



Ducks Unlimited



*M&T Ranch / Llano Seco Intake Project
Final Alternatives*

**Draft Engineering Analysis
Technical Memorandum**

September, 2008

M&T Ranch / Llano Seco Intake Project

Final Alternatives

Draft Engineering Analysis Technical Memorandum



September, 2008

Prepared by:



**2353 130th Avenue N.E., Suite 200
Bellevue, Washington 98005
(425) 896-6900 FAX: (425) 602-4020**

TABLE OF CONTENTS

1	INTRODUCTION.....	1-6
1.1	BACKGROUND.....	1-6
1.2	PURPOSE.....	1-6
2	TRAINING DIKE ALTERNATIVE.....	2-7
2.1	BACKGROUND DATA.....	2-7
2.2	TRAINING DIKE LAYOUT.....	2-7
2.3	ROCK SIZING.....	2-7
2.4	DIKE DESIGN.....	2-8
2.5	CONSTRUCTION METHODS.....	2-8
2.5.1	Access.....	2-8
2.5.2	Construction.....	2-8
2.6	ENVIRONMENTAL MITIGATION.....	2-9
2.7	OPINION OF PROBABLE CONSTRUCTION COST.....	2-9
2.8	OPERATIONS AND MAINTENANCE COSTS.....	2-9
2.9	REFERENCES.....	2-9
3	INTAKE AND PUMP STATION RELOCATION.....	3-1
3.1	BACKGROUND DATA.....	3-1
3.1.1	Previous Studies.....	3-1
3.1.2	Data.....	3-1
3.1.3	Site Selection.....	3-1
3.2	INTAKE DESIGN.....	3-2
3.2.1	Intake and Fish Screens.....	3-2
3.2.2	Pipe to Pump Station.....	3-2
3.3	PUMP STATION.....	3-2
3.3.1	Hydraulics.....	3-2
3.3.2	Description.....	3-3
3.4	PIPELINE.....	3-4
3.4.1	Transmission Pipe.....	3-4
3.4.2	Connection to Existing Pipe.....	3-4
3.5	ROCK REVETMENT.....	3-4
3.6	CONSTRUCTION METHODS.....	3-5
3.6.1	Access.....	3-5
3.6.2	Construction.....	3-5
3.7	ENVIRONMENTAL MITIGATION.....	3-5
3.8	OPINION OF PROBABLE CONSTRUCTION COST.....	3-5
3.9	OPERATIONS AND MAINTENANCE COSTS.....	3-5

3.10	REFERENCES.....	3-6
4	INTAKE AND PUMP STATION RELOCATION ALTERNATE	4-1
4.1	BACKGROUND DATA	4-1
4.1.1	Previous Studies.....	4-1
4.1.2	Data.....	4-1
4.1.3	Site Selection	4-1
4.2	INTAKE DESIGN	4-2
4.2.1	Intake and Fish Screens	4-2
4.2.2	Pipe to Pump Station.....	4-2
4.3	PUMP STATION.....	4-2
4.3.1	Hydraulics.....	4-2
4.3.2	Description.....	4-3
4.4	PIPELINE.....	4-4
4.4.1	Transmission Pipe.....	4-4
4.4.2	Connection to Existing Pipe	4-4
4.5	ROCK REVETMENT.....	4-4
4.6	CONSTRUCTION METHODS	4-5
4.6.1	Access	4-5
4.6.2	Construction.....	4-5
4.7	ENVIRONMENTAL MITIGATION	4-5
4.8	OPINION OF PROBABLE CONSTRUCTION COST	4-5
4.9	OPERATIONS AND MAINTENANCE COSTS.....	4-6
4.10	REFERENCES.....	4-6

List of Figures

Figure	Description
---------------	--------------------

Figure 1-1	Location and Vicinity Map
Figure 2-1	Site Plan
Figure 2-2	Area Plan - 1.
Figure 2-3	Area Plan - 2
Figure 2-4	Area Plan - 3
Figure 2-4	Profiles - 1
Figure 2-4	Profiles - 2
Figure 2-4	Profiles - 3
Figure 3-1	Pump/Intake Relocation Site Plan
Figure 3-2	Intake and Pump Station Plan and Profile
Figure 3-3	Transmission Pipe Plan and Profile
Figure 3-4	Typical Shore Protection Detail
Figure 4-1	Pump/Intake Relocation Site Plan
Figure 4-2	Intake and Pump Station Plan and Profile
Figure 4-3	Transmission Pipe Plan and Profile

1 INTRODUCTION

1.1 BACKGROUND

The west bank of the Sacramento River is eroding at RM 192.5, and, as a result, a gravel bar at the confluence of Big Chico Creek is migrating downstream. See Figure 1-1. The gravel bar threatens the viability of the water intake serving M & T Ranch and two wildlife reserves. Over the last five years, interim steps have been taken while a permanent solution is found. These steps included two projects to excavate the gravel bar and placement of rock at the toe of the west bank opposite the gravel bar.

A Technical Team was formed to identify a permanent fix to the problem. A Steering Committee was also formed to review and approve the recommendation of the Technical Team. As part of this work, a two dimensional hydrodynamic model was developed by Mussetter Engineering (MEI, 2006). Colorado State University was commissioned to construct and run a physical hydraulic model at their labs in Fort Collins, Colorado, to test the alternative of training dikes and excavated channels to provide water to the intake. In the four meetings of the Technical Team and in subsequent conference calls, two final alternatives were identified. These were: (1) construction of nine training dikes extending out from the west bank and (2) relocation of the intake and pump station downstream on the east bank.

1.2 PURPOSE

This Technical Memorandum (TM) is intended to be a reference document to be used by the Steering Committee in selection of a final design alternative. It also describes the two alternatives for the project record.

The TM summarizes the engineering analysis of these final two design options, training dikes and relocation of the intake and pump station. It describes the physical features of the two alternatives and provides preliminary cost opinions for construction and operation for both alternatives.

2 TRAINING DIKE ALTERNATIVE

2.1 BACKGROUND DATA

The primary sources of information used in performing the engineering analysis are described below.

1. Two dimensional hydrodynamic model by Mussetter Engineering, Inc. (MEI). Two reports were written regarding this model (Mussetter Engineering, 2005 and Mussetter Engineering, 2006). Topographic data from the 2006 model were used to locate and design the dikes. The output from the model runs was used to obtain depths and velocities on and near the proposed dikes.
2. Physical model report (Cox, August 2008) was utilized to verify the dike locations and sizes. The depth and velocities measured in the physical model were used to verify those values from the 2-D model.
3. The gradation of the bed material was based on bed samples taken at the west bank gravel bar directly across from the existing pump station and extending to approximately 400 feet to the north. These data were used to design the filter blanket under the dikes.

2.2 TRAINING DIKE LAYOUT

Initially, the velocities and depths provided from the 2-D computer model were compared with those reported in the physical model at the same locations near the dikes. Good agreement was found between the two models. Since the 2-D model reported more data around and on the dikes, the 2-D model data were used in the design of the dikes.

The number, location, length, height, and slope of the dikes were obtained from the physical model study (CSU, 2008). The same dike layout was also used in the numerical model study. MWH compared the dike layout parameters with those used in other engineering designs and found them to be consistent with current engineering practice.

The dikes are spaced approximately 250 to 350 feet apart. See Figure 2-1 through 2-8. They are approximately 150 to 250 feet long, including the dike root and nose. The tops of the dikes are 5 feet wide and flat along the center line of the dikes. The upstream and downstream sides of the dikes slope down to the existing bed at a 1V:2H slope. The elevation of the top of the dikes at the bank are set at the 35,000 cfs water surface elevation, which occurs annually. At this height water will overtop the furll length of the dikes approximately 7% of the time. The dikes slope downward longitudinally into the river at a 5% grade. The height at the nose of the dikes is approximately 10 feet above the bed.

2.3 ROCK SIZING

To size the rocks for the dikes, a design flood of 100-year recurrence interval was used. We first examined the velocities from the physical and numerical models for points on and around the dikes. Using this information, the velocities varied from 5.0 to slightly over 11 fps. A velocity of 11 feet per second with a corresponding depth of 19 feet over the top of the dike was selected for rock sizing. After reviewing multiple design manuals and technical papers, we used this velocity and flow depth to calculate rock sizes using different methods. These were computed using methods developed by Simon and Lewis, Croad, Brown and Clyde, Austroads, Lagasse, and Pagan-Ortiz as described in ASCE (2007). Calculated

rock sizes (D_{50}) ranged from 1.1 feet to 3.6 feet in diameter. Based on the application of the different methods to this site and historic performance of the different methods, a gradation of $D_{15} = 2.0$ feet, $D_{50} = 2.6$ feet, and $D_{85} = 3.0$ feet was selected for design. A filter layer with a gradation of $D_{15} = 0.3$ feet, $D_{50} = 0.6$ feet, and $D_{85} = 0.9$ feet was calculated based on the design rock size and river bed gradation using a method recommended by the Corps of Engineers (ASCE, 2007).

2.4 DIKE DESIGN

The dikes are positioned in the river as determined by the physical model study (CSU, 2008). In order to mitigate the effects of bank erosion on the dikes, the dike was extended into the bank 30 feet. See Figures 2-5 through 2-7. The physical model used a bank penetration of 30 feet. The physical model did not reveal erosion that endangered the root of the dike. Therefore, this root length is considered to be adequate to protect the dikes, and no bank revetment is proposed. The length of the dike varies as shown in the physical model study report (CSU, 2007). The height of the dike at the root is set at the 35,000 cfs water level. The top of the dike slopes downward at 5% from the root to the end. The dike foot print was determined by the dike elevation and the 5-foot top width. Side slopes of 2 horizontal to 1 vertical were extended from this elevation to the river bed.

A rock thickness of 2 times the D_{50} was selected. Therefore, the thickness of the rock layer is 5.2 feet. To prevent erosion under the dike and failure, a filter layer is to be located between the river bed and dike. The filter layer will be greater than 12" thick as recommended by the Corps (ASCE, 2007). The dike has a filter rock fill core, which has the same size characteristics as the filter material. See Figure 2-8, Section J. Another size of core material can be used in the center, however a filter blanket of one foot thickness would be required between the underlying soil and the riprap.

2.5 CONSTRUCTION METHODS

2.5.1 Access

The site can be accessed from the north and south via California Highway 45 running north-south on the west side of the Sacramento River. Two local means of access are possible. Access from the north is on County Road 23 east from Hwy-45 and then on a private road south along the Sacramento River to a turnaround at the north end of the site. The turnaround is also a potential site for a construction material stockpile area. Access from the south is on County Road 23 east to Rogers Ranch Road, then along Rogers Ranch Road to a private road east to the Sacramento River. At the end of this road there is an off-road track to access the river.

2.5.2 Construction

Construction will require an excavator(s) capable of lifting a one-ton rock or greater and placing it at least 15 feet away. Construction of the dikes will likely occur during the winter low-flow season. The following is a possible approach to construction. The dike root will be excavated first. Next, the filter rock and fill core will be placed from the root outward. The tracked excavator will place the rock on the filter to a level above the water surface. The excavator will then operate from the top of the partially constructed dike to build the dike out into the river and up to an elevation, which is wide enough to support the excavator. The excavator will place the launchable toe from the end of the dike. Then the excavator will build the dike up to its design height from the end back to the root.

2.6 ENVIRONMENTAL MITIGATION

Mitigation at the site during construction would consist of dust suppression, release of rock underwater, and bank excavation for dike roots at low river levels. The construction would be sequenced so that no machinery would enter the river. After construction is finished, plantings would be placed along the bank to protect against erosion of the bank between dikes.

In addition to the on-site mitigation, off site mitigation has been required for previous bank protection projects. In general, it is preferred by permitting agencies that project proponents remove existing bank protection rock from the river equal to the bank protection rock placed in the river by the new project. Based on conversations with CalTrans (Hagen personal communication, Aug 2008), it is assumed that rock placed in dikes is not as detrimental to the environment as rock bank revetment. Therefore, we have assumed that the rock required to be removed from the river would be about half the volume of rock placed in the river for dikes.

2.7 OPINION OF PROBABLE CONSTRUCTION COST

The opinion of probable construction cost is \$6.6 million. This estimated cost is considered to be a Class 4 cost opinion as defined by the Association for the Advancement of Cost Engineering. Class 4 cost opinions are for projects in which the design is generally developed to between 10% and 40% of completion. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. The expected accuracy range of a Class 4 cost opinion ranges from -15% to -30% on the low side and +20% to +50% on the high side. In this estimate, the primary costs are for the rock and excavation. A lump sum allowance has been included for off-site mitigation. We have assumed that about half the rock volume of the groins would have to be removed from another section of the river, and this removal would cost the same as dike installation on a per ton basis.

2.8 OPERATIONS AND MAINTENANCE COSTS

Maintenance costs will include rock replacement and repair for the dikes, which is estimated to occur on an infrequent basis, generally after large storm events. Maintenance will include adjusting and replacing washed-out rock and reshaping the dikes such that the river training effects are maintained. The annual operations and maintenance for the project is estimated as 1.5% of the overall cost, or approximately \$100,000 per year.

2.9 REFERENCES

1. ASCE, *Sedimentation Engineering: Processes, Measurements, Modeling, and Practice (ASCE Manuals and Reports on Engineering Practice No. 110)*. Garcia, Marcelo, ed., ASCE, 2007: 1150 pgs.
2. Cox, A. L., C. I. Thornton, and S. M. Scurlock, *M&T Pump Station Intake Physical Model Report*, August 2008
3. Hagen personal communication, Aug 2008
4. Mussetter Engineering, Inc., 2005. *Two-dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plan, Sacramento River, RM 192.5*. Prepared for Ducks Unlimited, Rancho Cordova, California, February.

5. Mussetter Engineering, Inc., 2006. *Two-Dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plant, Sacramento River, RM 192.5 (2005 Topography and Bed Material)*. Prepared for Ducks Unlimited, Rancho Cordova, California, revised April 12, 2006.

3 INTAKE AND PUMP STATION RELOCATION

3.1 BACKGROUND DATA

3.1.1 Previous Studies

Several discussions have discussed relocating the intake to sites further downstream. Proposed sites include moving the intake to (1) just downstream of the site of the existing City of Chico sewer outfall, about 600 feet downstream of the existing intake, (2) moving to the southern extent of the existing rock revetment bank protection on the left bank, about 2,000 feet downstream, or (3) as far downstream as practicable. An advantage of adding a new intake, as opposed to replacing the old intake, would be to provide flexibility of having two intakes. If future downstream progression of the gravel bar begins to impact operation at the new intake, operation could revert to the existing intake, if river conditions are suitable.

3.1.2 Data

The primary sources of information used in performing the engineering analysis are described below.

1. Design drawings from the existing pump station prepared for Duck Unlimited Inc. by MWH (then Montgomery Watson) in March, 1996. Structural information, layout, and elevations were obtained from the original design and used to calculate hydraulics for the new system and to size the mechanical aspects of the new pump station.
2. Two dimensional mathematical hydraulic model by Mussetter Engineering, Inc. (MEI). Two reports were written regarding this model (Mussetter Engineering, 2005 and Mussetter Engineering, 2006). Topographic data from the 2006 model were used to locate the intake structure. The output from the model runs was used to estimated rock sizes for the new rock revetment.
3. One-dimensional HEC-RAS model obtained from MEI. River water surface elevations at the new intake location were obtained from the HEC-RAS model for laying out the new intake structure and estimating the hydraulics of the new pump station.

3.1.3 Site Selection

The site for the new intake was selected based on the theory that the gravel bar will continue to move downstream over time. The City of Chico is also in the process of moving their outfall downstream. The City estimates that moving their outfall will afford them an additional 20 years of operation before the gravel bar moves to their new location. The new intake was relocated as far downstream as practicable to afford the most time before the gravel bar arrives. The site was selected at a point where the river begins to bend to the west. This affords the least disturbance of the flood plain while keeping the intake close to the levee for maintenance access during high water. Based on the rate of travel of the bar over the last few years, it is assumed that the gravel bar will arrive at the proposed site in about 30 years. See Figure 3-1.

3.2 INTAKE DESIGN

3.2.1 Intake and Fish Screens

The intake structure for the existing pump station is located in a natural deep pool where Big Chico Creek confluences with the Sacramento River and uses cylindrical tee fish screens. At the new location, the river is not deep enough for the use of cylindrical tee screens. As a result, an intake structure with vertical flat plate screens is required at this location. The Sacramento River bends to the west at the proposed intake structure location, and a small pool exists with a minimum depth of approximately 10 feet.

The intake structure will have a footprint that is 76 feet long and 27 feet wide and will have six vertical flat-plate screens, each 10 feet long by 8 feet high, along the front face that will provide fish screening that meets fish agency screening criteria. See Figure 3-2. The screens will have a maximum approach velocity of 0.31 fps. The top of the screens will be at elevation 111.0 feet, or approximately 0.5 feet below the estimated minimum water surface elevation in the Sacramento River. The screens will be kept clean by a water jet system that will also act to re-suspend sediment at the intake structure. It is assumed that the natural sweeping velocity of the river combined with the minimal approach velocity will be able to keep the screens clear of large debris.

The intake structure will be accessed by a road over the levee and a local road through the orchard to the east. The access road within the channel banks will be constructed on fill to reach the top of the inlet structure at elevation 128.0. Concrete wing walls will extend from the back side of the structure to support the access road and retain fill.

The intake structure will have a sediment re-suspension system using the same pumps as the back spray screen cleaning system. The structure will need to be accessed at times to remove excess sediment, clean fish screens, or repair the cleaning system.

3.2.2 Pipe to Pump Station

A 72-inch diameter reinforced concrete cylinder pipe (RCCP) approximately 345 feet in length will connect the intake structure and the new pump station on the land side of the levee. The pipe will have an invert elevation of 102.0 ft and run beneath the levee to the pump station. At this location, it is allowable to bury the pipe through the levee because it is not a state project levee. A gate structure with a 72"x72" sluice gate will be constructed on the river side of the levee to provide the ability to shut off and dewater the pipeline and pump station. At the maximum flow rate, the pipe will carry 150 cfs to the pump station with a velocity of approximately 5.3 fps.

The pipeline will be installed by an open cut through the levee, which will involve excavation of approximately 29,000 cubic yards of earth.

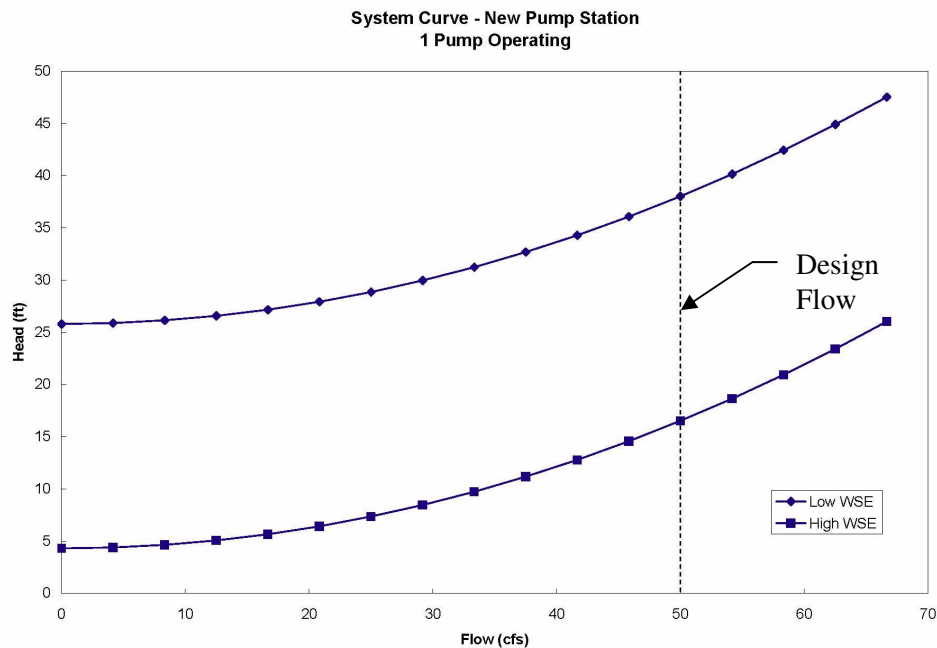
3.3 PUMP STATION

3.3.1 Hydraulics

The intake and pump station are designed to withdraw water from the Sacramento River and deliver it to the headworks of the Phelan Canal. The station will have 3 pumps, each designed with a maximum capacity of approximately 50 cfs. Water surface elevations in the Sacramento river can vary by up to 21.5 feet. The minimum estimated water surface elevation is 111.5 feet and the maximum design water

elevation is 133.0 feet at the 100-year event. Water discharged from the pumps will be conveyed through approximately 3,500 feet of 72-inch diameter concrete pipe to the connection with the existing pipe north of the existing pump station. From the connection to the canal the flow will be conveyed in the existing 72-inch diameter pipe. In total, there is 8,300 feet of pipe from the river to the canal. Water reaching the outlet structure flows over a weir with a crest elevation of 134.5 ft and into a free surface chamber, from which water is drawn through two 42-inch pipes into the canal.

At minimum water elevation and maximum flow, the pumps will be required to produce 38 feet of head to deliver water to the canal outlet structure. At a high water level, the pumps will operate at 16.5 feet of head. See the system curve below. The head loss in this system is too great to route the flow from the new intake to the existing pump station.



3.3.2 Description

The pump station layout will be similar to that of the existing structure. The 72-inch pipe from the intake structure will expand into a 120-inch pipe. The 35 feet of 120-inch pipe will enter a manifold structure at an invert elevation at approximately 98.75 feet. The manifold structure will consist of four branches to the three pumps and a spare pump bay. An above-ground building will house the pump motors and electrical equipment. Four pump barrels constructed of 54-inch RCP will rise to an above-ground elevation of 131.0 feet. The existing grade at the pump station is about 128.0 feet.

Three single-stage, variable speed, vertical turbine pumps similar to the those used in the existing pump station will be installed at the new pump station. The impeller diameter will be about 19.5 inches. The pump will be operated at 675 rpm to achieve a flow rate of 50 cfs at 38 feet total discharge head. The pumps will have variable frequency drives and will be operable at progressively lower rpm to achieve the desired flow rate at the water level in the Sacramento River.

Each pump will require a 300 hp electric motor and will draw approximately 350 kW at the maximum flow and head combination. This system will require about 22% more energy to pump the same amount of flow than in the existing pump station.

The pump station building will have a footprint of approximately 50 ft by 65-ft. In addition to about an acre of land around the pump station, additional land of about 7 acres will be required along the edge of the orchard for the pipeline to the existing pump station. Additional land of about 2.5 acres will be required for construction of the intake and pipe to the pump station.

3.4 PIPELINE

3.4.1 Transmission Pipe

The transmission pipeline from the new pump station will run along the east edge of the existing farm road at the base of the levee for about 1,800 feet to where it passes over the new City of Chico outfall pipe. Then, it will continue along the edge of the farm road until reaching the existing pump station. It will tee into the existing discharge line just north of the present pump station. See Figure 3-3. The pipe will be 72-inch diameter reinforced concrete cylinder pipe and will be buried at least 3 feet beneath the surface. The slope of the pipe will be essentially horizontal for the first 2,100 feet, then slope downward at a grade of 0.2% for the last 1,500 feet, to connect with the existing transmission line at an invert elevation of approximately 116.0 ft. It is estimated that 3,600 lineal feet of pipe will be required. The City of Chico Outfall pipe is anticipated to have a top elevation of 118.0 ft, which will give approximately 1 foot of clearance between the top of the outfall pipe and the invert of the new transmission pipeline. Special fill will be required around the two pipes at this location.

Total earth excavation for the transmission pipe is estimated to be 48,000 cubic yards. A clearing width of approximately 100 feet wide will be necessary along the 3,600 feet pipe for construction and future maintenance access.

3.4.2 Connection to Existing Pipe

At the point of intersection between the new and existing transmission pipelines, a segment of the old pipeline will be removed and a tee connection will be installed. To block off flow back to the existing pump station, two blind flanges will be installed, one on the end of the existing pipeline and the other at the end of the tee facing the old pump station. See Figure 3-3. By using blind flanges, this will allow the pipeline to be connected and re-activated more easily if future conditions require switching operation back to the existing pump station.

3.5 ROCK REVETMENT

An existing rock revetment is located along the east river bank just south of the proposed City of Chico outfall location. In order to prevent erosion of the bank upstream of the new intake location, this existing rock revetment will be removed, realigned, and extended. The new revetment will cover the sloping face of the bank and run approximately 1,600 feet along the river to the new intake location. No calculations were made to size the rock. Sizes were assumed based on observations of the revetment on the levee at the existing pump station. The revetment will be approximately 40 feet wide, with a 15-foot toe in the channel bottom. See Figure 3-4. The rock will be 24-inches thick with a $D_{50} = 1.0$ ft. Additional rock will be placed on the downstream side of the intake structure to prevent scouring and undermining of the structure. In total, approximately 14,400 tons of the rock will be placed.

3.6 CONSTRUCTION METHODS

3.6.1 Access

To the north, access will be from an existing local road that turns off River Road and runs parallel to the east bank levee along Big Chico Creek and the Sacramento River. This road provides direct access to the existing pump station and will also provide access to the pipeline and new pump station. To the south, another farm road from River Road would provide access to the intake and pump station. For access to the intake structure location, a new road will be constructed overtop the levee and down to the intake.

3.6.2 Construction

A cofferdam, probably consisting of sheet piles, will be constructed in the river around the intake and back into the bank to provide dewatering for the intake and pipeline back into the levee. The intake and pipeline will be constructed in the dry behind the cofferdam.

In-water work will be necessary for construction of the revetment. An excavator(s) will lift the rock and place it at least 30 feet away such that the excavator will not have to enter the water. Installation of the rock revetment will likely occur during the low-flow season.

3.7 ENVIRONMENTAL MITIGATION

Mitigation at the site during construction would consist of erosion control, dust suppression, and release rock underwater. After construction is finished, plantings would be made along all disturbed areas where pipe was buried, particularly over the levee, to prevent erosion.

In addition to the on-site mitigation, off site mitigation has been required. In general, it is preferred by permitting agencies that project proponents remove existing bank protection rock from the river equal to the bank protection rock placed in the river by a new project. It is anticipated that the rock revetment will have to be mitigated on a 1 for 1 basis for this project

3.8 OPINION OF PROBABLE CONSTRUCTION COST

The opinion of probable construction cost is \$13.2 million. This estimated cost is considered to be a Class 4 cost opinion as defined by the Association for the Advancement of Cost Engineering. Class 4 cost opinions are for projects in which the design is generally developed to between 10% and 40% of completion. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. The expected accuracy range of a Class 4 cost opinion ranges from -15% to -30% on the low side and +20% to +50% on the high side. In this estimate, the primary costs are for the pipe and excavation. An allowance for off-site mitigation equal to the cost of revetment placement has been included. Operations and maintenance of the structure should be similar to the costs incurred at the existing structure, but with an approximately 22% increase in power costs due to additional pumping head.

3.9 OPERATIONS AND MAINTENANCE COSTS

Annual operations and maintenance (O&M) for the pump station will include electricity for pumping, electricity for lights and other appurtenances, general maintenance and repair, and labor. Moving the pump station 3,600 ft downstream is estimated to increase the energy requirements by 22%. In addition to these annual costs, we have assumed that pumps will be replaced approximately every 15 years at a

present-value cost of \$130,000, and pump motors will be replaced every 25 years at a cost of \$70,000. Assuming other electrical costs and general maintenance and repair are similar to the existing pump station, annual O&M costs for the new pump station are estimated to be about \$332,000 per year in 2008 dollars or \$8.20 per acre-ft.

3.10 REFERENCES

1. M&T/Parrot Pumping Station and Fish Screen Project, Volume 2 – Drawings. Prepared for Ducks Unlimited Inc. by Montgomery Watson. March, 1996.
2. Mussetter Engineering, Inc., 2005. *Two-dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plan, Sacramento River, RM 192.5*. Prepared for Ducks Unlimited, Rancho Cordova, California, February.
3. Mussetter Engineering, Inc., 2006. *Two-Dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plant, Sacramento River, RM 192.5 (2005 Topography and Bed Material)*. Prepared for Ducks Unlimited, Rancho Cordova, California, revised April 12, 2006.
4. Mussetter Engineering, Inc., 2006. *One-Dimensional HEC-RAS model*

4 INTAKE AND PUMP STATION RELOCATION ALTERNATE

4.1 BACKGROUND DATA

4.1.1 Previous Studies

As discussed in 3.1.1, proposed sites for moving the intake include (1) just downstream of the site of the existing City of Chico sewer outfall, about 600 feet downstream of the existing intake, (2) moving to the southern extent of the existing rock revetment bank protection on the left bank, about 2,000 feet downstream, or (3) as far downstream as practicable. This section considers site 2, moving the intake to near the southern extent of the existing rock revetment bank protection on the left bank.

4.1.2 Data

The primary sources of information used in performing the engineering analysis are described below.

1. Design drawings from the existing pump station prepared for Duck Unlimited Inc. by MWH (then Montgomery Watson) in March, 1996. Structural information, layout, and elevations were obtained from the original design and used to calculate hydraulics for the new system and to size the mechanical aspects of the new pump station.
2. Two dimensional mathematical hydraulic model by Mussetter Engineering, Inc. (MEI). Two reports were written regarding this model (Mussetter Engineering, 2005 and Mussetter Engineering, 2006). Topographic data from the 2006 model were used to locate the intake structure. The output from the model runs was used to estimated rock sizes for the new rock revetment.
3. One-dimensional HEC-RAS model obtained from MEI. River water surface elevations at the new intake location were obtained from the HEC-RAS model for laying out the new intake structure and estimating the hydraulics of the new pump station.

4.1.3 Site Selection

The site for this intake is located near the southern extent of the existing rock revetment bank protection on the left bank. The site was selected at a point where there is appears to be enough depth near the bank for an intake. This affords the least disturbance of the flood plain while keeping the intake close to the levee for maintenance access during high water. In contrast to the furthest downstream intake location, this site would require less capital costs for pipe material and excavation, but the location of the site further upstream closer to the gravel bar will reduce the usable life until the intake is overrun by the gravel bar. Based on the rate of travel of the bar over the last few years, it is assumed that the gravel bar will arrive at the proposed site in about 20 years. See Figure 4-1.

4.2 INTAKE DESIGN

4.2.1 Intake and Fish Screens

The intake structure for the existing pump station is located in a natural deep pool where Big Chico Creek confluences with the Sacramento River and uses cylindrical tee fish screens. At the new location, the river is not deep enough for the use of cylindrical tee screens. As a result, an intake structure with vertical flat plate screens is required at this location. An existing rock revetment would surround the proposed intake location and project slightly into the Sacramento River at this location. The intake was placed in the revetment area and about 200 feet upstream from the southern end of the revetment at a small pool area near the bank. This area provides a minimum depth of approximately 10 feet.

The intake structure will have a footprint that is 76 feet long and 27 feet wide and will have six vertical flat-plate screens, each 10 feet long by 8 feet high, along the front face that will provide fish screening that meets fish agency screening criteria. See Figure 4-2. The screens will have a maximum approach velocity of 0.31 fps. The top of the screens will be at elevation 111.0 feet, or approximately 0.5 feet below the estimated minimum water surface elevation in the Sacramento River. The screens will be kept clean by a water jet system that will also act to re-suspend sediment at the intake structure. It is assumed that the natural sweeping velocity of the river combined with the minimal approach velocity will be able to keep the screens clear of large debris.

The intake structure will be accessed by a road over the levee and a local road through the orchard to the east. The access road within the channel banks will be constructed on fill to reach the top of the inlet structure at elevation 128.0. Concrete wing walls will extend from the back side of the structure to support the access road and retain fill.

The intake structure will have a sediment re-suspension system using the same pumps as the back spray screen cleaning system. The structure will need to be accessed at times to remove excess sediment, clean fish screens, or repair the cleaning system.

4.2.2 Pipe to Pump Station

A 72-inch diameter reinforced concrete cylinder pipe (RCCP) approximately 255 feet in length will connect the intake structure and the new pump station on the land side of the levee. The pipe will have an invert elevation of 102.0 ft and run beneath the levee to the pump station. At this location, it is allowable to bury the pipe through the levee because it is not a state project levee. A gate structure with a 72"x72" sluice gate will be constructed on the river side of the levee to provide the ability to shut off and dewater the pipeline and pump station. At the maximum flow rate, the pipe will carry 150 cfs to the pump station with a velocity of approximately 5.3 fps.

The pipeline will be installed by an open cut through the levee, which will involve excavation of approximately 36,000 cubic yards of earth.

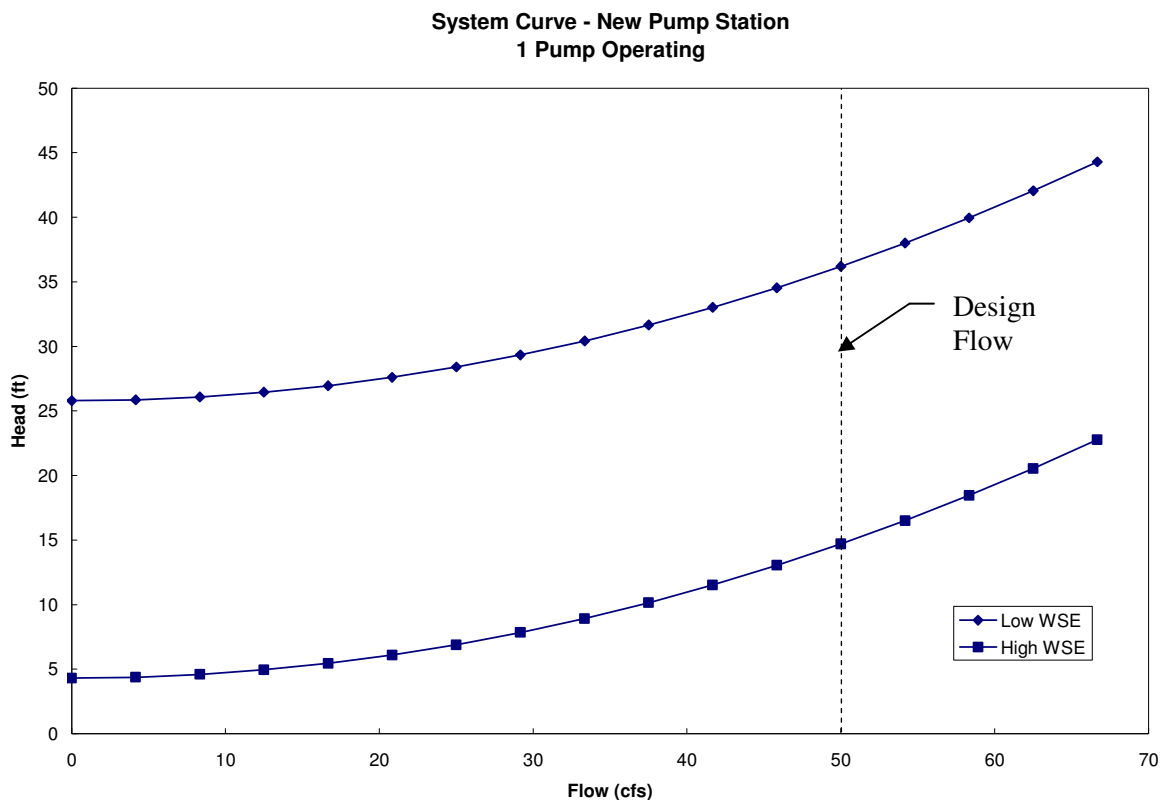
4.3 PUMP STATION

4.3.1 Hydraulics

The intake and pump station are designed to withdraw water from the Sacramento River and deliver it to the headworks of the Phelan Canal. The station will have 3 pumps, each designed with a maximum

capacity of approximately 50 cfs. Water surface elevations in the Sacramento river can vary by up to 21.5 feet. The minimum estimated water surface elevation is 112.0 feet and the maximum design water elevation is 133.5 feet at the 100-year event. Water discharged from the pumps will be conveyed through approximately 2,200 feet of 72-inch diameter concrete pipe to the connection with the existing pipe north of the existing pump station. From the connection to the canal the flow will be conveyed in the existing 72-inch diameter pipe. In total, there is 6,900 feet of pipe from the river to the canal. Water reaching the outlet structure flows over a weir with a crest elevation of 134.5 ft and into a free surface chamber, from which water is drawn through two 42-inch pipes into the canal.

At minimum water elevation and maximum pumped flow, the pumps will be required to produce about 36 feet of head to deliver water to the canal outlet structure. At a high water level, the pumps will operate at 14.7 feet of head. See the system curve below. The head loss in this system is too great to route the flow from the new intake to the existing pump station.



4.3.2 Description

The pump station layout will be similar to that of the existing structure. The 72-inch pipe from the intake structure will expand into a 120-inch pipe. The 30 feet of 120-inch pipe will enter a manifold structure at an invert elevation at approximately 98.75 feet. The manifold structure will consist of four branches to the three pumps and a spare pump bay. An above-ground building will house the pump motors and electrical equipment. Four pump barrels constructed of 54-inch RCP will rise to an above-ground elevation of 131.0 feet. The existing grade at the pump station is about 128.0 feet.

Three single-stage, variable speed, vertical turbine pumps similar to the those used in the existing pump station will be installed at the new pump station. The impeller diameter will be about 18.8 inches. The pump will be operated at 675 rpm to achieve a flow rate of 50 cfs at 36 feet total discharge head. The pumps will have variable frequency drives and will be operable at progressively lower rpm to achieve the desired flow rate for the water level in the Sacramento River.

Each pump will require a 300 hp electric motor and will draw approximately 300 kW at the maximum flow and head combination. This system will require about 12% more energy to pump the same amount of flow than in the existing pump station.

The pump station building will have a footprint of approximately 50 ft by 65-ft. In addition to about an acre of land around the pump station, additional land of about 4 acres will be required along the edge of the orchard for the pipeline to the existing pump station. Additional land of about 2.5 acres will be required for construction of the intake and pipe to the pump station.

4.4 PIPELINE

4.4.1 Transmission Pipe

The transmission pipeline from the new pump station will run along the east edge of the existing farm road at the base of the levee for about 360 feet to where it passes over the new City of Chico outfall pipe. Then, it will continue along the edge of the farm road until reaching the existing pump station. It will tee into the existing discharge line just north of the present pump station. See Figure 4-3. The pipe will be 72-inch diameter reinforced concrete cylinder pipe and will be buried at least 3 feet beneath the surface. The slope of the pipe will be essentially horizontal for the first 700 feet, then slope downward at a grade of 0.2% for the last 1,500 feet, to connect with the existing transmission line at an invert elevation of approximately 116.0 ft. It is estimated that 2,200 lineal feet of pipe will be required. The City of Chico Outfall pipe is anticipated to have a top elevation of 118.0 ft, which will give approximately 1 foot of clearance between the top of the outfall pipe and the invert of the new transmission pipeline. Special fill will be required around the two pipes at this location.

Total earth excavation for the transmission pipe is estimated to be 27,000 cubic yards. A clearing width of approximately 100 feet wide will be necessary along the 2,200 feet pipe for construction and future maintenance access.

4.4.2 Connection to Existing Pipe

At the point of intersection between the new and existing transmission pipelines, a segment of the old pipeline will be removed and a tee connection will be installed. To block off flow back to the existing pump station, two blind flanges will be installed, one on the end of the existing pipeline and the other at the end of the tee facing the old pump station. See Figure 4-3. By using blind flanges, this will allow the pipeline to be connected and re-activated more easily if future conditions require switching operation back to the existing pump station.

4.5 ROCK REVETMENT

An existing rock revetment is located along the east river bank just south of the proposed City of Chico outfall location. The new intake structure will be located in this revetment, approximately 200 feet upstream of the downstream end. The rock will need to be removed in order to excavate and construct the intake structure and connection pipeline. Some of the rock may be replaced to reinforce the upstream and

downstream toes of the structure to prevent scouring and undermining. In total, approximately 475 cubic yards of the rock will be removed and relocated.

4.6 CONSTRUCTION METHODS

4.6.1 Access

To the north, access will be from an existing local road that turns off River Road and runs parallel to the east bank levee along Big Chico Creek and the Sacramento River. This road provides direct access to the existing pump station and will also provide access to the pipeline and new pump station. To the south, another farm road from River Road would provide access to the intake and pump station. For access to the intake structure location, a new road will be constructed overtop the levee and down to the intake.

4.6.2 Construction

After removing the rock revetment at the intake area, a cofferdam, probably consisting of sheet piles, will be constructed in the river around the intake and back into the bank to provide dewatering for the intake and pipeline back into the levee. The intake and pipeline will be constructed in the dry behind the cofferdam.

In-water work will be necessary for replacement of the revetment. An excavator(s) will lift the rock and place it at least 30 feet away such that the excavator will not have to enter the water. Installation of the rock revetment will likely occur during the low-flow season.

4.7 ENVIRONMENTAL MITIGATION

Mitigation at the site during construction would consist of erosion control, dust suppression, and removal of rock from underwater. After construction is finished, plantings would be made along all disturbed areas where pipe was buried, particularly over the levee, to prevent erosion.

In addition to the on-site mitigation, off site mitigation has been required. It is anticipated that there will be more rock removal than placement of rock for this project, although mitigation may still be required for excavation and construction work in the riverbed.

4.8 OPINION OF PROBABLE CONSTRUCTION COST

The opinion of probable construction cost is \$9.5 million. This estimated cost is considered to be a Class 4 cost opinion as defined by the Association for the Advancement of Cost Engineering. Class 4 cost opinions are for projects in which the design is generally developed to between 10% and 40% of completion. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. The expected accuracy range of a Class 4 cost opinion ranges from -15% to -30% on the low side and +20% to +50% on the high side. In this estimate, the primary costs are for the pipe and excavation. Operations and maintenance of the structure should be similar to the costs incurred at the existing structure, but with an approximately 12% increase in power costs due to additional pumping head.

4.9 OPERATIONS AND MAINTENANCE COSTS

Annual operations and maintenance (O&M) for the pump station will include electricity for pumping, electricity for lights and other appurtenances, general maintenance and repair, and labor. Moving the pump station 2,200 ft downstream is estimated to increase the energy requirements by 12%. In addition to these annual costs, we have assumed that pumps will be replaced approximately every 15 years at a present-value cost of \$130,000, and pump motors will be replaced every 25 years at a cost of \$70,000. Assuming other electrical costs and general maintenance and repair are similar to the existing pump station, annual O&M costs for the new pump station are estimated to be about \$316,000 in 2008 dollars or \$7.80 per acre-ft.

4.10 REFERENCES

1. M&T/Parrot Pumping Station and Fish Screen Project, Volume 2 – Drawings. Prepared for Ducks Unlimited Inc. by Montgomery Watson. March, 1996.
2. Mussetter Engineering, Inc., 2005. *Two-dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plan, Sacramento River, RM 192.5*. Prepared for Ducks Unlimited, Rancho Cordova, California, February.
3. Mussetter Engineering, Inc., 2006. *Two-Dimensional Modeling to Evaluate Potential River Training Works at M&T Pumping Plant, Sacramento River, RM 192.5 (2005 Topography and Bed Material)*. Prepared for Ducks Unlimited, Rancho Cordova, California, revised April 12, 2006.
4. Mussetter Engineering, Inc., 2006. *One-Dimensional HEC-RAS model*