal addresses public safety and environmental concerns while enhancing recreation in the reach and creating an amenity for the community.

References

[1] Effects of Changing Height of Cape's Dam on Recreation, Texas Wild Rice and Fountain Darter Habitat in the San Marcos River, Textas, Dr. Thomas B. Hardy and Dr. Nolan Raphelt, October 12, 2015.
[2] Cape Dam and Mill Race Assessment, Dr. Thomas B. Hardy, City of San Marcos

COMMUNITY SERVICES

MEMO

TO: **Rodney Cobb, Executive Director of Community Services**
COPY: Steve Parker, Assistant City Manager / CFO
FROM: Drew Wells, Assistant Director of Community Services
DATE: January 11, 2019
RE: **Update on Cape's Dam**

SUMMARY

The purpose of this memorandum is to provide a summary of Cape's Dam. Since the City took possession of the Dam in 2014, the City Council authorized staff to coordinate with U.S. Fish and Wildlife to remove the structure. Attempts to obtain necessary permits for removal have failed. Hays County has approached the City with a request to pursue a partnership to have the Dam restored.

BACKGROUND

After taking possession of Cape's Dam in 2014, the City Council took action in March 2016, upon the recommendation of the Parks Advisory Board, for removal of the Dam. The City partnered with U.S. Fish and Wildlife Service (USFW) to have the Dam removed. USFW led the project efforts and was responsible for obtaining all necessary permits from entities with jurisdictional authority. The project stalled in late summer 2016 after objections from the Texas Historical Commission in approving the scope of the removal project. During this time, local groups opposed to the project organized and requested the City consider restoration of the Dam with hopes of maintaining historical significance of the structure and area and providing recreational opportunities in the river and Mill Race. Consequently, USFW discontinued the permitting process and has since severed their participation in the project including federal financial support.

In September 2018, the Historic Preservation Commission (HPC) directed Staff to add a Non-Consent agenda item to their September 6 agenda that would allow them to discuss and potentially consider initiation of a petition to designate Cape's Dam as a local historic landmark as outlined in Chapter 2, Article 5, Division 4 of the San Marcos Development Code. The Commission ultimately forwarded a favorable recommendation to the Planning and Zoning Commission to designate Cape's Dam as a local historic landmark. The Planning and Zoning Commission, however, rejected the HPC's recommendation and voted to deny the request. The item is scheduled for City Council consideration on January 29, 2019.

In the fall of 2018, city staff met with representatives from Hays County concerning their interest in having the Dam restored. The County, working with Kate Johnson, is interested in pursuing a partnership with the City to restore the Dam. They have indicated a desire to lead the project including design, construction, and long-term maintenance. They are interested in entering into the appropriate inter-local agreement to formalize the relationship that clearly defines the terms and responsibilities of each entity. The City budgeted $50,000 in 2015 CIP and $200,000 in 2016 CIP for Cape's Dam.

Approximately $73,000 has been expended for environmental studies. The County is requesting financial support consisting of the remaining funds as part of the proposed inter-local agreement. The County, in conjunction with participation from Ms. Johnson, would be responsible for all additional restoration costs.

Attached is a chronological history of events related to Cape's Dam. Staff is seeking direction from City Council concerning the possibility of entering into an agreement with the County for the restoration of Cape's Dam.

Capes Dam Time Line

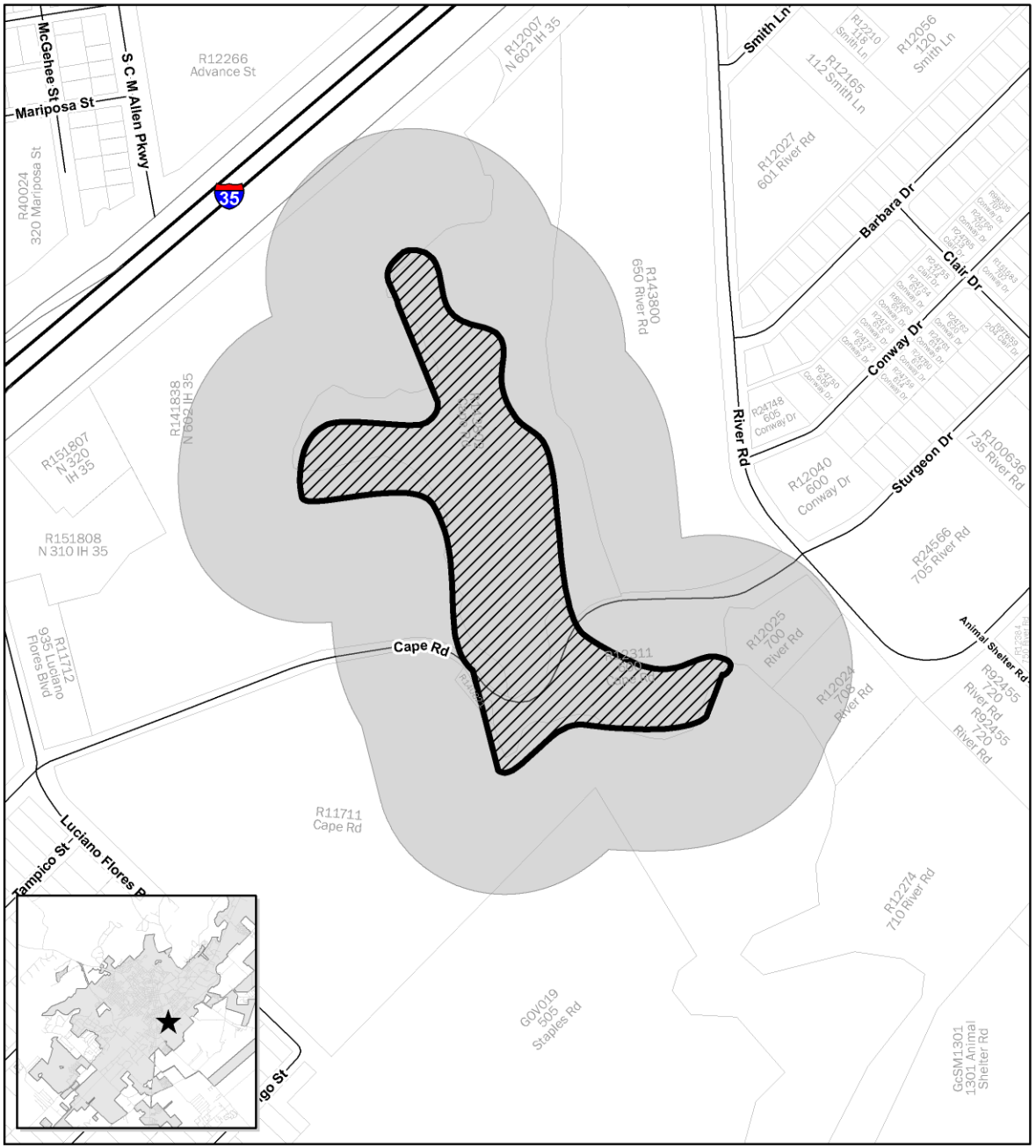
Tom Hardy does study on Capes Dam for USFW	January 2012
Deed for property and Dam Structure	June 18, 2014
Park area is cleaned and hazards are identified, and park rules established	June-July 2014 after deed
Evaluation of Capes Dam contract between the City and Tom Hardy	December 15, 2014
Sink hole near cape road dye tested by staff And covered to prevent someone from falling into. Half of water coming from Mill Race, half running clear undetermined where it is from.	January 2015
Presentation to Council by Tom Hardy Capes Dam Study	March 22, 2015
Memorial Day Flood	May 2015
Capes Camp closed to public for safety And clean up	May 2015
Cleanup of flood debris	June to September 2015
Tom Hardy Report: Effects of changing the height of Capes Dam on Recreation, Texas Wild Rice, and Fountain Darter habitat	October 12, 2015
All Saints Flood	October 2015
Park debris cleanup and damage review	November 2015 - January 2016
Council Approves Removal of Capes Dam	March 2016
Mike Montague with USFW begins permit process To remove dam.	April 2016
Permit to remove dam stalled after local Historical Commission's request of State Historical Commission Request for Consulting Party Status	July 17, 2016
Supplemental Capes Dam Mill Race Assessment	

Ordered from Tom Hardy	July 25, 2016
USWF unable to get permit for removal Option of removal is removed from table	2016
Additional hydraulic study of dam requested from REP engineering out of Boulder, CO.	March 2017
Hays county Historical Commission seeks Historical Designation and local “Save the dam” group organizes To get council to rebuild the dam	2015-2018
Historic Preservation Committee declares Capes Dam as Local Historic Landmark	2018
City of San Marcos P&Z commission rejects Local Historic Landmark Status	2018
Hays County and Kate Johnson with the County Historical Commission request to lease and Manage the capes dam from the City of San Marcos In hopes of raising funds to restore the dam.	2018

END

ORDINANCE 2019-04
ZC-18-20 (Thompson/Cape Dam and Ditch Engineering Structure)

Hold a public hearing and consider a request by the City of San Marcos to establish a local historic landmark for Thompson/Cape Dam and Ditch Engineering Structure located near the intersection of Cape Road and the San Marcos River.



HPC-18-30
Capes Dam
Landmark Designation
Map Date: 9/21/2018

Subject Property
400' Buffer
Parcels

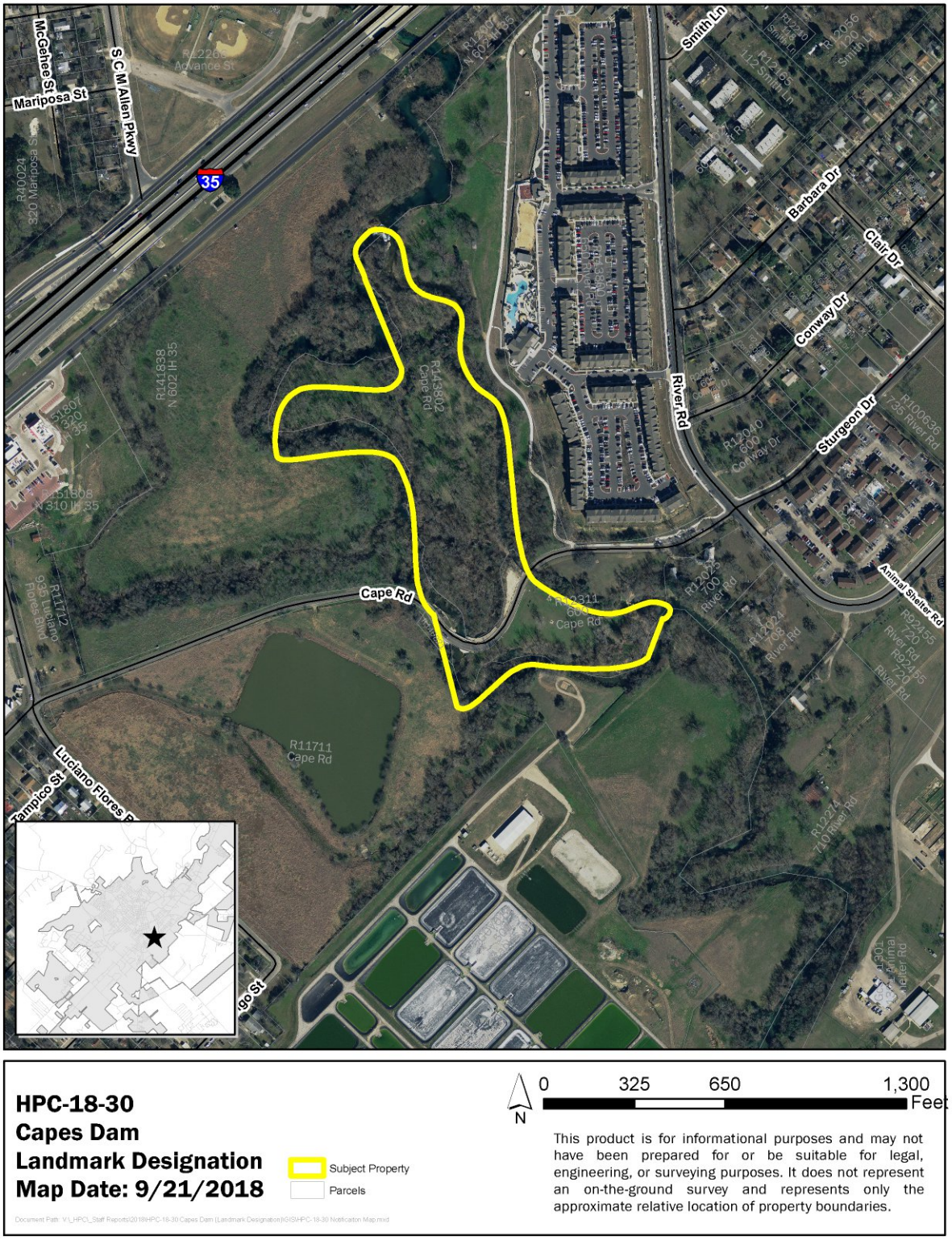
N
0 325 650 1,300 Feet

This product is for informational purposes and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. It does not represent an on-the-ground survey and represents only the approximate relative location of property boundaries.

Document Path: V:_HPC_Staff Reports\2018\HPC-18-30 Capes Dam (Landmark Designation)\GIS\HPC-18-30 Notificaiton Map.mxd

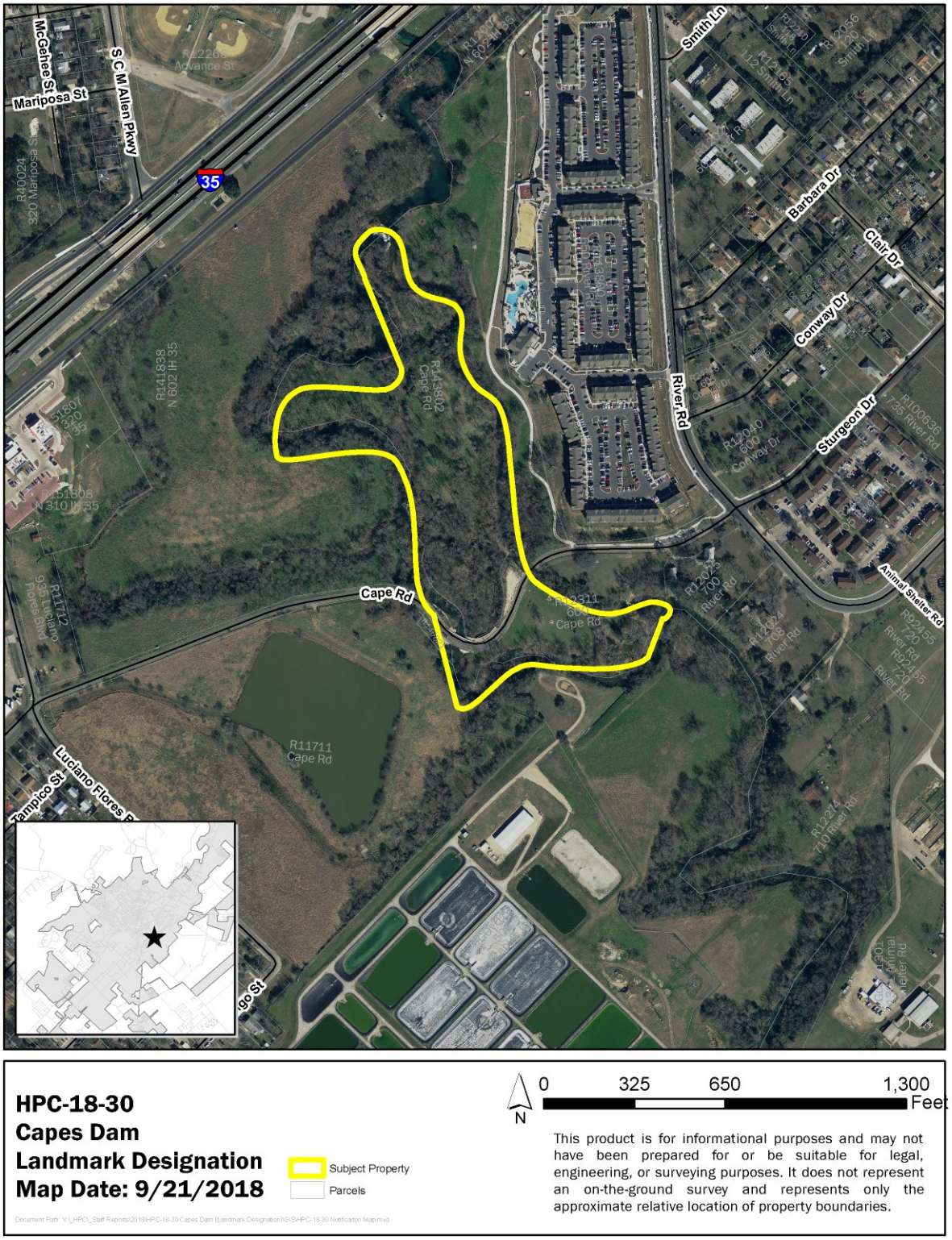
Location & Summary

- Located along the San Marcos River, east of IH-35
- Constructed in 1867 to divert water from river
- Three main components: dam, ditch, and wheel pit & machinery platform



History

- Determined eligible for listing on National Register of Historic Places (NRHP) in 1985
- Previous efforts to remove the dam with full financial support from the U.S. Fish and Wildlife Service (2016)
  - U.S. Fish and Wildlife has withdrawn all financial support for project
  - Permitting process for removal of the Dam is no longer occurring
- City is reassessing options and coordinating with Hays County to explore options
- October 18, 2018 Discussion at Parks Board - for informational purposes, not required by Code, no action taken



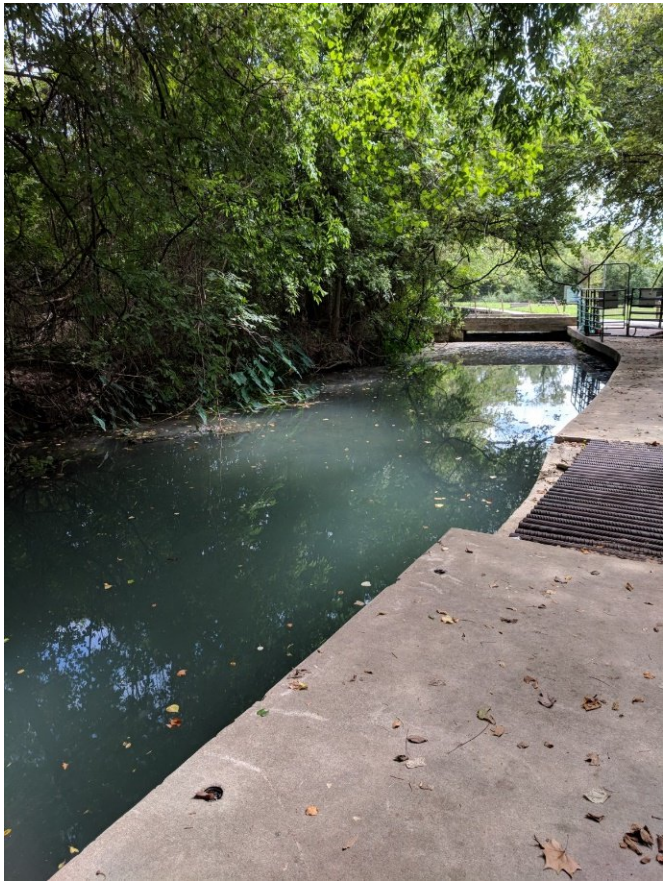
History

- Texas trinomial number associated with site - 41HY164
  - Archeological site has been previously identified which may be eligible for listing as a State Antiquities Landmark (SAL) or National Register of Historic Place (NRHP)

- Senior Archeologist with Hicks & Company (consultants conducting My Historic SMTX) confirmed site is NRHP-listed as a district (as an archeological site)

- Coordination with THC and likely US Army Corps of Engineers required if project undertaken impacts or involves property within the district boundary

Mill Race & Machinery



Staff Recommendation:

At their October 4, 2018 Regular Meeting, the Historic Preservation Commission recommended ***approval*** *of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark (4-2).*

At their November 27, 2018 Regular Meeting, the Planning and Zoning Commission recommended ***denial*** *of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark (5-4).*

- Staff provides this request to the Council for your consideration and Staff recommends **approval** of designating Thompson/Cape Dam and Ditch Engineering Structure as a local historic landmark as it meets the criteria of 2.5.4.5 of the San Marcos Development Code.

CITY COUNCIL WORK SESSION

Cape's Dam Work Session

Tuesday, June 18, 2019

Presentation

Staff presentation/discussion regarding the status of Cape's Dam and possible partnership opportunities with the County and the Hays County Historical Commission.

Background

January 15, 2019: City Council briefed in executive session to discuss possible partnership opportunities with Hays County and the Hays County Historical Commission.

January 29, 2019: City Council considered an item designating Cape's Dam as a historic landmark. This action was postponed for up to 6 months while staff gathered more information related to the project.

History

- In 2014, City Council approved Planned Development District (PDD) zoning for the Woodlands development project, and received 20 acres of dedicated parkland along the San Marcos River, which includes Capes Dam and the Mill Race.
- In October 2014, the Parks and Recreation Advisory Board requested a study of safety and environmental issues associated with the Dam.
- Scientific evaluation was completed which recommended the removal of Cape's Dam and filling of the Mill Race.

History

- On March 15, 2016, City Council approved a motion to remove Cape's Dam.
- On June 21, 2016, a stakeholder meeting was held at fish hatchery, including US Fish and Wildlife Service (USFWS), Texas Historical Commission (THC), US Army Corps of Engineers (USACE), Hays County Historical Commission, and the City.
- THC stated that the dam, mill race and associated structures retain sufficient historic integrity to remain eligible for listing in the National Register. USFWS stated that leaving the dam in place, in whole or in part, would make the City ineligible for USFWS funding for the project.

History

- On August 16, 2016, Council received a presentation from USFWS regarding the Cape's Dam removal planning and permitting process. The USFWS report states that the dam, "acts as a barrier to fish and other aquatic species" and "is in severe disrepair and poses a safety hazard to recreational users."
- Due to the conflicting positions of USFWS and THC, and the competing interests of other interested stakeholders, the City determines that the best course of action is to suspend the UFWS permit process and further investigate removal, repair and replacement options.

Key Issues

The property has a trinomial attached to it. What does this mean for the property?

- An archeological site has officially been recorded with the state. What is listed under the trinomial is smaller than the 17 acres noted in the 1985 National Register nomination form for Thompson/Cape Dam & Ditch Engineering Structure. An archeological survey would be required to determine the boundaries of the archeological site.
- Removal of or repairs to the dam and would fall under the Antiquities Code of Texas. Work must be coordinated with the THC.
- Archeological work would be required in advance of most projects.

Key Issues

How will designation of this property as a local historic landmark affect the property?

- Local Historic Landmark designation does not require the City to do anything to the dam or the associated structure(s).
- Ordinary repair and maintenance do not require a Certificate of Appropriateness.
- Exterior changes in material or design, including demolition, must be approved through a Certificate of Appropriateness (COA) by the Historic Preservation Commission (HPC).

Key Issues

Can Certificates of Appropriateness for City-owned property designated as historic landmarks or located in local historic districts be appealed to City Council?

- The current San Marcos Development Code requires that appeals of Certificates of Appropriateness are heard by the Zoning Board of Adjustments (ZBOA).

- City Council has directed that Section 2.5.5.5 of the San Marcos Development Code be reviewed with the upcoming annual update to the Code.

Hays County/Hays County Historical Commission Proposal

- Hays County, in partnership with the Hays County Historical Commission would like the City to consider a proposal that would:
  1. Transfer responsibility for operation and maintenance of the dam and mill race structures, and surrounding areas of City-owned park land, under agreement with the City.
  2. Hays County Historical Commission has stated their intent to secure funding for restoration of the dam structure, and ongoing operations and maintenance.
  3. County would work with the City on the scope and design of the proposed project.

Hays County Ownership Issues

- The County has also proposed transferring ownership of the Five Mile Dam Soccer Complex, Randy Vetter Park, and Dudley Johnson Park to the City. The City currently operates and maintains the Five Mile Dam Soccer Complex under (an expired) agreement with Hays County. Vetter and Johnson Parks are County-owned and maintained.

Components of the Proposed Project

- On June 4, 2019 the County approved a professional services agreement to design a conceptual master plan of Cape's Dam.
- Access points for park users to enter the river
- Proposed parking areas
- Picnic tables and recreation areas
- Trails along Thompson's Island and Stokes Park with interpretive signs about history and environment
- Safety of park users and emergency access
- Park Rules and Enforcement
- Neighboring developments and conflicts with access or alcohol.

Next Steps

- Work with the County and Hays County Historical Commission over the next couple of months to develop a proposed project
- Bring back costing data related to maintenance and operations of proposed park projects
- If Council approves of proposed project at a future council meeting, the City would negotiate an interlocal agreement designating the terms of the partnership

QUESTIONS?

Cape's Dam, Mill Race, Thompson's Island & San Marcos River

Visioning Study

City Council Work Session
October 15, 2019

vista Planning & Design

Presentation

Receive presentation from Hays County regarding Cape's Dam and seek Council direction on proposed project and possible partnership opportunities with Hays County and the Hays County Historical Commission.

Background

February 22, 2016: Capes Dam Workshop

- Presentation by Dr. Thomas Hardy
- Effects of changing height of Cape's Dam on recreation, Texas wild rice and fountain darter habitat (Hardy Report – 10/12/15)

August 15, 2016: Capes Dam Council Presentation

- Presentation by Mike Montagne, U.S. Fish and Wildlife Service
- Capes Dam Removal Analysis (Hydraulic Hardy Report – 3/27/2017)
- Supplement Cape's Dam and Mill Race Assessment (Supplemental Assessment-Hardy Report – 5/23/17)

January 11, 2019: Capes Dam Memo Staff Update

Background

January 15, 2019: City Council briefed in executive session to discuss possible partnership opportunities with Hays County and the Hays County Historical Commission.

January 29, 2019: City Council considered an item designating Cape's Dam as a historic landmark. This action was postponed for up to 6 months while staff gathered more information related to the project.

June 18, 2019: City Council briefed in Work Session on status of possible partnership opportunities with Hays County and the Hays County Historical Commission. Presentation from County on proposed project anticipated in fall 2019.

City Council Direction Needed

- Does Council want to proceed with an agreement with Hays County to partner on renovation/rehabilitation of Cape's Dam?

- Does Council want to explore the larger visioning/master plan concept with Hays County?

A note regarding this presentation:

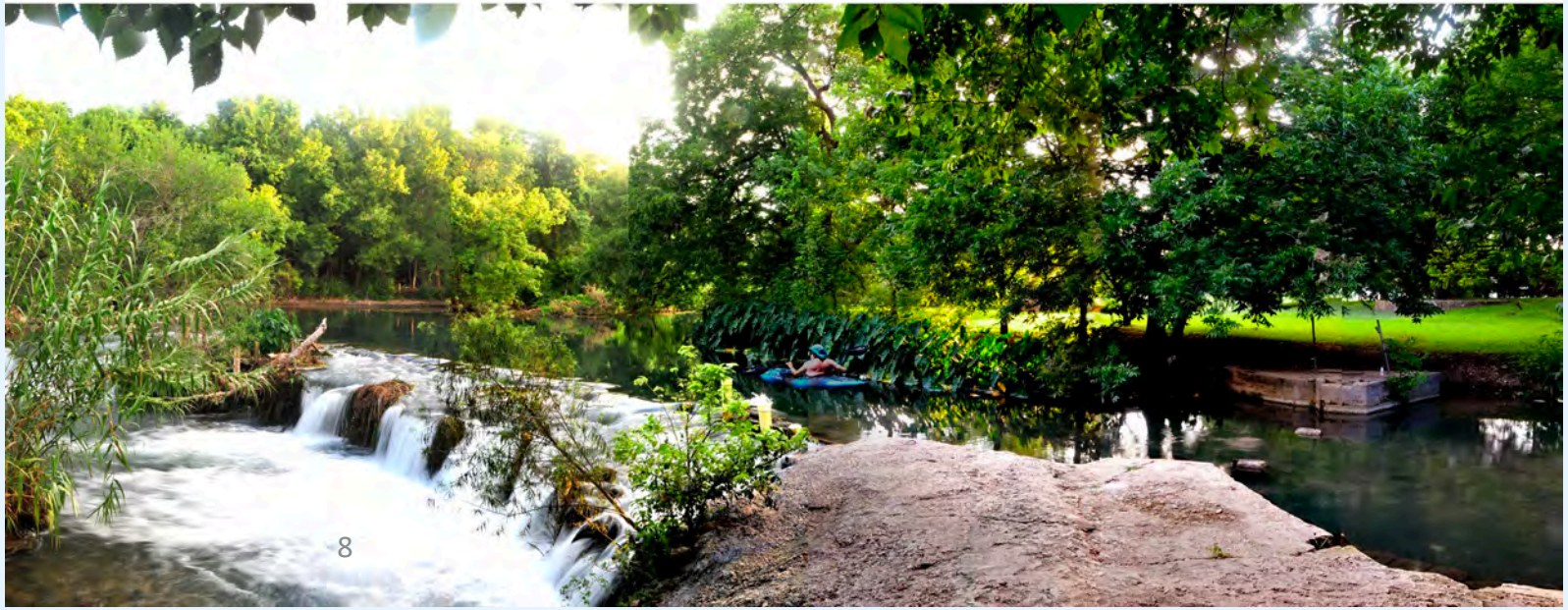
A master plan by its very nature and definition seeks a broad perspective from as many voices as possible to craft a plan and strategy that serves the most amount of residents in the best possible manner.

This presentation and the maps, comments, and strategies are conceptual only. The information contained in the work is only to explore the potential of a more comprehensive master plan.

The vision presented here;

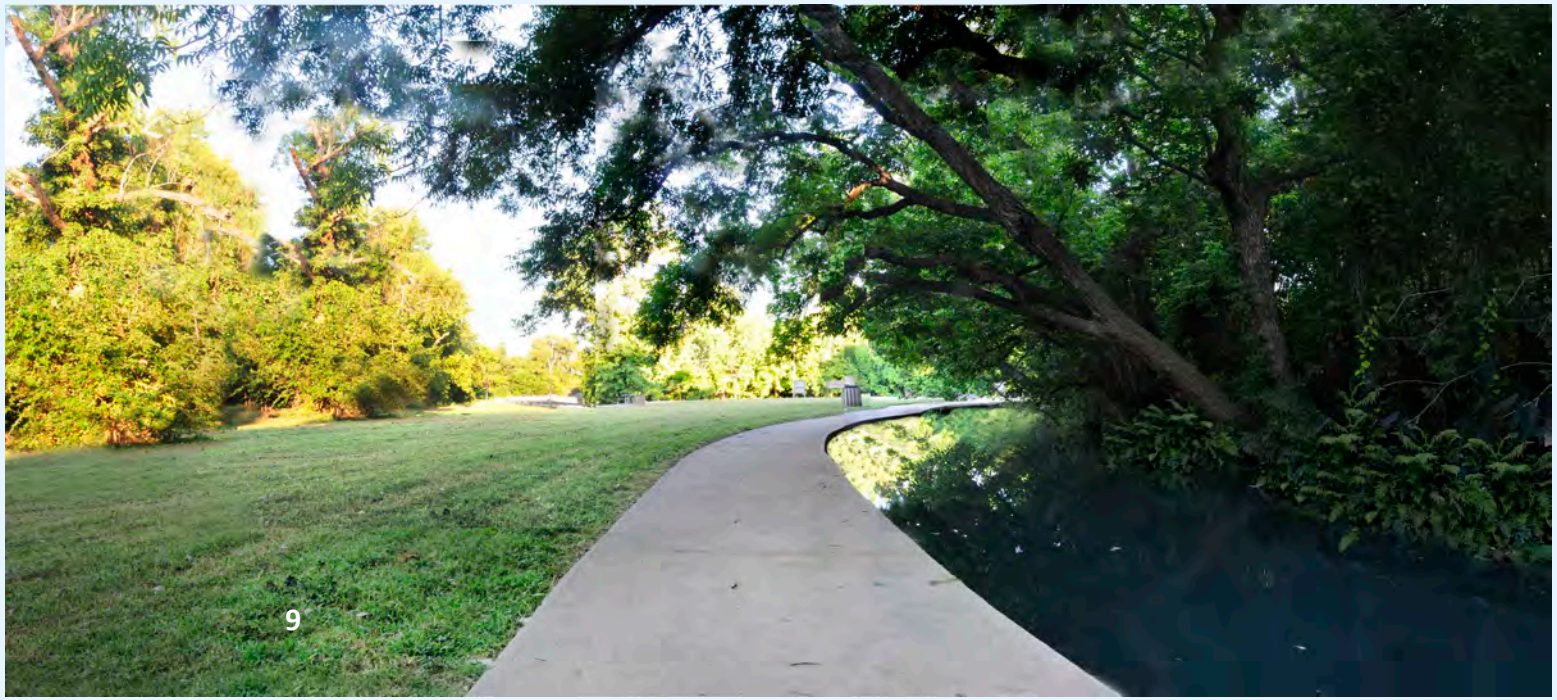
Seeks to promote the rehabilitation and interpretation of the Thompson/Cape dam, mill race, Thompson/Cape mill site and turbine structure, as a special place;

the very beginning of San Marcos industry.



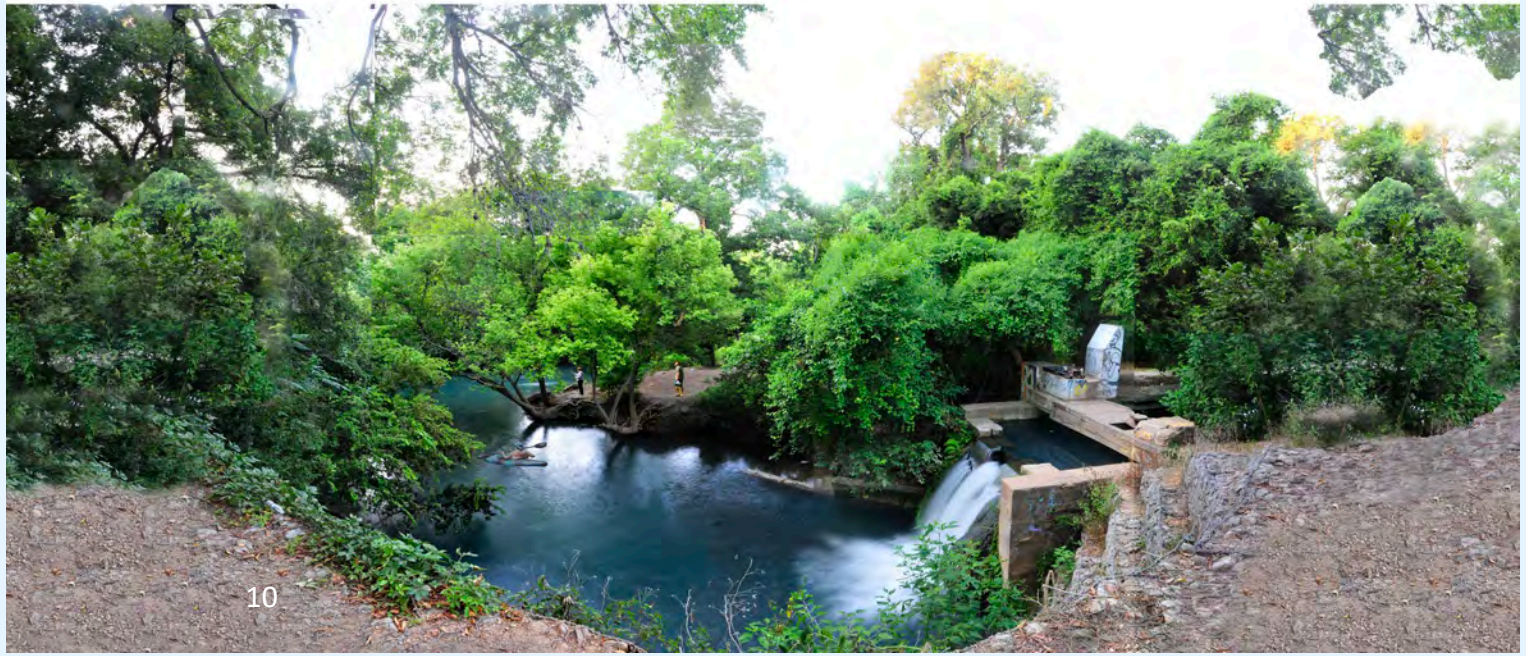
Thompson/Cape Dam & Mill Race Gate,

- Crib dam rehabilitation
- Limited River Access points
- Historic interpretation



Mill Race

- Higher water level in the Mill Race
- Safety access
- Passive, low level development



Thompson Dam & Mill Pond

- Safety railing & Access
- Observation platform
- Kayak ingress/egress
- Bank Stabilization

Overall Goals:

Overall Goals:

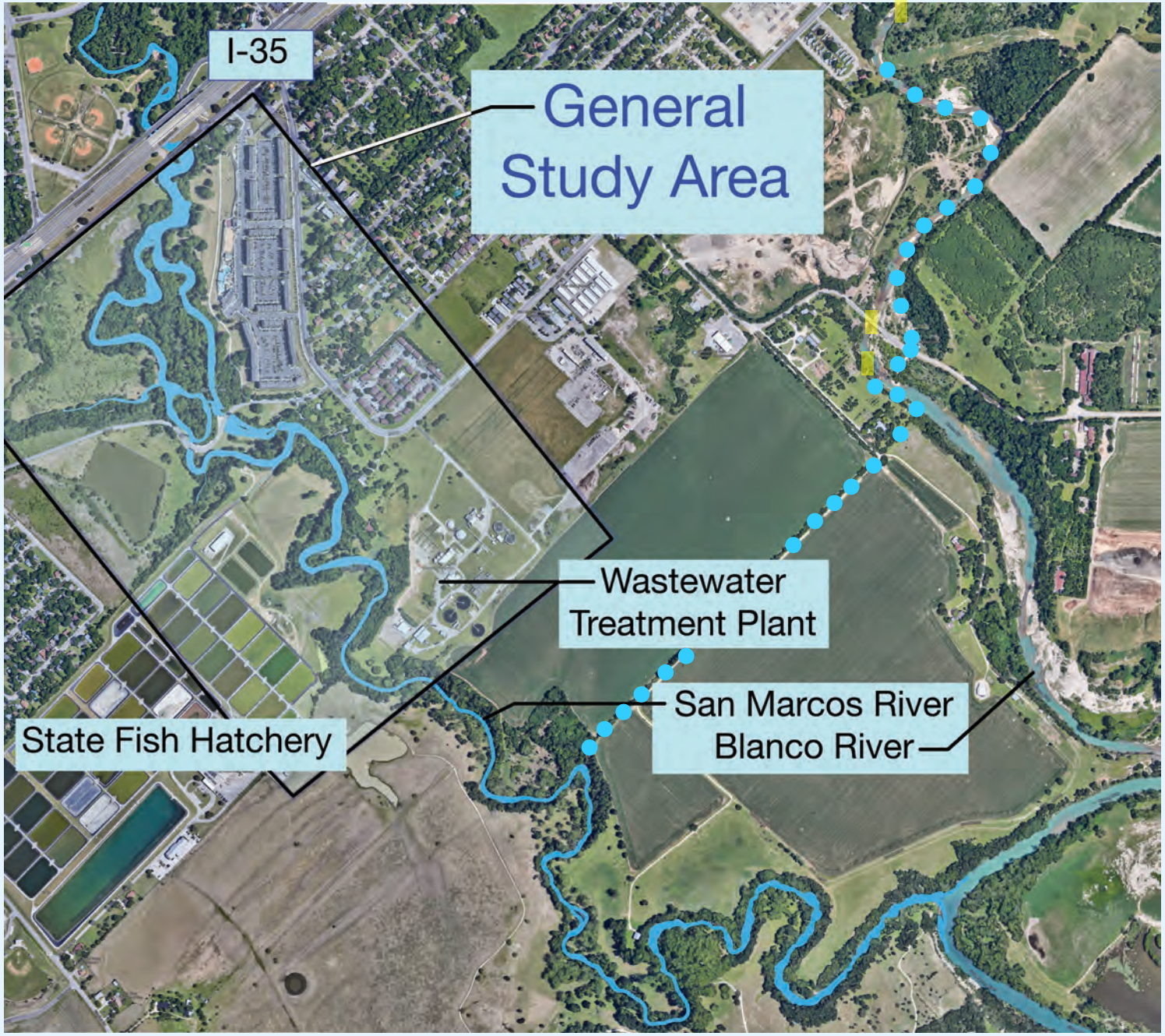
Prioritize historic features & environmental beauty

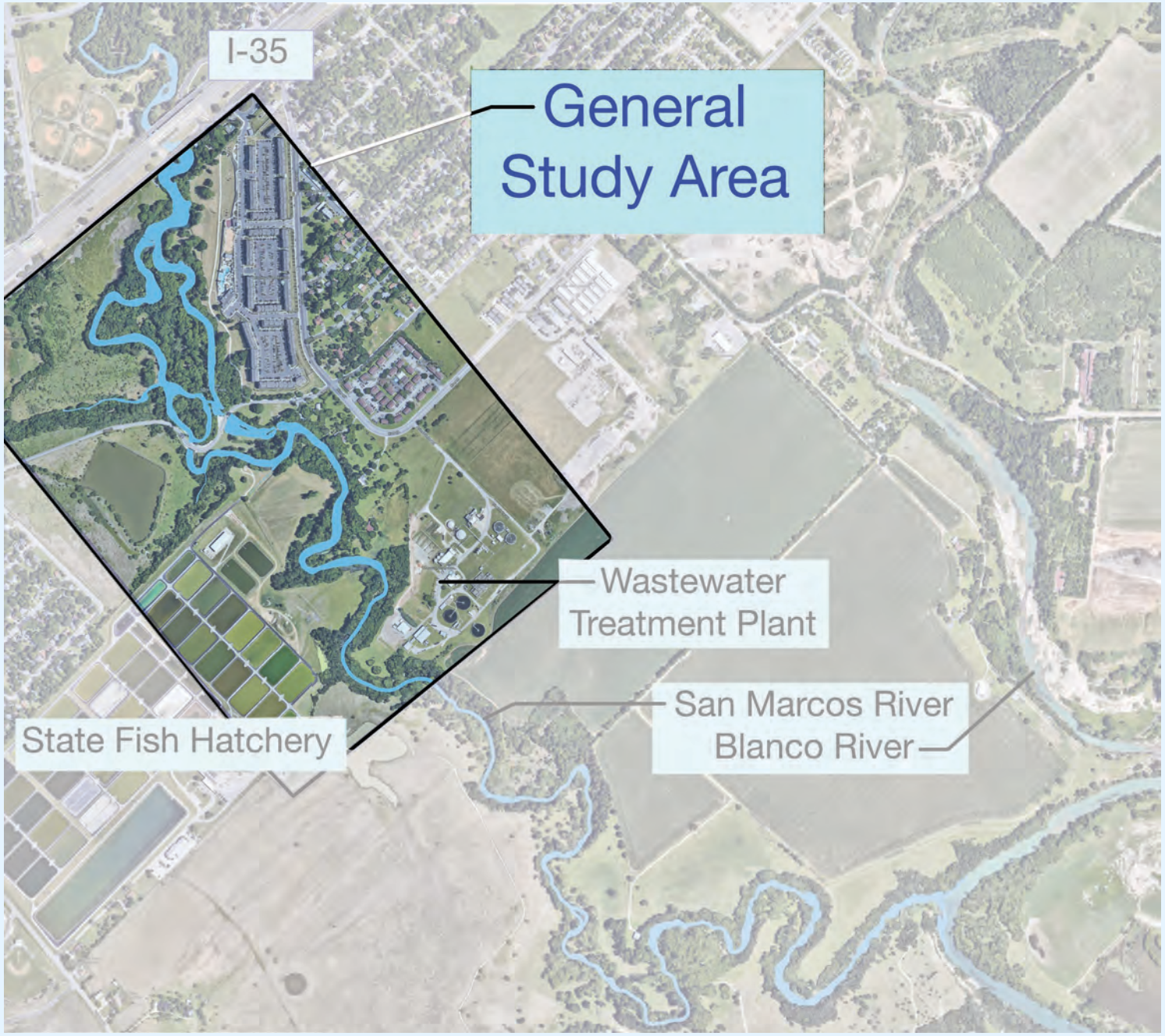
Overall Goals:

Achieving a balanced approach for historic structure rehabilitation, educational interpretation, and leisurely activities while preserving the ecological integrity of the San Marcos River through pragmatic conservation and restoration initiatives.

Providing a special & diverse asset to be enjoyed by San Marcos and Hays County residents, accessed by trails reaching out in all directions.

Providing comprehensive safety and access, focusing on ADA, EMS servicing, Trails, & Water Access.


I-35
General Study Area
Wastewater Treatment Plant
San Marcos River
Blanco River
State Fish Hatchery


I-35
General Study Area
Wastewater Treatment Plant
San Marcos River
Blanco River
State Fish Hatchery

#1 Achieving a Balanced Approach:

Vision Study Caters to Three Main Areas:

Environmental Integrity; A level of respect and action for the habitat and the sensitive species that exist there.

Historic Rehabilitation + Interpretation;
Understanding our history to learn and guide us forward.

Social and Leisure Access Equity;
New asset for an underserved area of San Marcos.

#1 Achieving a Balanced Approach:

Environmental Integrity; A level of respect and action for the habitat and the sensitive species that exist there.

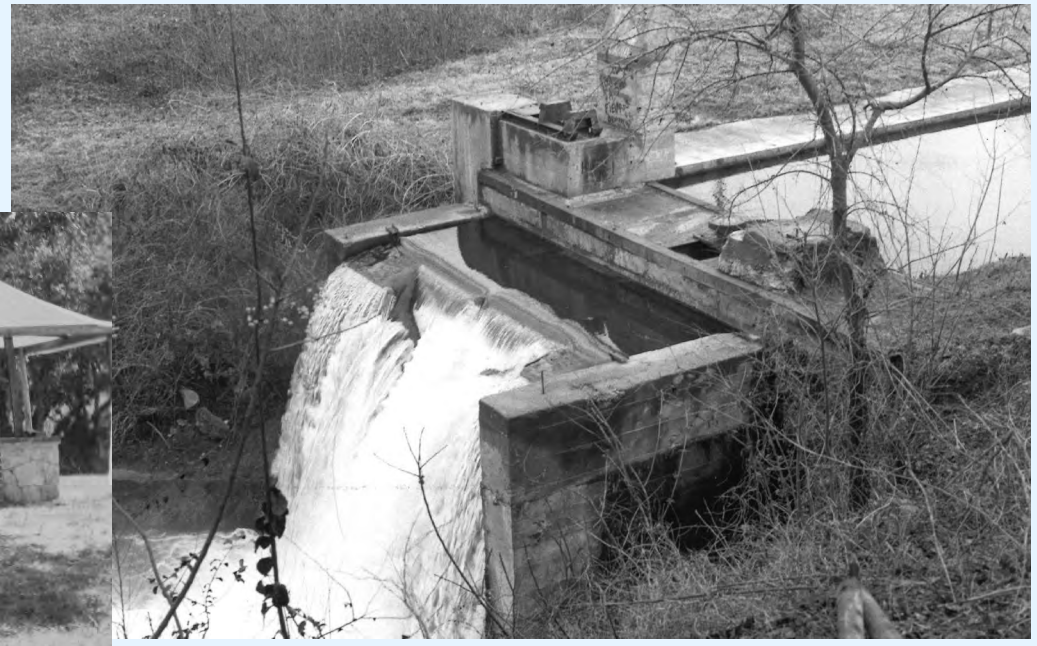
Analysis & Strategies

- Coordination with all necessary City and County departments
- Existing conditions assessment
- Flow-through design modeling of a rehabilitated Cape's Dam as part of the assessment informing design
- Post assessment after first phase improvements completed
- Monitoring to include recreational activity seasonal levels
- Establishment for strategies including river access points
- Terrestrial survey conducted on sensitive landscapes.
- Invasive species removal

#1 Achieving a Balanced Approach:

Historic Rehabilitation + Interpretation;

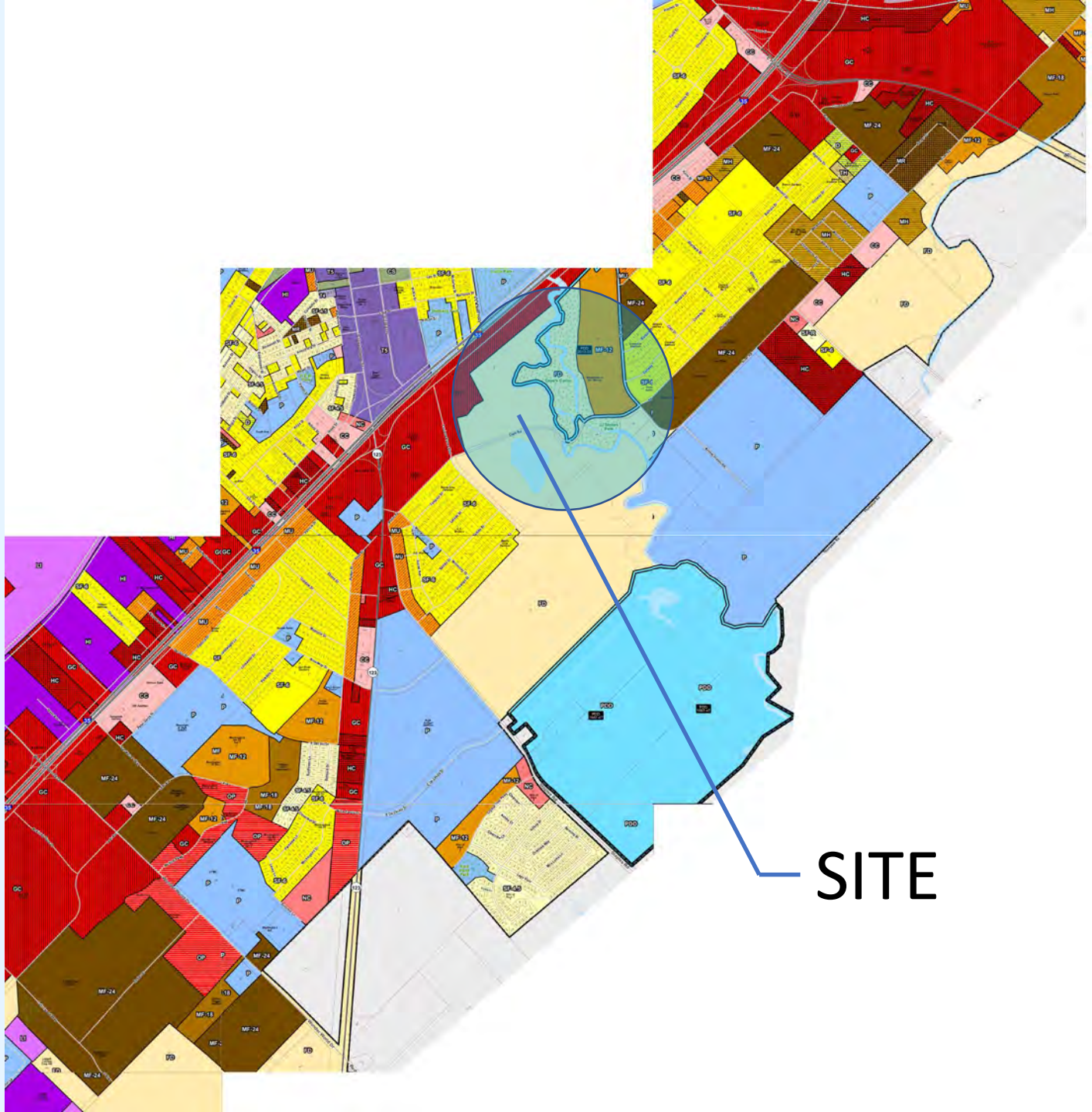
Understanding our history to learn and guide us forward.



#1 Achieving a Balanced Approach:

Social Equity;

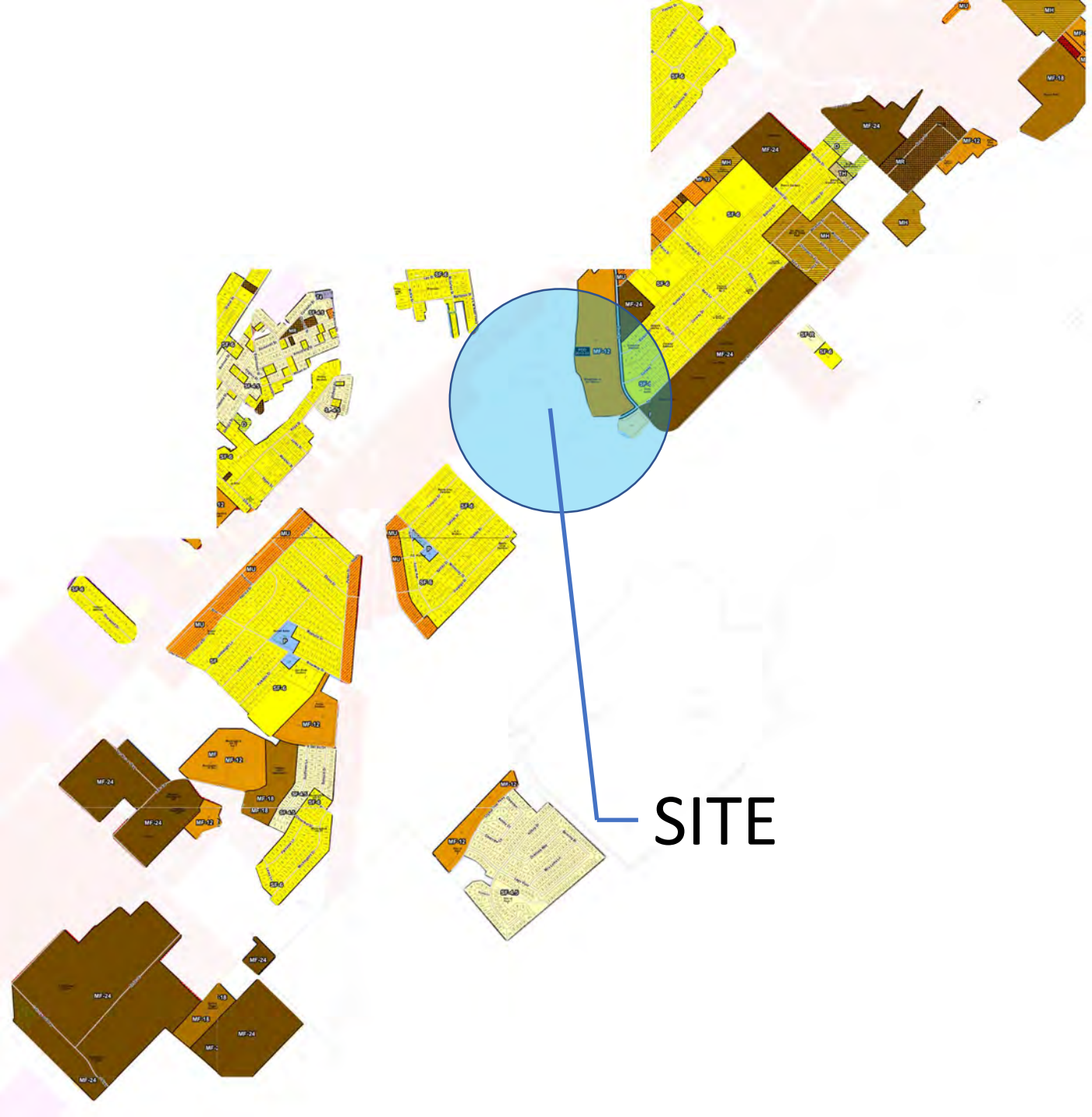
New asset for an underserved areas of San Marcos.



#1 Achieving a Balanced Approach:

Social Equity;

New asset for an underserved areas of San Marcos.

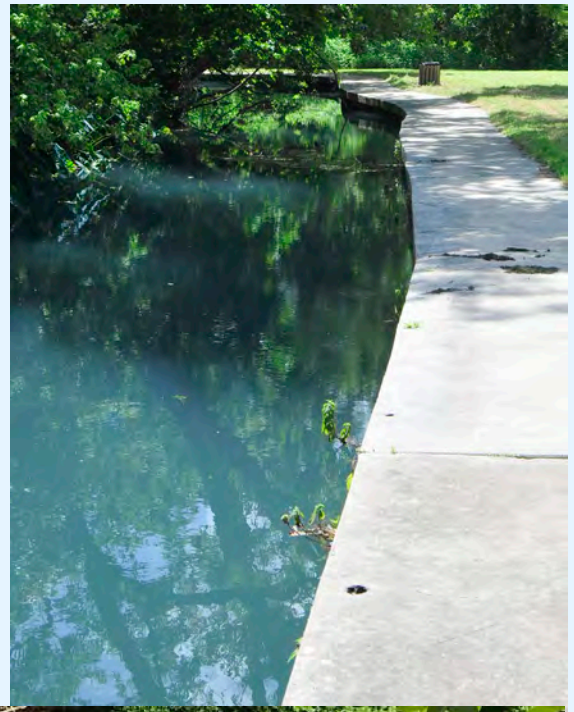


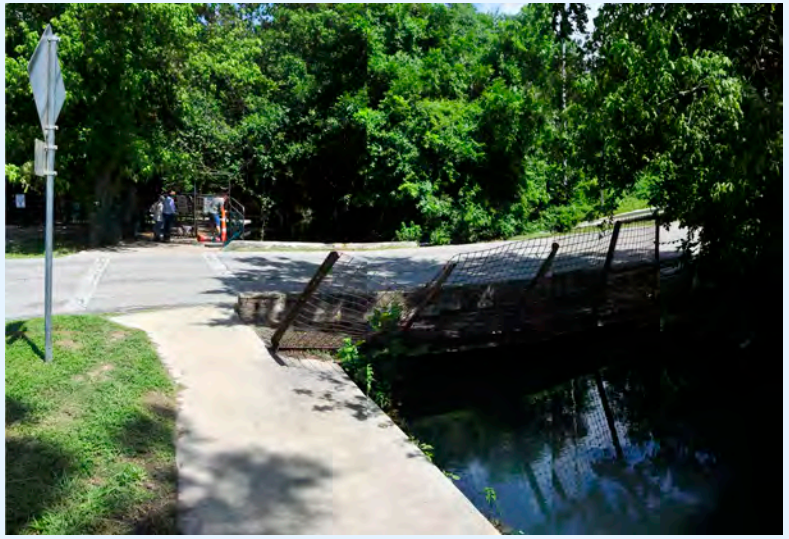
#2 Providing a Special and Diverse Asset:

- A place for historians to understand San Marcos History better
- A place for people interested in natural places for bird watching, hiking, relaxing, environmental study
- A place to learn about urban impacts on the environment
- A place to relax and enjoy being outdoors

#3 Access & Safety:

- Mill race water level to low; ingress/egress challenges
- Cape Road, sight distance, speed, dangerous edge.
- Waterfall; tragedy
- Cape's Dam; swimming and boating hazard
- ADA access upgrades on Cape's Road
- Comprehensive ADA review necessary





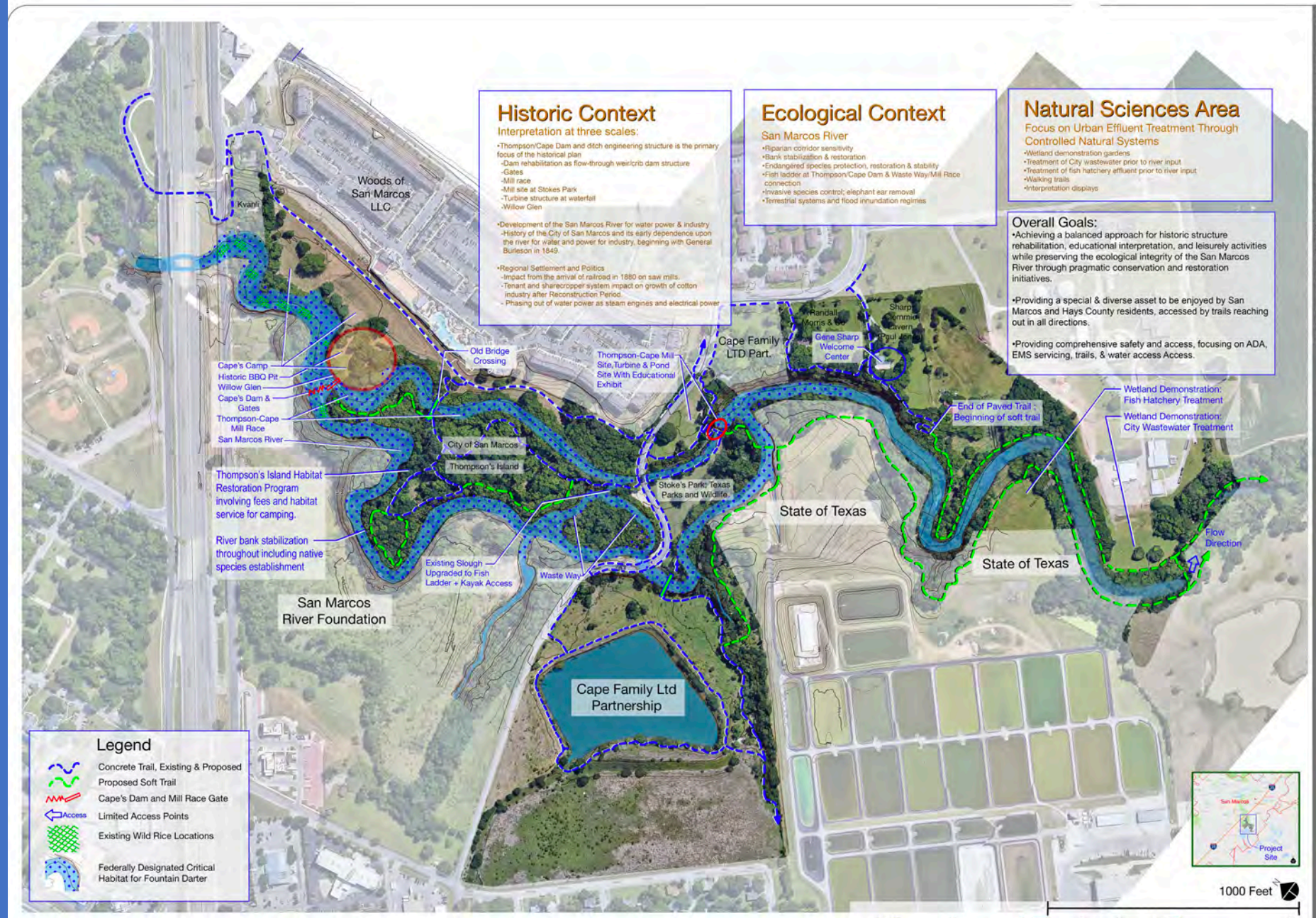
#3 Access & Safety:

A master planning process includes the lens of emergency services and stakeholder discussions.

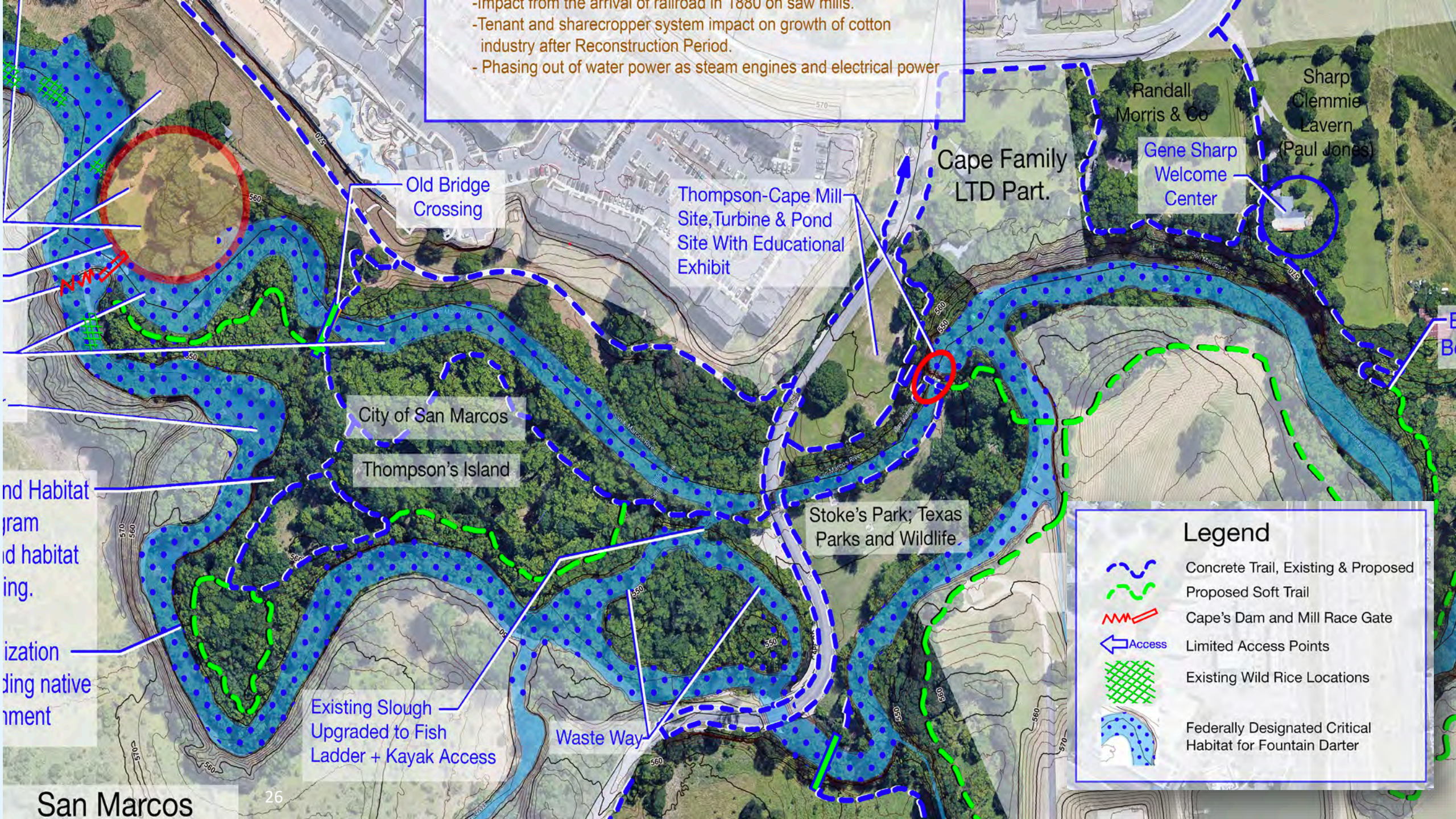
- Structural systems for natural grass EMS drives
- Emergency call boxes
- Safe ingress/egress places
- Traffic calming
- Addressing existing unsafe conditions
- Lighting as appropriate

First Map:

Historic & Ecological Framework



Historic and Ecological Framework


-Impact from the arrival of railroad in 1880 on saw mills.
-Tenant and sharecropper system impact on growth of cotton industry after Reconstruction Period.
- Phasing out of water power as steam engines and electrical power
Old Bridge Crossing
Thompson-Cape Mill Site,Turbine & Pond Site With Educational Exhibit
Cape Family LTD Part.
Randall Morris & Co
Sharp Clemmie Lavern (Paul Jones)
Gene Sharp Welcome Center
City of San Marcos
Thompson's Island
Stoke's Park; Texas Parks and Wildlife
Existing Slough Upgraded to Fish Ladder + Kayak Access
Waste Way
Legend
Concrete Trail, Existing & Proposed
Proposed Soft Trail
Cape's Dam and Mill Race Gate
Access
Limited Access Points
Existing Wild Rice Locations
Federally Designated Critical Habitat for Fountain Darter
San Marcos

Ecological Context

- Riparian corridor sensitivity
- Bank stabilization & restoration
- Endangered species protection, restoration & stability
- Fish ladder at Thompson/Cape Dam & Waste Way/Mill Race connection
- Invasive species control
- Terrestrial systems
- Leave No Trace/ controlled access
- Regional Riparian Water Quality; Mitigation of City & State impacts
- Program of extensive assessment
- Program of conservation projects

Historic Context

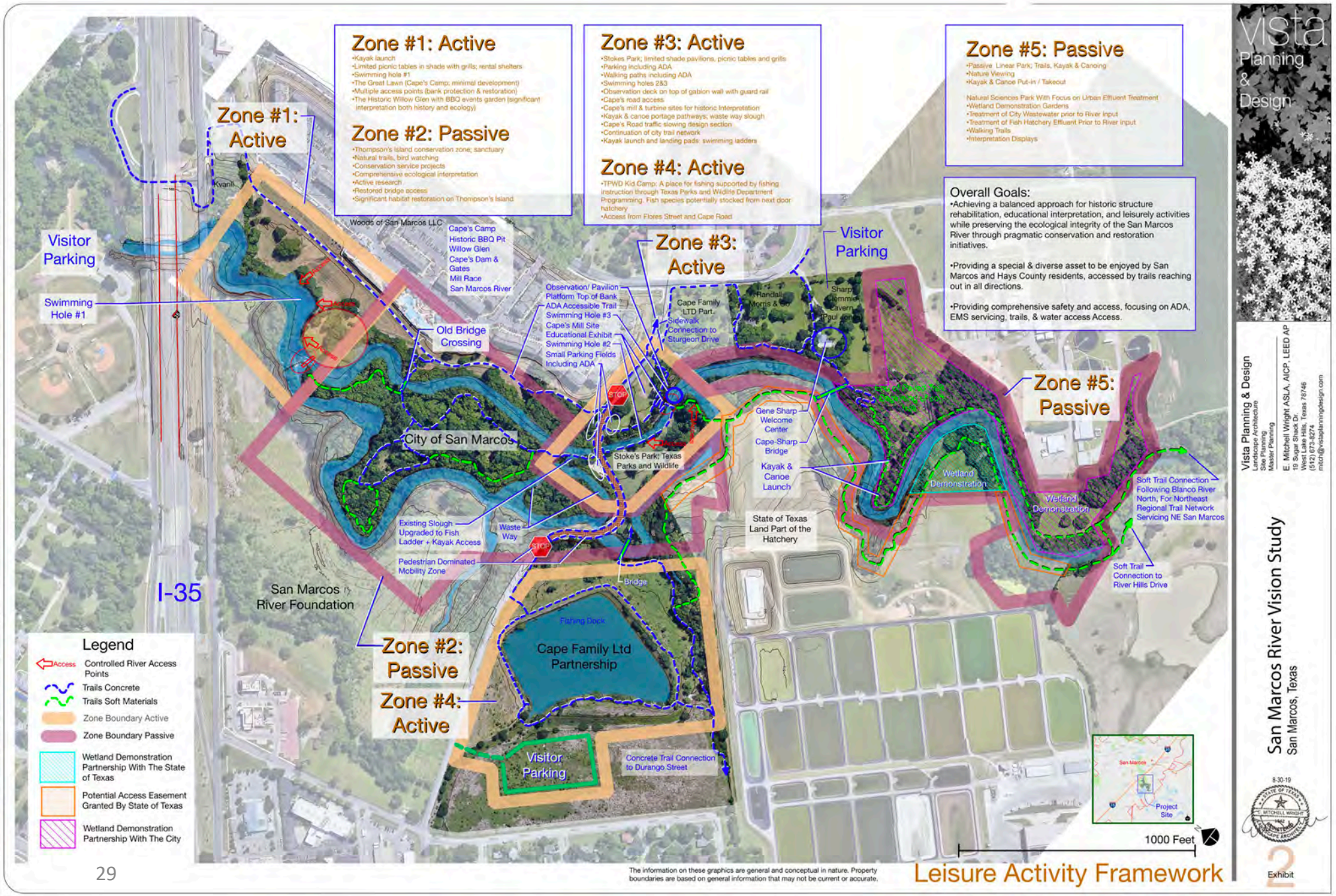
- Thompson/Cape Dam and ditch engineering structure is the primary focus of the historical plan
  - -Dam rehabilitation as flow-through weir/crib dam structure
  - -Mill site, gates, mill race, turbine structure/ waterfall, mill pond
- Development of the San Marcos River for water power & industry
- History of regional settlement and politics; The industrial beginnings of San Marcos
- Program of assessment and comprehensive interpretation

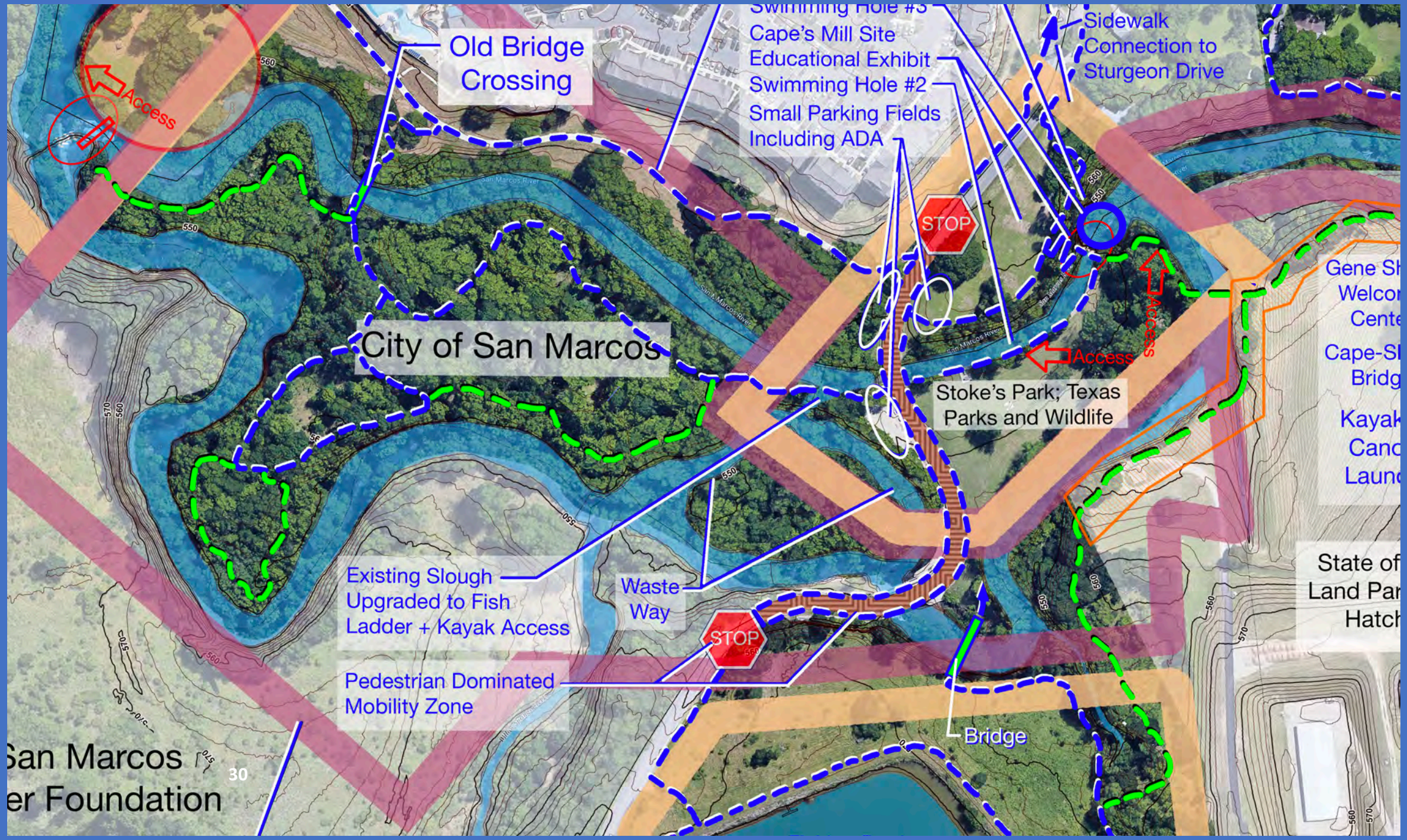
Natural Sciences Park

- Wetland demonstration gardens
  - -Treatment of City wastewater
  - -Treatment of fish hatchery effluent
- Walking trails
- Program of Education
  - -Interpretation displays

Second Map:

Leisure Activity Framework


Zone #1: Active
•Kayak launch
•Limited picnic tables in shade with grills; rental shelters
•Swimming hole #1
•The Great Lawn (Cape's Camp; minimal development)
•Multiple access points (bank protection & restoration)
•The Historic Willow Glen with BBQ events garden (significant interpretation both history and ecology)
Zone #2: Passive
•Thompson's Island conservation zone; sanctuary
•Natural trails, bird watching
•Conservation service projects
•Comprehensive ecological interpretation
•Active research
•Restored bridge access
•Significant habitat restoration on Thompson's Island
Zone #3: Active
•Stokes Park; limited shade pavilions, picnic tables and grills
•Parking including ADA
•Walking paths including ADA
•Swimming holes 2&3
•Observation deck on top of gabion wall with guard rail
•Cape's road access
•Cape's mill & turbine sites for historic Interpretation
•Kayak & canoe portage pathways; waste way slough
•Cape's Road traffic slowing design section
•Continuation of city trail network
•Kayak launch and landing pads: swimming ladders
Zone #4: Active
•TPWD Kid Camp: A place for fishing supported by fishing instruction through Texas Parks and Wildlife Department Programming. Fish species potentially stocked from next door hatchery
•Access from Flores Street and Cape Road
Zone #5: Passive
•Passive Linear Park; Trails, Kayak & Canoing
•Nature Viewing
•Kayak & Canoe Put-in / Takeout
Natural Sciences Park With Focus on Urban Effluent Treatment
•Wetland Demonstration Gardens
•Treatment of City Wastewater prior to River Input
•Treatment of Fish Hatchery Effluent Prior to River Input
•Walking Trails
•Interpretation Displays
Overall Goals:
•Achieving a balanced approach for historic structure rehabilitation, educational interpretation, and leisurely activities while preserving the ecological integrity of the San Marcos River through pragmatic conservation and restoration initiatives.
•Providing a special & diverse asset to be enjoyed by San Marcos and Hays County residents, accessed by trails reaching out in all directions.
•Providing comprehensive safety and access, focusing on ADA, EMS servicing, trails, & water access Access.
Zone #1: Active
Visitor Parking
Swimming Hole #1
Kyanite
Woods of San Marcos LLC
Cape's Camp
Historic BBQ Pit
Willow Glen
Cape's Dam & Gates
Mill Race
San Marcos River
Old Bridge Crossing
Zone #3: Active
Observation/ Pavilion
Platform Top of Bank
ADA Accessible Trail
Swimming Hole #3
Cape's Mill Site Educational Exhibit
Swimming Hole #2
Small Parking Fields Including ADA
Cape Family LTD Part.
Sidewalk Connection to Sturgeon Drive
Randall Morris & Co
Sharp Clemmick Cavern Paul Sorg
Visitor Parking
Zone #5: Passive
City of San Marcos
Stoke's Park; Texas Parks and Wildlife
Gene Sharp Welcome Center
Cape-Sharp Bridge
Kayak & Canoe Launch
Wetland Demonstration
Wetland Demonstration
Soft Trail Connection Following Blanco River North, For Northeast Regional Trail Network Servicing NE San Marcos
Soft Trail Connection to River Hills Drive
Existing Slough Upgraded to Fish Ladder + Kayak Access
Waste Way
Pedestrian Dominated Mobility Zone
State of Texas Land Part of the Hatchery
I-35
San Marcos River Foundation
Bridge
Fishing Dock
Cape Family Ltd Partnership
Zone #2: Passive
Zone #4: Active
Visitor Parking
Concrete Trail Connection to Durango Street
Legend
Controlled River Access Points
Trails Concrete
Trails Soft Materials
Zone Boundary Active
Zone Boundary Passive
Wetland Demonstration Partnership With The State of Texas
Potential Access Easement Granted By State of Texas
Wetland Demonstration Partnership With The City
San Marcos
Project Site
1000 Feet
The information on these graphics are general and conceptual in nature. Property boundaries are based on general information that may not be current or accurate.
Leisure Activity Framework
Vista Planning & Design
Vista Planning & Design
Landscape Architecture
Site Planning
Master Planning
E. Mitchell Wright ASLA, AICP, LEED AP
19 Sugar Shack Dr.
West Lake Hills, Texas 78746
(512) 673-9274
mitch@vistaplanningdesign.com
San Marcos River Vision Study
San Marcos, Texas
8-30-19
Exhibit 2


Old Bridge Crossing
Swimming Hole #3
Cape's Mill Site Educational Exhibit
Swimming Hole #2
Small Parking Fields Including ADA
Sidewalk Connection to Sturgeon Drive
Access
STOP
Access
Access
City of San Marcos
Stoke's Park; Texas Parks and Wildlife
Existing Slough Upgraded to Fish Ladder + Kayak Access
Waste Way
STOP
Pedestrian Dominated Mobility Zone
Bridge
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Canc
Laun
State of
Land Par
Hatch
San Marcos
er Foundation

Leisure Activity Goals:

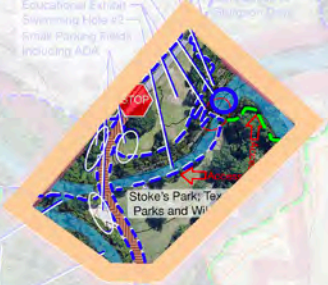
- Prioritize local residents by limited parking areas
- Prioritize safety
- Controlled river access
- Provide wide variety of experiences
- Low level improvements not detracting from natural beauty

Z1

Zone #1: Active

- Kayak launch
- Cape's Camp- The Great Lawn; minimal development)
- Multiple access points (bank protection & restoration)
- The historic Willow Glen with BBQ events garden (significant interpretation both history and ecology

Z3



Zone #3: Active

- Stokes Park; limited improvements
- Parking including ADA
- Walking paths including ADA
- Observation deck on top of gabion wall with guard rail
- Cape road access
- Cape's mill & turbine sites for historic interpretation
- Kayak & canoe portage pathways; waste way slough
- Cape Road traffic slowing design
- Continuation of City trail network
- Kayak launch and landing pads; swimming ladders

Z4

Zone #4: Active

- TPWD Kid Fish: A place for fishing supported by fishing instruction through Texas Parks and Wildlife Department programming. Fish species potentially stocked from next door hatchery
- Access from Flores Street and Cape Road

Leisure Activity Goals:

- Prioritize local residents by limited parking areas
- Prioritize safety
- Controlled river access
- Provide wide variety of experiences
- Low level improvements not detracting from natural beauty

Zone #5: Passive

- Passive linear park; trails, kayak & canoing
- Nature viewing
- Kayak & canoe put-in / takeout
- Natural sciences park with focus on effluent treatment with wetland demonstration gardens
- Interpretation displays

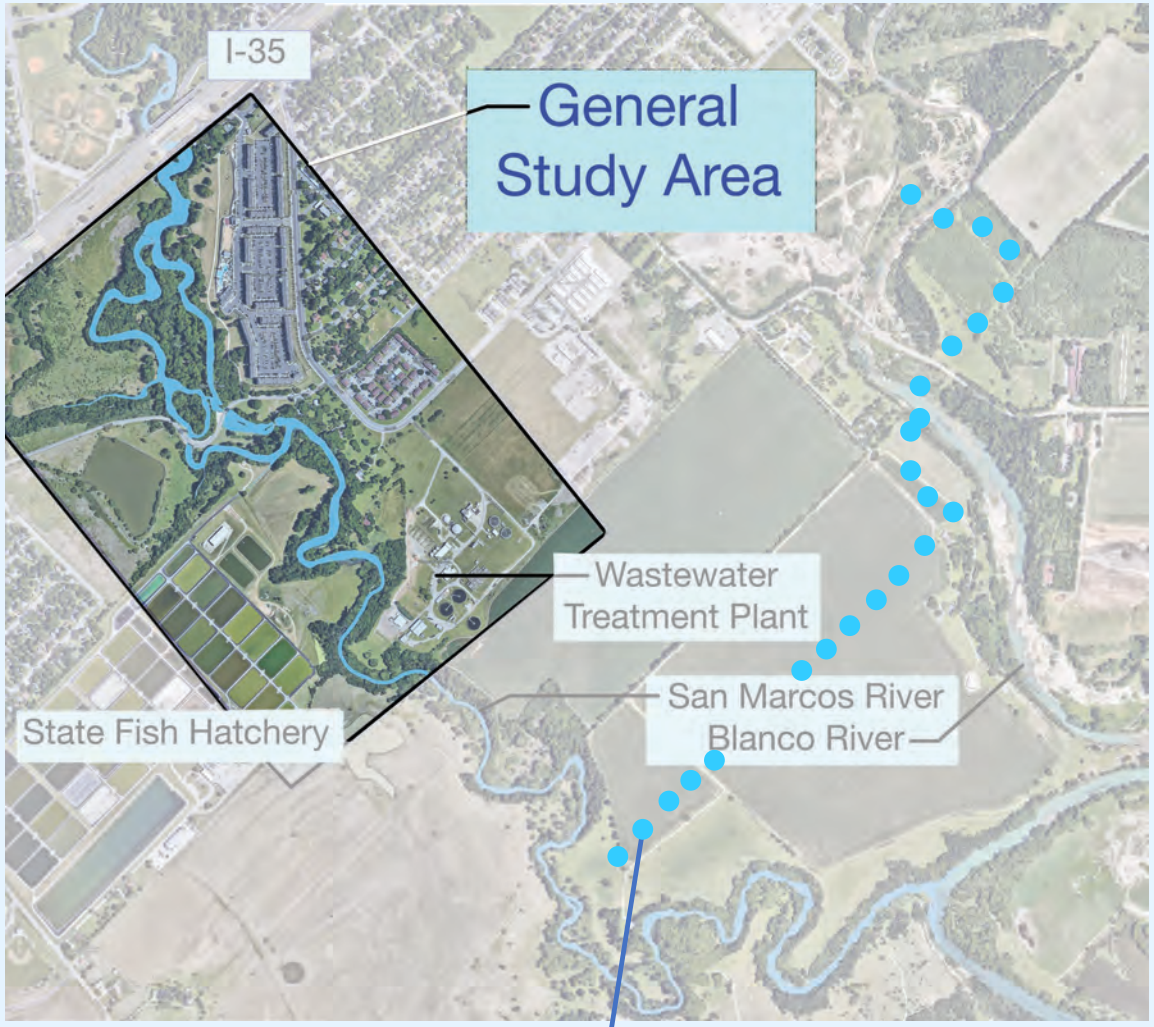
Zone #2: Passive

- Thompson's Island conservation zone; sanctuary
- Natural trails, bird watching
- Conservation service projects
- Comprehensive ecological interpretation
- Active research
- Restored bridge access
- Significant habitat restoration on Thompson's Island

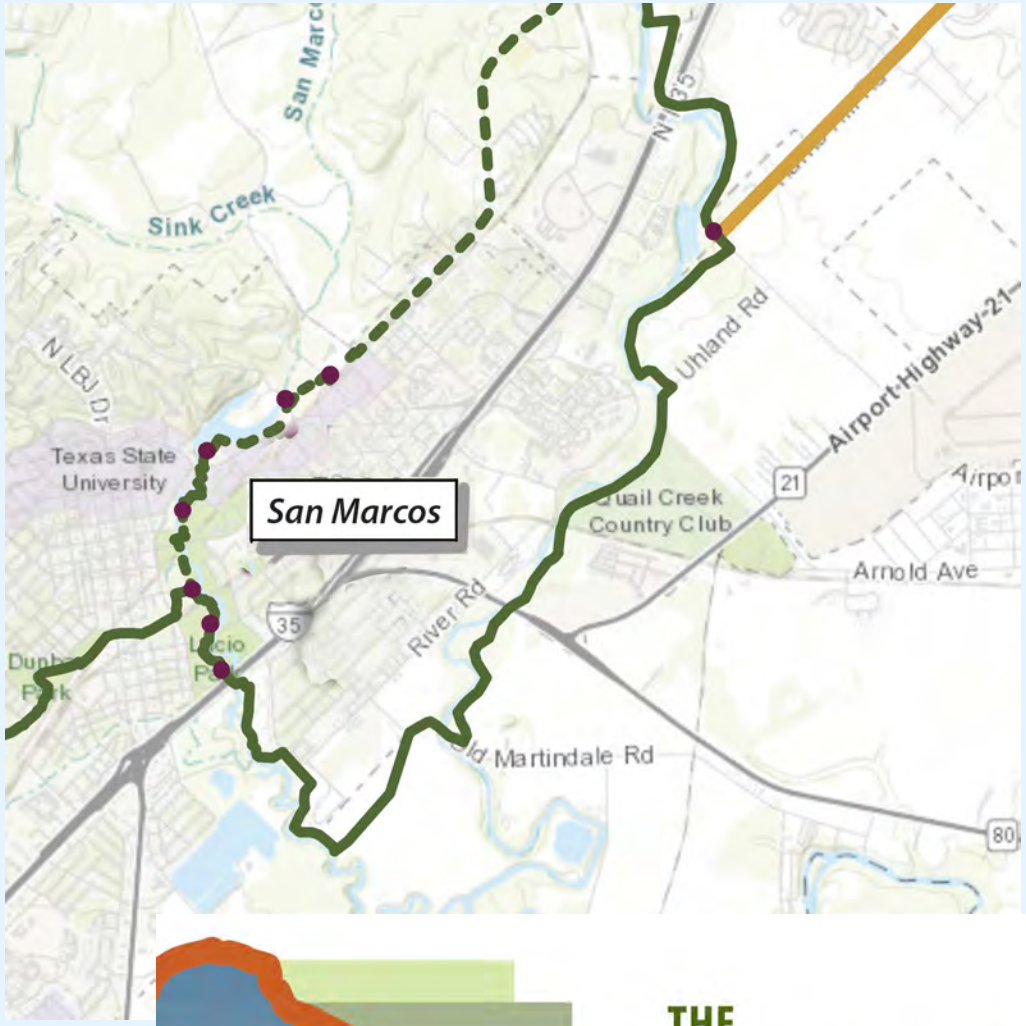
Opportunities!

Unique Leisure Opportunities

- Multiple Public Jurisdictions working together.
- Providing a beautiful asset to an underserved area of San Marcos
- Creating potential trail linkages, including the Emerald Crown Trail.
- An area for educational aspects of natural and cultural interpretation, demonstration, and restoration to a high value environmental quality, and leisure activities.

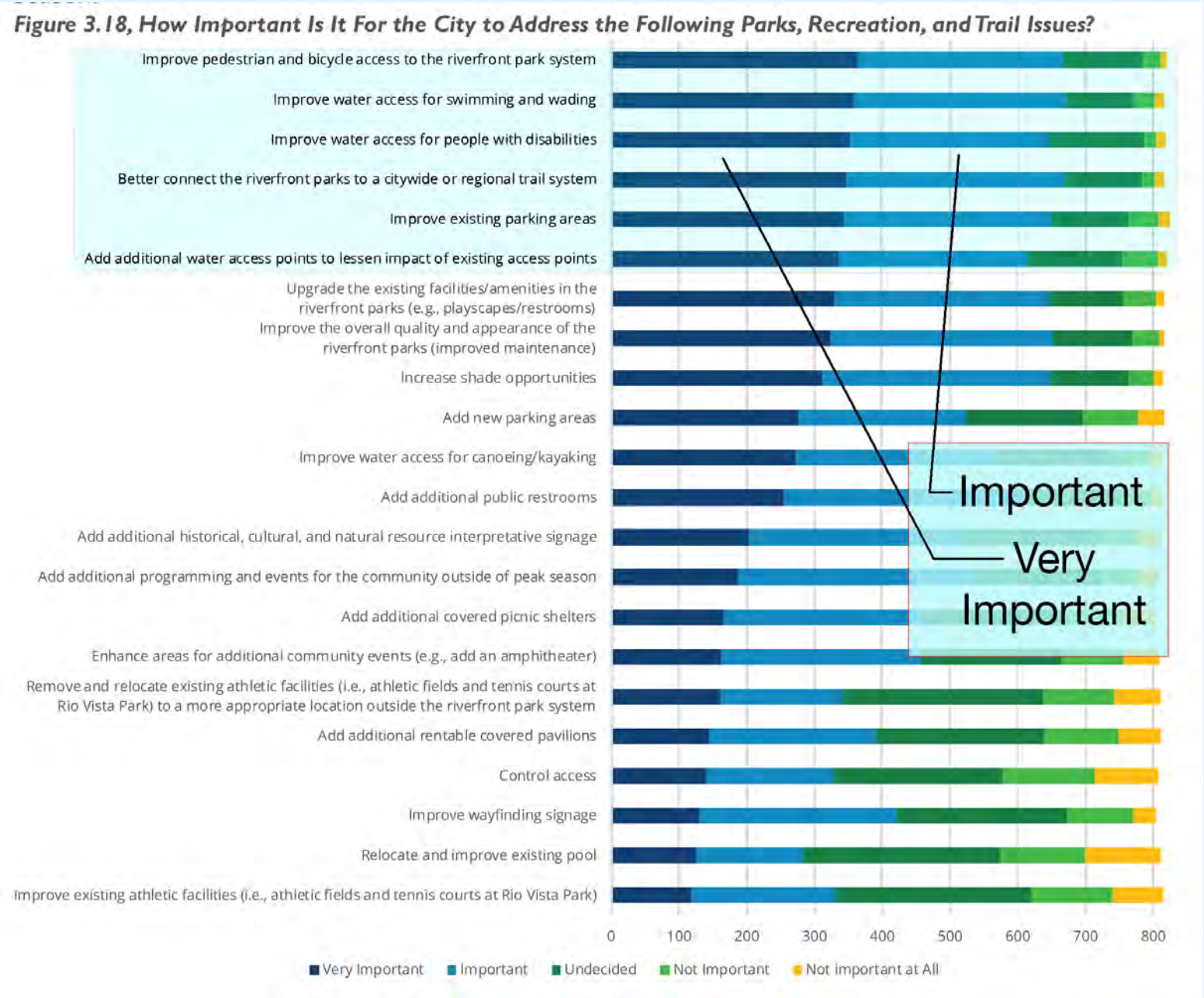


Emerald Crown Trail



San Marcos

Parks, Recreation, and Open Space Master Plan



How Important Is it For the City to Address the Following Parks, Recreation, and Trail Issues?

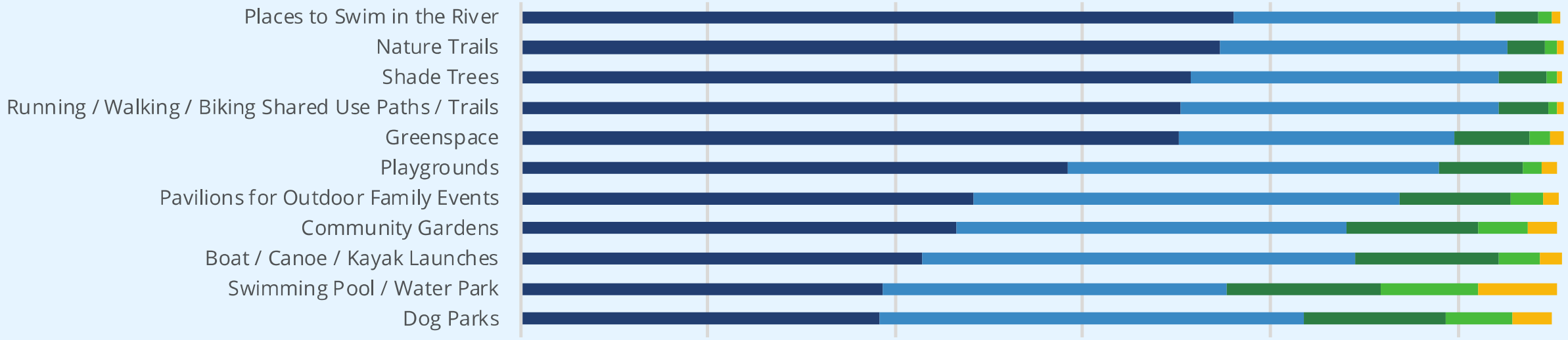
1) Improve pedestrian and bicycle access to the riverfront park system
2) Improve water access for swimming and wading
3) Improve water access for people with disabilities
4) Better connect the riverfront parks to a citywide or regional trail system
5) Improve existing parking areas
6) Add additional Water access points to lessen impact of existing access points

On a separate survey…again…

1) Places to swim in the river
2) Nature trails
3) Shade trees
4) Running/walking/biking shared use paths/trails

to be provided or added in San Marcos.

Figure 3.16, Importance of Park Facilities to be Provided or Added in San Marcos



City Council Direction Needed

- Does Council want to proceed with an agreement with Hays County to partner on renovation/rehabilitation of Cape's Dam?

- Does Council want to explore the larger visioning/master plan concept with Hays County?

Next Steps

- If Council provides direction on proposed project concept at a future council meeting, the City would negotiate an interlocal agreement designating the terms of the partnership covering items such as:

  - Financial participation of City
  - Design, permitting, and construction participation and responsibilities
  - Termination clause
  - Land acquisition and/or related leases
  - Compliance with HCP conservation measures
  - Operation and maintenance responsibilities
  - Safety of park users and emergency access
  - Park Rules and Enforcement
  - Neighboring developments and conflicts with access or alcohol
  - Public participation, outreach and engagement in master plan

- Any special considerations or concerns from Council?
- Future work session to review formal plan?

QUESTIONS?

File #: ID#19-827, **Version:** 1

AGENDA CAPTION:

Executive Session in accordance with the following Government Code Sections:

A. Section § 551.072 - Real Property: to receive a staff briefing and deliberation regarding acquisition of property in Downtown San Marcos for Public Use

Meeting date: 1/7/2020

Department: City Clerk's Office on behalf of the City Council

Amount & Source of Funding

Funds Required: Click or tap here to enter text.

Account Number: Click or tap here to enter text.

Funds Available: Click or tap here to enter text.

Account Name: Click or tap here to enter text.

Fiscal Note:

Prior Council Action: Click or tap here to enter text.

City Council Goal: [Please select goal from dropdown menu below]

Choose an item.

Choose an item.

Choose an item.

Comprehensive Plan Element (s): [Please select the Plan element(s) and Goal # from dropdown menu below]

☐ Economic Development - Choose an item.

☐ Environment & Resource Protection - Choose an item.

☐ Land Use - Choose an item.

☐ Neighborhoods & Housing - Choose an item.

☐ Parks, Public Spaces & Facilities - Choose an item.

☐ Transportation - Choose an item.

☐ Not Applicable

Master Plan: *[Please select the corresponding Master Plan from the dropdown menu below (if applicable)]*

Choose an item.

Background Information:

Click or tap here to enter text.

Council Committee, Board/Commission Action:

Click or tap here to enter text.

Alternatives:

Click or tap here to enter text.

Recommendation:

Click or tap here to enter text.