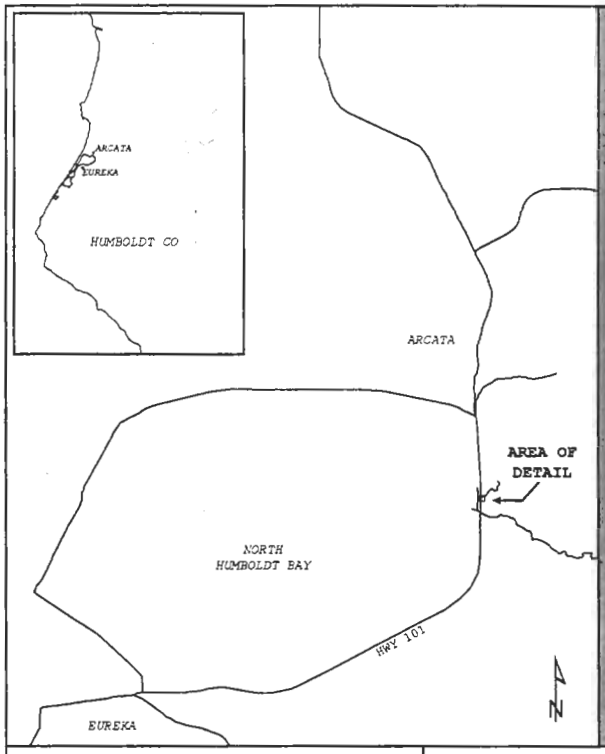
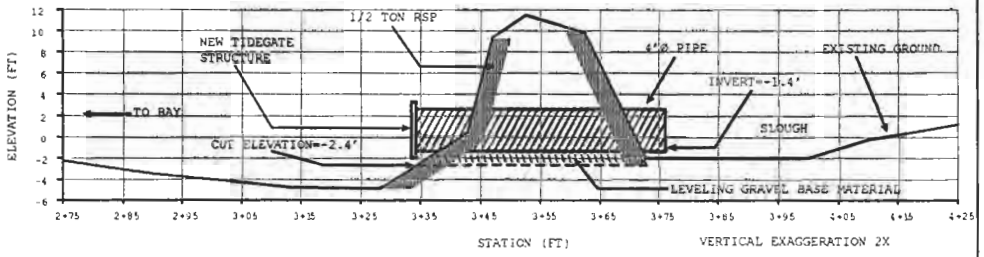
NOT FOR CONSTRUCTION

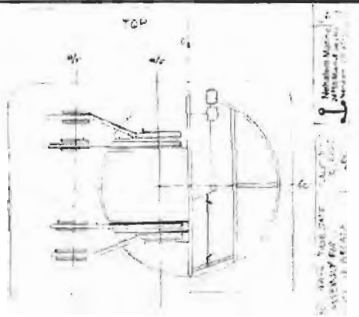


QUANTITIES:

TOTAL CUT:	**343 CUBIC YARDS**
TOTAL FILL:	**343 CUBIC YARDS**
RSP:	121 CUBIC YARDS
SOIL:	179 CUBIC YARDS
GRAVEL:	43 CUBIC YARDS

NEW TIDE GATE STRUCTURE
CROSS SECTION A-A'





SIDE HINGED TIDE GATE WITH FISH DOOR (NTS)

EXHIBIT NO. 4
APPLICATION NO.
1-09-030
CITY OF ARCATA
PROJECT PLANS (1 of 10)

PREPARED UNDER THE SUPERVISION OF:
Jeffery K. Anderson, RCE 50713
DATE

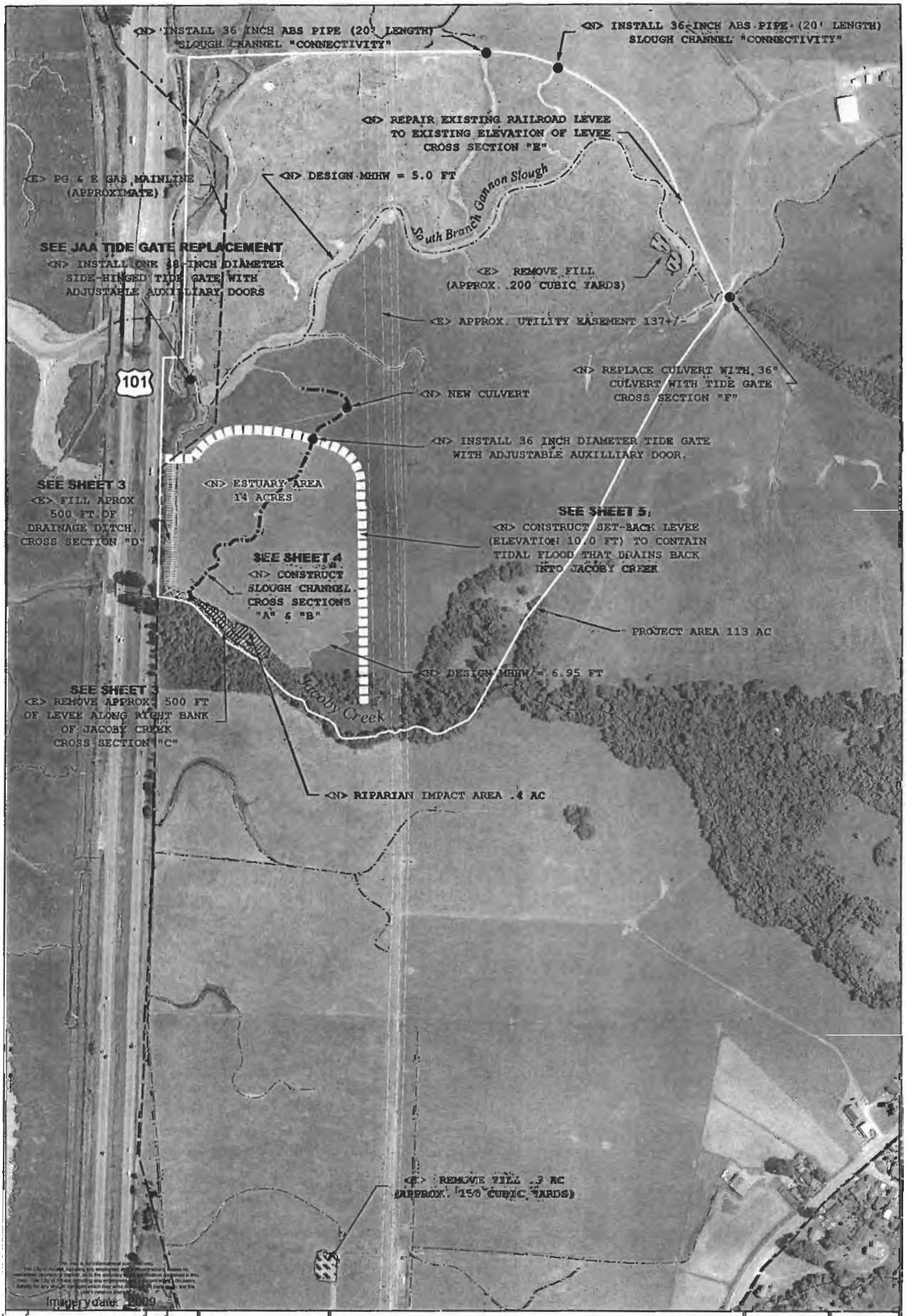
DESIGNED: JKA	DRAWN: JKA
CHECKED: JKA	DATE: 03/19/09
PROJECT NUMBER: 2007-02	

Jeff Anderson and Associates
Engineering – Hydrology – Restoration
1225 Central Avenue, Suite 15
McKinleyville, CA 95519

PREPARED FOR:
CITY OF ARCATA
ENVIRONMENTAL SERVICES
736 F STREET
ARCATA, CA 95521

JACOBY CREEK
ESTUARY ENHANCEMENT
SOUTH GANNON SLOUGH
TIDE GATE REPLACEMENT
30% DESIGN

SHEET 1
1 OF 1



NO.	REVISION	BY	DATE

DESIGNED BY: M. A.
DRAWN BY: B. K.
CHECKED BY: M. A.

CITY OF ARCATA
Environmental Services

Arcata Baylands Project

Jacoby Creek Estuary Overview

USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

SHEET 2 of 6 | DATE 5/7/2009

Jacoby Estuary Overview2-24-2010.mxd

0 100 200 Feet
1:4,374

NORTH

2410

NO.	REVISION	BY	DATE

Arcata Baylands Project

Jacoby Creek Estuary Upland Area, Levee Removal, & Ditch Fill Location

USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5N., R.1E. of H.B. & M.

CITY OF ARCATA
Environmental Services Department

DESIGNED BY: M. ANDRE
DRAWN BY: B. KANG
CHECKED BY: M. ANDRE
EXPIRES:

SHEET 3 of 6

DATE: 4/6/2010

3 of 10

NO.	REVISION	BY	DATE

Arcata Baylands Project

Jacoby Creek Estuary Channel Construction

USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

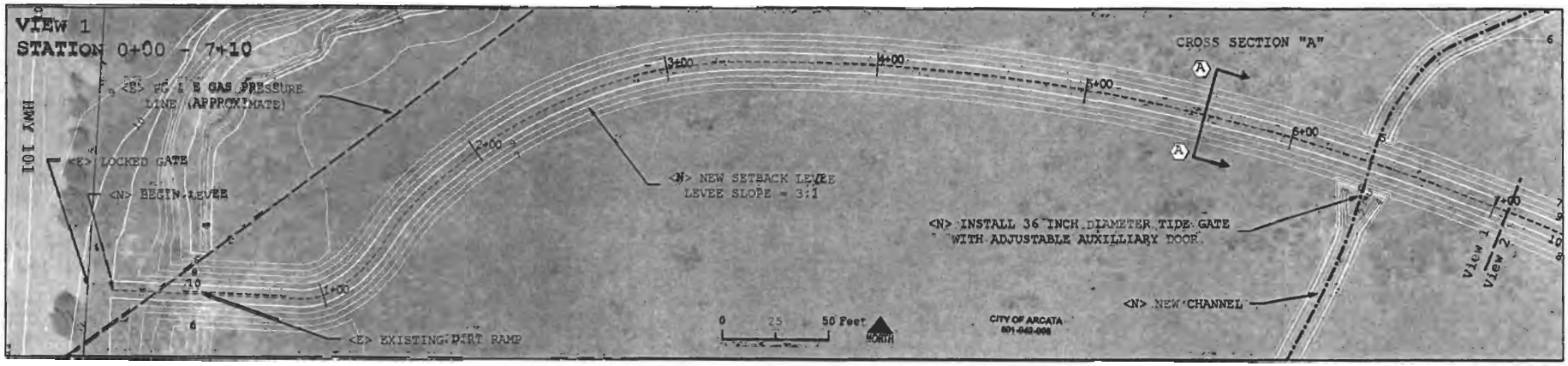
CITY OF ARCATA
Environmental Services Department

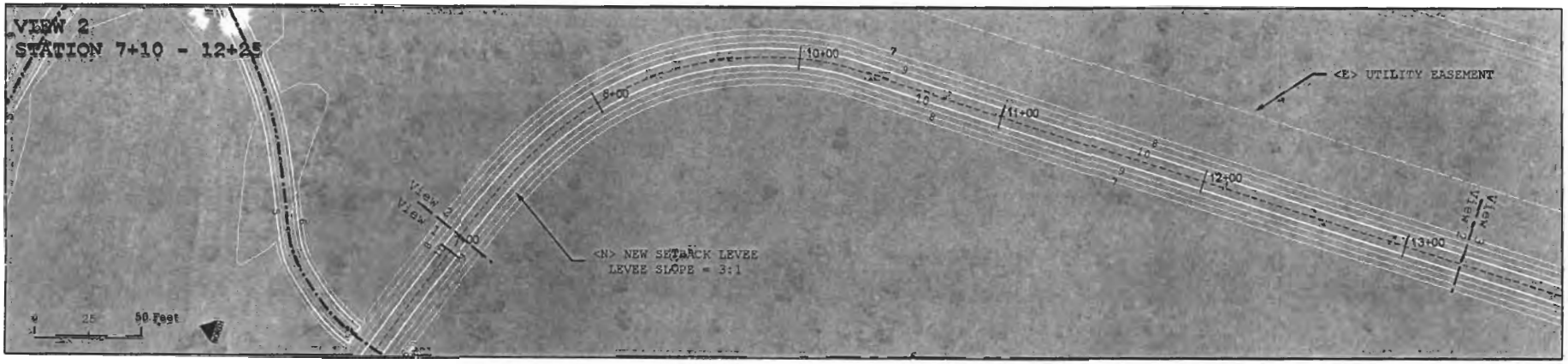
DESIGNED BY: M. ANDRE
DRAWN BY: B. KANG
CHECKED BY: M. ANDRE
EXPIRES:

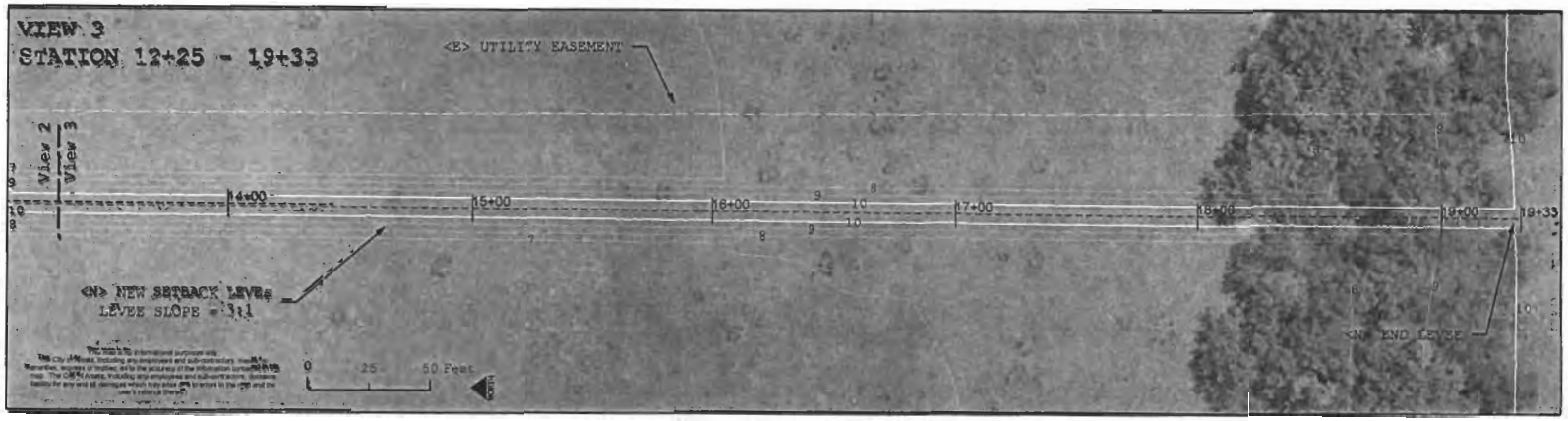
SHEET 4 of 6

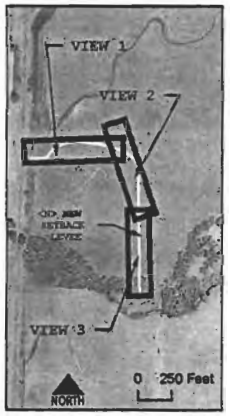
DATE: 4/6/2010

4/9/10









NO.	REVISION	BY	DATE

Arcata Baylands Project

Jacoby Creek Estuary
Set-Back Levee Construction

USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5 N., R.1 E. of H.B. & M.

CITY OF ARCATA
Environmental Services Department

DESIGNED BY: M. ANDRE
DRAWN BY: B. KANG
CHECKED BY: M. ANDRE
EXPIRES:

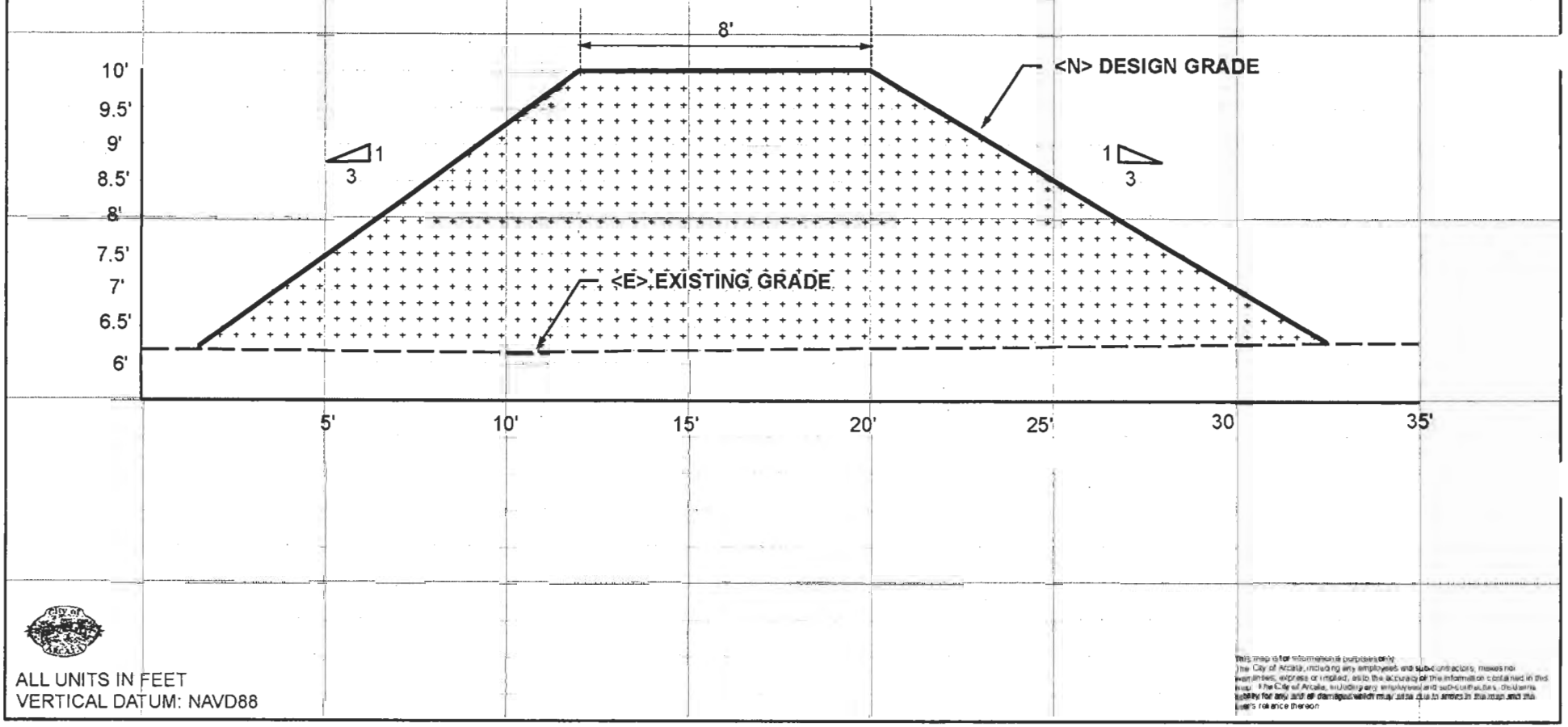
SHEET 5 of 6

5-Setback Levee4-6-2010.mxd

DATE: 4/6/2010

5 of 6

SET BACK LEVEE CROSS-SECTION "A"



ALL UNITS IN FEET
VERTICAL DATUM: NAVD88

NO.	REVISION	BY	DATE

CITY OF ARCATA
Environmental Services Department

DESIGNED BY: M.A.
DRAWN BY: B.K.
CHECKED BY: M.A.
EXPIRES

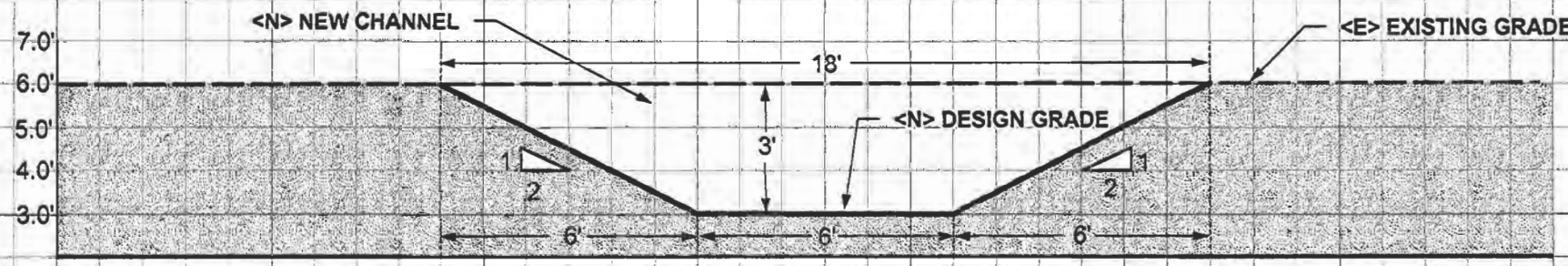
Arcata Baylands Project

Jacoby Creek Estuary Set-Back Levee Cross-Section "A"

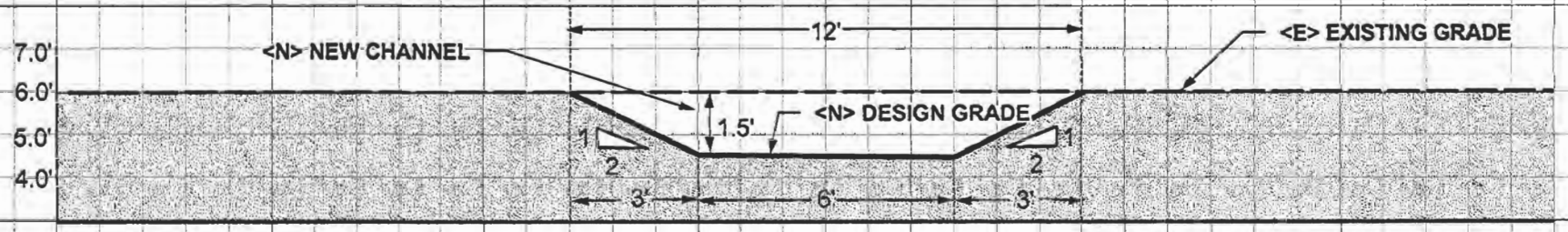
USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

SCALE	DATE 5/15/2009
JACOBY ESTUARY CROSS-SECTIONS.MXD	
SHEET 6	
OF 6	

NEW ESTAURINE CHANNEL @ JACOBY CREEK - TYPICAL CROSS-SECTION "A"



NEW ESTAURINE CHANNEL @ S. GANNON SLOUGH - TYPICAL CROSS-SECTION "B"



ALL UNITS IN FEET
VERTICAL DATUM: NAVD88

NO.	REVISION	BY	DATE

CITY OF ARCATA
Environmental Services Department

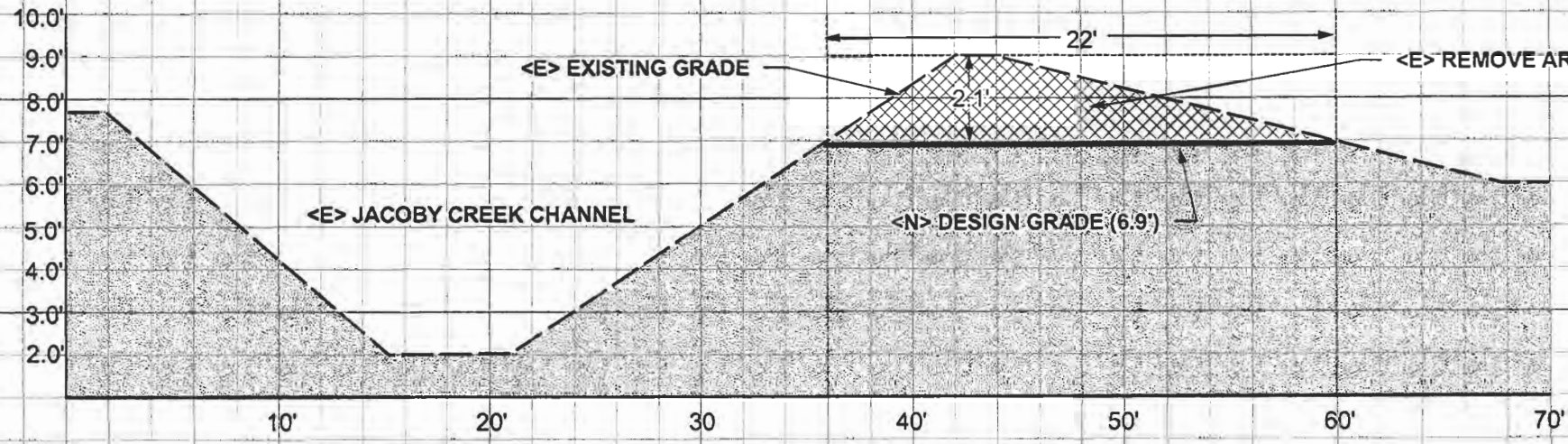
DESIGNED BY: M.A.
DRAWN BY: B.K.
CHECKED BY: M.A.
EXPIRES

Arcata Baylands Project
Jacoby Creek Estuary:
New Estaurine Channel Cross Section

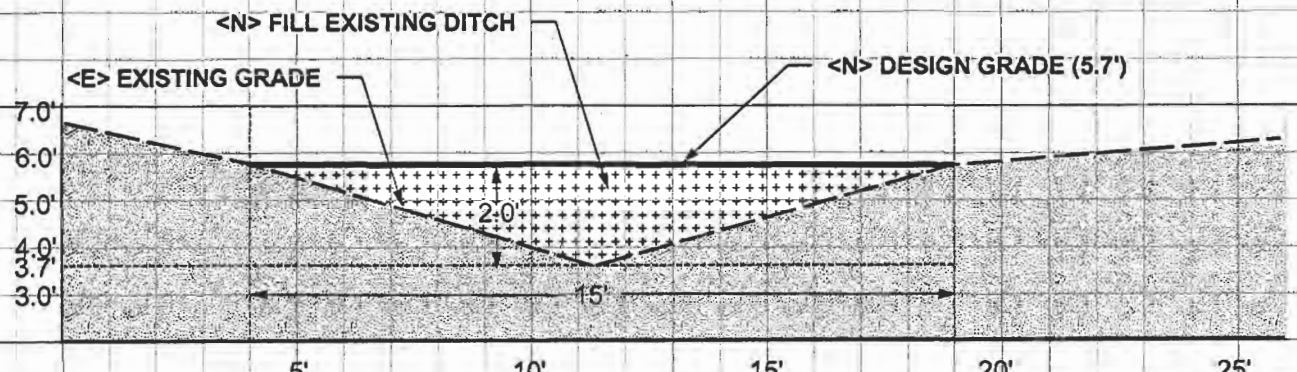
USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

SCALE	DATE 2/22/2009
NEWESTAURINECHANNEL.MXD	
SHEET 1	
OF 1	

LEVEE REMOVAL @ JACOBY CREEK - TYPICAL CROSS-SECTION "C"



FILL DITCH - TYPICAL CROSS-SECTION "D"



ALL UNITS IN FEET
VERTICAL DATUM: NAVD88

NO.	REVISION	BY	DATE

CITY OF ARCATA
Environmental Services Department

DESIGNED BY: M.A.
DRAWN BY: B.K.
CHECKED BY: M.A.
EXPIRES

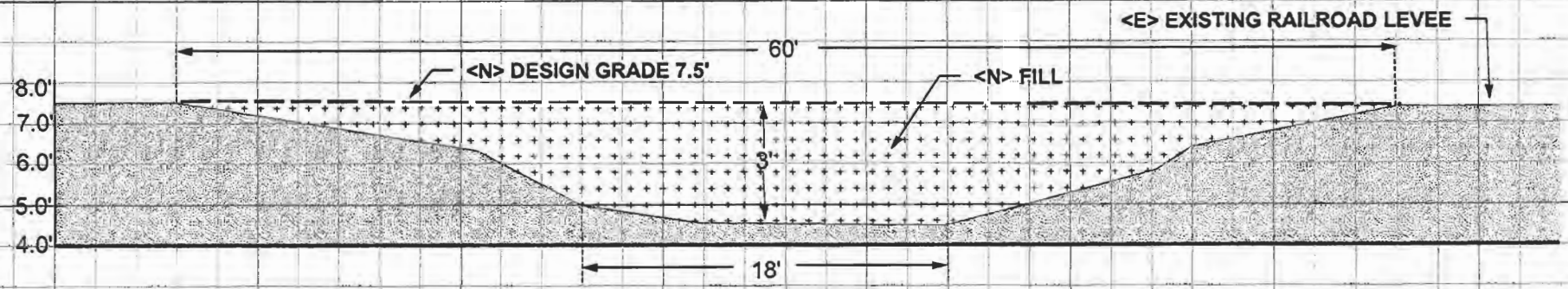
Arcata Baylands Project

Jacoby Creek Estuary:
Levee Removal & Ditch Fill Cross Sections

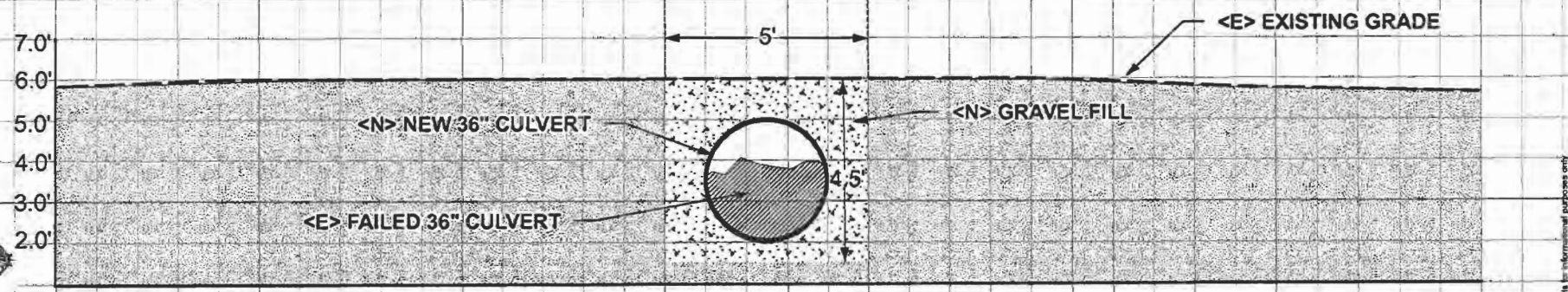
USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

SCALE	DATE
	2/22/2009
LeveeRemovalDitchFillCross_section.mxd	
SHEET 1	
OF 1	

RAILROAD LEVEE REPAIR - TYPICAL CROSS-SECTION "E"



TYPICAL CULVERT REPAIR - CROSS SECTION "F"



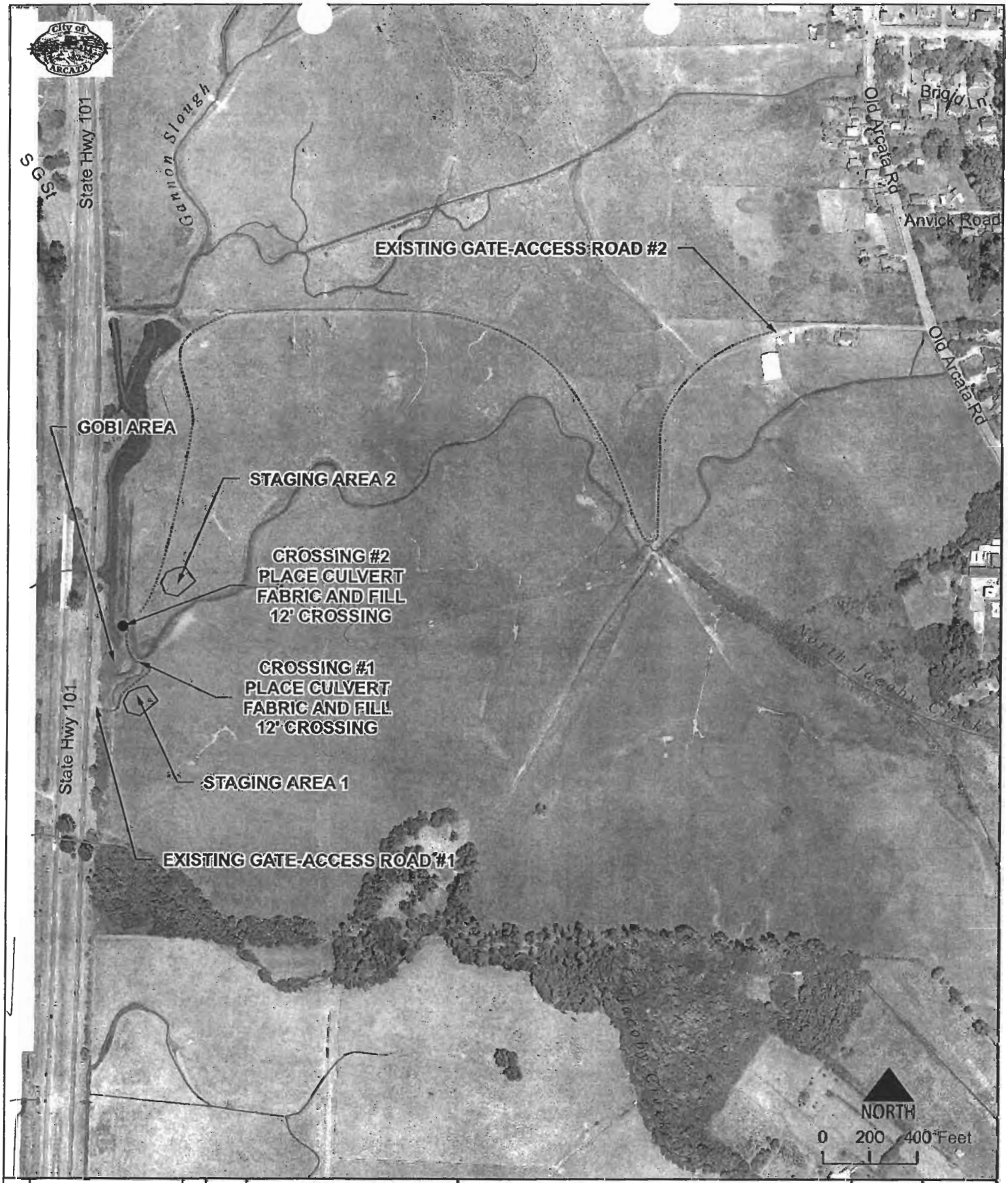
ALL UNITS IN FEET
VERTICAL DATUM: NAVD88

NO.	REVISION	BY	DATE

CITY OF ARCATA
Environmental Services Department
DESIGNED BY: M.A.
DRAWN BY: B.K.
CHECKED BY: M.A.
EXPIRES

Arcata Baylands Project
Jacoby Creek Estuary:
RR Road Levee Repair & Culvert Repair Typical Cross Section
USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

SCALE	DATE 2/22/2009
ROADREPAIRCROSSSECTION.MXD	
SHEET 1	
OF 1	



NO.	REVISION	BY	DATE

CITY OF ARCATA
Environmental Services Department
DESIGNED BY: M.A.
DRAWN BY: B.K.
CHECKED BY: M.A.
EXPIRES

Arcata Baylands Project

Access and Staging Area

USGS 7.5 Minute Topographic Map: Arcata South Quadrangle
Section 4, T.5.N., R.1.E. of H.B. & M.

SCALE	DATE
1:24,000	5/15/2009
Access-Staging Area Map.mxd	
SHEET	
OF	

10910

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802- 4213

MAR 0 9 2010

In response refer to:
2010/00795

Lieutenant Colonel Laurence M. Farrell
San Francisco District
U.S. Army Corps of Engineers
1455 Market Street
San Francisco, California 94103-1398

Dear Colonel Farrell:

On January 7, 2010, NOAA's National Marine Fisheries Service (NMFS) received your January 4, 2010, letter and associated information, requesting informal consultation on the City of Arcata's Lower Jacoby Creek Estuary enhancement and South Gannon Slough tide gate installation projects (Project), located just south of the City of Arcata, on the east side of Highway 101, Humboldt County, California, pursuant to section 7(a)(2) of the Endangered Species Act (ESA), as amended (16 U.S.C. 1532 *et seq.*) and its implementing regulations (50 CFR 402).

This letter constitutes completion of informal consultation on the Project for Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit (ESU; 70 FR 37160, June 28, 2005), and their designated critical habitat (64 FR 24049, May 5, 1999) under the ESA. This letter also serves as consultation for threatened California Coastal (CC) Chinook salmon (*O. tshawytscha*) ESU (64 FR 50394, September 16, 1999) and Northern California (NC) Steelhead (*O. mykiss*) ESU (65 FR 36074, June 7, 2000). This letter also serves as consultation for coho salmon and Chinook salmon under the authority of an in accordance with provisions of the Fish and Wildlife Coordination act of 1934 (FWCA), and Essential Fish Habitat (EFH) as required under the Magnuson-Stevens Fishery and Conservation Act of 1976, as renewed and modified in 1996.

Description of the Proposed Action

The U.S. Army Corps of Engineers (USACE) proposes to authorize a Nationwide Permit pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act, the Lower Jacoby Creek Estuary enhancement and South Gannon Slough tidal gate installation project. The proposed Project is located adjacent to the U.S. Fish & Wildlife Service Humboldt Bay Wildlife Refuge, within the 225-acre Arcata Marsh and Wildlife

EXHIBIT NO. 5
APPLICATION NO.
1-09-030
CITY OF ARCATA
INFORMAL CONSULTATION LETTER – NOAA FISHERIES
(1 of 5)

Sanctuary, the 508-acre California Department of Fish and Game Mad River Slough Wildlife Area, and Jacoby Creek Land Trust. The project lands are owned and managed by the City of Arcata in perpetuity for the conservation of coastal wetland habitats and dependant fish and wildlife populations. The project will be initiated in the late summer of 2010 and take approximately 3 weeks to complete.

The Project involves connecting aquatic habitat throughout over 1,300 acres, including:

1. Restoring up to 15 acres of estuarine channels associated with Gannon Slough by repairing an existing top-hinged tide gate and installing one 4 foot side-hinged tide gate with fish door to allow muted tidal flow to reestablish estuarine conditions in the remnant channel. The new tide gate will have a muted opening with an adjustable "guillotine-style" auxiliary door with a maximum aperture opening of two square feet. Installation of two 24-inch diameter by 20-foot length culverts with screw gates under the existing railroad grade will connect additional remnant channels to Gannon Slough and its tributaries while allowing the City to control flow to prevent flooding of adjacent agricultural lands. A 950-foot ditch along an existing interior access road adjacent to the South Gannon Slough channel will be filled to ground surface elevation to direct wet weather flows to the Gannon Slough Channel. This part of the project will take approximately one week to complete.

2. Reconnecting the Jacoby Creek floodplain which is currently constrained by levees. A new 1,760-foot setback levee will be constructed to an elevation of 10 feet Mean Higher High Water (MHHW) to create a 15-acre estuary at the mouth of Jacoby Creek. The new levee will fill 0.9 acres of riparian area and impact 0.7 acres of wetlands. A new channel, extending from Jacoby Creek through the tide gate to the remnant South Gannon Slough Channel, will be constructed in the new estuary area to provide hydrologic connectivity during flood events. The new channel will have a bottom elevation of 4-feet and a trapezoidal cross section with a bottom width of 6 feet and side slopes at a 3:1 ratio. Approximately 500 feet of an existing drainage ditch will be filled to prevent trapping fish after the estuary expansion is completed. The existing levee adjacent to Jacoby Creek will be reduced in elevation to 6.9 feet to direct tidal drainage into the new channel, but allow overflow from Jacoby Creek during high flow events. A 36-inch culvert and tide gate with adjustable auxiliary door will be installed at an elevation of 4.5 feet in the new levee to allow freshwater flows to enter the estuary area during storm events.

3. About 4,714 cubic yards of fill will be used for levee construction, as ditch fill, and for tide gate installation. Fill removed from levees and ditches would be about 1,607 cubic yards. Additional fill required for levee construction will be provided by the construction of a seasonal wetland. Fill that cannot be used for levee construction will be used to fill the 500-foot and 950-foot ditches or will be transported and stored at the Jacoby Creek Quarry.

Effects of the Action

Installation of the new tide gates and restoration of estuarine channels may create short term changes in water quality, alter existing habitat, and may temporarily decrease the amount of riparian vegetation. Individual salmonids found in Jacoby Creek are not likely to be adversely affected because the work will be done outside of the wetted channel, work will be performed in the dry season when water quality conditions make the area uninhabitable, and best management practices will be implemented to decrease all out of channel effects to a minimum. Long term effects will be beneficial, with an increase in quantity of off low velocity rearing habitat, a more natural hydrograph, and decreases in flood flows in Jacoby Creek.

Due to the location of the new tide gates and the timing of the project, the effects from this part of the Project will likely consist of insignificant increases in turbidity during tide gate installation, increases in salinity immediately below the culvert, and temporary impacts to vegetation in the surrounding area where installation took place. These effects will be minimized by the timing of the project and the placement of the tidegates outside the wetted channel. Construction for all aspects of the proposed Project will end prior to adult migration of anadromous salmonids, and commence after the usual times when juvenile and smolting salmonids are moving downstream to estuary areas. The proposed Project will create an increase in fish passage into Jacoby Creek and restore up to 15 acres of historic estuarine channels. Additionally, new winter rearing habitat will be created by the connection of remnant channels in Gannon Slough and the adjacent Jacoby Creek floodplain, as well as decrease the likelihood of stranding events during high flows.

Changes in the height and placement of the Jacoby Creek levee will be beneficial to the stream channel, with some short term effects to water quality and habitat characteristics. Effects to water quality and instream habitat will likely include increases in turbidity for the first winter, changes in the location of the water course, changes in the location of pools and riffles, and changes in hydrology. The placement of the new levee and decrease in height of the old levee will decrease stranding potential for salmonids during high flows, increase low gradient habitat availability, reconnect the Jacoby Creek floodplain, and create a more natural hydrograph in the lower stream and estuary sections of Jacoby Creek.

Effects will be short term, and insignificant due to the timing of the Project in the dry season (June through October), and the location of the new channel away from the wetted channel. Due to the poor water quality found in this area during the dry season there is a small likelihood of salmonids inhabiting the work area. Effects will include small and temporary increases in turbidity when the new channel is connected to Jacoby Creek and while the new riparian vegetation becomes established, and a readjustment in the hydrograph during high flow events in the first winter. Construction for the proposed Project will end prior to adult migration of anadromous salmonids, and commence after the usual times when juvenile and smolting salmonids are moving downstream to estuary areas.

ESA CONCLUSION

Based on review of the documents provided by the USACE, and site conditions within the action area, NMFS concurs with the USACE determination that the Project may affect, but is not likely to adversely affect SONCC coho salmon, CC Chinook salmon or NC Steelhead because: (1) the majority of work will occur away from the wetted channel, (2) work will be done in the dry season when no salmonids are likely to be present, (3) no equipment will be operated directly within the channel of flowing streams, and (4) the use of BMP's is expected to minimize sediment mobilization within the project action area. Effects from this project are expected to be largely beneficial and increase the quantity and quality of winter rearing habitat, create a more natural hydrograph in lower Jacoby Creek, and decrease stranding events in the lower Jacoby Creek watershed.

Reinitiation of consultation may be necessary where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (2) the action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered, or (3) a new species is listed or critical habitat designated that may be affected by the action.

EFH CONSULTATION

The Pacific Fishery Management Council has delineated EFH for Pacific Coast salmon, which includes the action area of the Project. The Project area is located within an area identified as EFH for various life stages of coho salmon and Chinook salmon managed under the Pacific Coast Salmon Fishery Management Plan (FMP) under the MSA. NMFS has evaluated the Project for potential adverse effects to EFH pursuant to Section 305(b)(2) of the MSA. Under the EFH implementing regulations [50 C.F.R. 600.810(a)], the term "adverse effect" is defined as any impact that reduces quality and/or quantity of EFH and may include direct or indirect physical, chemical, or biological alterations of the waters or substrate and loss of, or injury to, benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce quantity and/or quality of EFH.

The potential adverse effects to EFH from the Project would be from temporary increases in sediment and turbidity, temporary loss of habitat while the channel adjusts to the alterations in the levee and installation of the new levee and changes in the salinity downstream of the tide gate. The increases in sediment and turbidity are expected to be minor, the loss of habitat is being mitigated by the beneficial post project effect of a more natural hydrograph and newly connected floodplain. Beneficial effects include the opening up of all suitable habitat above the currently perched tide gate, increased passage into Jacoby Creek, and an overall increase in the amount of EFH.

NMFS has determined that the Project would adversely affect EFH for Chinook salmon and coho salmon. However, the anticipated adverse effects are so minimal in nature, and the beneficial effects so great, that no EFH conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the adverse effects to EFH. This concludes EFH consultation for the Project. Pursuant to 50 CFR 600.920(l), the ACOE must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH.

FWCA CONSULTATION

The purpose of the FWCA is to ensure that wildlife conservation receives equal consideration, and is coordinated with other aspects of water resources development (16 U.S.C. 661). The FWCA establishes a consultation requirement for Federal departments and agencies that undertake any action that proposes to modify any stream or other body of water for any purpose, including navigation and drainage [16 U.S.C. 662(a)]. Consistent with this consultation requirement, NMFS may provide recommendations and comments to Federal action agencies for the purpose of conserving fish and wildlife resources. NMFS has no recommendations to make beyond the methods for avoiding impact already incorporated into this project's design.

Please contact Ms. L. Kasey Sirkin at (707) 825-5167, or via email at kasey.sirkin@noaa.gov, if you have any questions regarding these consultations.

Sincerely,

for Rodney R. McInnis
Regional Administrator

cc: Copy to file – ARN 151422SWR2010AR00025
Julie Neander, City of Arcata

5945

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, California 95521
Phone: (707) 822-7201 FAX: (707) 822-8411

In Reply Refer To:
8-14-2010-3746
81331-2010-F-0016

EXHIBIT NO. 6
APPLICATION NO.
1-09-030
CITY OF ARCATA
DRAFT BIOLOGICAL OPINION - U.S. FISH & WILDLIFE SERVICE (1 of 26)

Ms. Jane M. Hicks
Chief, Regulatory Division
Department of the Army
San Francisco District, Corps of Engineers
1455 Market Street
San Francisco, California 94103

Subject: **DRAFT** Formal Consultation on the Lower Jacoby Creek Estuary Enhancement and South Gannon Slough Tidal Gate Installation Project (File No. 2009-00464N)

Dear Ms. Hicks:

This document transmits the Fish and Wildlife Service's (Service) biological opinion (BO) based on our review of the proposed Lower Jacoby Creek Estuary Enhancement and South Gannon Slough Tidal Gate Installation Project (File No. 2009-00464N) and effects to the federally-listed as endangered tidewater goby (*Eucyclogobius newberryi*; goby) and designated goby critical habitat. We received your request for consultation on January 7, 2010. This document was prepared in accordance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act) and its implementing regulations (50 CFR §402).

This BO is based on information provided in the April 19, 2010, project description from the City of Arcata (City); the U.S. Army Corps of Engineers (Corps) consultation request letter to the Service, dated January 4, 2010; and other sources of information. Documents related to this consultation are on file in this office.

CONSULTATION HISTORY

January 7, 2010 The Service received a request for informal consultation from the Corps on the Project, dated January 4, 2010.

March 4, 2010	The Service responded with a letter which stated that we did not concur with "may affect" determination the Corps made in their January 4, 2010, letter and recommended formal consultation. The Service also determined that the project is within designated goby critical habitat and may affect but is not likely to adversely affect designated goby critical habitat.
April 15, 2010	The Service requested additional information regarding potential negative impacts to goby from the project.
April 19, 2010	The City provided an updated project description for the lower Jacoby Creek Estuary Restoration and Gannon Slough Tide Gate Installation project. The project description was updated after finalizing the project design.
April 23, 2010	The City responded to the Service's April 15, 2010, request for additional information.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

The Lower Jacoby Creek Estuary Enhancement and South Gannon Slough Tidal Gate Installation projects will restore hydraulic interconnectivity between Jacoby, Gannon, Beith, Grotzman, and Fickle Hill Creeks (Jacoby Creek Estuary Overview Map, sheet 2 of 6 in the April 19, 2010 Project Description and also attached to this BO). Historically, these channels merged and flooded the lands adjacent to the north east corner of Humboldt Bay during winter rains. Interconnections and important habitat were lost when the land was drained, channels were ditched and straightened, and levees were constructed to support agriculture. Improving connectivity between major drainages and seasonal freshwater channels and wetlands is expected to improve the rearing success and provide winter rearing habitat for juvenile salmonids including Coho salmon and will also increase the habitat area available to tidewater goby.

The project area is owned and managed by the City. Some restoration and enhancement work has been completed to date, including construction of deep and shallow ponds for waterfowl habitat. This next phase of the restoration and enhancement work involves restoring up to 48.7 acres (ac) of tidal habitat, including:

- Restoring estuarine function to up to 17.1 ac within Gannon Slough and tributaries by repairing an existing top hinged tidegate and installing one 4' side hinged gate with fish door. This restoration will allow muted tidal flow to reestablish estuarine conditions in the remnant channel located upstream of the tide gates.

- Restoring historical connectivity between fringe tidal channels at the transition between tidal and non-tidal lands (15.9 ac) by installing two 24" diameter 20' length culverts with screw gates under the existing railroad grade to connect additional remnant channels to Gannon Slough and its tributaries (Beith, Grotzman and Fickle Hill creeks), while allowing the City to control flow to prevent flooding of adjacent agricultural lands.

- Restoring 15.3 ac of tidal habitat and channels associated with the Jacoby Creek Estuary by constructing a new setback levee to elevation 10'MHHW and removing approximately 500' of existing levee adjacent to Jacoby Creek to allow the creek to reoccupy this area. Maps from the 1870's were referenced to design a tidal channel to be constructed in the new estuary area. A 36" culvert and tide gate with adjustable auxiliary door will be installed in the new levee to allow freshwater flows to enter the estuary area during storm events and to reestablish estuarine connectivity with adjacent seasonal freshwater wetland and channel habitats. Also, there will be placement of 245 cubic yards of fill in the 500 ft of existing drainage ditch which is approximately 0.1 acre in size. Filling the ditch is needed to insure that flows are directed to the newly created channel and to prevent ponding adjacent to the levee that abuts highway 101. The ditch is in the area that will be converted to tidal estuary.

- Constructing 1394 lineal feet of new connecting channel between Jacoby Creek and South Gannon Slough (0.4 acre) to restore an historical tidal channel, provide hydrologic connectivity during flood events and establish a properly functioning tidal drainage network.

Conservation Measures

When used in the context of the Act, "conservation measures" represent actions proposed by the Federal agency that are intended to further the recovery of and/or to minimize or compensate for project effects on the species under review. Because conservation measures are pledged in the project description by the action agency, their implementation is required under the terms of the consultation (USDI Fish and Wildlife Service and USDC National Marine Fisheries Service 1998). The following measures will be incorporated into the project to avoid or minimize adverse project effects:

1. Construction activities will only occur between June 15th and October 31st (and November 15th if there is no significant rain event) to avoid or minimize adversely affecting fish, bird, and plant species of concern and to minimize soil compaction and sediment transport.

2. Equipment will not be operated directly within tidal waters or stream channels of flowing streams.

3. Work will be done during low tide when no water or fish are present, to temporarily prevent fish species of concern gaining access to the vicinity of the tidegate installation

area. If water is present, the tidegate area will be seined and a fish barrier installed to isolate the work area. At this time, gobies are susceptible to being injured or crushed by workers while they are entangled in, or being removed from netting. In order to minimize potentially adverse effects to gobies, all translocation/removal of tidewater gobies will be conducted by qualified biologists under a scientific recovery permit pursuant to section10(a)(1)(A) of the Act.

4. Placement of tidegate-related structures will occur when the project site is exposed during low tide.

5. The temporary fish barrier will be removed during low tide, after work in the tidal zone is completed.

6. Silt fences will be deployed at the connection point for the new channel to Jacoby Creek and at culvert installation areas to prevent any sediment from flowing into the creek or wetted channels. If the silt fences are not adequately containing sediment, construction activity will cease until remedial measures are implemented that prevents sediment from entering the waters below.

7. Excess water will be pumped into the surrounding fields to prevent sediment-laden water from entering any water courses, if ground water is encountered while excavating the new channel.

8. All exposed surfaces will be mulched and seeded with appropriate seed, when the new channel has been completed.

9. Construction materials, debris, or waste, will not be placed or stored where it may be allowed to enter into or be placed where it may be washed by rainfall into waters of the U.S./State.

10. Turbid water will be contained and prevented from being transported in amounts that are deleterious to fish, or in amounts that could violate state pollution laws. Silt fences or water diversion structures will be used to contain sediment. If sediment is not being contained adequately, as determined by visual observation, the activity will cease.

11. Areas subject to disturbance during tidegate installation and estuary expansion activities will be surveyed by a qualified biologist. Endangered plant populations (western lily-(*Lilium occidentale*)) or populations of species of special concern encountered will be flagged before the commencement of any restoration work. Work crews will be trained to avoid endangered plants.

12. City staff will be on site during final grading to assure that the area is recontoured as per approved design specifications.

13. Exposed soil will be mulched and seeded with appropriate grass seed, once fill removal is completed.

14. Upland areas will be used for equipment refueling. If equipment must be washed, washing will occur where wash water cannot flow into wetlands or waters of the U.S./State.

15. Best Management Practices (BMPs) will be implemented to prevent entry of storm water runoff into the excavation site, the entrainment of excavated contaminated materials leaving the site, and to prevent the entry of polluted storm water runoff into coastal waters during the transportation and storage of excavated materials.

16. Disturbed, grazed, seasonal wetlands will be de-compacted and seeded as needed, with a commercially available seed mixture composed of the same grass species that currently dominate the area, following completion of work.

STATUS OF THE SPECIES AND CRITICAL HABITAT

Legal Status

On February 4, 1994, the tidewater goby was listed as endangered throughout its entire historic range (59 FR 5494). We did not designate critical habitat at the time we listed this species, explaining that, "In the case of the tidewater goby, critical habitat is not presently determinable. A final designation of critical habitat requires detailed information on the possible economic effects of such a designation. The Service does not currently have sufficient information needed to perform the economic analysis."

On September 18, 1998, the Natural Resources Defense Council, Inc. filed a lawsuit in Federal District Court in California against the United States Department of the Interior et al. for failure to designate goby critical habitat. On April 5, 1999, Judge Carlos R. Moreno ordered that the "Service publish a proposed critical habitat designation for the tidewater goby in 120 days" (Natural Resources Defense Council, Inc. v. United States Department of the Interior et al. CV 98–7596).

On June 24, 1999, we published a proposed rule to: (1) delist populations of goby in areas north of Orange and San Diego counties, California, and (2) retain goby populations in Orange and San Diego counties as endangered based on our re-evaluation of the species' status throughout its range (64 FR 33816).

On August 3, 1999, we proposed critical habitat for the goby in Orange and San Diego counties (64 FR 42250); we did not propose critical habitat for this species throughout the rest of its geographic range in 1999 because we had proposed to delist the species where it occurred in areas north of Orange County. On November 20, 2000, the Service designated critical habitat for

the goby in Orange and San Diego counties (65 FR 69693). The critical habitat designation consisted of 10 coastal stream segments that collectively measured 9 linear miles (14.5 km) in length.

On November 7, 2002, we withdrew our proposal to delist the goby in areas north of Orange County (67 FR 67803). Therefore, the goby has remained listed as an endangered species throughout its historic geographic range since 1994.

On August 31, 2001, Cabrillo Power L.L.C. (Cabrillo) filed a lawsuit in the U.S. District Court for the Southern District of California challenging a portion of the final rule that designated the 10 critical habitat units in Orange and San Diego counties. Specifically, Cabrillo objected to the critical habitat unit involving Agua Hedionda Lagoon and Creek. In a consent decree dated February 27, 2003, the U.S. District Court: (1) agreed to vacate the critical habitat designation involving Agua Hedionda Lagoon and Creek; (2) stated the nine other critical habitat units should remain in effect; (3) stated the final rule designating critical habitat was remanded in its entirety for reconsideration; and (4) directed the Service to promulgate a revised critical habitat rule that considers the entire geographic range of the goby and any currently unoccupied goby habitat. The consent decree requires that the Service submit proposed and revised rules to the Federal Register no later than November 15, 2006, and November 1, 2007, respectively.

A proposed revised critical habitat rule was published in the Federal Register November 28, 2006. The rule proposes to designate approximately 10,003 ac (4,050 ha) range-wide. This is an increase of approximately 8,422 ac (3,408 ha) from the currently designated critical habitat, and a considerable expansion to the north. In the previous rule, critical habitat was only designated in Orange and San Diego counties due to uncertainty over the future listing status of tidewater goby populations to the north. The proposed revised critical habitat is located in Del Norte, Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles counties, California.

A final critical habitat rule was designated and published in the Federal Register on January 31, 2008 (73 FR 5020), and included approximately 10,003 ac (4,050 ha) range-wide.

Taxonomy and Life History

Accounts of the taxonomy, ecology, and reproductive characteristics of the goby are found in the following publications: final rule listing the species (USDI 1994), the proposed rule to delist northern goby populations (USDI 1999), the final rule withdrawing the Service's proposal to delist the northern goby populations (USDI 2002), the recovery plan (USDI 2005), and the proposed revised critical habitat rule (USDI 2006).

The goby is a small gray-brown fish rarely exceeding 2 inches (5 centimeters) in length. This species possesses large pectoral fins, and the pelvic, or ventral fins are joined to each other below the chest and belly from below the gill cover back to just anterior of the anus.

Male gobies are nearly transparent with a mottled brownish upper surface. Females develop darker colors, often black, on the body and dorsal and anal fins.

The goby is a short-lived species; the lifespan of most individuals appears to be about 1 year (Irwin and Soltz 1984, Swift et al. 1989). They prey opportunistically on benthic invertebrates including small crustaceans, insect larvae and snails (Swift et al. 1989; Irwin and Soltz 1984; Swenson and McCray 1996). They use three different foraging styles to capture prey: plucking prey from substrate surface, sifting sediment in their mouth, and mid-water capture (USDI 2005a).

The goby has only been found in California, and occurs in coastal brackish water habitats, such as lagoons, tidal bays and estuaries of rivers and streams along the coastline. The species is unique among Pacific coast fish in its restriction to brackish waters of coastal wetlands where the water is fairly still but not stagnant. They are weak swimmers concentrating in slack-water areas and generally avoiding swiftly moving waters. The species appears to spend all life stages in these brackish waters but may enter marine environments when flushed out by flooding or breaching of sandbars.

Gobies are most commonly found in areas with a muted or intermittent connectivity to tidal waters (Chamberlain 2006). Relatively low salinities, i.e., less than 10-12 parts per thousand (ppt), are frequently characteristic of these habitats. However, the species has been collected in salinities as high as 63 ppt (Goldsmith 2006). The species' tolerance of high salinities likely enables it to withstand some exposure to the marine environment, allowing it to recolonize nearby lagoons and estuaries following flood events (USDI 2006). Gobies also occur in freshwater streams up-gradient and tributary to brackish habitats; the salinity of these freshwater streams is typically less than 0.5 ppt. They can occur 1.6 to 7.3 miles (2.6 to 11.7 km) upstream from the ocean environment (Irwin and Soltz 1984, Swift et al. 1997, Chamberlain 2006, and Goldsmith 2006). Although the reasons for the variation in up-stream movement between one locality and another have not been determined, stream gradient and velocity are likely to be important factors.

Previous sampling for gobies has most commonly occurred in water less than 6 feet (2 m) deep (Wang 1982, Worchester 1992). Consequently, most observations have been made within this depth range. However, gobies were recently collected in Big Lagoon in Humboldt County during the breeding season at a water depth of 15 feet (4.6 m) (Goldsmith 2006).

Gobies have been documented in habitats with water temperatures that range from 46 to 77 degrees F (8 to 25 degrees C) (Irwin and Soltz 1984, Swift et al. 1989).

Current and Historical Range

The goby historically ranged from Tillas Slough in Del Norte County south to Agua Hedionda Lagoon in San Diego County. The species is currently found entirely within the original known

range. The known localities are discrete lagoons, estuaries, or stream mouths separated by marine conditions. Natural gaps in the species' distribution occur where the coastline is steep and streams do not form lagoons or estuaries. Some of the largest gaps in distribution occur in Humboldt and Mendocino Counties, as well as in northern Sonoma County. From Tomales Bay southward to San Francisco, habitat loss and other anthropogenic-related factors have resulted in the creation of unnatural gaps in the species' distribution where the species is absent from several locations where it historically occurred (Capelli 1997). Several large natural and unnatural gaps occur between San Francisco Bay and San Diego County. Gobies have been documented at 134 localities within the historical geographic range of the species. Of these 134 localities, 23 (17 percent) are considered extirpated and 55 to 70 of the localities are naturally so small or have been degraded that long-term persistence is uncertain (USDI 2005).

Reproductive Biology

Reproduction can occur at all times of the year, however peak spawning usually occurs in the spring and then again in late-summer (Swenson 1999). Males excavate burrows, typically in clean coarse sand but also in mud, in which females lay an average of about 400 eggs per clutch. Females can lay 6 to 12 clutches per year (Swenson 1999). Males remain in the burrow to guard the eggs. Larvae emerge in 9 to 10 days and live in a pelagic form, becoming benthic after reaching a length of about 0.5 to 0.7 inches (Moyle et al. 1995). Length of the pelagic larval period is not well studied, but is believed to last anywhere from a couple of days to two weeks or more (Camm Swift, personal communication). Spawning occurs in lagoons/estuaries from April through November, suitable water temperatures for nesting are 75.6 to 79.6 degrees F (most likely a limiting factor in Brainard Slough or Humboldt Bay) with salinities of 2 to 27 ppt. and larvae emerge and live in vegetated areas until they reach 0.5-0.7 inches when as juveniles they ascend and occupy streams for rearing.

Threats

Factors responsible for the historic decline and extirpation of goby populations and habitat include: human development in coastal salt marsh and riparian habitats, dredging, channelization of rivers, loss of habitat due to sediment deposition from upstream watershed disturbances, upstream water diversions that alter downstream flows, drought, groundwater overdrafting, and agricultural and sewage discharge (i.e., pollution) (USDI 1994). Existing threats to the goby include historic threats as well as artificial breaching of creek mouths and lagoons, extreme weather and streamflow conditions, predation by introduced species including mosquitofish (*Gambusia affinis*), sunfish (*Lepomis* spp.), and bass (*Micropterus* spp.), and competition with introduced species (e.g., yellowfin goby [*Acanthogobius flavimanus*] and chameleon goby [*Tridentiger trigonocephalus*]) (USDI 2005).

Conservation Strategy

The goby recovery plan provides a strategy for recovery that is designed to: (1) preserve the diversity of habitats throughout the range, (2) preserve the natural processes of recolonization and population exchange that enable population recovery following catastrophic events, and (3) preserve genetic diversity (USDI 2005). Recovery actions include: (1) protecting and enhancing currently occupied habitat, (2) conducting biological research to enhance the ability to integrate land use practices with tidewater goby recovery, (3) evaluating and implementing translocation where appropriate, and (4) increasing public awareness about gobies.

The recovery plan subdivides the geographic distribution of the goby into 6 recovery units, encompassing a total of 26 sub-units defined according to genetic differentiation and geomorphology. A description of each recovery unit and subunit with recommended tasks for recovery are provided in Appendix G of the recovery plan (USDI 2005).
The recovery plan states that downlisting may be considered when the following criteria have been met: (1) specific threats to each metapopulation, such as habitat destruction and alteration, introduced predators, and competition with introduced species have been addressed through the development and implementation of individual management plans that cumulatively cover the full range of the species, and (2) a metapopulation viability analysis based on monitoring over a 10-year period indicates that each Recovery Unit is viable. Downlisting criteria for the North Coast Recovery Unit specifies that 5 of the 6 identified sub-units must have at least 75 percent chance of persistence for a period of 100 years. The delisting criterion specifically calls for a 95 percent chance of persistence for a period of 100 years (USDI 2005).

Current Conditions Range-wide

Current conditions incorporate the effects of all past human and natural activities or events that have led to the present-day status of the species (USDI Fish and Wildlife Service and USDC National Marine Fisheries Service 1998).

Habitat: Amount, Distribution and Quality

The wetland habitat of individual goby localities varies on a site-specific basis, and is affected in part by local precipitation patterns and topography. For example, in coastal areas where the topography is steep and precipitation is relatively low, the habitats occupied by tidewater gobies may be a few acres in size, only extend a few hundred feet inland from the ocean, and backwater marshes may be small or absent. In coastal areas where topography is less steep and precipitation is more abundant, habitats occupied by gobies may be hundreds of acres in size, extend many miles inland, and contain extensive backwater marshes (USDI 2006).

Appendix E in the recovery plan describes for each of 151 localities of known and potential habitat within 26 recovery subunits, the relative amount and quality of existing habitat (USDI 2005). The amount of habitat is characterized by a description of the size of water bodies and

available habitat: large, medium, and small. Large water bodies are those meeting at least one of the following general physical parameters: streams with channel bankfull widths in excess of 66 feet (20 meters) at any point and/or with estuarine (areas with salt water intrusion) habitats exceeding 0.6 mile (1 kilometer) in length; or lagoons and ponds larger than 5 ac (2 ha) surface area. Medium sized water bodies include smaller streams less than 66 feet (20 meters) bankfull width and/or estuaries longer than 328 feet (100 meters) but less than 0.6 mile (1 kilometer) in length. Medium sized lagoons and ponds have a surface area between 1 ac (0.4 ha) and 5 ac (2 ha) in size. Small water bodies include the remaining streams, ditches, sloughs, lagoons, and ponds that are smaller than the dimensions of medium sized water bodies.

Rangewide, 49 (32 percent) localities contain large water bodies, 44 (29 percent) contain medium sized water bodies, 55 (36 percent) contain small water bodies, and 3 (2 percent) localities were not ranked. The relative quality of habitat is characterized by a statement of the need for habitat restoration at a particular locality: much, some or none. Rangewide, 61 (40 percent) localities require much restoration, 80 (53 percent) require some restoration, 9 (6 percent) require no restoration, and 1 site was not ranked.

The distribution of currently occupied, historically occupied and potential habitat is discontinuous along the California coast. Several large natural gaps in habitat occur throughout the North Coast Unit where the coastline is steep and streams do not form lagoons or estuaries. The Greater Bay Unit contains unnatural gaps in suitable habitat due to habitat loss and anthropogenic-related factors that have degraded habitat and resulted in the extirpation of species from several historic sites. A large natural gap in habitat occurs in the north half of the Central Coast Unit. Both natural and unnatural gaps in habitat occur throughout the Conception, LA/Ventura and South Coast Units (USDI 2005).

Population Numbers, Distribution, and Reproduction

The current goby population is known to occur from Tillas Slough in Del Norte County to Cockleburr Canyon in San Diego County, 9.2 miles (14.8 km) north of Agua Hedionda Lagoon. Gobies do not currently occur in Agua Hedionda Lagoon (USDI 2006). The recovery plan identifies the following 6 recovery units that encompass the historic and current geographic range of the species: North Coast Unit, Greater Bay Unit, Central Coast Unit, Conception Unit, LA/Ventura Unit, and South Coast Unit (USDI 2005).

Currently, there are no long-term monitoring programs in place for this species. Population dynamics are not well documented, and few data are available on the general size of goby populations. However, when present, gobies are frequently the most abundant fish species found at a site (Lafferty et al. 1999a). Population distribution and density can be highly variable within a site. Gobies have been reported in densities as high as 0-138 per square meter and as low as 0-4 per square meter (USDI 2005).

Female gobies are capable of producing as many as 400 eggs in a single reproductive effort. Female gobies frequently initiate more than one reproductive effort per year (Swenson 1995). Reproductive success of each effort is likely highly variable, with some egg laying efforts completely failing.

The goby is known to have formerly inhabited at least 134 localities. In 2005, approximately 17 percent of the 134 documented localities are considered extirpated and 41 to 52 percent are naturally so small or have been degraded over time that long-term persistence is uncertain (USDI 2005). Recolonization of extirpated localities has been documented when extant populations are present within several kilometers (Holland 1992, Lafferty et al. 1999a, 1999b). However, recently gobies have been found in localities considered extirpated that are separated from the nearest population by 6 to 12 miles. These records suggest that distant movement and recolonization is possible (USDI 2005).

Goby densities are highly variable and can fluctuate from year to year, season to season, and within a sampled area. Therefore, determining goby density can be difficult. The recovery plan for the goby discusses density surveys that were conducted by Worchester (1992) and Swift and Holland (1998) using meter-square (ms) drop nets. The distribution of gobies within an area, was found to be quite patchy and not evenly dispersed. The results indicated the following range of densities of tidewater gobies per square meter sampled (twg/ms): Little Pico Creek, San Luis Obispo County: May 1990 0-67 twg/ms, November 1990 0-138 twg/ms, February 1991 0-27 twg/ms, and Camp Pendleton Marine Corps Base, San Diego County: (all samples in October 1996) San Mateo Creek 2-11 twg/ms, San Onofre Lagoon 1-102 twg/ms, Hidden Creek 0-6 twg/ms, Los Flores Creek 0-4 twg/ms, and French Creek Lagoon 1-51 twg/ms.

Current Conditions in the North Coast Sub-Unit 3

Sub-Unit 3 of the North Coast Recovery Unit is completely within Humboldt County. The sub-unit extends about 25 miles in length from the mouth of the Mad River south across Humboldt Bay to the Eel River. The recovery plan identifies five localities within Humboldt Bay watersheds. These localities include Freshwater Slough, Mad River Slough, McDaniel Slough/Klopp Lake, KATA Radio Station, and Jacoby Creek/Gannon Slough. These sites were known to exist prior to 2004, during development of the recovery plan. In addition, White Slough and Hookton Slough had goby detections that were unknown to the Service until 2005 (Cole 2004). From 2005 to the present, gobies have been located in at least five additional areas within Humboldt Bay, including Elk River, Hookton Slough, White Slough, Highway 101 Ditch, and Rocky Gulch. At the same time, the previously known localities of Klopp Lake and Liscom Slough have been resurveyed without detection. Currently, the status of the Mad River Slough, KATA Radio Station, Klopp Lake, and Highway 101 Ditch localities is unknown.

The localities within Humboldt Bay encompass approximately 500 to 1,000 ac, although due to the apparent transient nature of some of the populations, it is likely that the area inhabited by gobies at any given time is probably somewhat smaller.

At this time, very little is known about the relationships between goby populations in Humboldt Bay. Research investigations focusing on genetic relationships within Humboldt Bay are underway to determine whether the known locations are inhabited by separate populations, or whether they are part of one larger metapopulation that uses Humboldt Bay as a means of travel from one suitable site to another.

Sub-Unit 3 also includes the separate Eel River locality, located approximately 8.7 miles south of Humboldt Bay, connected only via the Pacific Ocean. Extensive surveys have not been conducted to determine the extent of tidewater goby presence in the Eel River.

Habitat Amount, Distribution and Quality in North Coast Sub-Unit 3

The margins of Humboldt Bay and the Eel River in Humboldt County consist of generally broad low elevation benches historically dominated by mudflats, tidal marshes, estuarine channels, and brackish marshes. Within these complex estuaries, a substantial amount of historic salt and brackish marsh habitat was converted to agricultural, urban, and industrial uses through the construction of levees and drainage channels. This alteration in Humboldt Bay resulted in the loss of up to 10,000 ac (4,047 ha) of potentially suitable habitat (USDI 2006).

As a result of habitat alteration, several of the localities occupied by the goby do not contain natural sandbars between the ocean and habitat where the species is present. Instead, manmade water control structures, such as tidegates and culverts, exist between tidal waters and the locations where gobies occur. Many of these tidegates have been in place for decades, and in some cases, they provide habitat conditions similar to those created by the presence of a seasonal sandbar. In fact, most of the occupied goby habitat in both the Humboldt Bay and Eel River estuaries is separated from full tidal influence by tidegates.

The Eel River delta contains many small, slough channels and other backwater areas that provide suitable habitat for tidewater gobies, but it also contains larger channels open to direct tidal influence that do not provide suitable habitat. The Eel River is subject to infrequent but severe flooding. In addition to human-caused alterations of the estuary, major floods during the past century may have severely altered habitat in most channels, including the one known location. Much of the suitable habitat in the Eel River is on private lands, and consequently has not been surveyed for tidewater gobies.

Population: Numbers, Distribution, and Reproduction in North Coast Sub-Unit 3

Mad River Slough

This population was actually not found within Mad River Slough, but in the system of adjacent channels connected to McDaniel Slough, which is separated from Mad River Slough by tidegates. Gobies were first detected in 1988 by Dr. Camm Swift in the inboard ditch immediately north of the levee at the junction of State Highway 255 and Mad River Slough. As

a result of that effort, approximately 50 gobies were collected and released, noted as "common". This location was surveyed again in either 1999 or 2000 by Dr. Swift, and tidewater gobies were again detected. In addition, gobies were reported in 2001 from nearby Liscom Slough, which is a tributary slough to Mad River Slough approximately 1.3 miles north of where State Highway 255 crosses Mad River Slough. Gobies were not detected here in subsequent surveys by Service staff in 2003.

McDaniel Slough

This location includes the estuary of Janes Creek, as well as tributary slough and ditch channels that run the length of the levee system bordering the northeast portion of Humboldt Bay. This location is connected hydrologically with the Mad River Slough location described above. Goby surveys were conducted here by Service staff in 2005 with no detections. In 2006, gobies were found in two tributary channels to the inboard ditch along the levee system.

Arcata Marsh/KATA Radio station site

This site, 0.5 mile east of the project boundary, was surveyed in July 1975 by Dr. Camm Swift, with detections of 6 or 7 adult gobies noted as "scarce". This area was resurveyed in 1981 with gobies noted as "common". This area was resurveyed by Service staff in 2003 with no detections.

Klopp Lake

This location, 0.25 mile east of the project boundary, was surveyed in 1982, resulting in detection of an unknown number of tidewater gobies. Since that time, the only known survey was conducted by Service staff in 2004, and did not result in any detections.

Gannon Slough

A tidally muted slough channel system, Gannon Slough includes channels of three small freshwater streams, as well as remnant channels. Gobies were first detected here in 2005, and have been present during several repeat visits in 2005 and 2006.

During the initial detection, it is apparent that gobies were breeding in this location. An estimate of density was recorded for this observation, of 1-3 fish per square meter.

Jacoby Creek

The Jacoby Creek location may be unique among known tidewater goby locations within Humboldt Bay in that it is the only system open to full tidal fluctuation. The location has been surveyed several times between 1975 and 2004 with detections during most or all survey efforts.

Freshwater Slough

Service staff recently discovered gobies in a small elevated channel behind a leaking tidegate adjacent to Wood Creek, a tributary to Freshwater Slough.

Elk River

This location was first documented as containing tidewater gobies in a 2006 survey by Service staff.

White Slough and Hookton Slough, Humboldt Bay National Wildlife Refuge

These two locations, in the South Bay portion of Humboldt Bay, were first documented as containing gobies in 2000. The Hookton Slough location was re-located in 2004 by Service staff.

To date, monitoring has consisted primarily of conducting presence/absence surveys for the species throughout the north coast. In general, many areas that contain suitable goby habitat remain unsurveyed. From 2005-2007 the Service conducted sporadic presence/absence surveys, in the Gannon Slough system, to monitor goby response to the installation of a new "fish-friendly" tidegate (Greg Goldsmith pers. comm.). Gobies were detected in Gannon Slough during the two year span of that survey.

Conservation Strategy for the North Coast Sub-Unit 3

The recovery plan identifies the following management tasks for recovery: (1) monitor, (2) establish degree of genetic isolation of the sub-unit, (3) transfer tidewater gobies to the Mad River Estuary, Klopp Lake, Hookton Slough, and White Slough from the Mad River Slough, Jacoby Creek, Gannon Slough, KATA Station, and Freshwater Slough, (4) consider other sites around the margin of Humboldt Bay for transfer of gobies, and (5) consider localities for transfer from persisting sites after 2 years of absence (USDI 2005). No efforts at transferring tidewater gobies from one location to another have occurred to date in the north coast recovery unit.

Status of Critical Habitat

Primary Constituent Elements

As part of our responsibility in designating critical habitat, the Service has identified the known physical and biological features essential to the conservation of the goby as primary constituent elements. Based on current knowledge of the life history, biology, and ecology of the goby, and the requirements of the habitat to sustain the essential life history functions of the species, we have determined that the primary constituent elements are:

1. Persistent, shallow (in the range of about 0.3 to 6.5 feet [0.1 to 2 m]), still-to-slow-moving, aquatic habitat most commonly ranging in salinity from less than 0.5 ppt to about 10–12 ppt, which provides adequate space for normal behavior and individual and population growth.

2. Substrates (e.g., sand, silt, mud) suitable for the construction of burrows for reproduction.

3. Submerged and emergent aquatic vegetation, such as *Potamogeton pectinatus* and *Ruppia maritima,* that provides protection from predators.

4. Presence of a sandbar(s) or a sill formation across the mouth of a lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, thereby providing relatively stable water levels and salinity.

Current Condition in Critical Habitat Unit HUM-3

The HUM-3 critical habitat unit is located within and around Humboldt Bay and its tributaries, and totals 1,478 ac. HUM-3 is located in the center of the recovery plan's North Coast Sub-unit 3, and it contains the majority of known pops in Sub-unit 3. HUM-3 is comprised of several disjunct and interconnected estuary sloughs, streams, ponds, and ditches along the periphery of Humboldt Bay. These channels collectively mimic, on a much reduced scale, habitats that were lost through past management practices. Many of the channels have muted tidal action compared to the open portions of Humboldt Bay, due to water control structures placed as an interface between fresh and marine waters.

Conservation Strategy for Critical Habitat Unit HUM-3

We anticipate that the persistence of the goby source population within this unit may require protection of localities that are not occupied every year, but collectively form a source population through an interconnected complex of channels and shallow water habitats. That is, any of the several known occupied localities within a channel complex may be used by gobies during various years in response to dynamic habitat conditions during seasonal, annual, and longer term climatic cycles (e.g., drought). Data collected by the Service within the HUM-3 unit since 2002 suggests that in some locations where gobies were recently present, they were subsequently found to be absent. This data supports the idea that tidewater gobies within the unit appear to use locations intermittently.

The interconnectivity of habitat within this unit will reduce the chance of losing the goby along this portion of the coast, help conserve genetic diversity within the species, and help facilitate colonization of currently unoccupied locations.

Recently, significant restoration efforts have occurred or are anticipated to occur within this unit. The outcome of these restoration efforts for gobies is unknown, and will likely vary with their design features and location, but in general, net gains of tidewater goby habitat should result.

Known threats in this unit that may require special management include coastal development, channelization of habitats, non-point and point source pollution, and cattle grazing.

Threats related to coastal development are not well defined for this unit, but could result from a variety of construction related projects in and adjacent to designated critical habitat. The threats related to channelization of habitats consist of creating, modifying, and maintaining artificial channels designed to drain agricultural lands of surface water. The resulting channels have had water control structures, usually tidegates, installed to protect these lands from tidal inundation. Pollution threats include the potential for oil spills, other spills associated with transportation on adjacent highways, and pollutants from nearby paper and lumber mills. Grazing threats in this unit include the potential for destruction of critical habitat due to animal use of the channels, by trampling and eroding channel banks, aquatic vegetation, and modification of slough and stream channels. Humboldt Bay is designated as "Water Quality Limited" by the State Water Resources Control Board. These known threats are listed in detail in Appendix E of the recovery plan.

ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR §402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation process.

According to 50 CFR § 402.02 pursuant to section 7 of the Act, the "action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. Subsequent analyses of the environmental baseline, effects of the action, and levels of incidental take are based upon the action area. We consider the action area for the proposed project to be the approximate 49 ac (20 ha) estuarine area associated with Gannon Slough, that are proposed for restoration, and the area above the Highway 101 bridges, where expansion and restoration of the Jacoby Creek Estuary and floodplain is proposed - (Jacoby Creek Estuary Overview Map, sheet 2 of 6 in the April 19, 2010, Project Description and also attached to this BO).

Project Location

The Lower Jacoby Creek Estuary and south Gannon Slough tidegate installation project is a component of the Arcata Baylands Project which establishes a connectivity of habitat encompassing over 1,300 acres of locally-, state- and federally-protected lands adjacent to the

northern edge of Humboldt Bay. The Arcata Baylands Project Area is directly adjacent to or near the Service's Humboldt Bay National Wildlife Refuge lands, the 225-acre Arcata Marsh and Wildlife Sanctuary, the 508-acre California Department of Fish and Game Mad River Slough Wildlife Area, and Jacoby Creek Land Trust. Most of the Arcata Baylands Project Area consists of former tidelands that now support grazing and other agricultural uses. The project area is zoned Agriculture Exclusive (A-E) and Natural Resource (NR) with a Wetland and Creek Protection Overlay Zone. The site is in the 100 year FEMA floodplain. It is located in the coastal zone.

Goby Habitat: Type, Distribution, and Quality

Gannon Slough and Jacoby Creek form tidally influenced estuarine tributaries to Humboldt Bay. They are the result of a perennial stream, other seasonal freshwater channels that meet areas of tidal flow on Humboldt Bay mudflats, and marsh wetlands that are isolated behind human-created levees. Site vegetation is comprised of agricultural grasslands upstream of the tidegate work site and salt marsh vegetation downstream of the tide gate. The Jacoby Creek work site is dominated by pasture grasses, and Himalaya and California blackberry on the existing levees. Construction of the new levee will require removal of some riparian vegetation comprised primarily of willow and alder.

Throughout the action area, there are seasonal breaks in hydrologic connections, causing periodic isolation of tidewater gobies, especially during the dry season. This condition can result in poor water quality, increased predation from wading birds, stranding from higher quality habitat, and in extreme conditions, desiccation of the habitat and resident fish.

Status of the Species within the Action Area

Within the action area, gobies occupy several known locations in a spatially distributed network that has the potential to change over time as new locations are colonized and others are extirpated. Direct evidence of goby breeding locations is limited in the Humboldt Bay region, but has been documented as occurring, in early July, in Gannon Slough.

Gobies have been found in the lower reaches of Jacoby Creek. Service staff surveyed Gannon Slough and Beith and Campbell Creek on July 6, 2005. Gobies were found in Gannon Slough up to the Beith Creek outlet to Gannon Slough and in a tidal pool adjacent to the proposed tide gate installation area. Service staff surveyed Jacoby Creek Estuary on May 18, 2010, and confirmed the presence of gobies, with the capture of one specimen.

Service staff conducted a goby density survey in Jacoby Creek Estuary, in the vicinity of both Highway 101 bridges, on May 18, 2010. Twelve seine hauls were conducted which thoroughly sampled the area. Only one goby was captured; however, this is not necessarily an accurate representation of goby population density at the site, since goby population numbers can wildly fluctuate from year to year and season to season. Service staff produced a density estimate, for

nearby McDaniel Slough, based on the capture of 8 tidewater gobies in 1.3 ac (0.5 ha) sampled from August 23-25, 2006 (Goldsmith 2006). The Service estimated a density of 6 tidewater gobies per acre for that action area (McDaniel Slough). Because of variability of habitat quality, and the extremely small sample size upon which that density estimate was based, the Service considers 6 tidewater gobies per acre, a maximum density estimate for that action area.

Tidewater Goby Critical Habitat

All potentially suitable goby habitat within the action area (48.7 acres) is contiguous with the HUM-3 goby critical habitat unit, and is associated with Gannon Slough and lower Jacoby Creek. The majority of the area encompasses lower reaches of Jacoby Creek and the branched channels of South Gannon Slough that are hydrologically connected to known locations where gobies have been found.

The 0.1 ac, 500' long ditch, that is proposed to be filled, is within designated goby critical habitat. The April 19, 2010, project update describes the ditch as palustrine emergent wetland that is less than one foot deep in winter, and dries up in summer. This ditch may support gobies during high winter flows. However, when the ditch dries out in the summer, it may trap gobies and become a sink. Although the ditch is within designated goby critical habitat, this ditch has never been surveyed for tidewater gobies (Greg Goldsmith pers. comm.). The ditch is located in the area that will be converted from pasture land to tidal estuary. The placement of 245 CY of fill in the ditch is necessary to ensure that flows are directed to the newly created channel and to prevent ponding adjacent to the levee that abuts the Highway 101 right of way.

Within the HUM-3 unit, some human-made water control structures appear to provide the stability that would typically occur from the formation of a natural sandbar. These elements are all present within the critical habitat located in the action area, and include areas above the tidegate in Gannon Slough and the lower reaches of Jacoby Creek in the vicinity of the Highway 101 bridges, and the pooled area, just downstream of the bridges. Designated critical habitat in this unit includes known locations of goby populations, as well as contiguous habitat located up-channel and down-channel from the known location.

EFFECTS OF THE ACTION

This section presents an analysis of the direct and indirect effects of the proposed project on the goby and its designated critical habitat, together with the effects of other activities that are interrelated and interdependent with the proposed action. These effects are evaluated along with the environmental baseline and the predicted cumulative effects to determine the overall effect to the species and its critical habitat.

Restoration of approximately 49 ac of tidal habitat, contiguous to designated critical habitat for the goby, and re-establishment of hydrologic interconnectivity between estuarine and freshwater habitats, is expected to result in an overall benefit to the goby and its designated critical habitat;

however, indirect adverse effects to gobies could occur from habitat degradation due to sedimentation, scour, and soil compaction. Adults and young could also be indirectly adversely affected from human disturbance. In addition, adult gobies, eggs, and young could be directly injured or killed as a result of construction related activities. Implementation of the proposed conservation measures will minimize or avoid these effects.

Removal and setback of levees; channel creation; and fill of 500' of a disconnected ditch, which will impact 0.1 ac of designated critical habitat for the goby; during the dry season may have temporary adverse effects to gobies in Jacoby Creek due to the release of sediment. If excess sediment is allowed to enter Jacoby Creek from the restoration site, gobies or their burrows may be smothered. Filling of the 0.1 ac, 500' ditch may have short term adverse impacts to designated goby critical habitat. However, this fill is necessary to provide proper drainage of the adjacent tidal habitat to be created, resulting in an overall net gain of 15.3 ac of tidal habitat that will be available to tidewater gobies.

Increased scour could also destroy goby burrows. If increased scour occurs below the project site, the sediment sill that currently exists downstream of the highway 101 may be eroded. If this occurs, the slow water refuge, lagoon-type area, upstream of the sill, which is occupied by gobies, may be eliminated or reduced in size. In addition, designated critical habitat for gobies could be reduced or eliminated and individuals would be exposed to faster currents, and could be flushed out of the system and into Humboldt Bay. As part of project implementation, silt fences, water diversion structures, and other measures included in the project description will be used to minimize these potential adverse effects.

Construction and equipment access in and over wetlands (grazed seasonal wetlands) during summer/fall may compact the ground if it is saturated, and/or crush vegetative cover. To minimize this effect, heavy equipment use in wetted areas will be limited, and no equipment will be operated directly within tidal waters or stream channels of flowing streams.

Adverse effects to adult gobies and their young could occur when work activities result in behavioral modifications such as displacement from a work site that cause a loss or reduction in reproductive effort or survival of individuals. Effects of disturbance depend on the frequency, timing, location, and intensity of the activities. Disturbance will be minimized by exclusion and translocation/removal of gobies from work areas, as described in the project description (conservation measures 1-6). To minimize these effects, all translocation/removal of tidewater gobies will be conducted by qualified biologists under a scientific recovery permit pursuant to section10(a)(1)(A) of the Act.

Gobies, their eggs or young could also be directly injured or killed as a result of a variety of construction related activities:

1. Capture, handling, and removal of tidewater gobies from the work area: using fine-mesh seine nets, gobies will be excluded or relocated from the area to be dewatered for the

replacement of the culvert and addition of a tide gate. At this time, they are susceptible to being injured or crushed by workers while they are entangled in, or being removed from netting.

2. Dewatering of or lowering of water level within suitable habitat: gobies are very small, especially in the planktonic larval form; it is not possible to relocate and move all of the larval or small juvenile size classes to permanently watered habitat outside the work area nor is it likely that all fish will successfully move out of the work area as the water level is lowered. Any remaining fish in the area that is dewatered or has had water levels lowered may die from desiccation, predation, or other causes.

3. Trampling or crushing by people, equipment, or material while operating in suitable habitat: trampling or other physical damage to tidewater goby breeding burrows and the crushing of individuals is possible as a result of fish exclusion activities, and the filling of channels and ditches.

4. Excavation work or erosion can cause excessive sedimentation of burrows containing eggs and adult males while their mobility is restricted.

5. Accidental spill of petroleum products or other waste materials into suitable habitat.

To minimize the potential for injury or death of gobies, tidegate installation and repair will occur when work areas are dry or at low tide. However, these activities may need to occur when some water is present. If work needs to occur when water is present, most gobies will be excluded, but some may remain in the work areas and suffer mortality or injury. Adverse impacts will be minimized because construction will occur on the falling tide and low tide to prevent impacts to fish downstream of the work area. The upstream work area will be isolated from the slough using a temporary dam. Prior to installing the tidegate, the adjacent areas will be seined and a temporary dam installed to remove gobies from the work area. Spills or other potential sources of contamination will be minimized by storage of construction materials, debris, and waste away from waterways; use of silt fences; refueling equipment in upland areas; and other BMPs.

The number of gobies that could be affected by project implementation is difficult to determine, because goby densities are highly variable and can fluctuate by season, year, and within a sampling area. However, 6 gobies/ac is a maximum estimate for the action area, based on survey information collected from the project area. Adverse effects will be minimized through implementation of the conservation measures proposed in the project description. In addition, the project is expected to benefit the goby and its designated critical habitat in the long-term through improved tidal exchange, restoration of goby habitat through changes in salinity and water surface elevations, and a muted tide cycle and lagoon-type conditions in the lower reaches of Jacoby Creek.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur within the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. Proposed actions on City and CDFG lands within and adjacent to the action area are likely to have a Federal nexus with the Corps and require section 7 consultation with the Service. There are no other actions on private or State lands within the action area that are reasonably certain to occur; therefore, cumulative effects would not be likely for activities within the action area.

CONCLUSION

After reviewing the current status of the tidewater goby, the environmental baseline for the action area, the effects of implementing the proposed action, and the cumulative effects, it is the Service's biological opinion that issuance of a permit for the City's Lower Jacoby Creek Estuary Enhancement and South Gannon Slough Tidal Gate Installation Project, as proposed, is not likely to jeopardize the continued existence of the tidewater goby and is not likely to adversely modify critical habitat.

The Service reached the non-jeopardy conclusion based on the following:

1. The proposed project would only impact a small amount of the overall numbers and range of the goby.

2. The number of gobies adversely affected will be minimized through implementation of the conservation measures identified in the project description.

3. The proposed action will improve the long-term viability of the goby population by restoring a historical tidal channel and re-establishing connectivity between tidal and non-tidal lands.

The Service reached the no adverse modification conclusion based on the following:

1. Restoring up to 48.7 ac of PCEs adjacent to currently designated critical habitat for the goby will improve the quality of the PCEs and increase the viability of the goby population in the area and support goby recovery by:

    a. Restoring estuarine function to up to 17.1 ac of estuarine channels associated with Gannon Slough and tributaries.

    b. Restoring historical connectivity between tidal and non-tidal channels (15.9 ac).

c. Restoring 15.3 ac of tidal habitat and channels associated with Jacoby Creek and constructing a new connecting channel between Jacoby Creek and South Gannon Slough (0.4 ac).

2. Within the action area, only 0.1 ac of designated critical habitat for the goby will be altered, which represents 0.007% of the total area of critical habitat designated for the goby in the Unit HUM-3 area.

INCIDENTAL TAKE STATEMENT

*An Incidental Take Statement will be included in the final Biological Opinion.

COORDINATION OF INCIDENTAL TAKE WITH OTHER LAWS, REGULATIONS, AND POLICIES

The incidental take statement provided in this biological opinion satisfies the requirements of the Act. The Service will not refer the incidental take of any migratory bird or bald eagle for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. §§ 668-668d), if such take is in compliance with the terms and conditions, including the amount and/or number specified herein.

CONSERVATION RECOMMENDATIONS

Sections 2(c) and 7(a)(1) of the Act direct Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species and the ecosystems upon which they depend. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The Service has identified the following conservation recommendation which could be implemented by the Corps:

- Anticipating future projects within suitable habitat surrounding Humboldt Bay that may require a Corps permit, the Corps should fund surveys for presence/absence of tidewater gobies.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed, proposed, or candidate species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINTIATION NOTICE

This concludes formal consultation on the proposed Lower Jacoby Creek Estuary Enhancement and South Gannon Slough Tidal Gate Installation Project. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operation causing such take must cease pending reinitiation. If you have any questions regarding this biological opinion, please contact Steve Kramer or Greg Goldsmith of my staff at (707) 822-7201.

Sincerely,

Nancy J. Finley
Field Supervisor

cc:
U.S. Army Corps of Engineers, Eureka, CA (Attn: Carol Heidsiek)
City of Arcata, Arcata (Attn: Julie Neander)

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Lower Jacoby Creek Estuary Enhancement Conceptual Design Alternatives

For the City of Arcata Baylands Project

Prepared for:

City of Arcata, and

California Department of Fish and Game

Draft:

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Final:

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Prepared by:

Jeff Anderson & Associates
Engineering – Hydrology – Geomorphology – Water Resources
P.O. Box 841, Arcata, California 95518-0841
(707) 822-5444; jeff@northernhydrology.com

1. Introduction

1.1. Background

The City of Arcata is proposing to restore and enhance tidal wetland function to Lower Jacoby Creek and its adjacent northerly pasture, an area that historically sustained extensive estuarine and salt marsh habitat. Currently the Lower Jacoby Creek system has limited function due to: (1) in-channel flood flow loss upstream and downstream of Old Arcata Road; (2) channel constriction (aggradation and levees) through the coastal plain reach; (3) hydrologic disconnection of the channel from the adjacent floodplain (pasturelands); and (4) a rapid transition between the freshwater and saltwater zone (i.e. stream-estuary ecotone).

This project consists of developing conceptual design alternatives for enhancing estuarine and intertidal habitats by reconnecting pasturelands to Gannon Slough and Jacoby Creek. It is anticipated that the restored tidal exchange will enhance mudflat, slough channel and tidal wetland habitats.

As part of a California Department of Fish & Game Grant (Grant No. P0410312), the City of Arcata retained Jeff Anderson & Associates (JAA) to help prepare conceptual design alternatives.

1.2. Project Location

The Jacoby Creek watershed drains the easterly forested mountains surrounding Humboldt Bay, California. The 15.6 square mile watershed flows east to west ultimately draining into North Bay. Approximately 3 miles upstream from North Bay, Jacoby Creek flows across pasturelands of the Eureka Plain through an aggraded and leveed channel. Within this 3 mile reach Jacoby Creek flows under three bridges, one at Old Arcata Road and two at Highway 101.

This conceptual design phase focuses on the lower 800 feet of Jacoby Creek upstream of Highway 101 and the adjacent northerly pasture (project area) shown in Figure 1-1. Also shown on this figure are the common names of adjacent pastures, roads, creeks and sloughs used in this report.

1.3. Project Limitations

This work focused on developing conceptual design alternatives for the project area based on the existing available data and information. Since the extent of tidal inundation of the project area was the major identified constraint, the major effort of this work focused on analyzing the increased tidal prism of each conceptual alternative, and understanding the extent, elevation and duration of tidal flooding within the project area under a range of tidal and streamflow conditions. The analysis of each alternative also focused on understanding the increased flooding potential, if any, by allowing a larger tidal prism into the project area.

2. Historic Changes and Conceptual Models of Lower Jacoby Creek

2.1. Historic Changes to Lower Jacoby Creek

A review of historic maps and photos (Figure 2-1) indicates that Lower Jacoby Creek and estuary were part of a larger tidal wetland complex with multiple and sometimes interconnected slough channels that drained to Humboldt Bay. Higher flow events that overtopped the banks along Lower Jacoby Creek likely flowed laterally north towards Gannon Slough and south towards Brainard Slough. Between 1870 and 1916 a levee was constructed along a parcel line that borders the northern bank (right bank) of Jacoby Creek, disconnecting the stream channel from the north bank floodplain and tidal wetland system.

The following provides a brief history of the conditions and changes that have occurred to Lower Jacoby Creek and estuary over time (Figure 2-1).

2.1.1. 1870 U. S. Coast Survey Map

The 1870 U. S. Coast Survey Map of Humboldt Bay illustrates the Jacoby Creek estuary prior to development:

- Pre-railways, levees or bay front roads,
- Extent of historic salt marsh habitat and the density of slough channels,
- Dendritic channel formation typical of tidal systems,
- Narrow single thread channel of Jacoby Creek at the approximate location it occupies today,
- Small branch slough channels on Lower Part of Jacoby Creek,
- During overbank events Jacoby Creek could spread across tidal wetland towards slough channels to north and south.

2.1.2. 1916 U.S. Army Map

The 1916 U.S. Army Map shows the Jacoby Creek estuary post-railway development:

- Roads, railroads and/or levees ran north-south and bisected Jacoby Creek and adjacent slough channels,
- Jacoby Creek appears to be draining into the slough channel south of what is considered the main channel today (could be a mapping error),
- South Branch Gannon Slough is not mapped,
- It's likely that tidal wetlands adjacent to Jacoby Creek were converted for agricultural uses.

2.1.3. 1931 Aerial Photograph

The 1931 aerial photograph shows the highway has been built (2 lanes) and a number of the slough channels have been blocked from tidal inundation:

- Jacoby Creek is flowing through a single-thread, leveed channel,
- Slough channels are visible, north of the creek,
- A large levee extends along the north edge of Jacoby Creek west towards North Bay, then extends north-east towards Gannon Slough, this is the right bank levee that exists along Lower Jacoby Creek today,
- Riparian channel is intact within the lower channel perhaps indicating a limited estuary (tide water – fresh water ecotone).

2.1.4. 1958 Aerial Photograph

The 1958 aerial photograph shows Jacoby Creek estuary after Highway 101 is changed from a 2-lane to a 4-lane highway (north-bound lanes have been added):

- Jacoby Creek flows straight into North Bay, an oxbow was created upstream of Highway 101, which could have occurred during expansion of the highway,
- The oxbow is still visible,
- It appears that the Jacoby Creek delta/tidal marsh is expanding into North Bay,
- Slough channels are becoming less pronounced.

2.1.5. 1988 Aerial Photograph

The 1988 aerial photograph shows Lower Jacoby Creek and estuary in its current alignment:

- The oxbow is not visible and has overgrown with vegetation,
- The Jacoby Creek delta/tidal marsh continues to form bay ward into North Bay,
- The mouth of Jacoby Creek runs straight west in North Bay and appears to have abandoned its historic north-west flowing slough channel, perhaps an effect of rapid delta formation, and/or being captured by another slough channel.

2.1.6. 2005 Aerial Photograph

The 2005 aerial photograph shows Lower Jacoby Creek and estuary in its current alignment:

- The Jacoby Creek delta/tidal marsh continue to form into North Bay, increasing the complexity of the channels, bay ward of the highway,
- Slough channels north of Jacoby Creek appear to have filled in.

Jeff Anderson & Associates

Figure 1-1 Location and general vicinity map.

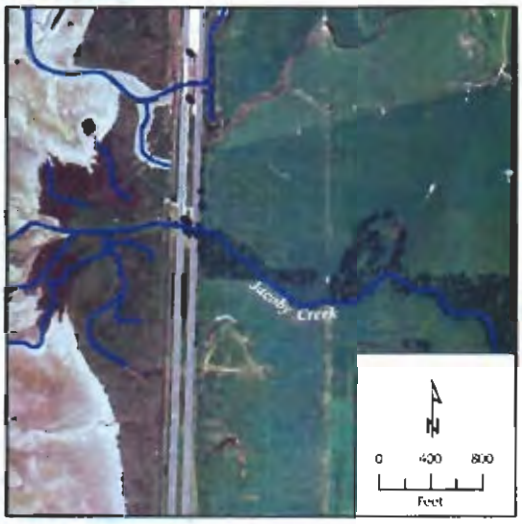
1870 U.S. Coast Survey Map

1916 U.S. Army Map

1931 Aerial Photograph

1958 Aerial Photograph

1988 Aerial Photograph



2005 Aerial Photograph

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Engineering - Hydrology - Geomorphology - Water Resources

Figure 2-1 Historical Evolution of the Jacoby Creek Estuary.

2.2. Conceptual Model of the Geomorphic Evolution of Jacoby Creek Proposed by Phillip Williams & Associates

In 2000 the Coastal Conservancy requested Philip Williams and Associates (PWA) to outline preliminary concepts for the lower part of Jacoby Creek. As part of that work, PWA developed a conceptual model of the geomorphic evolution of Jacoby Creek, which is repeated below (PWA, 2000, page 5):

> "While some geomorphic studies have been carried out on Jacoby creek (e.g. Lisle, Turtle) they do not appear to describe the floodplain and wetland landscape in the lower 1.5 miles. In the absence of a geomorphic analysis or of detailed topography, the following describes a conceptual model based only on a generalized understanding of floodplain/estuarine transitions, and a review of USGS 7.5 minute topography, aerial photos and a site visit. This conceptual model underlies the rationale for elements of the restoration concept described in succeeding sections.
>
> In its natural state sediments deposited by overbank flows created low natural levees and a floodplain that sloped away from the channel near the mouth of Jacoby Creek. The riparian corridor would have been wooded with large trees that were progressively undermined by channel migration and bank erosion creating a complex structure of fallen trees, scour holes, bars and pools. The floodplain may also have been wooded or was wet meadow sustained by high water tables just above the area of tidal influence. Here the floodplain intersected with a flat vegetated marshplain formed of estuarine sediments and peat accumulation at about the Mean Higher High water level. In the lower part of Jacoby Creek backwater from high tides would cause floodflows to spill out of the channel forming a natural riparian leveed corridor extending into the tidal marsh. During major flood events overflow onto the floodplain would tend to be concentrated by fallen trees into pools or parallel channels that might drain back into the main channel further downstream. Closer to the mouth flood overflows would be captured by tidal sloughs that fed tidal water onto the marshplain.
>
> Over the last 150 years this river system was substantially altered by clearing of the floodplain woodland and leveling of floodplain fields, thereby eliminating back channels and pools and reducing the complexity of floodplain habitat. Clearing and grazing also greatly reduced the amount of woody debris in the river channel allowing it to create a more simple form and significantly reducing the amount of pools and overhanging structure. Logging in the watershed greatly increased sediment delivery probably causing significant creekbed aggradation and filling of pools. The construction of roads and bridges 'pinched' the ability of the creek channel to migrate laterally as well as possibly increasing flood elevations upstream. Diking and draining of the tidal wetlands caused them to subside. Channel straightening and levee construction isolated the stream from the former wetlands and speeded up floodflows simplifying habitat structure.
>
> Over the next 100 year with no action taken to protect and restore the riparian corridor, the creek channel will continue to migrate and erode banks making it likely that individual landowners will attempt to harden or artificially control erosion, thereby degrading riparian habitat; in addition continued grazing will prevent recruitment of new riparian woodland leading to further degradation; sediment delivery may decline causing long term channel incision; and sea level will rise causing water-logging of low-lying areas and increased maintenance costs for dikes and drains."

2.3. Revised Conceptual Model and Vision of Lower Jacoby Creek Proposed by Jeff Anderson (Jeff Anderson & Associates) and Darren Mierau (McBain & Trush)

Recently Darren Mierau (McBain & Trush) and Jeff Anderson (JAA) have expanded on the PWA conceptual model based on ongoing work and field observations within Lower Jacoby Creek. As part of a recent California Department of Fish and Game grant proposal submitted by the Jacoby Creek Land Trust, they developed the following summary of their expanded conceptual model and vision for Lower Jacoby Creek, portions of which are repeated below:

Background Information

Jacoby Creek has limited functioning estuary. Other, more productive tributaries to Humboldt Bay (e.g. Freshwater Creek, Rocky Gulch) descend from the watershed and have two significant mainstem reaches, the "stream-estuary ecotone" defined as the tidally influenced freshwater reach, and a slough channel with a gradual transition from freshwater to brackish to marine salinities. Both these reaches occur below approximately 10 ft elevation (NAVD88). In Freshwater Creek the 10 ft contour crosses at approximately Howard Heights Bridge. In contrast, Jacoby Creek's profile is much steeper nearly all the way to Humboldt Bay, crossing the 10 ft contour 2,470 ft from Hwy 101, thus compressing the estuary and stream-estuary ecotone along the mainstem. We'll discuss juvenile salmonid use of these estuarine reaches below.

Jacoby Creek is an aggrading coastal plain that has been confined by levees for many decades in one valley-bottom location. Its high sediment load has promoted the formation of natural levee deposits (an alluvial delta) that have perched the mainstem at or near the valley floor elevation along much of the project reach. For example, the thalweg elevation in Jacoby Creek just upstream of the Old Arcata Road Bridge is approximately 19.5 ft, but 1,200 ft to the north, the floodplain elevation is approximately at the 20 ft elevation. The significant feature here is that for nearly the entire length of the reach from Brookwood Bridge to Humboldt Bay (3.3 miles of mainstem), Jacoby Creek has essentially no connectivity to its floodplain. Floodwaters that leave the mainstem channel do not return to the mainstem, but instead sheet-flow across wetland pastures and coalesces in a dysfunctional system of drainage ditches. We speculate that salmonids entrained in floodwaters and swept out of channel encounter nearly 100% mortality.

What We Know About Salmonid Use of Estuaries

A broad generalization of ecological and fisheries literature is that tidal marshes support high secondary production and contribute significantly to the early life history of many fish species (Simenstad et al. 2000), including juvenile salmonids. Healey (1982) proposed the concept of "estuarine dependence" in which tidal marshes are considered a requisite rearing habitat for juvenile salmonids. Several recent studies have shown that estuaries may even enable juvenile salmonids to recruit disproportionately to the adult population compared to fish that rear in upstream habitats, because larger fish have higher ocean survival rates (Beck et al. 2001, Ricker 2003, Miller and Sadro 2003, Bond 2006). Factors hypothesized to contribute to the disproportionate success of estuarine reared fish include higher growth rates resulting from abundant invertebrate food and

favorable water temperatures, suppressed predation resulting from high turbidity and deeper channels, and a favorable transition area for smoltification.

We define this highly productive rearing zone to include the "stream-estuary ecotone", the area extending from the upper limit of tidal influence downstream to where channels becomes surrounded by mudflats, and the downstream-most freshwater reach. This definition of the ecotone, borrowed from Merrell and Koski (1978) and Miller and Sadro (2003) includes all tidal channels and fringing marsh habitats that are accessible to fish for at least some portion of the tidal cycle. Additionally, we include the stream reach from the head of the valley to the head of the tide, because it is potentially equally productive if hydraulic and habitat conditions are optimal. Our goal is to attribute survival of returning adult salmonids to juvenile rearing within the stream-estuary ecotone. As Bond (2006) concluded, "In light of population declines, it is necessary to make the link between individuals that recruit to the reproductive population, and the factors that may have lead to their survival." Higher ocean survival of salmonids reared in the ecotone would be an important justification for continued and increased focus on estuary and tidal marsh restoration in Humboldt Bay and elsewhere in the Pacific Northwest.

We view salmonid populations in a manner similar to Mobrand et al (1997) who describe salmonid ecology in terms of three elements: habitat capacity and productivity, and life history diversity. Capacity encompasses density-dependent processes or habitat quantity, productivity encompasses density-independent processes or habitat quality, and life history diversity focuses on the multiple pathways or "tactics" individual organisms or cohorts utilize in completing their life cycle. Some basic management goals are thus to (1) increase capacity by restoring access to available or critical habitats (e.g., estuarine rearing), increase carrying capacity by increasing pool frequency, large woody debris, etc., (2) increase growth rates, condition factor, off-channel habitat with more favorable energetics, etc., all of which translate into higher productivity and a larger size-class distribution of rearing juveniles, and subsequent increased survival through the next life stage, and (3) increased life history diversity by providing alternative pathways (e.g., juvenile rearing in tributary, mainstem, or estuarine habitats), which renders salmonid populations more resilient to external disturbance and threat of extinction.

Our conceptual model is not new. Quinn and Peterson (1996) note that coho salmon populations may be limited by the amount of freshwater rearing habitat available, and that the carrying capacity may be set during the summer low-flow period by the amount of pool space. Their study found a strong correlation between the size of fish in early October and subsequent winter survival. Ricker (2003) back calculated steelhead smolt lengths at ocean entry from scale samples collected from adult steelhead returning to Freshwater Creek to spawn, and a regression relationship between scale radius and fish length. This analysis indicated the average size at ocean entry of returning adults was 194 mm whereas the average smolt length at the HFAC trap was 156 mm. Ricker speculated that steelhead spend time growing in the estuary before entering the ocean. Mike Wallace of CDFG has been sampling salmonids in the stream-estuary ecotone of several Humboldt Bay tributaries for several years, and has identified at least three different coho salmon life stages utilizing tidal zones (M. Wallace, personal communication): (1) extended summer rearing of age-0 coho in freshwater zones with suitable water temperatures, (2) extended winter rearing, potentially by an entirely

different cohort of age-1 coho, during which increased stream runoff expands the boundaries of the freshwater-dominated zone, and (3) brief rearing of spring age-1 in brackish zones for smolting.

Our Vision for a Functioning Stream-Estuary Ecotone

The key to understanding the potential for restoration of the stream-estuary ecotone on Jacoby Creek is to understand the pathway of floodwaters. Currently, water that exits Jacoby Creek via overbank flow cannot reenter Jacoby Creek anywhere downstream.

Jacoby Creek likely never had a "typical" estuary characterized by a long, low-gradient meandering channel with gradual transition from fresh to saline water. Instead, Jacoby Creek's estuary lies in the adjacent former tidelands to the north and south, lands wholly owned by the City of Arcata. On the north side, several small tributaries drain into Gannon Slough from the surrounding hillsides, including Campbell, Fickle Hill, and Beith Creeks. Hydrologic connectivity occurs between Gannon Slough and its tributaries, and Jacoby Creek, only briefly during large storm events, or at the very bottom of the system to the west of Hwy 101. This area, however, "receives" a large portion of the overbank flows from upstream reaches of Jacoby Creek, all of which are confined to drain through Gannon Slough into the bay. To the south of Jacoby Creek, remnant slough channels and pasture drainage ditches flow to a small, perched tide gate. The only hydrologic connection between this landscape and Jacoby Creek is one-way: overbank flows leave Jacoby Creek and flow down the pasture and into the tide gate, or across Bayside Cutoff into Brainard Slough.

The third zone of "hydrologic dysfunction and disconnection" is the broad valley upstream of Old Arcata Road. This area was partially described in a project completed in December 2006 for the Jacoby Creek Land Trust by Jeff Anderson and Associates (JAA). According to the JAA final memorandum (JAA 2006), the bankfull discharge for Jacoby Creek upstream of JCLT property is approximately 1150 cfs. Overbank flows on the Kokte Ranch property and downstream properties were observed by JAA staff on 13 December 2006. Using gaged streamflows for Jacoby Creek at the Brookwood Bridge (Randy Klein, personal communication), the observed discharge that overtopped the banks in the vicinity of Old Arcata Road was approximately 300 cfs and occurred both upstream and downstream of the Old Arcata Road bridge. Attachment 4 [see JAA, 2006] shows the general flow paths of overbank flow within the project area and adjoining properties observed by JAA staff on 13 December 2006. Conclusions for the JAA (2006) work include:

1. Lower Jacoby Creek is confined by levees along much of its length.
2. Overbank events occur at lower discharges than expected from a flood frequency analysis. This is likely a combination of channel aggradation and levee confinement.
3. Overbank flows have no return pathways to the stream channel and are intercepted by the existing storm drain system.
4. Overbank flows overwhelm the storm drain system resulting in flooding of the road and adjacent properties.

5. The frequency of flooding events will increase if lower Jacoby Creek is undergoing similar aggradational changes as those measured upstream.
6. Lower Jacoby Creek does not provide much low-velocity habitat or refugia due to the levees, existing flow paths, and nature of the existing floodplains.
7. Overbank flows have limited opportunities to directly return to the creek as flows recede. This also increases the potential of salmonid and other aquatic species stranding.

To summarize, overbank flows from Jacoby Creek upstream of Old Arcata Road occur frequently, and at a fraction of the bankfull discharge. Flood flows drain away from the channel into undersized and poorly-maintained ditches, across cattle pastures, and coalesce in either drainage ditches or relict slough channels before exiting under Hwy 101 into Humboldt Bay. Floodwaters do not reconnect to Jacoby Creek. Tidal marshes at the bottom of this "system" occupy less than 5% of the former tideland area.

Our vision for a functioning stream-estuary ecotone is to reconnect lower Jacoby Creek with restored tidal and freshwater marshes and a network of reconnected adjacent slough channels, and purposefully route upper Jacoby Creek's floodwaters into these habitats. This vision entails a mosaic of habitats, broad-gradient transitions between distinct zones, and multiple species including juvenile salmonids, tidewater goby, estuarine-dependent fish, and likely open space for cattle and goose grazing.

3. Existing Conditions

This chapter describes the existing conditions of the Lower Jacoby Creek area, with an emphasis towards the project area.

3.1. Project Area

The project area consists of an approximate 114 acre pasture immediately north of Lower Jacoby Creek (Figure 3-1). It is bounded by Jacoby Creek to the south, Highway 101 and Gannon Slough to the west, the historic railroad berm to the north and north-east, and a slightly elevated pasture road and drainage ditch to the east. South Branch Gannon Slough (also known as North Fork Jacoby Creek) bisects the project area and discharges into Gannon Slough via a tide gate structure.

3.2. Available Topography and Bathymetry

One foot photogrammetric topography of the project area and surrounding areas were conducted by the City of Arcata in 2003. The photogrammetry covered the overbank/pasture areas, but in-channel bathymetry of Jacoby Creek and slough channels was limited due to vegetation and surface water.

In 2006 McBain & Trush (M&T) conducted a limited thalweg and channel cross section survey of the project area, which included:

- 2,000 foot longitudinal profile, and three cross sections over an 800 foot reach of Lower Jacoby Creek directly upstream of Highway 101,
- 800-foot longitudinal profile, and one cross section in the drainage/borrow ditch north of Jacoby Creek and parallel to Highway 101, and
- 3,325-foot longitudinal profile, and two cross sections of South Branch Gannon Slough (or North Jacoby Creek).

Upstream of Old Arcata Road, six channel cross sections and a longitudinal profile was surveyed in Jacoby Creek by Jeff Anderson & Associates (JAA) and M&T in December 2006. Within this reach the survey showed that Jacoby Creek has simple channel geometry and a featureless floodplain that lacks high flow channels.

All vertical elevations reported in this report are referenced to NAVD88, unless otherwise noted.

3.3. Setting

Historically the project area was a part of a larger tidal wetland complex. The construction of levees, Highway 101, and the installation of tide gates has allowed the conversion of these tidal wetlands into pasture.

A large remnant slough channel known as South Branch Gannon Slough bisects the project area. This slough channel is tide gated at its downstream end just prior to discharging into Gannon Slough. Over the years this slough channel has filled with

sediment due to the loss of tidal flushing, and ranges from approximately 2 to 6 feet in elevation. The existing tide gate leaks, which has allowed enough saltwater to flow into South Branch Gannon Slough to sustain a small intertidal zone within the lower portions of this slough channel. However, the saltwater flow is entirely contained to the slough channel and the tidal prism (volume of tidal water) is not enough to establish substantial tidal wetlands within the pasture areas. Based on visual observations it appears that the upper extent of the existing intertidal zone is approximately elevation 3 to 4 feet.

The project area is completely surrounded by levees along the south, west and north to north-east side's (Figure 3-1). Jacoby Creek is separated from the project area by a large right bank levee along the lower end of the channel, and higher overbank sediment deposits on the upper end, with elevations ranging from 9 to 13 feet. The westerly edge of the project area is defined by a continuous levee with elevations ranging from 9 to 12 feet that parallels Highway 101. The historic railroad grade also functions as a levee along the north and north-east sides of the project area. The elevation of the railroad grade is approximately 8 to 10 feet. A breach exists in the railroad grade that allows flood waters to flow in and out of the project area from adjacent pastures.

Along the east project area boundary ground elevations rise to approximately elevation 7 to 8 feet. The ground in the easterly pasture continues to increase in elevation towards old Arcata Road. Historically the upper end of South Branch Gannon Slough continued east into the easterly pasture and north towards Beith Creek. Currently South Branch Gannon Slough terminates at the north-east corner of the project area at an old farm road and perhaps collapsed crossing. The easterly pasture drainage, which slopes in a north-west direction towards the upper end of South Branch Gannon Slough, backs up at the farm road during flood events and eventually overtops the road flowing into South Branch Gannon Slough.

Pasture elevations within the project area range from 5 to 8 ft, with the majority of the area at an approximate 6 foot elevation. Ground elevations are highest towards Jacoby Creek and slope in a north to north-east direction towards the historic railroad grade. The north and north-east portions of the project area are approximately one foot lower in elevation than the southerly portions, perhaps due to a lack of tidal sediment deposition and/or subsidence. Any overbank flows from Jacoby Creek within the project area would naturally flow towards South Branch Gannon Slough and exit out the existing tide gate.

The project area has no continual freshwater inflows except precipitation, overbank flows from Jacoby Creek, and perhaps some spring seeps along the easterly edge. Drainage from the entire project area is through a single 4 foot wide by 5 foot tall tide gate into Gannon Slough. The tide gate is top hinged and has an invert elevation of 0.46 feet.

During wet-weather periods overbank flows from Jacoby Creek, both upstream and downstream of Old Arcata Road, flood into this area causing standing water over a large portion of the pasture until drained through the single existing tide gate structure. Following high flood conditions water levels in the project area can sometimes take a number of days to drain completely.

3.4. Tidal Hydrology

3.4.1. Measured Tidal Data

The nearest active tidal station to the project area is the North Spit tide gage (NOAA Station 9418767) near the Humboldt Bay entrance. Since tide levels in North Arcata Bay are generally higher and lag other areas of Humboldt Bay (e.g. entrance and South Bay). NOAA briefly monitored tide elevations in Mad River Slough (NOAA Station 9418865) for a four month period (December 1978 to March 1979), and has updated tidal data for this station to the current epoch.

As part of reference tidal wetland work, JAA measured tide elevations in the north-east corner of North Bay near a reference wetland. This tide gage was active for an approximate 12 month period (August 2006 to July 2007), and preliminary tidal data from this gage was used for this project. It should be noted that the JAA North Bay tide gage was above a downstream control (sill) that effected or controlled low tide elevations.

Table 3-1 summarizes tidal data for the North Spit, Mad River Slough, and JAA North Bay tide gages. Based on the Mad River Slough tidal data, the diurnal tide range is approximately 7.63 ft between mean higher high water (MHHW) and mean lower low water (MLLW). Also listed in Table 3-1 for the JAA North Bay tide gage is the mean monthly maximum water, which is the average of the maximum measured tide levels each month. This is not a typical tidal datum such as MHHW or an indicator of average spring tides, but was used as an indicator of the anticipated highest average monthly tide elevation.

Table 3-1 Tidal Data for North Spit and Mad River Slough Tide Gages (Tidal Epoch 1983-2001) and JAA North Bay Tide Gage (POR: August 2006 to July 2007) referenced to NAVD88.

Tidal Data	North Spit (NOAA Sta. 9418767) (feet, NAVD88)	Mad River Slough (NOAA Sta. 9418865) (feet, NAVD88)	JAA North Bay Tide Gage (feet, NAVD88)
Highest Observed Water Level (1/26/1983)	9.39		
Mean Monthly Maximum Water	7.74		7.84
Mean Higher High Water (MHHW)	6.53	6.63	6.87
Mean High Water (MHW)	5.82	5.91	6.14
Mean Sea Level (MSL)	3.37	3.25	
Mean Tidal Level (MTL)	3.37	3.13	
Mean Low Water (MLW)	0.93	0.35	
Mean Lower Low Water (MLLW)	-0.33	-1.00	
Lowest Observed Water Level (1/19/1988)	-3.23		

McBain & Trush monitored tide elevations in Lower Jacoby Creek immediately upstream of the Highway 101 Bridge for an approximate 7 month period (December 2005 to July 2006). Figure 3-2 shows the tidal curve for Lower Jacoby Creek and the North Spit Gage for the period from 3 to 16 July 2007. This measured tidal curve from the MT Jacoby

Creek tide gage was used in the hydraulic analysis for this project. It is apparent that Lower Jacoby Creek tide elevations are higher and lag North Spit tide levels. Due to the aggraded nature of Jacoby Creek a downstream low flow control is apparent at an approximate elevation of 4.2 feet. In fact, at the beginning of the tidal curve some of the North Spit lower high tides do not propagate into Lower Jacoby Creek.

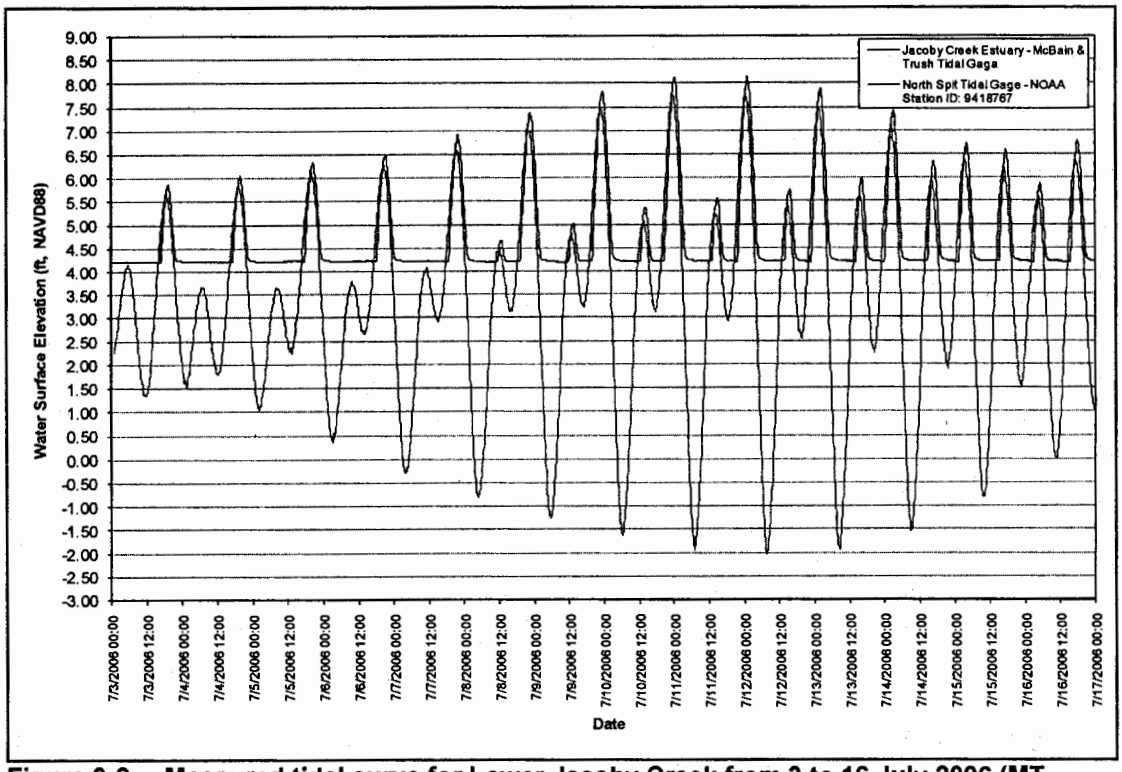

Figure 3-2 Measured tidal curve for Lower Jacoby Creek from 3 to 16 July 2006 (MT Jacoby Creek Tide Gage) and North Spit Gage (NOAA Station 9418767).

3.4.2. Synthetic Tidal Curve

To provide additional tidal data for project analysis a synthetic tidal curve was generated for Lower Jacoby Creek at its exit discharge point into North Bay. The synthetic tidal curve matches mean water levels (MHHW to MLLW), and can be used to simulate long-term average water levels and project intertidal habitat changes within the project area.

The synthetic tidal curve for Jacoby Creek was generated using a two-dimensional hydrodynamic model (2d model) of Humboldt Bay created by JAA (modeling work in progress) for producing tidal elevation boundary conditions for restoration projects in Humboldt Bay. The downstream boundary condition for the 2d model was a MHHW to MLLW synthetic tidal curve for the North Spit tide gage (Table 3-1) described as:

$$\mathbf{Ht\ (t) = a \cos (360t/T) + Z}$$

where Ht (t) = astronomical tide at time t, a = tidal amplitude, t = time, T = tidal period, and Z = vertical offset or datum adjustment. For this curve the tidal amplitude varied between 3.82 ft (MHHW to MLLW) with a tidal period of 12.42 hours (half of 21.84 hour tidal day).

Figure 3-3 shows the MHHW to MLLW synthetic tidal curve generated for Lower Jacoby Creek from the 2d model, along with the North Spit synthetic tidal curve boundary condition. As with the measured Lower Jacoby Creek tidal curve (Figure 3-2) the modeled synthetic tide curve shows a similar tidal propagation and lag compared to North Spit. The modeled Lower Jacoby Creek tide levels also show the effects of the higher mudflat and slough channel elevations that generally exist in North Bay.

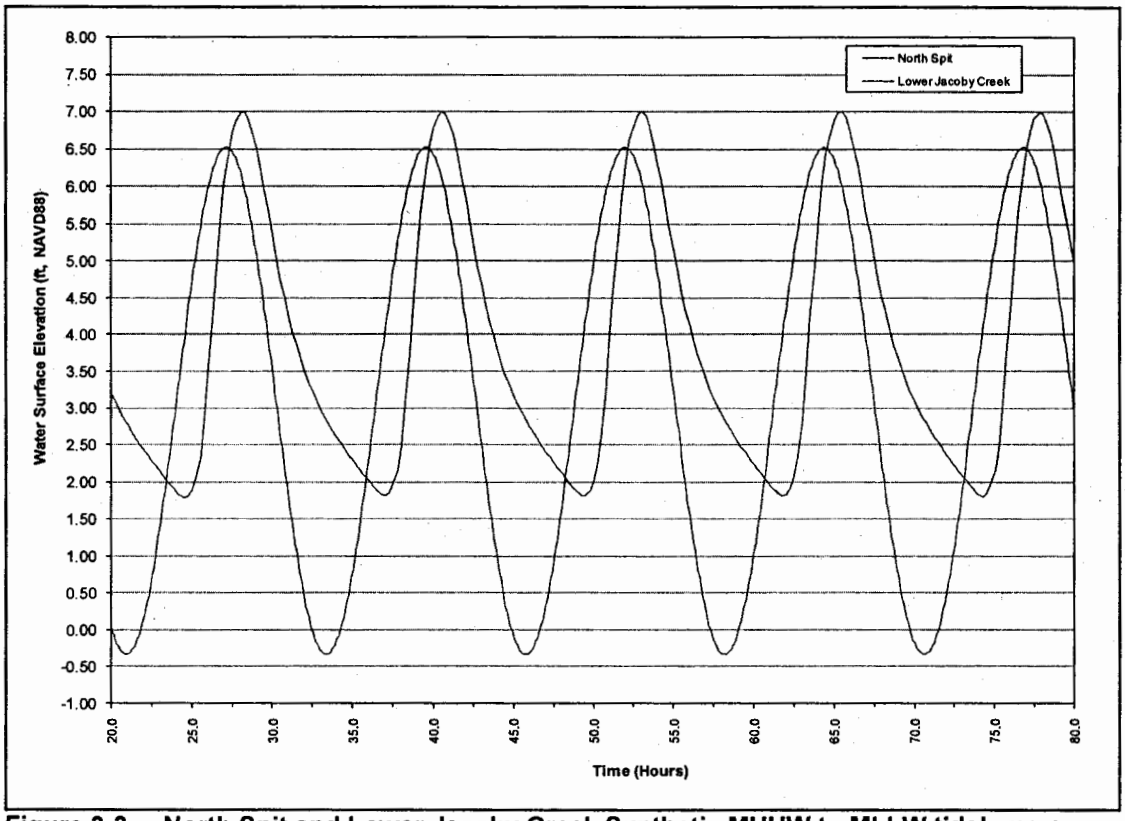

Figure 3-3 North Spit and Lower Jacoby Creek Synthetic MHHW to MLLW tidal curve.

3.5. Surface Water Hydrology

Currently Jacoby Creek is gaged at the Brookwood Bridge by Randy Klein (unfunded, volunteer basis). Based on gaged streamflows (Randy Klein, personal communication) a low flow estimate for Jacoby Creek in the months of May and June of 2006 was approximately 10 cfs. Bankfull discharge is the amount of flow a stream channel is capable of conveying before overtopping its banks. The typical annual recurrence interval for a bankfull event is 1.5-2 years (Leopold et al, 1964). Based on existing flow records, the bankfull discharge for Jacoby Creek near the Brookwood Bridge is approximately 1150 cfs (Lisle, 1986).

3.6. Existing Condition Hydraulic Model Results

To provide insight into existing hydraulic conditions within the project area, the hydraulic model developed for this project (described in Chapter 4) was run for two of the three analyzed conditions. Figure 3-4 shows modeled results for the Jacoby Creek

MHHW to MLLW synthetic tidal curve (Figure 3-3) and the low Jacoby Creek base flow of 10 cfs. The modeled high tide levels in Jacoby Creek are consistent with the downstream boundary condition. An assumption of the existing condition hydraulic model is that the tide gate does not leak, which is evident by the lack of tidal water in the storage areas.

To demonstrate flooding within the project area for existing conditions the hydraulic model was run for the MHHW to MLLW synthetic tidal curve boundary condition and the 1,200 cfs triangular flood hydrograph (Figure 3-5). Model results indicate that a large portion of the flood flow exits the Jacoby Creek channel and flows into the storage areas (overbank areas). Note that the stage in the storage areas are approximately elevation 10 feet, while the stage in Jacoby Creek is at 7.6 feet, only about 0.6 feet above MHHW. Previous flood work and observations on Jacoby Creek have shown that overbank flows occur on Jacoby Creek upstream and downstream of Old Arcata Road at approximately 300 cfs (Jeff Anderson & Associates, December 2006), and once flows go overbank there is no opportunity for flows to re-enter Jacoby Creek. In fact, results from the hydraulic model indicate that a little over 300 cfs remains in Jacoby Creek downstream of Old Arcata Road, indicating that a majority of flood flows overtop the existing channel levees and flow onto the floodplains. Model results also indicate that it takes over two days for the accumulated flood waters to drain from the project area (storage areas) through the single existing tide gate structure.

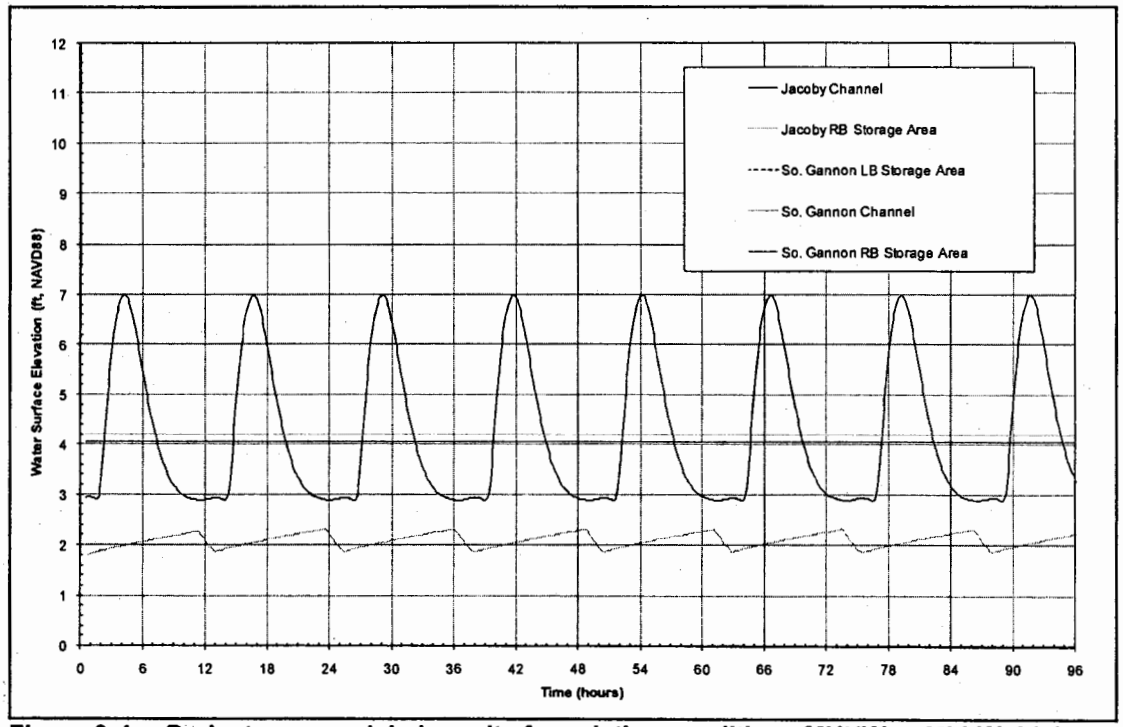

Figure 3-4 Project area modeled results for existing conditions MHHW to MLLW tidal conditions and low Jacoby Creek base flow.

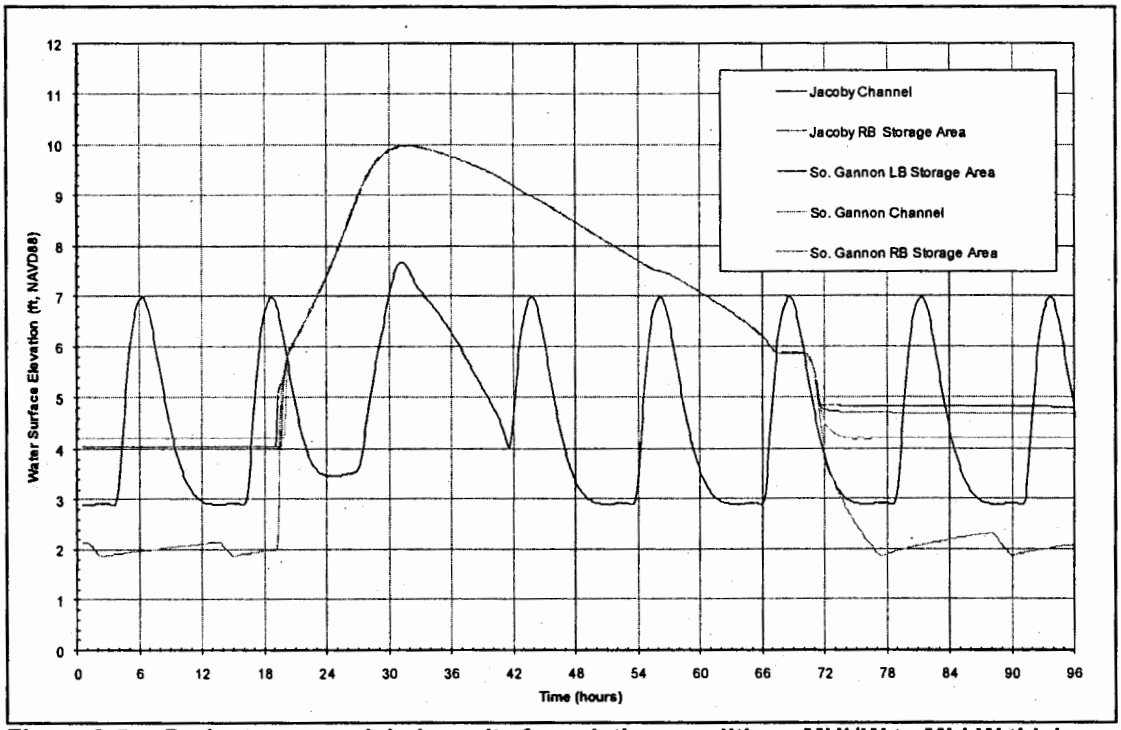

Figure 3-5 Project area modeled results for existing conditions MHHW to MLLW tidal conditions and a Jacoby Creek bankfull flood event.

4. Hydraulic Modeling

An important component of this work was to analyze the potential extent of tidal inundation under varying tidal and creek conditions for each of the different design alternatives. The tidal inundation shows the potential extent of land conversion from pasture/grazing to tidal and fresh water wetland, and the effects on utility infrastructure within the project area. To accomplish this analysis, a planning level hydraulic model was developed based on existing data and information. The hydraulic model was used to analyze existing conditions and each design alternative.

4.1. One-Dimensional Hydraulic Model

A one-dimensional hydraulic model (hydraulic model) was developed for this project using the U.S. Army Corps of Engineers HEC-RAS modeling system (USACE, HEC 2002). The HEC-RAS model calculates one-dimensional water surface profiles and average channel velocities for both steady gradually varied flow, and unsteady flow through a network of channels. For this analysis unsteady modeling was used to predict tidal and flood levels within the project area for a range of tidal conditions and creek flows. Reference can be made to the HEC-RAS manual for information specific to unsteady modeling. The hydraulic analysis addressed the effects of average tidal conditions (i.e. MHHW to MLLW) and extreme higher tides (i.e. mean monthly maximum tides.

4.1.1. Study Area and Model Extent

The general modeling area extends from North Bay to approximately 2,300 feet east of Old Arcata Road, and includes the large overbank areas to the north, and the South Jacoby Pasture to the south (Figure 4-1). Previous hydraulic modeling efforts for Jacoby Creek north of Old Arcata (Jeff Anderson & Associates, December 2006) and the South Jacoby Pasture Road (Jeff Anderson & Associates, March 2006) were incorporated into this modeling effort. The hydraulic model consists of a network of channels defined by cross sections for Jacoby Creek, the South Branch Gannon Slough channel within the project area, the Gannon Slough channel west into North Bay, and the westerly slough channel flowing into North Bay within the South Jacoby Pasture area. These cross section bed elevations were systematically lowered below MLLW elevation at the downstream cross sections (within North Bay) so that low tidal boundary conditions were not problematic in computations.

The existing large pasture/overbank areas within the study area were incorporated into the hydraulic model as a series of interconnected hydrologic storage areas. These storage areas were linked to adjacent storage areas, and to the primary channel network along channel banks and channel links. The hydrologic storage areas also defined the restored wetland areas, and the stage-volume relationships included the volume effects of the slough channels.

Tide gates and other hydraulic structures were incorporated into the model as required.

The existing conditions model for the study area was modified to represent the project elements for each conceptual alternative. The various project elements consisted of the addition of new tide gate structures, levee breaches or removal, construction of new slough channels, the construction of setback levees, and the reconfiguration of the hydrologic

storage areas with the project area to define restored wetlands, depending on the conceptual alternative.

4.1.2. Topographic, Bathymetric and Flow Structure Data

Where available, cross sections were based on topographic channel field surveys for Jacoby Creek and South Gannon Slough channel. For Jacoby Creek three channel cross sections were available for an approximate 800 foot reach of channel immediately upstream of HWY 101 (McBain & Trush 2006 field surveys). Upstream of Old Arcata Road six cross sections were surveyed along a 2,300 foot reach of Jacoby Creek by JAA and M&T in December, 2006. Due to large unsurveyed reaches of Jacoby Creek, it was necessary to interpolate a number of cross sections for the hydraulic model.

Two surveyed cross sections (M&T 2006 field surveys) were available for the South Gannon Slough channel. As with the Jacoby Creek channel, it was necessary to interpolate a number of cross sections to better define the South Gannon Slough channel within the hydraulic model.

The South Jacoby Pasture Slough and Gannon Slough channel cross sections were obtained from the 1-ft topographic map and Humboldt Bay Lidar data (provided by City of Arcata), field observations, and aerial photo interpolation.

The hydrologic storage areas were defined by stage-volume relationships extracted from the 1-ft topographic map. The stage-volume relationships included the volume of the existing remnant slough channels that exist in many of the storage areas.

Tide gates and hydraulic structures geometry and elevations were obtained from field surveys and measurements.

4.1.3. Channel Parameters

Manning' roughness coefficients (n) were estimated based on prior modeling efforts in Humboldt Bay, professional experience, and field comparison of channel conditions with published color photos, descriptive data, and computed n values for stream channels found in Barnes (1967), French (1985) and Hicks and Mason (1991). Slough channel n values ranged from 0.03 to 0.06 depending on location and vegetation, and an n value of 0.07 was used for Jacoby Creek.

The HEC-RAS default culvert and tide gate entrance and exit losses were used in the hydraulic analysis.

4.1.4. Boundary Conditions

For unsteady modeling, upstream and downstream temporal boundary conditions are necessary for the hydraulic model.

Upstream Boundary Conditions (Streamflow)

Upstream boundary conditions consisted of streamflows for Jacoby Creek. A low-flow continuous streamflow of 10 cfs was used to demonstrate the effects of tidal inundation within the project area for each conceptual design. To demonstrate the effects on flooding within the project area an approximate bankfull synthetic flood hydrograph was developed that was superimposed onto the 10 cfs baseflow. The bankfull event consisted of a 24 hour

triangular flood hydrograph that peaked at 1,200 cfs within the first 8 hours, with the flow recession lasting 16 hours.

Downstream Boundary Conditions (Tidal Stage)

The downstream boundary conditions will consist of tidal stages at the downstream ends of Jacoby Creek, Gannon Slough, and the South Jacoby Pasture slough. For this analysis two tidal stage series were used. To help analyze the average extent of tidal wetland restoration within the project area for each alternative, the synthetic MHHW to MLLW tidal curve generated for North Bay near Jacoby Creek, as discussed in Chapter 3, was used. This same tidal curve was also used with the synthetic 2-year flood hydrograph (upstream boundary condition) to demonstrate the effects of flooding within the project area for each conceptual alternative.

To provide insight on the extent of tidal inundation during tidal events higher than MHHW, the hydraulic model was run for a measured tidal period that included tidal levels above and below the mean monthly maximum water. For this area of North Bay the mean monthly maximum water is approximately 7.9 feet, as discussed in Chapter 3. Using the measured Jacoby Creek tidal data collected by McBain & Trush in 2006, a period of summer tidal levels was selected that covered a 14 day period from 3 to 16 July 2006 (Figure 3-2). This 14 day tidal series was used for downstream boundary conditions at Jacoby Creek, Gannon Slough, and the South Jacoby Pasture slough, for the high tidal event analysis.

5. Conceptual Design Alternatives

Five conceptual design alternatives were developed for the project area that spans a range of enhancement opportunities, land and resource commitments. The following sections list the project objectives and constraints, the conditions for which the alternatives were analyzed and compared, and a description and comparison of each design alternative.

5.1. Project Objectives (Goals) and Constraints

The primary objectives (goals) of this work are to develop conceptual design alternatives for the project area that restores and enhances estuarine and intertidal habitats.

As part of the City of Arcata Mitigated Negative Declaration for the Baylands Enhancement/Restoration Project the following restoration/enhancement goals were identified for the Jacoby Creek/Gannon Slough project area (City of Arcata Mitigated Negative Declaration, May 2006).

> (a.) Restore 65 acres in the Jacoby Creek/Gannon Slough Project Area: (1) Restore 30.0 acres of estuarine channels associated with Jacoby Creek via tide gate modification/removal, (2) restore 15.0 acres of estuarine channels associated with Gannon Slough via tide gate modification/removal, and (3) restore 20.0 acres of Jacoby Creek floodplain and riparian forest along 3,767 lineal feet of Jacoby Creek by removing 4,291.5 feet of levees, fencing out livestock (7,534 feet of fencing) and revegetating the riparian corridor with Sitka spruce, Red alder and native willow.

The City of Arcata has identified the following two constraints for the project area:

- Limit the full conversion of pasture land to tidal wetland and/or intertidal habitats within the project area, and
- Limit tidal inundation of utility easements within the project area.

This conceptual design report specifically addresses goals (1) and (2), which is to enhance/restore 45 acres of estuarine habitat within the Jacoby Creek/Gannon Slough project area.

Due to project site topography and the aggraded nature of Jacoby Creek it was difficult to develop an alternative that meets the stated project objectives within the identified constraints. Instead of identifying a preferred design, we developed a number of design alternatives that provide the City of Arcata a range of tidal inundation and habitat enhancement options within the project area. It will be necessary for the City of Arcata to select the alternative that satisfies these constraints.

On a final note, any of the selected or pursued alternatives can be expanded upon in the future. Therefore, none of the alternatives limit or constrain enhancement actions into the future.

5.2. Conditions Hydraulically Analyzed for Each Alternatives

Each design alternative was analyzed for three hydrologic conditions:

1. Synthetic MHHW to MLLW Lower Jacoby Creek tidal curve (Figure 3-3) with a low creek streamflow of 10 cfs. This analysis provides long-term average water levels and potential intertidal habitat changes within the project area for each alternative.
2. Measured Lower Jacoby Creek tidal curve (Figure 3-2) with a low creek streamflow of 10 cfs. Results are provided for the peak highest tide in this series (approximately 8.1 feet), which is above the estimated mean monthly maximum tide level (7.9 feet) for this area of North Bay. This analysis provides a picture of the average maximum monthly extent of tidal inundation within the project area for each alternative.
3. Synthetic MHHW to MLLW Lower Jacoby Creek tidal curve (Figure 3-3) with the synthetic bankfull 24-hour triangular flood hydrograph peaking at 1,200 cfs. This analysis demonstrates the project area flood effects for each alternative.

5.3. Preliminary Cost Estimates

A preliminary cost analysis was performed for each conceptual alternative for comparative purposes. These cost estimates focused on construction costs only, and are based on estimated material volumes for each alternative. Unit costs, equipment mobilization and clearing and grubbing costs (as a percentage of total construction costs) were provided by the City of Arcata, and are based on actual construction costs for similar projects recently completed. A 15% contingency was included in the cost estimates.

Pre- and post-construction costs, such as flagging and staking, flow diversion, as-built surveys, revegetation, exclusion fencing, and erosion control, are not included in these costs. Indirect costs, such as permitting, additional engineering, design and analysis needs, final design plans and specifications, construction management, engineering oversight, compliance and performance monitoring, are also not included in these costs. Once an alternative is chosen, these items, along with updated contingency funds, and revised construction costs should be calculated into the total project cost.

5.4. Conceptual Alternatives Description and Analysis

5.4.1. Design Alternative 1: Full Restoration

Alternative 1 represents an approximate full restoration of the project area; reestablishing unimpeded tidal conditions to the project site and converting approximately 85 acres of pasture to intertidal channels and salt and brackish wetlands. Alternative 1 design

elements are listed in Table 5-1 and shown graphically on Figure 5-1. The design elements focus on removing existing obstructions from Jacoby Creek and South Branch Gannon Slough, filling historic drainage ditches, and creating marsh plain surfaces by restoring a large unimpeded tidal prism to the project area.

Table 5-2 summarizes the restored and created habitat areas, and Table 5-3 lists the estimated construction costs for Alternative 1. In Table 5-2 a range of potential restored or created habitat areas was provided that includes a lower limit at the MHHW level to an upper limit at the mean monthly maximum tide level.

Results of the hydraulic analysis for Alternative 1 indicate that a restored MHHW tide elevation of 6.8 feet can be expected within the project area (Figure 5-1), and an average maximum monthly tidal inundation of 7.9 feet (Figure 5-2). Figure 5-3 shows the tidal response for the MHHW to MLLW tidal series for different locations within the project area. High tide levels are essentially the same across the project area and Jacoby Creek, indicating essentially fully restored tidal function. Figure 5-4 shows that Alternative 1 greatly improves flood routing through the project area compared to existing conditions (Figure 3-5). The maximum water elevation within the project area is approximately 7.2 feet, which is almost 3 feet lower than the existing conditions peak stage of 10 feet. Also, for Alternative 1 the flood peak drains from the project area in approximately one low tide (6 hours) compared to the 2 days required for existing conditions.

For this alternative it will be necessary to construct a levee along the east boundary of the project area to contain tidal water from inundating the easterly pasture, and pastures to the north. It will also be necessary to install a tide gate(s) along the north east boundary to drain the easterly pasture during floods.

Design Alternative 1 Advantages and Disadvantages:

- Potential to capture Jacoby Creek during high flow events and re-route flow out of South Branch Gannon Slough. Further analysis of this alternative would address this issue and provide elevations for any necessary channel invert control.
- The highest potential for habitat diversity for salmonids, fish and other aquatic species.
- The greatest commitment of land to restoration.
- Open tidal marsh area allows for even marsh plain accretion from available suspended sediments throughout site.
- Open tidal marsh area along Jacoby Creek and Gannon Slough allows for better water quality exchange within the project area. This alternative creates the greatest opportunity for both salt and brackish marsh creation.
- A levee and tide gate structure will be necessary along the east project area boundary to prevent tidal inundation of the easterly pasture.

Table 5-1 Alternative 1 Design Elements

	Design Element	Cut (cy)	Fill (cy)
1.	Remove levee along 800 ft of the north bank of lower Jacoby Creek	1,030	
2.	Construct a slough channel in the floodplain north of lower Jacoby Creek	2,720	
3.	Breach levee at mouth of South Branch Gannon Slough	925	
4.	Fill spoils in borrow ditch along the highway levee		350
5.	Fill spoils in drainage ditch along the interior access road		900
6.	Fill breach in northern levee		50
7.	Build up northern levee to elevation 10 feet		1,700
8.*	Build up road (levee) along east project boundary to contain tidal water		1,075
9.*	Install two 48-in tide gates at the upstream extent of S. Branch Gannon Slough (north-east corner of project area) to drain Easterly Pasture	-	-
	TOTAL	**4,675**	**4,075**

* Prescriptive solution at this location will be tailored to chosen alternative.

Table 5-2 Alternative 1 Proposed Habitat Benefits

	Restored or Created Habitat	Length (ft)	MHHW Area (acres)	Peak Event Area (acres)
1.	Convert pasturelands within project area to tidal wetland		85	100
2.	Restore tidal regime and flood flow drainage to South Branch Gannon Slough	3,600		
3.	Restore hydrologic connectivity between lower Jacoby Creek and South Branch Gannon Slough by constructing a slough channel across floodplain	1,600		

Table 5-3 Alternative 1 Construction Costs Estimate

Item	Description	Unit	Unit Price	Quantity	Item Price
1	Equipment mobilization/demobilization (1% of construction costs)	LS	1%	$101,556	$1,016
2	Clearing and grubbing (2% of construction costs)	LS	2%	$101,556	$2,031
3	Breach South Branch Gannon Slough	CY	$3.63	925	$3,358
4	Remove levee north of Jacoby Creek, breach and spoil	CY	$3.63	1,030	$3,739
5	Cut slough channel north of Jacoby Creek and spoil	CY	$3.63	2,720	$9,874
6	Build road/levee along eastern project boundary	CY	$5.33	1,075	$5,730
7	Eastern boundary prescription to connect project to upstream pasture	LS	$78,856	1	$78,856
	Rounded Subtotal				$105,000
	Contingencies	%	15%	$105,000	$15,750
	Total Construction Costs				$120,750

Figure 5-1 Design Alternative 1: Full Restoration at MHHW.

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Figure 5-2 Design Alternative 1: Full Restoration at Peak Tide.

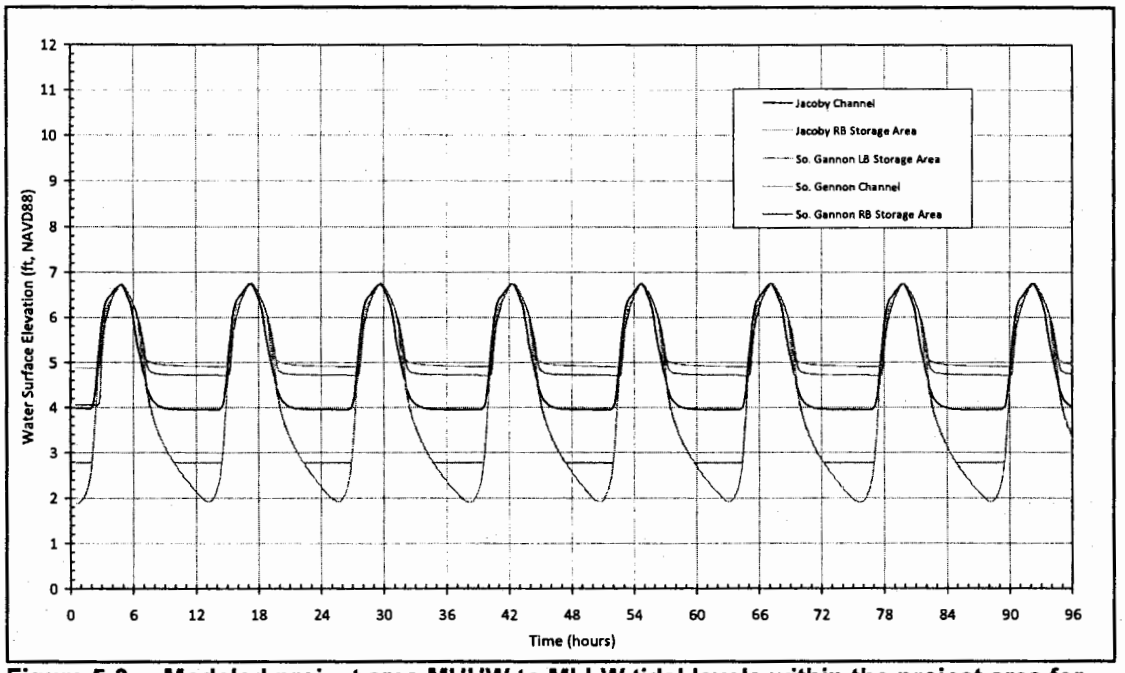

Figure 5-3 Modeled project area MHHW to MLLW tidal levels within the project area for Alternative 1 at low Jacoby Creek streamflow (10 cfs).

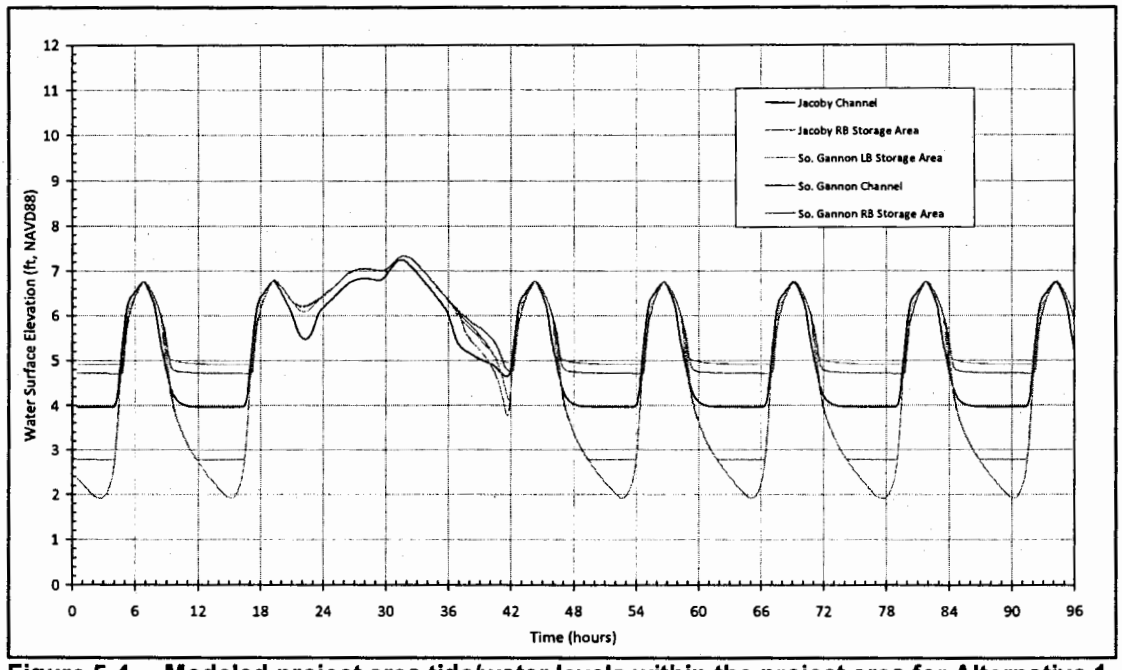

Figure 5-4 Modeled project area tide/water levels within the project area for Alternative 1 for the bankfull flood (1200 cfs) and the MHHW to MLLW tidal series.

5.4.2. Design Alternative 2: Remove Levee, Install Tide Gates

Alternative 2 represents a reduced version of full tidal inundation of the project area by reestablishing unimpeded tidal conditions from Jacoby Creek and a muted tidal prism from new tide gates at the mouth of South Branch Gannon Slough. This alternative proposes to convert approximately 52 acres of pasture within the project area to salt, brackish and fresh water wetland. Alternative 2 design elements are listed in Table 5-4 and shown graphically on Figure 5-5. The design elements focus on removing the existing right bank levee along Jacoby Creek, installing new tide gates on South Branch Gannon Slough that allow an adjustable muted tidal prism, filling historic drainage ditches, and creating marsh plain surfaces by restoring a muted tidal prism to the project area.

Table 5-5 summarizes the restored and created habitat areas, and Table 5-6 lists the estimated construction costs for Alternative 2. In Table 5-5 a range of potential restored or created habitat areas was provided that includes a lower limit at the MHHW level to an upper limit at the mean monthly maximum tide level.

Results of the hydraulic analysis for Alternative 2 indicate that a restored MHHW tide elevation of 6.1 feet in the northerly portions of the project area, and 6.3 feet near Jacoby Creek can be expected (Figure 5-5). An average maximum monthly tidal inundation of 6.8 feet can be expected across the project area (Figure 5-6). Figure 5-7 shows the tidal response for the MHHW to MLLW tidal series for different locations within the project area. Due to the muting effect from the proposed South Branch Gannon Slough tide gates, tide levels are higher in and near Jacoby Creek than in other portions of the project area. Figure 5-8 shows that Alternative 2 also improves flood routing through the project area compared to existing conditions (Figure 3-5). The maximum water elevation within the project area is approximately 8.2 feet, which is approximately 2 feet lower than the existing conditions peak stage of 10 feet. Also, for Alternative 2 the flood peak drains from the project area in approximately 12 hours compared to the 2 days required for existing conditions.

For this alternative it will be necessary to construct a levee along the east boundary of the project area to contain tidal water from inundating the easterly pasture, and pastures to the north. It will also be necessary to install a tide gate(s) along the north east boundary to drain the easterly pasture during floods.

Design Alternative 2 Advantages and Disadvantages:

- Potential to capture Jacoby Creek during high flow events and re-route flow out of South Branch Gannon Slough. Further analysis of this alternative would address this issue and provide elevations for any necessary channel invert control.
- High potential for habitat diversity for salmonids, fish and other aquatic species.
- A commitment of at least 52 acres of land to tidal wetland restoration.
- Open tidal marsh area along Jacoby Creek allows for more even marsh plain accretion, but the muted tide gate could slow accretion rates.

- Open tidal marsh area along Jacoby Creek allows for better water quality exchange with Jacoby Creek, but the muted tide gate would limit water quality exchange from Gannon Slough and North Bay. This alternative creates the greatest opportunity for brackish marsh creation.

- A levee and tide gate structure will be necessary along the east project area boundary to prevent tidal inundation of the easterly pasture.

Table 5-4 Alternative 2 Design Elements

	Design Element	Cut (cy)	Fill (cy)
1.	Remove levee along 800 feet of the north bank of lower Jacoby Creek	1,030	
2.	Construct a slough channel in the floodplain north of lower Jacoby Creek	2,720	
3.	Install two 48-in tide gates at the mouth of South Branch Gannon Slough	150	100
4.	Fill spoils in borrow ditch along the highway levee		350
5.	Fill spoils in drainage ditch along the interior access road		900
6.	Fill breach in northern levee		50
7.	Build up northern levee to elevation 10 feet		1,700
8.*	Build up road (levee) along east project boundary to contain tidal water		1,075
9.*	Install two 48-in tide gates at the upstream extent of South Branch Gannon Slough (north-east corner of project area) to drain Easterly Pasture	-	-
	TOTAL	**3,900**	**4,075**

* Prescriptive solution at this location will be tailored to chosen alternative.

Table 5-5 Alternative 2 Proposed Habitat Benefits

	Restored or Created Habitat	Length (ft)	MHHW Area (acres)	Peak Event Area (acres)
1.	Convert pasturelands within project area to tidal wetland		52	85
2.	Restore tidal regime and flood flow drainage to South Branch Gannon Slough	3,600		
3.	Restore hydrologic connectivity between lower Jacoby Creek and South Branch Gannon Slough by constructing a slough channel across floodplain	1,600		

Table 5-6 Alternative 2 Construction Costs Estimate

Item	Description	Unit	Unit Price	Quantity	Item Price
1	Equipment mobilization/demobilization (1% of construction costs)	LS	1%	$159,577	$1,596
2	Clearing and grubbing (2% of construction costs)	LS	2%	$159,577	$3,192
3	Install two 48-inch tide gates at mouth of South Branch Gannon Slough	LS	$91,500	1	$91,500
4	Remove levee north of Jacoby Creek, breach and spoil	CY	$3.63	1030	$3,739
5	Cut slough channel north of Jacoby Creek and spoil	CY	$3.63	2720	$9,874
6	Build road/levee along eastern project boundary	CY	$5.33	1075	$5,730
7	Eastern boundary connection of project to upstream pasture	LS	$48,100	1	$48,100
8	Import fill from adjacent City of Arcata lands	CY	$3.63	175	$635
	Rounded Subtotal				$165,000
	Contingencies	%	15%	$165,000	$24,750
	Total Construction Costs				$189,750

Figure 5-5 Design Alternative 2: Levee Removal and Tide Gate Installation at MHHW.

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Figure 5-6 Design Alternative 2: Levee Removal and Tide Gate Installation at Peak Tide.

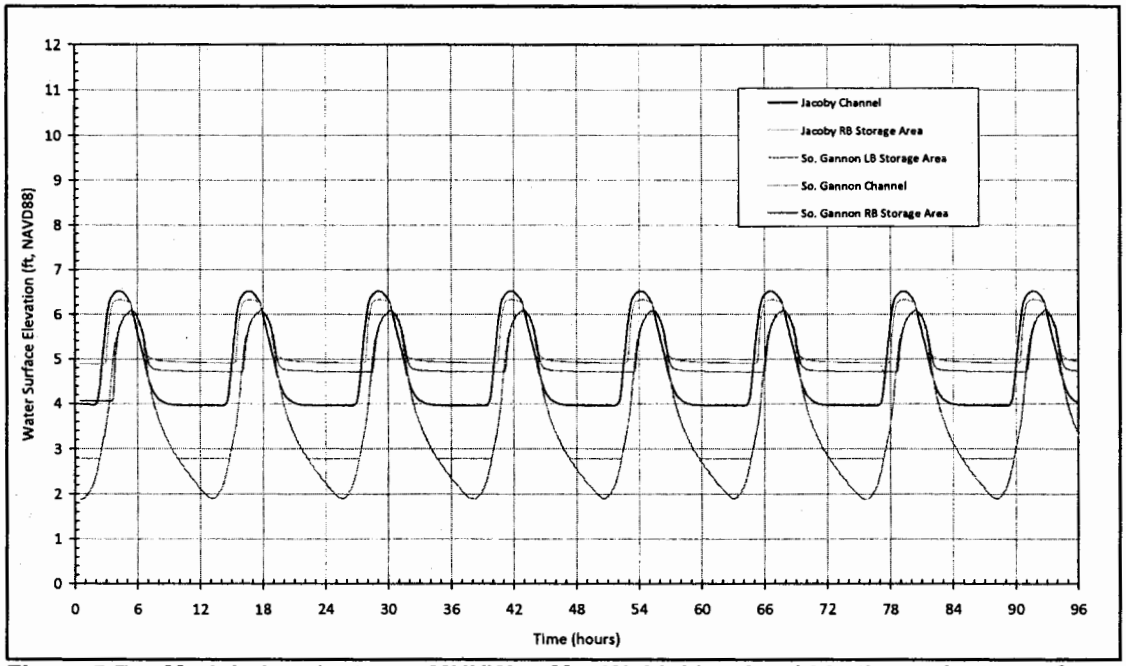

Figure 5-7 **Modeled project area MHHW to MLLW tidal levels within the project area for Alternative 2 at low Jacoby Creek streamflow (10 cfs).**

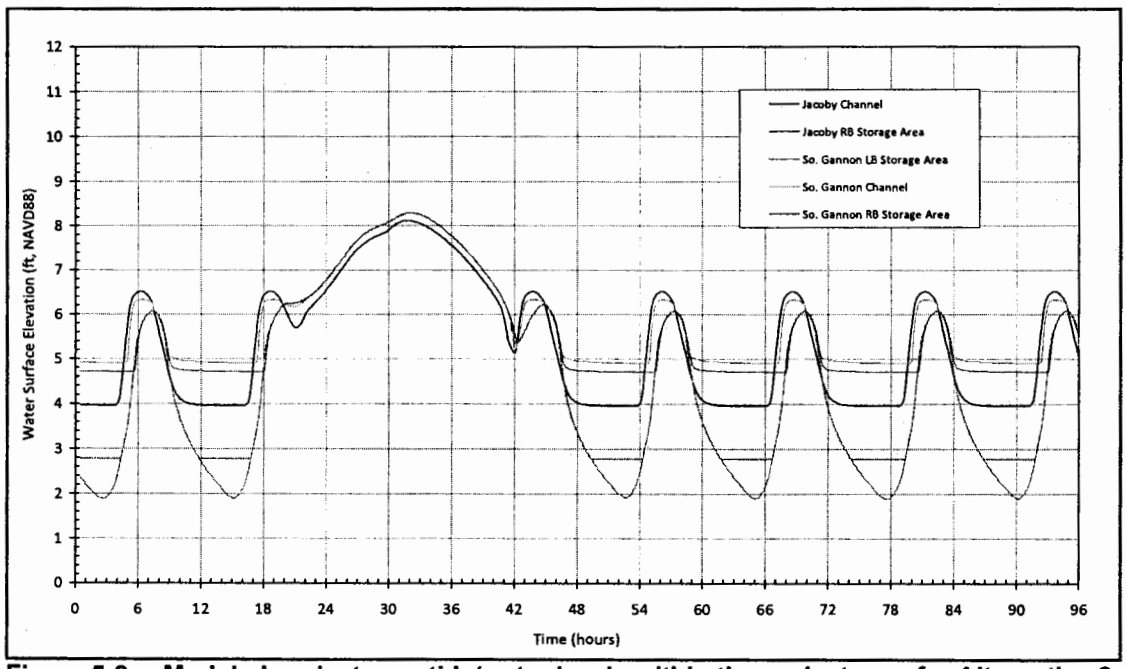

Figure 5-8 **Modeled project area tide/water levels within the project area for Alternative 2 for the bankfull flood (1200 cfs) and the MHHW to MLLW tidal series.**

5.4.3. Design Alternative 3: Breach Levee, Install Tide Gates

Alternative 3 represents a muted version of full tidal inundation of the project area by establishing muted tidal conditions from a small breach in the north levee of Jacoby Creek and a muted tidal prism from new tide gates at the mouth of South Branch Gannon Slough. This alternative proposes to convert approximately 38 acres of pasture within the project area to salt, brackish and fresh water wetland. Alternative 3 design elements are listed in Table 5-7 and shown graphically on Figure 5-9. The design elements focus on creating a small breach within the north levee along Lower Jacoby Creek that allows a muted tidal prism, install new tide gates on South Branch Gannon Slough that allow an adjustable muted tidal prism, construct a slough channel between Jacoby Creek and Gannon Slough, filling historic drainage ditches, and creating marsh plain surfaces by restoring a muted tidal prism to the project area.

Table 5-8 summarizes the restored and created habitat areas, and Table 5-9 lists the estimated construction costs for Alternative 3. In Table 5-8 a range of potential restored or created habitat areas was provided that includes a lower limit at the MHHW level to an upper limit at the mean monthly maximum tide level.

Results of the hydraulic analysis for Alternative 3 indicate that a restored MHHW tide elevation of 6.0 feet in the northerly portions of the project area, and 6.3 feet near Jacoby Creek can be expected (Figure 5-5). An average maximum monthly tidal inundation of 6.4 feet can be expected across the project area (Figure 5-10). Figure 5-11 shows the tidal response for the MHHW to MLLW tidal series for different locations within the project area. Due to the muting effect from the proposed Jacoby Creek levee and the South Branch Gannon Slough tide gates, tide levels are higher in and near Jacoby Creek than in other portions of the project area. Figure 5-12 shows that Alternative 3 also improves flood routing through the project area compared to existing conditions (Figure 3-5). The maximum water elevation within the project area is approximately 8.6 feet, which is approximately 1.4 feet lower than the existing conditions peak stage of 10 feet. For Alternative 3 the flood peak drains from the project area in approximately 18 hours (two tide cycles) compared to the 2 days required for existing conditions.

For this alternative it will not be necessary to construct a levee along the east boundary of the project area to contain tidal water, but some minor improvements of this area may be required. It may be necessary to install or improve the north east boundary flow conditions to better drain the easterly pasture during floods.

Design Alternative 3 Advantages and Disadvantages:

- Potential to capture Jacoby Creek during high flow events and re-route flow out of South Branch Gannon Slough. Further analysis of this alternative would address this issue and provide elevations for any necessary channel invert control.
- High potential for habitat diversity for salmonids, fish and other aquatic species.
- A commitment of at least 38 acres of land to tidal wetland restoration.
- Muted tidal conditions could limit or slow marsh plain accretions rates.

- Muted tidal conditions will limit water quality exchange from Jacoby Creek and Gannon Slough.
- Some improvements to the project area east boundary may be required.

Table 5-7 Alternative 3 Design Elements

	Design Element	Cut (cy)	Fill (cy)
1.	Cut a small breach in the levee of the north bank of Jacoby Creek at the mouth of constructed slough channel	120	
2.	Construct a slough channel in the floodplain north of lower Jacoby Creek	2,720	
3.	Install two 48-IN tide gates at the mouth of South Branch Gannon Slough	150	100
4.	Fill spoils in borrow ditch along the highway levee		350
5.	Fill spoils in drainage ditch along the interior access road		900
6.	Fill breach in northern levee		50
7.	Build up northern levee to elevation 10 feet		1,700
8.*	Install one 48-in tide gates at the upstream extent of South Branch Gannon Slough (north-east corner of project area) to drain Easterly Pasture	-	-
	TOTAL	**2,990**	**3,100**

* Prescriptive solution at this location will be tailored to chosen alternative.

Table 5-8 Alternative 3 Proposed Habitat Benefits

	Restored or Created Habitat	Length (ft)	MHHW Area (acres)	Peak Event Area (acres)
1.	Convert pasturelands connecting Jacoby Creek and Gannon Slough Estuary to tidal wetland		38	71
2.	Restore tidal regime and flood flow drainage to South Branch Gannon Slough	3,600		
3.	Restore hydrologic connectivity between lower Jacoby Creek and South Branch Gannon Slough by constructing a slough channel across the floodplain	1,600		

Table 5-9 Alternative 3 Construction Costs Estimate

Item	Description	Unit	Unit Price	Quantity	Item Price
1	Equipment mobilization/demobilization (1% of construction costs)	LS	1%	$158,108	$1,581
2	Clearing and grubbing (2% of construction costs)	LS	2%	$158,108	$3,162
3	Install two 48-inch tide gates at mouth of S. Branch Gannon Slough	LS	$91,500	1	$91,500
4	Breach levee north of Jacoby Creek	CY	$3.63	120	$436
5	Riprap levee breach	TON	$60	130	$7,800
6	Cut slough channel north of Jacoby Creek and spoil	CY	$3.63	2,720	$9,874
7	Eastern boundary prescription to connect project to upstream pasture	LS	$48,100	1	$48,100
8	Import fill from adjacent City of Arcata lands	CY	$3.63	100	$399
	Rounded Subtotal				$163,000
	Contingencies	%	15%	$163,000	$24,450
	Total Construction Costs				$187,450

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Figure 5-9 Design Alternative 3: Levee Breach and Tide Gate Installation at MHHW.

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Figure 5-10 Design Alternative 3: Levee Breach and Tide Gate Installation at Peak Tide.

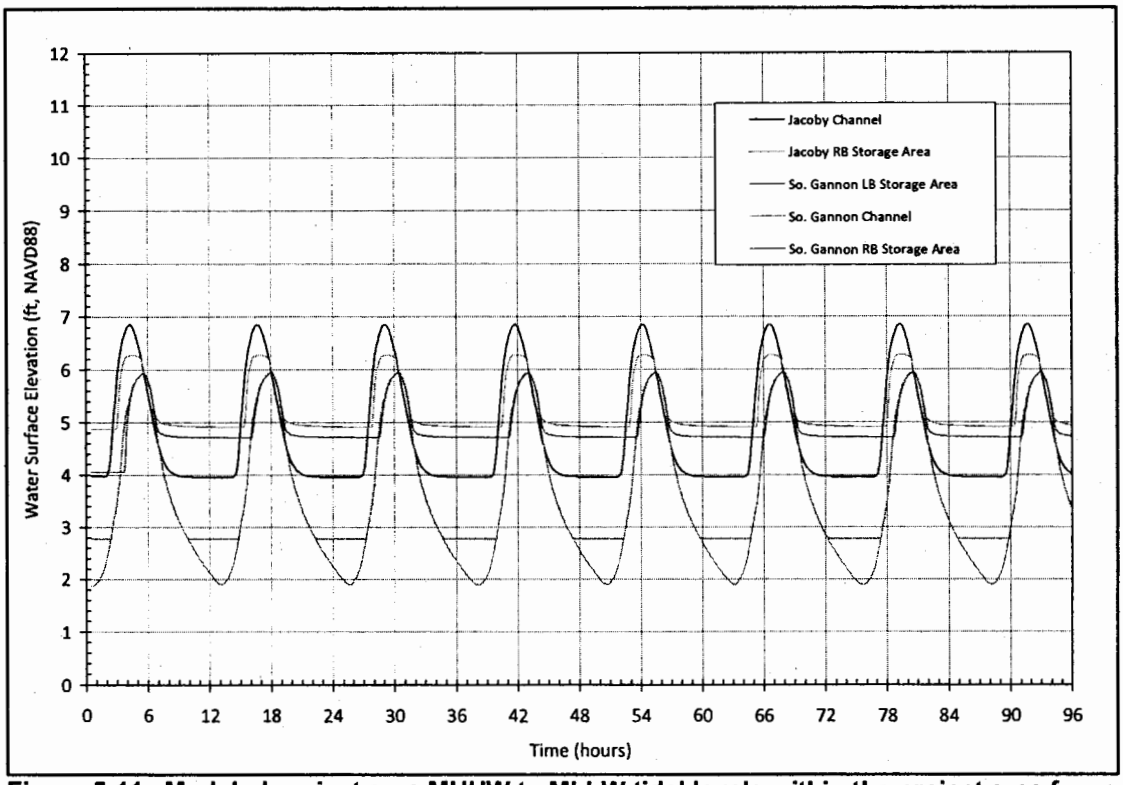

Figure 5-11 Modeled project area MHHW to MLLW tidal levels within the project area for Alternative 3 at low Jacoby Creek streamflow (10 cfs).

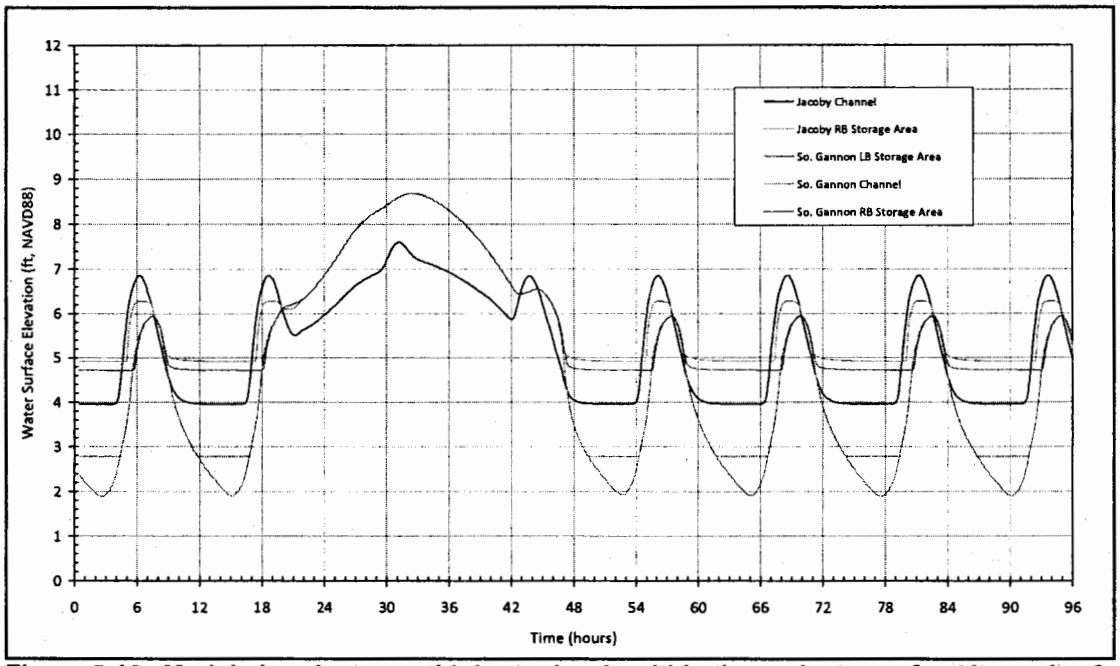

Figure 5-12 Modeled project area tide/water levels within the project area for Alternative 3 for the bankfull flood (1200 cfs) and the MHHW to MLLW tidal series.

5.4.4. Design Alternative 4: Remove Levee, Construct Setback Berm, Install Tide Gates

Alternative 4 allows unimpeded tidal inundation from Jacoby Creek onto 15 acres at the southern end of the project site, contained by an setback levee constructed to an elevation of 7.5 feet. Muted tidal inundation onto the northern end of the project site is through the proposed tide gates at the mouth of South Branch Gannon Slough. This alternative proposes to convert approximately 21 acres of pasture within the project area to salt, brackish and fresh water wetland. Alternative 4 design elements are listed in Table 5-10 and shown graphically on Figure 5-14. The design elements focused removing the north levee along Jacoby Creek, construct a offset berm to elevation 7.5 feet, install a tide gate through the offset berm that allows fish to move from South Branch Gannon Slough back into Jacoby Creek, install new tide gates on South Branch Gannon Slough that allow an adjustable muted tidal prism, filling historic drainage ditches, and creating marsh plain surfaces by restoring a muted tidal prism to the project area.

Table 5-11 summarizes the restored and created habitat areas, and Table 5-12 lists the estimated construction costs for Alternative 4. In Table 5-11 a range of potential restored or created habitat areas was provided that includes a lower limit at the MHHW level to an upper limit at the mean monthly maximum tide level.

Results of the hydraulic analysis for Alternative 4 indicate that a restored MHHW tide elevation of 7.0 feet in the created Jacoby Creek estuary (contained by offset berm), and 5.0 feet in the northerly portions of the project area (Figure 5-13). An average maximum monthly tidal inundation of 6.3 feet can be expected in the northerly portion of the project area as higher tides spill over the offset levee, and 7.7 feet in the created Jacoby Creek estuary (Figure 5-14). Figure 5-15 shows the tidal response for the MHHW to MLLW tidal series for different locations within the project area. Due to the muting effect from the South Branch Gannon Slough tide gates and the offset berm the tide levels in the northerly portion of the project area are muted well below Jacoby Creek and the created Jacoby Creek estuary. However, the created Jacoby Creek estuary is in sync with the Jacoby Creek channel. Figure 5-16 shows that Alternative 4 also improves flood routing through the project area compared to existing conditions (Figure 3-5). The maximum water elevation within the project area is approximately 8.2 feet, which is approximately 1.8 feet lower than the existing conditions peak stage of 10 feet. For Alternative 4 the flood peak drains from the project area in approximately 18 hours (two tide cycles) compared to the 2 days required for existing conditions.

For this alternative it will not be necessary to construct a levee along the east boundary of the project area to contain tidal water, but some minor improvements of this area may be required. It may be necessary to install or improve the north east boundary flow conditions to better drain the easterly pasture during floods.

Design Alternative 4 Advantages and Disadvantages:

- Containment of the open tidal regime from Jacoby Creek up to elevation 7.5 feet by the offset berm.
- Reduced potential for habitat diversity for salmonids, fish and other aquatic species.

- Movement of fish species between Sough Branch Gannon Slough and Jacoby Creek requires fish to pass over offset berm during high flows, or swim through small tide gated culvert in offset berm.
- A commitment of at least 21 acres of land to tidal wetland restoration.
- Potential for increased accretion rates in created Jacoby Creek estuary from Jacoby Creek due to offset berm.
- Muted tidal conditions could limit or slow marsh plain accretions rates.
- Muted tidal conditions will limit water quality exchange from Jacoby Creek and Gannon Slough.
- Some improvements to the project area east boundary may be required.

Table 5-10 Alternative 4 Design Elements

	Design Element	Cut (cy)	Fill (cy)
1.	Remove levee along 800 feet of the north bank of lower Jacoby Creek	1,030	
2.	Construct a slough channel in the floodplain north of lower Jacoby Creek	2,720	
3.	Construct a berm parallel to the creek channel to elevation 7.5 feet (~1.5 feet above the floodplain), impeding peak tidal inundation north of the berm	0	450
4.	Install one 24-in tide gate where the setback berm crosses the constructed slough channel to drain flood flows from South Branch Gannon Slough into Jacoby Creek and to allow for fish passage	0	0
5.	Install two 48-in tide gates at the mouth of South Branch Gannon Slough	150	100
6.	Fill spoils in borrow ditch along the highway levee	0	350
7.	Fill spoils in drainage ditch along the interior access road	0	900
8.	Fill breach in northern levee	0	50
9.	Build up northern levee to elevation 10 feet		1,700
10.*	Install one 48-in tide gate at the upstream (eastern) extent of South Branch Gannon Slough within the project area	-	-
	TOTAL	**3,900**	**3,550**

* Prescriptive solution at this location will be tailored to chosen alternative.

Table 5-11 Alternative 4 Proposed Habitat Benefits

	Restored or Created Habitat	Length (ft)	MHHW Area (acres)	Peak Event Area (acres)
1.	Convert pasturelands connecting Jacoby Creek and Gannon Slough Estuary to tidal wetland		21	76
2.	Restore tidal regime and flood flow drainage to South Branch Gannon Slough	3,600		
3.	Restore hydrologic connectivity between lower Jacoby Creek and South Branch Gannon Slough by constructing a slough channel across the floodplain	1,600		

Table 5-12 Alternative 4 Construction Costs Estimate

Item	Description	Unit	Unit Price	Quantity	Item Price
1	Equipment mobilization/demobilization (1% of construction costs)	LS	1%	$168,172	$1,682
2	Clearing and grubbing (2% of construction costs)	LS	2%	$168,172	$3,363
3	Install two 48-inch tide gates at mouth of South Branch Gannon Slough	LS	$91,500	1	$91,500
4	Remove levee north of Jacoby Creek, breach and spoil	CY	$3.63	1,030	$3,739
5	Cut slough channel north of Jacoby Creek and spoil	CY	$3.63	2,720	$9,874
6	Build setback berm	CY	$5.33	450	$2,399
7	Install one 24-inch culvert and tide gates in setback berm	LS	$12,560	1	$12,560
8	Eastern boundary prescription to connect project to upstream pasture	LS	$48,100	1	$48,100
	Rounded Subtotal				$174,000
	Contingencies	%	15%	$174,000	$26,100
	Total Construction Costs				$200,100

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Figure 5-13 Design Alternative 4: Levee Removal, Setback Berm & Tide Gate Installation at MHHW.

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Figure 5-14 Alternative 4: Levee Removal, Setback Berm and Tide Gate Installation at Peak Tide.

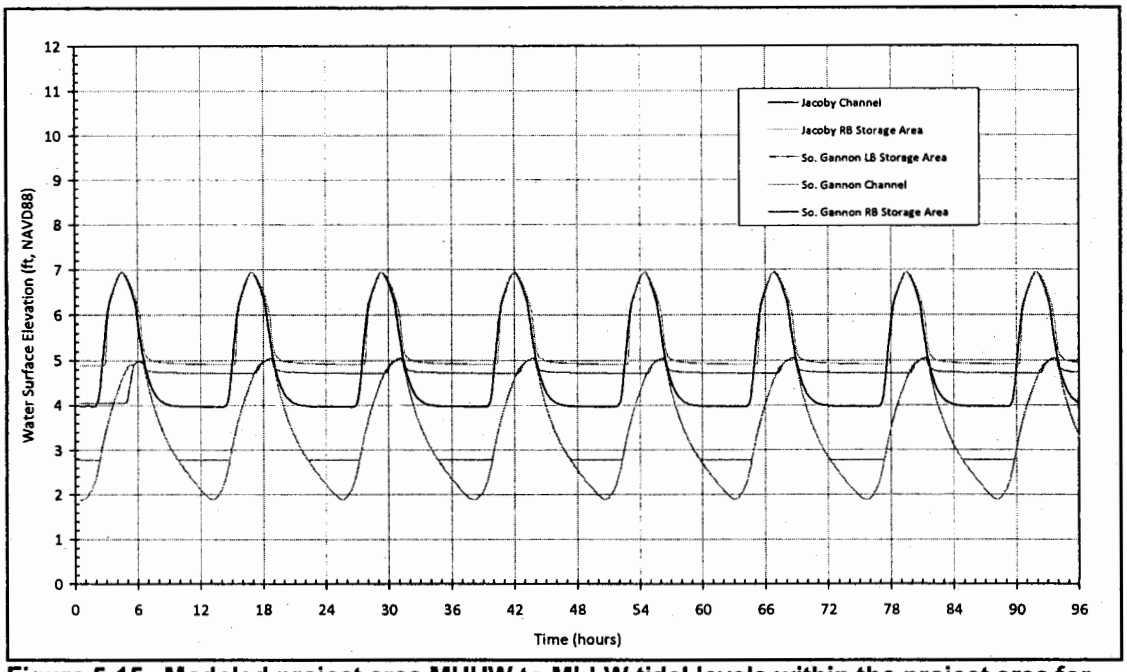

Figure 5-15 Modeled project area MHHW to MLLW tidal levels within the project area for Alternative 4 at low Jacoby Creek streamflow (10 cfs).

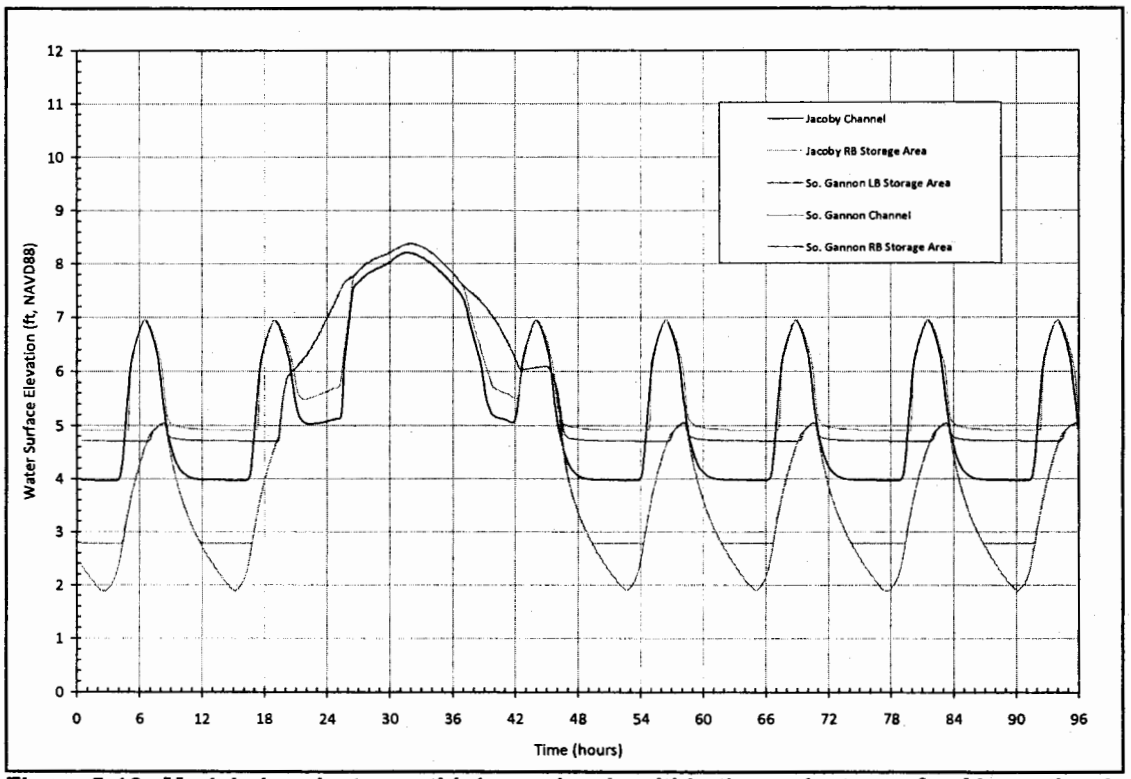

Figure 5-16 Modeled project area tide/water levels within the project area for Alternative 4 for the bankfull flood (1200 cfs) and the MHHW to MLLW tidal series.

5.4.5. Figure Design Alternative 5: Remove Levee, Construct Setback Levee, Install Tide Gates

Alternative 5 allows unimpeded tidal inundation onto 15 acres at the southern end of the project site from Jacoby Creek, contained by a setback levee constructed to an elevation of 10 feet. Muted tidal inundation onto the northern end of the project site is through the proposed tide gates at the mouth of South Branch Gannon Slough. This alternative proposes to convert approximately 21 acres of pasture within the project area to salt, brackish and fresh water wetland. Alternative 5 design elements are listed in Table 5-13 and shown graphically on Figure 5-17. The design elements focus on removing the north levee along Jacoby Creek, constructing an offset berm to elevation 10 feet to fully contain tidal flow from Jacoby Creek to the created 15 acre marsh, installing a tide gate through the offset berm that allows fish to move from South Branch Gannon Slough back into Jacoby Creek, installing new tide gates on South Branch Gannon Slough that allow an adjustable muted tidal prism, filling historic drainage ditches, and creating marsh plain surfaces by restoring a muted tidal prism to the project area.

Table 5-14 summarizes the restored and created habitat areas, and Table 5-15 lists the estimated construction costs for Alternative 5. In Table 5-14 a range of potential restored or created habitat areas was provided that includes a lower limit at the MHHW level to an upper limit at the mean monthly maximum tide level.

Results of the hydraulic analysis for Alternative 5 indicate that a restored MHHW tide elevation of 7.0 feet in the created Jacoby Creek estuary (contained by setback levee), and 5.0 feet in the northerly portions of the project area (Figure 5-17). An average maximum monthly tidal inundation of 5.6 feet can be expected in the northerly portion of the project area, and 8.1 feet in the created Jacoby Creek estuary (Figure 5-18). Figure 5-19 shows the tidal response for the MHHW to MLLW tidal series for different locations within the project area. Due to the muting effect from the South Branch Gannon Slough tide gates and the setback levee the tide levels in the northerly portion of the project area are muted well below Jacoby Creek and the created Jacoby Creek estuary. However, the created Jacoby Creek estuary is in sync with the Jacoby Creek channel. Figure 5-20 shows that Alternative 5 also improves flood routing through the project area compared to existing conditions (Figure 3-5). The maximum water elevation within the project area is approximately 9.3 feet, which is approximately 0.7 feet lower than the existing conditions peak stage of 10 feet. For Alternative 5 the flood peak drains from the project area in approximately 18 hours (two tide cycles) compared to the 2 days required for existing conditions.

For this alternative it will not be necessary to construct a levee along the east boundary of the project area to contain tidal water, but some minor improvements of this area may be required. It may be necessary to install or improve the north east boundary flow conditions to better drain the easterly pasture during floods.

Design Alternative 5 Advantages and Disadvantages:

- Complete containment of the open tidal regime from Jacoby Creek up to elevation 7.5 feet by the setback levee.

- Reduced potential for habitat diversity for salmonids, fish and other aquatic species.
- Movement of fish species between Sough Branch Gannon Slough and Jacoby Creek requires fish to swim through a small tide gated culvert in the setback levee.
- A commitment of at least 21 acres of land to tidal wetland restoration.
- Fill may be required to be imported to the site for the construction of the setback levee.
- Potential for increased accretion rates in created Jacoby Creek estuary from Jacoby Creek due to the setback levee.
- Muted tidal conditions could limit or slow marsh plain accretions rates.
- Muted tidal conditions will limit water quality exchange from Jacoby Creek and Gannon Slough.
- Some improvements to the project area east boundary may be required.

Table 5-13 Alternative 5 Design Elements

	Design Element	Cut (cy)	Fill (cy)
1.	Remove levee along 800 feet of the north bank of lower Jacoby Creek	1,030	
2.	Construct a slough channel in the floodplain north of lower Jacoby Creek	2,720	
3.	Construct a levee parallel to the creek channel to elevation 10 feet (~4 feet above the floodplain), restricting peak tidal inundation north of the levee	0	3,800
4.	Install one 24-in tide gate where the setback levee crosses the constructed slough channel to drain flood flows from South Branch Gannon Slough into Jacoby Creek and to allow for fish passage	0	0
5.	Install two 48-in tide gates at the mouth of South Branch Gannon Slough	150	100
6.	Fill spoils in borrow ditch along the highway levee	0	350
7.	Fill spoils in drainage ditch along the interior access road	0	900
8.	Fill breach in northern levee	0	50
9.*	Install one 48-in tide gate at the upstream (eastern) extent of South Branch Gannon Slough within the project area	-	-
	TOTAL	**3,900**	**5,200**

* Prescriptive solution at this location will be tailored to chosen alternative.

Table 5-14 Alternative 5 Proposed Habitat Benefits

	Restored or Created Habitat	Length (ft)	MHHW Area (acres)	Peak Event Area (acres)
1.	Convert pasturelands connecting Jacoby Creek and Gannon Slough Estuary to tidal wetland		21	34
2.	Restore tidal regime and flood flow drainage to South Branch Gannon Slough	3,600		
3.	Restore hydrologic connectivity between lower Jacoby Creek and South Branch Gannon Slough by constructing a slough channel across the floodplain	1,600		

Table 5-15 Alternative 5 Construction Costs Estimate

Item	Description	Unit	Unit Price	Quantity	Item Price
1	Equipment mobilization/demobilization (1% of construction costs)	LS	1%	$190,692	$1,907
2	Clearing and grubbing (2% of construction costs)	LS	2%	$191,692	$3,814
3	Install two 48-inch tide gates at mouth of South Branch Gannon Slough	LS	$91,500	1	$91,500
4	Remove levee north of Jacoby Creek, breach and spoil	CY	$3.63	1,030	$3,739
5	Cut slough channel north of Jacoby Creek and spoil	CY	$3.63	2,720	$9,874
6	Build setback levee	CY	$5.33	3,790	$20,201
7	Install one 24-inch culvert and tide gates in setback berm	LS	$12,560	1	$12,560
8	Eastern boundary prescription to connect project to upstream pasture	LS	$48,100	1	$48,100
9	Import fill from adjacent City of Arcata lands	CY	$3.63	1,300	$4,719
	Rounded Subtotal				$197,000
	Contingencies	%	15%	$197,000	$29,550
	Total Construction Costs				$226,550

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Figure 5-17 Alternative 5: Levee Removal, Setback Levee & Tide Gate Installation at MHHW.

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Figure 5-18 Design Alternative 5: Levee Removal, Setback Levee and Tide Gate Installation at Peak Tide.

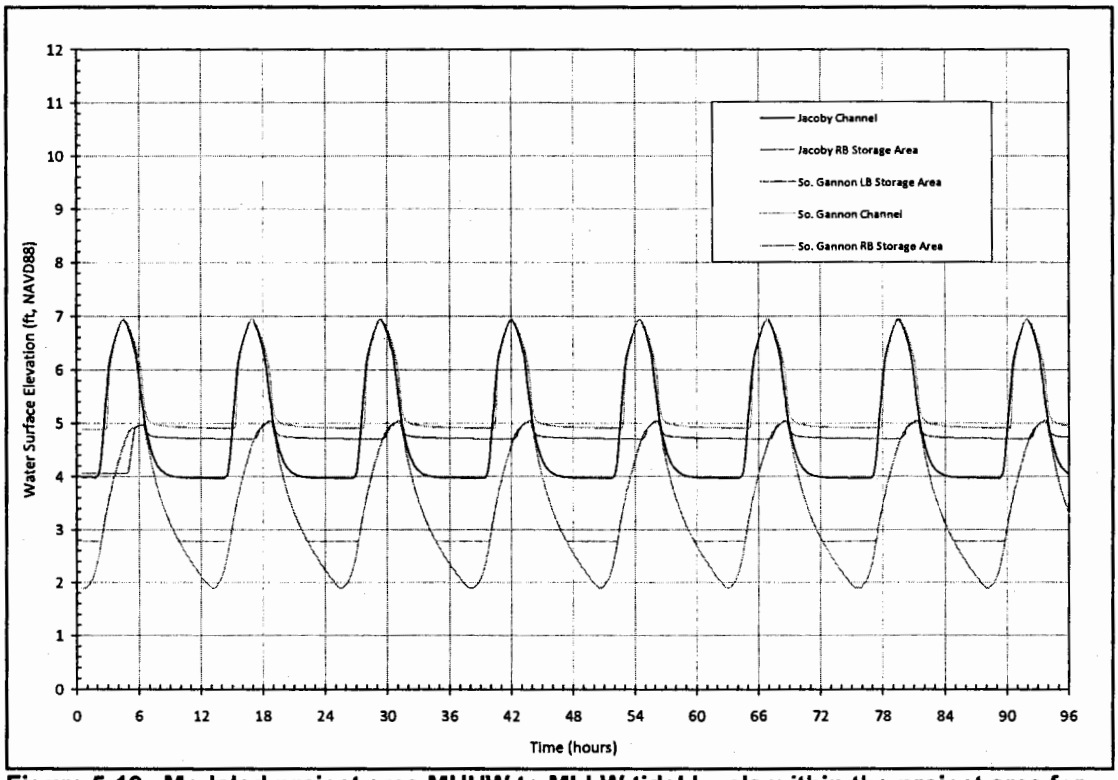

Figure 5-19 Modeled project area MHHW to MLLW tidal levels within the project area for Alternative 5 at low Jacoby Creek streamflow (10 cfs).

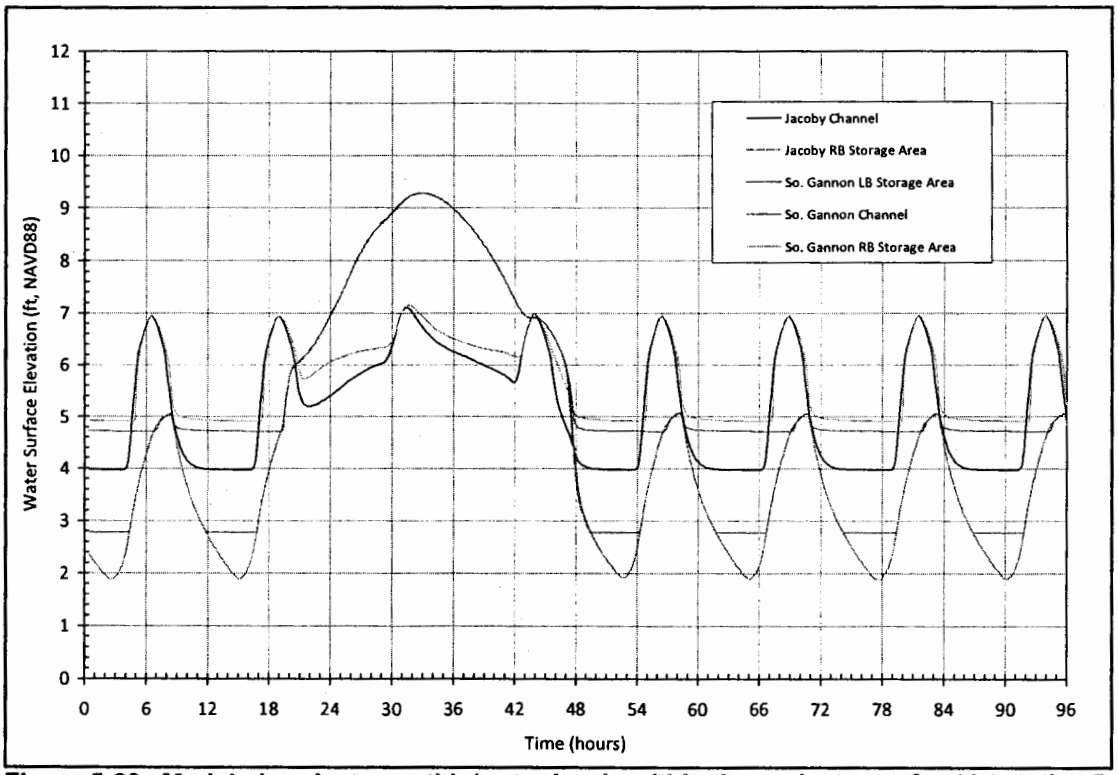

Figure 5-20 Modeled project area tide/water levels within the project area for Alternative 5 for the bankfull flood (1200 cfs) and the MHHW to MLLW tidal series.

5.5. Required Steps for Implementation

Alternatives developed and analyzed in this report are conceptual in nature. They are not engineered designs and additional technical and quantitative work will be required prior to implementing any one of the developed conceptual design alternatives.

Following is a list of additional work items that may be required prior to implementing one of the conceptual design alternatives, and will likely be determined by permitting, engineering and construction needs:

- Collect additional Jacoby Creek channel bathymetry data from North Bay to Old Arcata Road to better assess and understand the potential for creating backwater habitats, setback levees, levee removal, or levee breaching.
- Collect bathymetry in Gannon Slough to assess the invert of the proposed tide gate(s).
- Identify, locate and measure elevations of the infrastructure that needs to be protected in relation to the project.
- Collect water quality data in Lower Jacoby Creek and Gannon Slough to better understand existing conditions.
- Evaluate expected water quality conditions of restored habitats.
- Assess if ESA species are present within the project area.
- Evaluate impacts, both positive and negative, to ESA species from proposed action.
- Design proposed tide gate(s), and other water control structures. Assess erosion potential of these structures.
- Conduct detailed hydraulic analysis of the preferred alternative design that includes additional topography/bathymetry data and specified design details, and determine circulation patterns within restored habitats. This type of analysis may require two-dimensional modeling.
- Assess the potential sedimentation of restored habitats from Jacoby Creek.
- Conduct necessary engineering analysis, such as geotechnical studies; assess impacts to existing infrastructure (e.g. Gannon Slough bridge), and assess construction season groundwater levels.
- Work with Caltrans to address plans for the Highway 101 expansion project and opportunities to remove instream obstructions.
- Based on the selected design alternative, assess, design and engineer the east project area boundary tie-in to the easterly pasture.
- Develop construction plans and specifications for the selected design alternative, refine cut/fill volumes, design habitat structures, incorporate revegetation designs, and post-project monitoring studies.

6. Additional Enhancement Concepts Outside of Project Area

Another requirement of this work was to develop additional enhancement concepts for Jacoby Creek outside of the project area. Three specific areas were identified, (1) Lower South Jacoby Pasture, (2) Upper South Jacoby Pasture, and (3) the Easterly Pasture. All of the proposed enhancement concepts are preliminary. Additional data and analysis will be required to better assess the validity of each proposed enhancement concept.

Figure 6-1 shows a schematic of the proposed enhancement concepts along with projected MHHW elevations for Alternative 3 within the project area.

6.1. Lower South Jacoby Pasture

Potential enhancement concepts for the Lower South Jacoby Pasture include retrofitting the existing tide gate that drains this area under Highway 101 with a tide gate that allows a muted tidal prism, and either breaching or removing the levee along the left bank of Lower Jacoby Creek. Also, reconnecting Lower Jacoby Creek with the historic oxbow upstream of Highway 101 (Figure 2-1) could be explored. Reconnection of the historic oxbow along with an east-west trending setback levee constructed along the south boundary of the oxbow area could be evaluated as a stand-alone project, or could supplement the estuary enhancement to the north. The setback levee would allow reconnection and enhancement of the oxbow area without affecting the existing Lower South Jacoby Pasture area agricultural activities.

Jeff Anderson & Associates (March 2006) has already assessed some potential tide gate options for this area. Based on this work, it was estimated that a muted tidal prism from the modified tide gate and connection with Jacoby Creek could produce a MHHW elevation of approximately 6.5 feet in this area.

To pursue this concept further the hydraulic model developed in this study could be modified to include the modified tide gate and connection with Jacoby Creek. This would be a straight forward process as the South Jacoby Pasture area has already been included into the hydraulic model.

6.2. Upper South Jacoby Pasture

Potential enhancement concepts for the Upper South Jacoby Pasture include left bank levee removal along Jacoby Creek, the creation/enhancement of high flow channels, and the installation of tide gated culverts to improve flood flow drainage of this area into the Lower South Jacoby Pasture.

To pursue this concept further it will be necessary, at a minimum, to survey the thalweg elevation of Jacoby Creek from North Bay to Old Arcata Road, and better understand salmonid rearing habitat and high-flow refugia use within this reach of Jacoby Creek. For example, it has been observed that Jacoby Creek is perched such that thalweg elevations are higher than adjacent floodplain elevations. Creating a levee breach or backwater channel could inadvertently daylight Jacoby Creek and aquatic species onto its floodplain.

6.3. Easterly Pasture from Project Area

Potential enhancement concepts for the Easterly Pasture east of the current project area include reconnecting historic high flow channels with South Branch Gannon Slough. These restored high flow channels could better intercept overbank flood flows and the entrained aquatic species (e.g. salmonids) from Jacoby Creek and redirect them back into the project area and South Branch Gannon Slough.

This concept would require assessing the existing high flow channels and interconnectivity with drainage features under Old Arcata Road. Also, it would require assessing and designing a compatible connection at the north-east corner of the project area. For example, this connection could consist of a set of tide gated culverts depending on the extent of the restored tidal prism within the project area. It is likely that any improved connection between the Easterly Pasture and the project area would improve survival conditions for salmonids and also improve flood routing within this area.

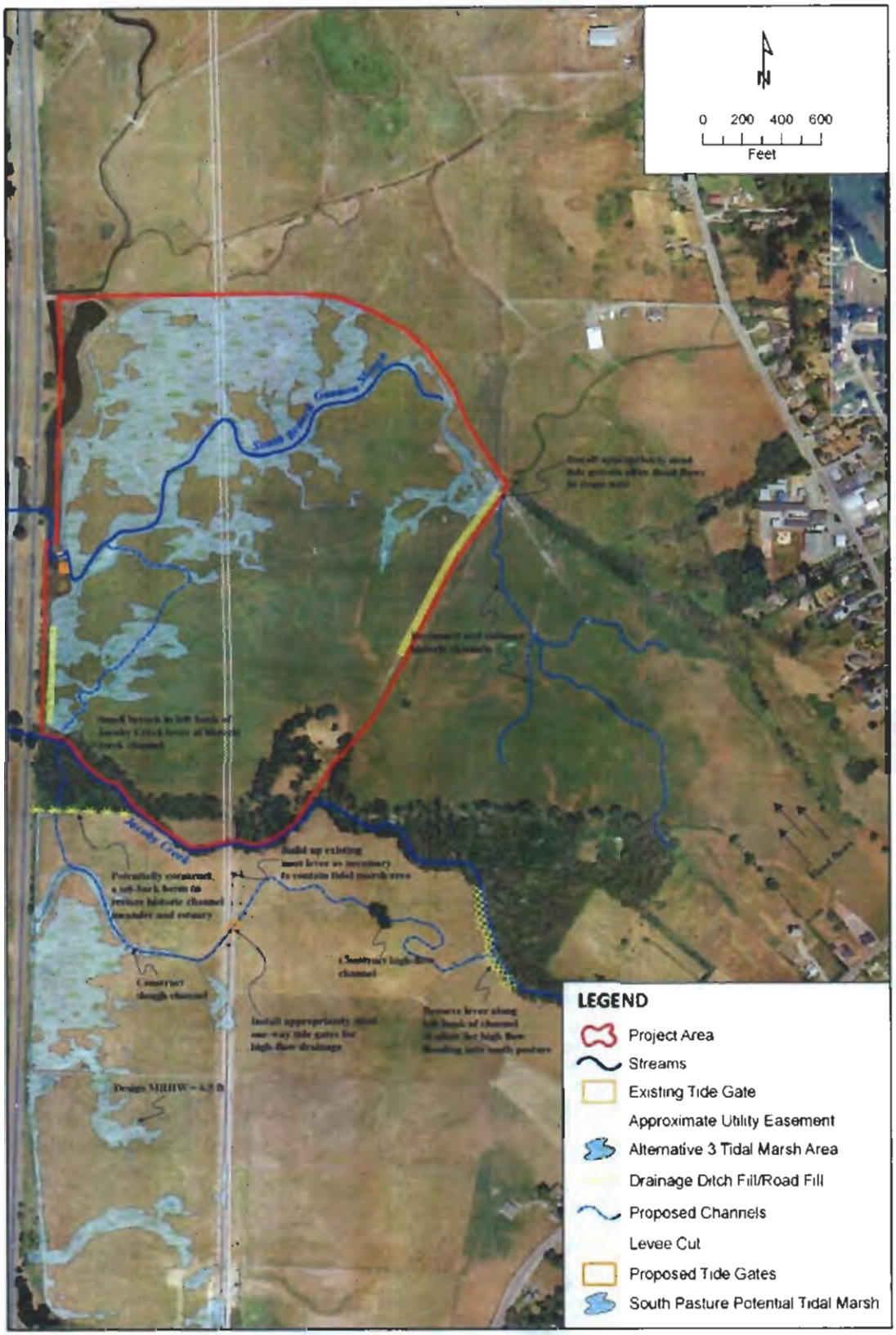

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Figure 6-1 Additional Conceptual Design Elements Shown in Combination with Design Alternative 3.

Existing Conditions in area to be converted to tidal estuary habitat.

Existing Conditions (during the wet season) in the ditch to be filled in along the western edge of the project area.

EXHIBIT NO. 8

APPLICATION NO.

1-09-030

CITY OF ARCATA

PROJECT AREA PHOTOS
(1 of 2)

Two views of the vegetation along the portion of the levee along lower Jacoby Creek proposed to be lowered. Dominant vegetation is native willows and native and nonnative blackberries.