2009

Church Ditch Master Plan

Ecological Resource Consultants, Inc.

CDWA
Church Ditch Water Authority

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I. INTRODUCTION

A. PURPOSE AND SCOPE

The purpose of the Church Ditch Master Plan (CDMP) was to create a master plan for the major improvements required along the entire stretch of the Church Ditch (Ditch) from Golden, CO to the Wilson Flume near the intersection of West 100th Avenue and Simms Street in Westminster, CO. Issues evaluated as part of this report were based on issues observed by the Church Ditch Water Authority (CDWA). This report also outlines areas along the Ditch that require more detailed inspection and analysis. The basic project scope included the following task items:

- Identify areas of concern likely requiring repairs, maintenance or modification and
- Develop costs associated with recommended improvements where applicable

B. DATA COLLECTION

Information and records were obtained from the CDWA during the course of the study. The information used to generate this report included copies of previous related studies, personal input from the CDWA and observations based on Ecological Resource Consultants, Inc. (ERC) experience with the Ditch.

C. MAPPING AND SURVEYS

Mapping used was received from CDWA and included the Ditch alignment based on 1980 topography. Certain areas along the ditch required ERC to perform a field visit. Two field visits occurred, one in August 2008 and one in January 2009. Culvert sizes, channel slopes and cross sections required for analysis and the condition of structures along the ditch were determined during both visits. Features were photographed to provide visual documentation of existing conditions.

D. PREVIOUS STUDIES

In May 1983 Water Resource Consultants, Inc. of Denver, CO completed the Plans for Major Maintenance and Repair of the Ditch. The report analyzed the existing conditions of the ditch based on capacity, seepage and erosion/sedimentation and recommended improvements for any existing issues. The report prioritized the existing issues based on 4 conditions:

- required for ditch capacity
- recommended for 1’ freeboard
- may be required due to potential problems (seepage, stability, erosion)
- suggested to improve the operation of the ditch.

Many of the issues presented in the report have either been resolved or have not been seen as problems since the 1983 report was completed.

II. STUDY AREA DESCRIPTION

A. GENERAL

The Church Ditch (Ditch) is a carrier ditch operated by the CDWA. It begins at its headgate near Golden, CO in Clear Creek and runs approximately 26 miles in a generally northeasterly direction through Jefferson County until it ends at the Wilson Flume near the intersection of West 100th Avenue and Simms Street in Westminster, CO. It carries municipal water for the Cities of Northglenn and Westminster and carries irrigation water for Inchholders. An Inchholder is anyone who has a current carriage contract for their respective number of inches from the Ditch thus entitling them to take delivery during the irrigation season. It has 113.03-cfs in decreed flows, historically a flow of 125-cfs has been used for capacity analysis. A flow of 125-cfs was used for all analysis in this report. A minimum of 2' freeboard was also used per the Church Ditch Water Authority's design criteria.

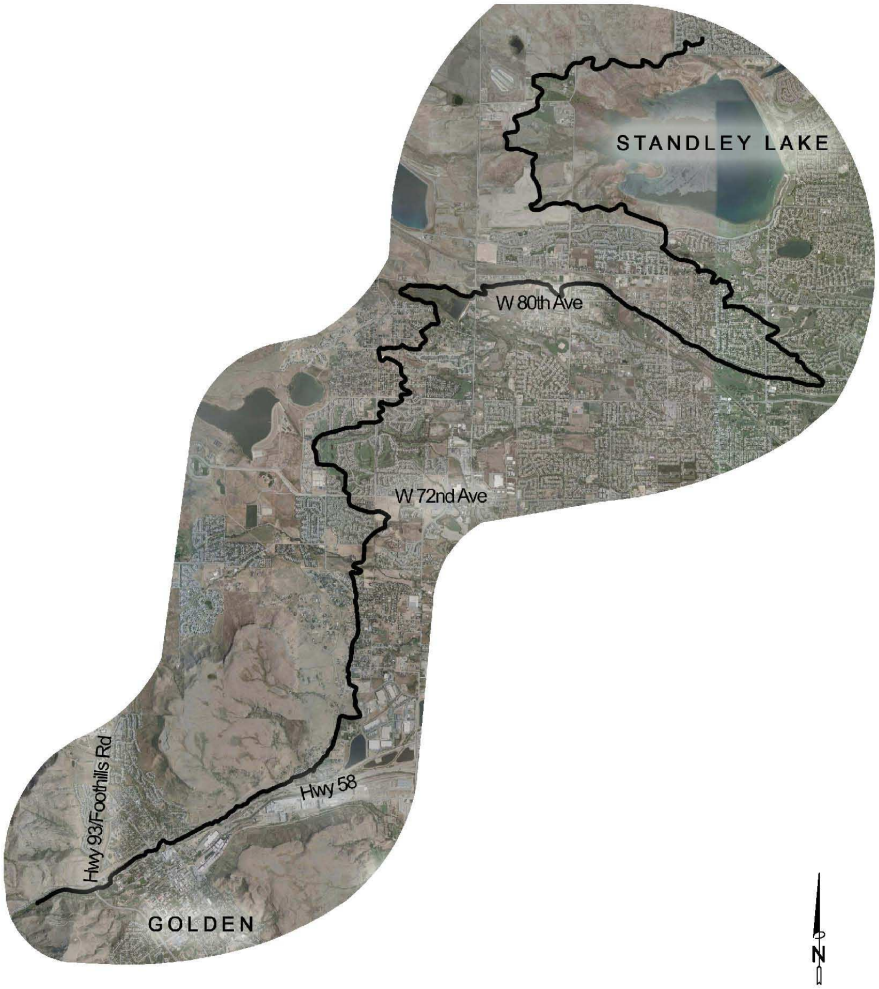

FIGURE 1 - STUDY AREA

III. RECENT DITCH IMPROVEMENTS

Several recent Ditch improvements have been made and included the piping of the Ditch, the lining of the Ditch and the construction of bypass structures. A summary of recent improvements is provided below.

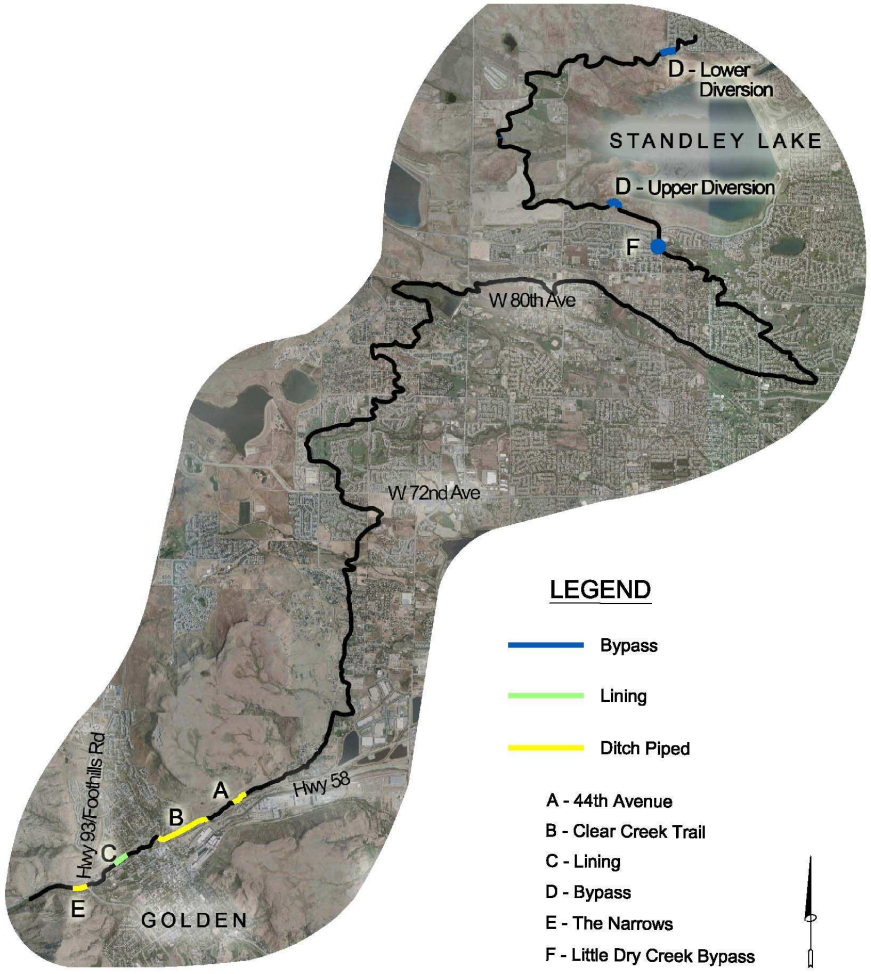

FIGURE 2 – LOCATIONS OF RECENT IMPROVEMENTS

A. 44th Avenue Pipeline Replacement Project

The improvements included the installation of approximately 811 LF of 60" HDPE, a headwall and a wingwall structure. This allowed for the installation of a bike trail between 44th Avenue and Hwy 58 in Golden, CO. These improvements were completed in 2004.

B. Clear Creek Trail – Phase II Church Ditch Pipeline

The improvements included the installation of approximately 1635 LF of 60" HDPE, an approximately 735 LF 5' x 6' concrete box culvert (CBC), an approximately 341 LF 5' x 7' CBC, an approximately 110 LF 5' x 8' CBC and two headwall structures. This allowed for the continuation of the Clear Creek Trail along the Church Ditch. These improvements were completed in 2004.

C. Church Ditch Lining

The improvements included the lining of approximately 900 LF of the Church Ditch as it flows from 8th Street to Illinois Street in Golden, CO. It consisted of the ditch being reshaped and lined with a 30 ml PVC liner and a triple layer of 2'x2'x6' interlocking blocks. An underdrain was also installed. These improvements were constructed in response to seepage issues reported by local residents. These improvements were completed in 2005.

PHOTO 1 - DITCH LINING

D. Bypass

A portion of the Ditch as it traverses the perimeter of Standley Lake was converted to a stormwater bypass system in 2008. The bypass system has the ability to divert Ditch water into Standley Lake leaving the Ditch available to collect and convey stormwater flows around Standley Lake. Collected stormwater is then conveyed back into the Big Dry Creek basin via a canal and pipe system. The system includes gates diversion points with measuring capabilities at the upper and lower end of the bypass system and a 48" rundown pipe into Standley Lake at the upper end.

E. Narrows Pipeline Project

This improvement was completed in 2008 and was located in an area of the Ditch just downditch of the headworks along Highway 58 and west of 6th Avenue in Golden, CO known as the Narrows. The improvements included the installation of approximately 265 LF of 81"x59" 12 gauge CMP, two cut off wall structures and a gravel road. Placing the ditch in a box removed common maintenance concerns and allowed for access through this section on top of the pipe.

F. Little Dry Creek Bypass

The proposed plan consists of a box culvert that will route Ditch flows under Little Dry Creek. The system includes two gates that allow both normal as well as flushing operations. One gate will be located at the entrance of the box culvert and will lead down to the Ditch. During normal operations this gate will remain open. The other gate, which will be used when flushing the Ditch, will be located updtich of the box culvert and will lead to Little Dry Creek via a corrugated metal pipe. The project will also require placing one to two feet of fill on a berm that separates the two channels and constructing a 20 foot wide emergency overflow through the berm. The overflow will be constructed updtich of the diversion and will allow water to flow from the Ditch into Little Dry Creek in the event the box culvert becomes clogged. The construction project has been bid and it is anticipated that construction will be completed in the winter/spring of 2009.

IV. EXISTING CONDITIONS ASSESSMENT

As part of ERC's assessment of existing conditions, input was received from the CDWA on problems along the project reach. Each location identified by the CDWA was considered an area of concern (AOC). These AOCs were the basis for ERC's recommended improvements. Certain AOCs were identified by the CDWA as requiring further inspection. They were inspected by ERC during the site visits and a detailed description for each Inspection Area can be found below.

Areas of concern were grouped into seven categories based on the nature of the issue:

- Ditch capacity
- seepage concerns
- erosion and sedimentation concerns
- prescriptive easements
- stormwater entry points
- existing structure concerns and
- access concerns

To understand the basis for ERC's assessment, the sections below describe types of problems that were noted and why these issues are concerns to the overall integrity of the system. Specific areas along the project reach where each type of problem occurs are shown on Drawings 1 – 5 in Appendix B. A table describing the issue(s) at each AOC can be found in Appendix C.

Please note that in this report ditch right and ditch left refer to the ditch bank located on the side of a person looking downditch. For example, ditch right refers to the right bank when looking downditch.

A. CAPACITY CONCERNS

Some areas along the Ditch may not have adequate capacity to effectively pass the design flows with the required two feet of freeboard. This issue may stem from sediment building up in the channel, areas where the cross section and slope of the channel are not adequate, a culvert or crossing that is not adequately sized or low ditch banks. As part of this analysis, Flowmaster models were created by ERC to analyze the hydraulic capacity in specific areas along the Ditch where capacity concerns exist. The areas analyzed were areas identified by the CDWA. A design flow of 125-cfs and an assumed slope of 0.1% was used for culverts and crossings in the analysis. Locations of capacity concerns that were evaluated as part of this study are found in Figure 3.

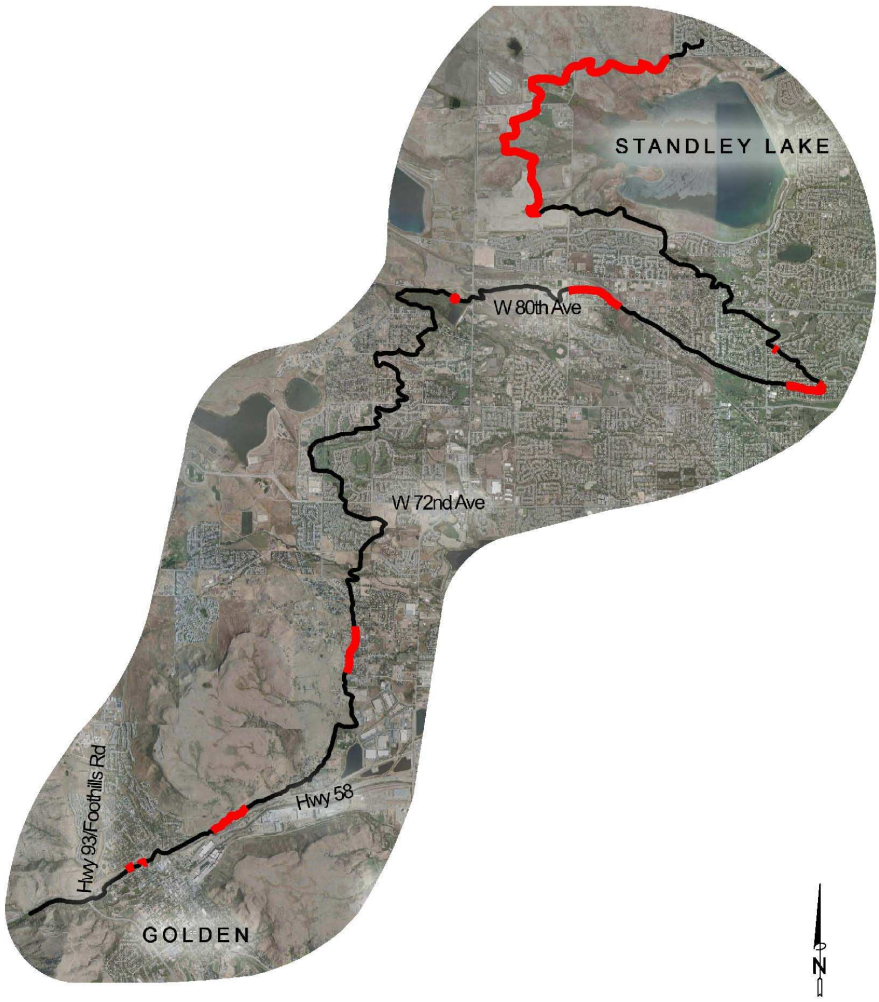

FIGURE 3 – LOCATIONS OF CAPACITY CONCERNS

PHOTO 2 – VEGETATION AND SEDIMENT IN THE CHANNEL MAY DECREASE DITCH CAPACITY

PHOTO 3 - DOUBLE CULVERTS AND INADEQUATELY SIZED STRUCTURES CAUSE A LOSS IN DITCH CAPACITY

B. SEEPAGE CONCERNS

Areas with seepage concerns have primarily been identified by property owners located down gradient from the Ditch. The amount of water seen by these owners ranges from small amounts when digging holes to more consistent flows. Seepage is a concern not only because it may cause damage to private property but also because it decreases the amount of flow in the Ditch. It may also reduce stability or potentially undermine structures within the Ditch. Locations where seepage may be a cause for concern based on observations and the history of landowner complaints can be found in Figure 4.

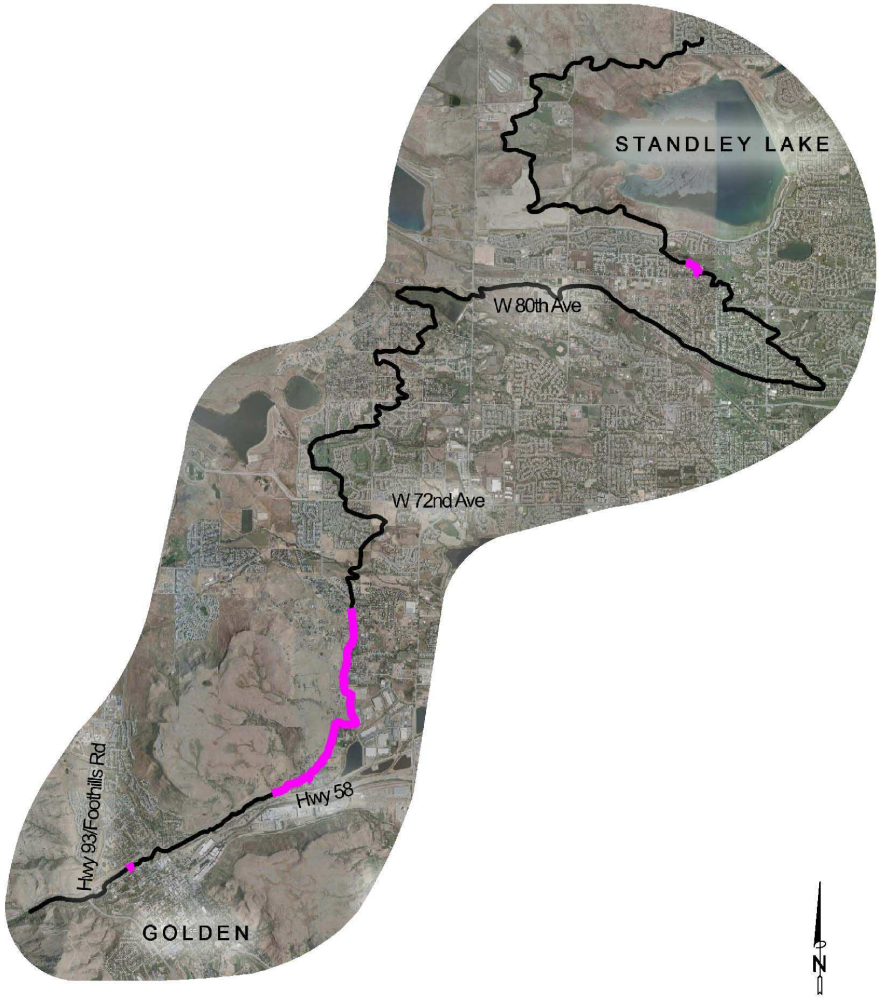

FIGURE 4 – LOCATIONS OF SEEPAGE CONCERNS

C. EROSION AND SEDIMENTATION CONCERNS

Erosion and sedimentation affect channel shape, capacity and water quality. Eroding banks can cause the ditch to widen, migrate laterally or create a new bend. An eroding channel bottom can create low points along the ditch and can alter the ditch's longitudinal slope and effect flow. The sediment from an eroding bank can settle along the bottom of the ditch and change the ditch's slope and capacity. Erosion and sedimentation can be found along many locations of the Ditch and range from minor surface erosion to undercutting. In some locations, the undercutting is stabilized by existing vegetation. Steep bank slopes are closely correlated with bank instability in severely eroded sections of the ditch.

New areas of bank instability may develop over time in sections that are not identified in this CDMP. Locations where erosion and sedimentation are occurring can be found in Figure 5.

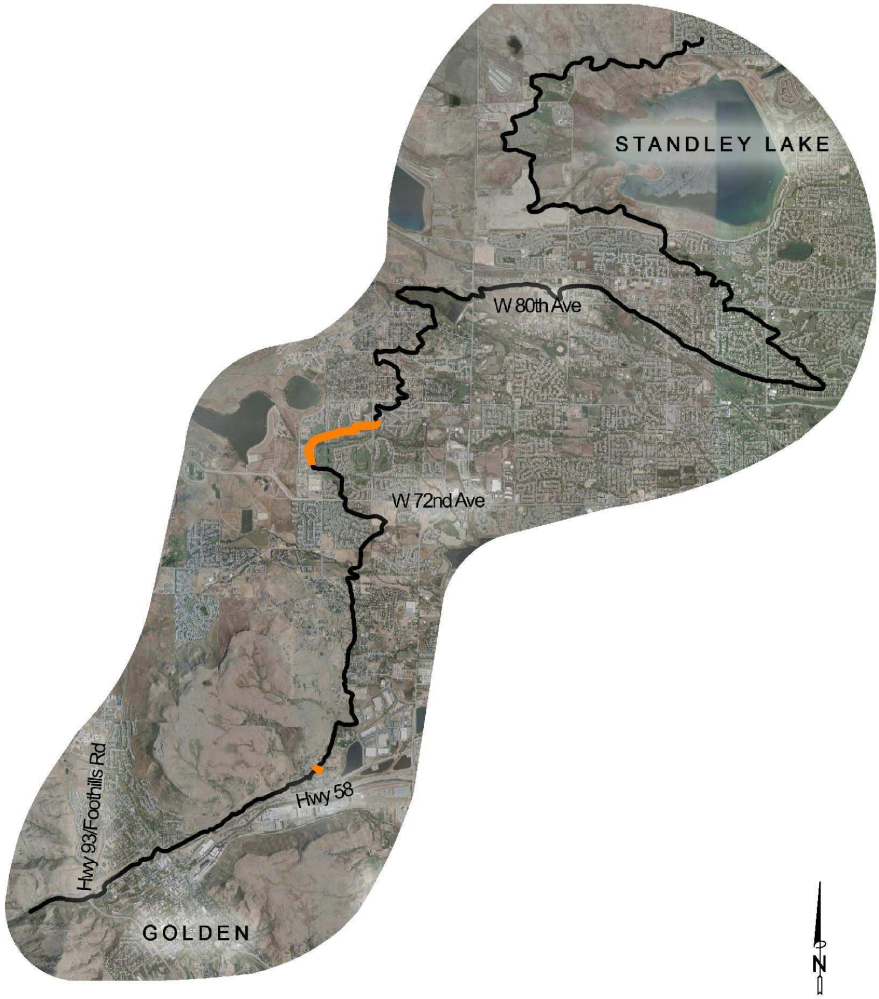

FIGURE 5 – LOCATIONS OF EROSION AND SEDIMENTATION CONCERNS

PHOTO 4 - UNDERCUTTING HAS OCCURRED ALONG THE DITCH IN AREAS THAT HAVE STEEP BANKS AND INADEQUATE ARMORING

PHOTO 5 - SEDIMENTATION ALONG THE CHANNEL BOTTOM CHANGES THE SLOPE AND CROSS SECTION OF THE CHANNEL AND DECREASES THE DITCH'S CAPACITY

D. PRESCRIPTIVE EASEMENTS

In the state of Colorado, claims for prescriptive easements require a showing of continued open, notorious and adverse use of an easement for the period of 18 years. Many of these types of easement occur along the ditch and they allow the CDWA access for ditch maintenance. Although these areas were not identified by the CDWA as AOCs, the CDWA requested that their locations be represented in the CDMP. Locations of these easements can be found in Figure 6.

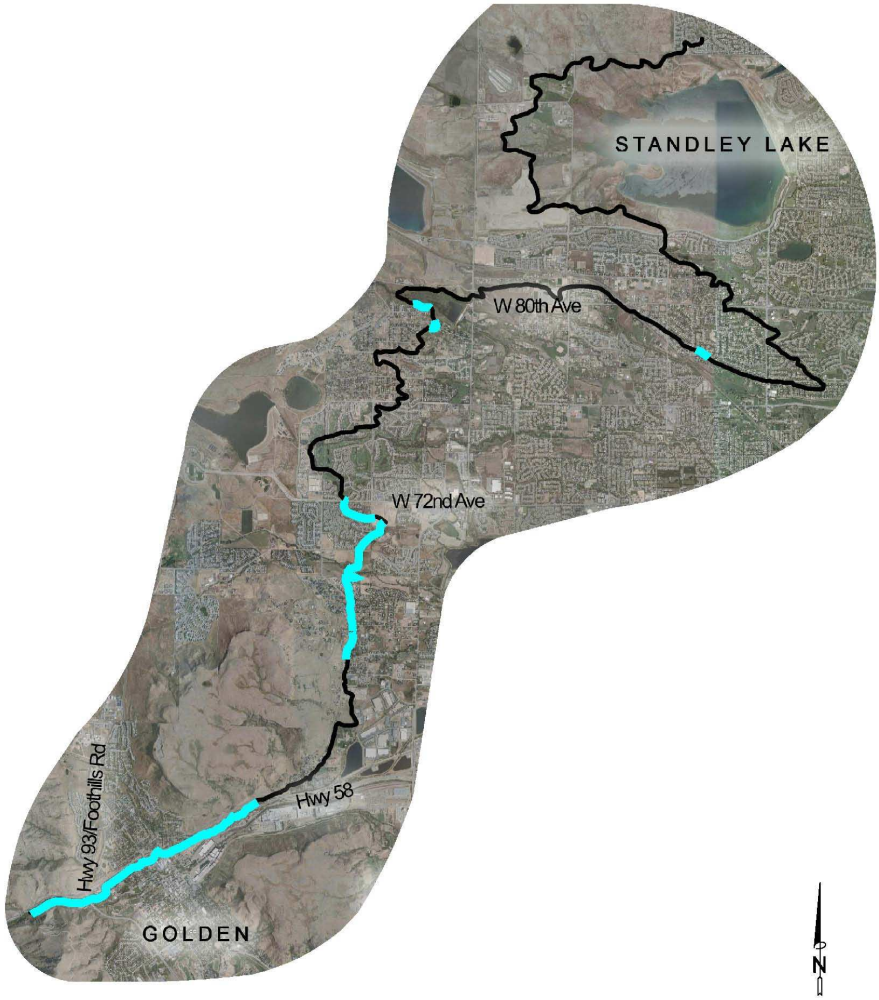

FIGURE 6 – LOCATIONS OF PRESCRIPTIVE EASEMENTS

E. STORMWATER ENTRY POINTS

Stormwater enters the Church Ditch system at many points along the ditch. Stormwater may contain debris and trash that may create blockages in the Ditch and structures and may contain contaminants that decrease the water quality of the flow in the Ditch. Additionally, stormwater inflows add to the volume of flow carried in the Ditch and increase the potential for overtopping and flooding. Debris and trash in stormwater may also damage structures along the Ditch. Locations of stormwater entry points can be found in Figure 7.

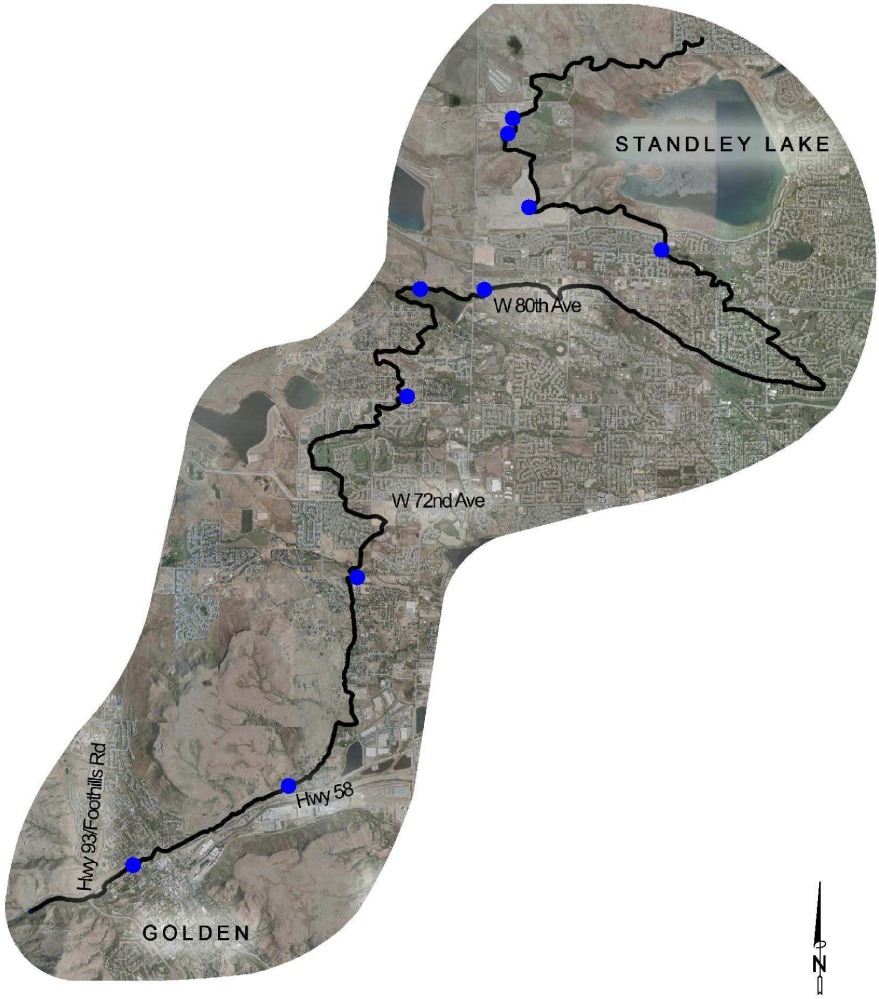

FIGURE 7 – LOCATIONS OF STORMWATER ENTRY POINTS

PHOTO 6 - STORMWATER ENTRY POINTS CAN DECREASE THE QUALITY OF THE WATER IN THE DITCH AND IMPACT DITCH CAPACITY

F. EXISTING STRUCTURE CONCERNS

Concerns with the integrity of ditch structures exist in many areas along the Ditch. These concerns include leaking structures, structures needing repair or replacement and structures that may be causing a backwater condition. Structure concerns also occur in locations where the structure may not have the capacity to pass the flow adequately. Locations of structures that have issues can be found in Figure 8.

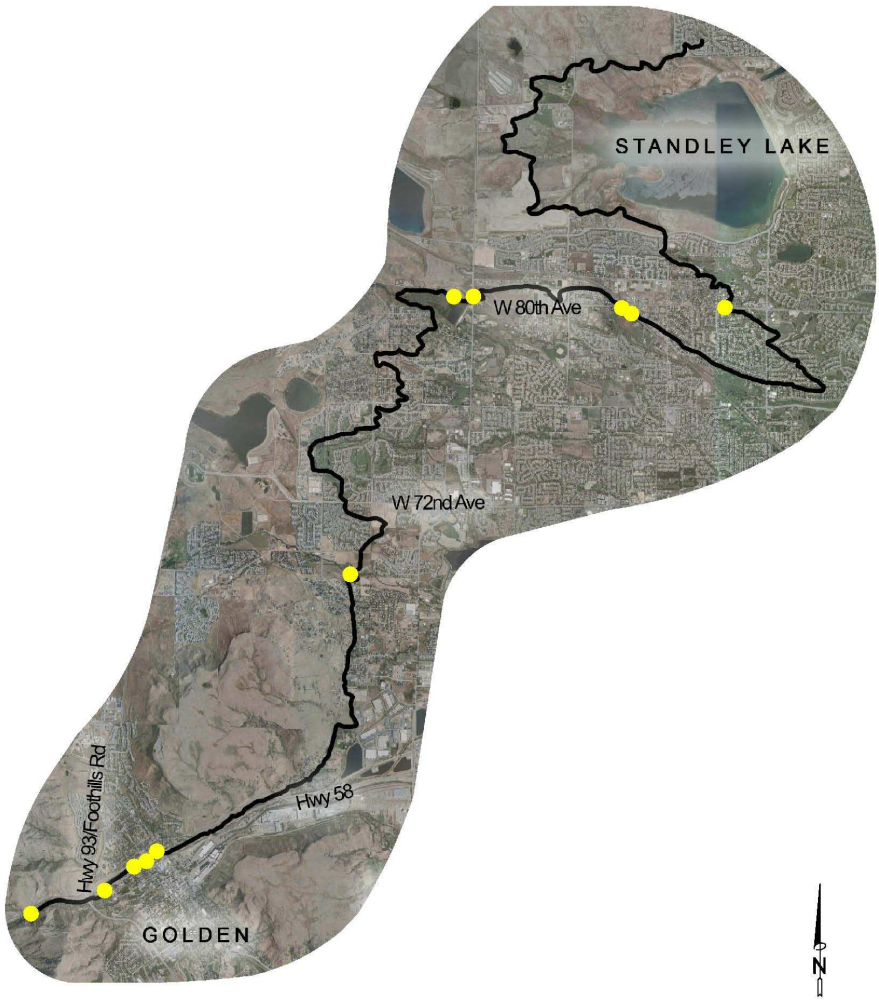

FIGURE 8 – LOCATIONS OF STRUCTURE CONCERNS

PHOTO 7 - GATES LOCATED AT THE HEAD WORKS DO NOT CLOSE PROPERLY AND LEAK AND ARE MANUALLY OPERATED

PHOTO 8 - LEAKING AT THE STRUCTURE CROSSING VAN BIBBER CREEK HAS CAUSED COMPLAINTS FROM ADJACENT PROPERTIES

PHOTO 9 – MANY STRUCTURES ALONG THE DITCH DO NOT ALLOW FOR THE PASSAGE OF DEBRIS AND CAUSE BLOCKAGES

G. ACCESS CONCERNS

Adequate access to the Ditch is required for operations and maintenance and to protect the integrity of the Ditch. Along the project reach there are locations where access is currently not available. Access issues typically involve encroachment of private properties and structures precluding access roads or uncooperative land owners. Locations with access concerns can be found in Figure 9.

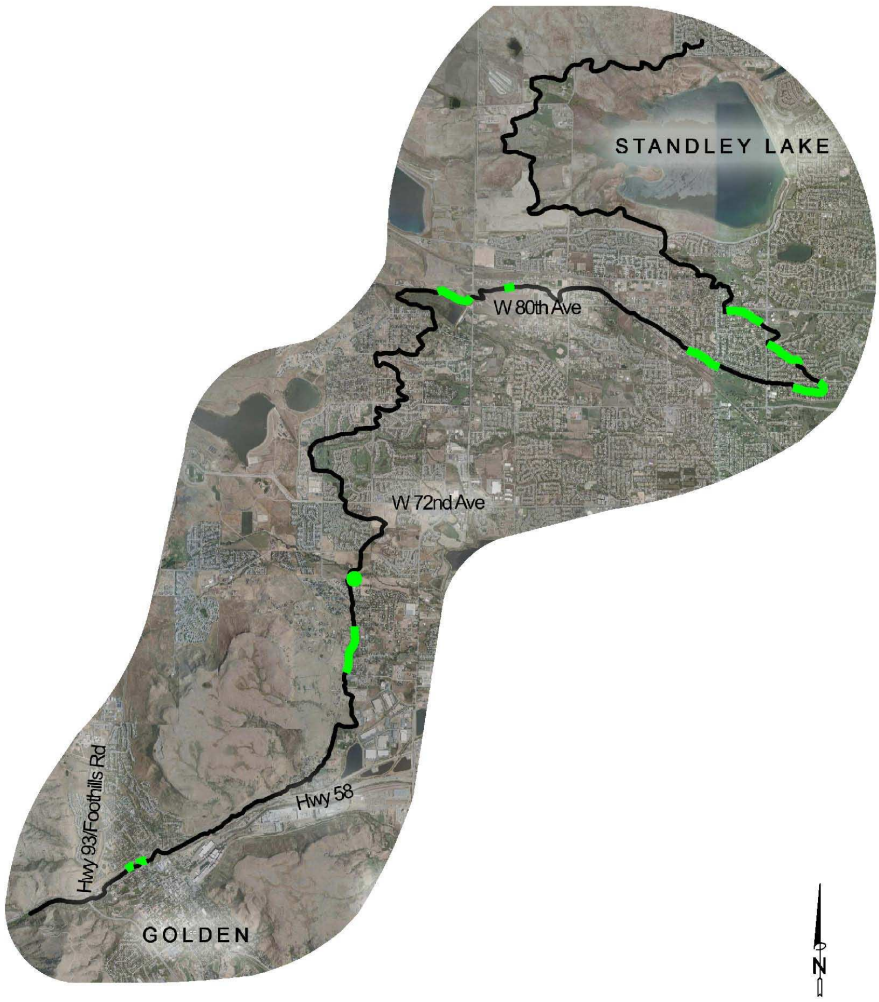

FIGURE 9 – AREAS WITH ACCESS CONCERNS

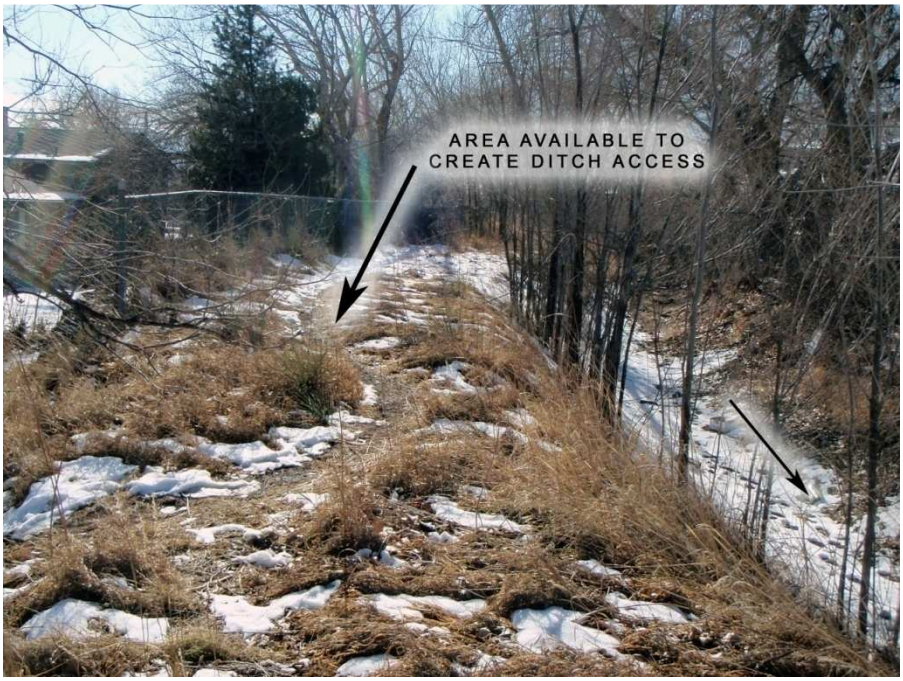

PHOTO 10 - IN SOME AREAS, CONSTRUCTING A ROAD ADJACENT TO THE DITCH IS NOT POSSIBLE DUE TO THE PROXIMITY OF PRIVATE PROPERTY AND/OR EXISTING STRUCTURES

H. INSPECTION AREAS

Thirteen AOCs have been identified by the CDWA as areas requiring inspection. These areas included AOCs from each of the concern categories and were located along the entire project reach. As part of the existing conditions assessment, ERC completed a reconnaissance level inspection of these sites.

1. AREA 1: CHURCH DITCH HEADWORKS

The Church Ditch begins at its headworks in Golden, CO. Flow is diverted from Clear Creek and enters the headworks. The headworks consist of gates that allow flow to enter the Ditch, two gates that return flow to Clear Creek and one gate designated for municipal use. The headworks is accessed from a gravel road off of US 6 that is located approximately 0.5 miles west of the intersection of US 6 and US 93 in Golden, CO.

- Church Ditch Gates

The gates that allow flow to enter the Ditch do not seal properly. This has led to the use of pea gravel to ensure a tight seal. Currently, these gates are operated manually which requires an employee of the CDWA to be present to open and close the gates when the ditch is brought online or taken offline or when otherwise indicated. There are three (3) 4.8'x4.5' gates, one (1) 1.5'x4.5' gate, one (1) 0.79'x4.5' gate, one (1) 0.63'x4.5' gate, one (1) 0.4'x4.5' gate and one (1) 0.2'x4.5' gate.

- Clear Creek Gate

The main gate to Clear Creak does not function properly and has required the placement of a wench onto the top of the gate by CDWA to ensure that the gate opens and closes. This gate is used very infrequently. This gate is 11.5'x 4.5'.

One additional gate that returns flow to Clear Creek is also located in this area. It is located updtich of the headworks and appears to be in good condition. The size of this gate could not be determined during the inspection due to inaccessibility.

- Gates for Municipal Use

One additional gate, located updtich of the Church Ditch gate, is designated for municipal use. This gate appears to be in good condition. The size of this gate could not be determined during the inspection due to inaccessibility.

- Ditch conditions

There is some erosion along the channel between the headworks and the measuring flume. The City of Golden has complained of silt within the ditch during the winter months.

- Measuring Flume

The measuring flume is in good working condition. There are no concerns regarding the flume.

PHOTO 11 - DOWNDITCH SIDE OF THE CHURCH DITCH HEADWORKS

PHOTO 12 - UPDITCH SIDE OF THE CHURCH DITCH HEADWORKS

PHOTO 13 - DOWNDITCH SIDE OF THE CLEAR CREEK GATE

PHOTO 14 –EROSION AND UNDERCUTTING IS PRESENT ALONG THE BANKS OF THE CHANNEL BETWEEN THE HEADWORKS AND THE MEASURING FLUME

PHOTO 15 –MEASURING FLUME LOCATED DOWNDITCH OF THE CHURCH DITCH HEADWORKS

2. AREA 4: DOUBLE 48" CMP CULVERT UNDER 8TH STREET

This area consists of a double 48" CMP culvert under 8th Street in Golden, CO. The double culvert designs may cause capacity and blockage issues. There is some erosion along the banks of the ditch on both the updtich and downditch sides. Although the erosion is not severe now, it may need to be addressed in the future.

PHOTO 16 - UPDITCH END OF THE DOUBLE 48" CMP CULVERT UNDER 8TH STREET

PHOTO 17 - DOWNDITCH END OF THE DOUBLE 48" CMP CULVERT UNDER 8TH STREET

3. AREA 5: CHURCH DITCH BETWEEN ILLINOIS STREET AND CHEYENNE STREET

This area lies downditch of an already lined length of ditch. The CDWA has received complaints of seepage from local residents and ditch capacity concerns have been raised by the CDWA. Heavy vegetation is present along both banks of the ditch and debris is present within the ditch. The heavily vegetated banks combined with the ditch's close proximity to the adjacent roadway makes maintenance access very difficult. The extent of the seepage for this area has not been measured. No complaints of seepage along the lined length of the Ditch have been received by the CDWA from local residents.

PHOTO 18 - EXISTING DITCH LINING AND TRANSITION LOCATED UPDITCH OF THIS AREA

PHOTO 19 - CHURCH DITCH DOWNDITCH OF EXISTING DITCH LINING - LOOKING DOWNDITCH

PHOTO 20 - CHURCH DITCH BETWEEN ILLINOIS STREET AND CHEYENNE STREET - LOOKING UPDITCH

PHOTO 21 - LIMITED AREA EXISTS TO CREATE DITCH ACCESS AT THIS LOCATION

4. AREA 7: DOUBLE 48" CMP CULVERT UNDER CHEYENNE STREET

This area consists of a double 48" CMP culvert under Cheyenne Street. The double culvert designs may cause capacity and blockage issues. There is some erosion along the banks of the ditch on both the updtich and downditch sides. Although the erosion is not severe now it may need to be addressed in the future.

PHOTO 22 - UPDITCH END OF DOUBLE 48" CMP CULVERT UNDER CHEYENNE STREET

PHOTO 23 - DOWNDITCH END OF DOUBLE 48" CMP CULVERT UNDER CHEYENNE STREET

5. AREA 8: CHURCH DITCH BETWEEN ARAPAHOE STREET AND WASHINGTON AVENUE

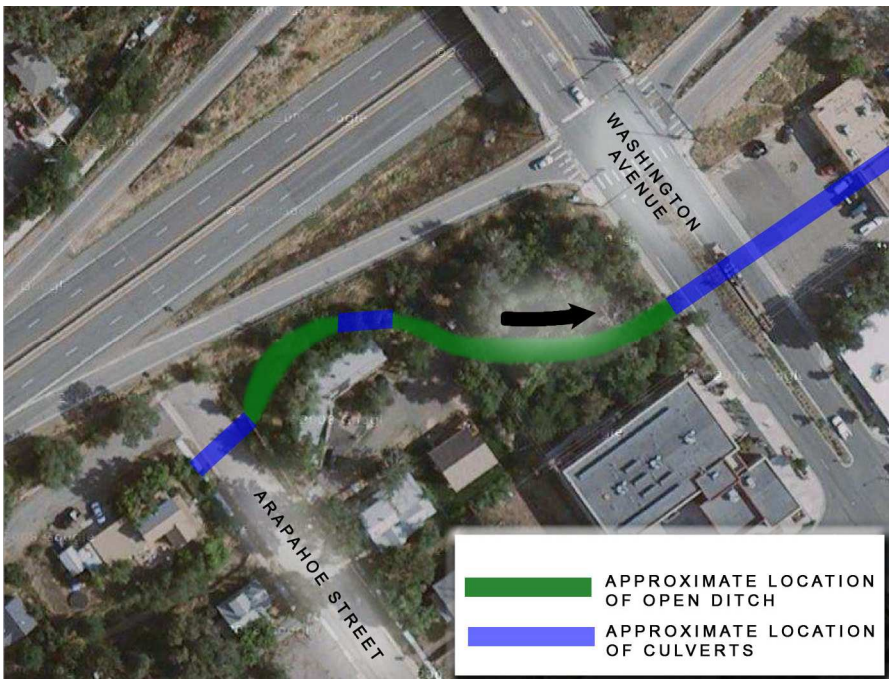

PHOTO 24 - SCHEMATIC OF AREA 8

Ditch capacity issues have been raised by the CDWA for this length of ditch. The area begins with a double 48" CMP culvert under Arapahoe Street. From here it enters an open ditch that is very close to

an existing dwelling on ditch right. It then enters a concrete box culvert (11'-8"x5' at its updtich end and 8' x 4'-7" at its downditch end). It then enters another open ditch section that is partially lined with stone before entering a 14'-5"x5' open span under Washington Avenue. The heavily vegetated banks combined with the ditch's close proximity to the adjacent roadway makes maintenance access very difficult. The extent of the seepage for this area has not been measured.

PHOTO 25 - UPDITCH END OF DOUBLE 48" CMP CULVERT UNDER ARAPAHOE STREET

PHOTO 26 – DOWNDITCH END OF DOUBLE 48" CMP CULVERT UNDER ARAPAHOE STREET

PHOTO 27 – UPDITCH END CONCRETE BOX CULVERT BETWEEN ARAPAHOE STREET AND WASHINGTON AVENUE

PHOTO 28 – DOWNDITCH END CONCRETE BOX CULVERT BETWEEN ARAPAHOE STREET AND WASHINGTON AVENUE

PHOTO 29 – THE DITCH BETWEEN THE CONCRETE BOX CULVERT AND THE STRUCTURE UNDER WASHINGTON AVENUE

PHOTO 30 – UPDITCH END OF THE STRUCTURE UNDER WASHINGTON AVENUE

6. AREA 15: CHURCH DITCH BETWEEN W. 50TH AVENUE AND W. 54TH AVENUE

This area begins at W. 50th Avenue and proceeds north to W. 54th Avenue. The bank is actively eroding and bank undercutting is present along most of the ditch. Sedimentation from this erosion is present. Debris is collecting along the bottom of the ditch and may lessen capacity. The ditch's close proximity to private property makes maintenance access impossible. Historically, maintenance has required employees to walk the ditch and manually removing debris.

PHOTO 31 - SEDIMENT BUILD UP IN THE BOTTOM OF THE DITCH IS A RESULT OF EROSION ALONG DITCH BANKS

PHOTO 32 – EROSION AND CROSSINGS ALONG THE CHURCH DITCH

PHOTO 33 – ACCESS TO THE DITCH IS NOT POSSIBLE DUE TO ITS PROXIMITY TO PRIVATE PROPERTY

7. AREA 19: STRUCTURE OVER VAN BIBBER CREEK

This area consists of a double concrete box culvert structure that allows the Church Ditch to cross over Van Bibber Creek. There have been complaints, from local residents, regarding leaking at this structure. Visual indications of leaking at the joints are present.

PHOTO 34 – CONCRETE STRUCTURE OVER VAN BIBBER CREEK

PHOTO 35 – TYPICAL SIGNS OF LEAKING AT JOINTS

8. AREA 20: PROPOSED ROADWAY OVER VAN BIBBER CREEK

A road crossing over Van Bibber Creek that will connect two roadways that terminate at the creek is desired by the CDWA in this area. The roadway would be constructed adjacent to the emergency overflow structure located in this area. This area is located on private property indicating that approval from the property owner will be required prior to roadway construction.

PHOTO 36 – THE POPOSED LOCATION OF A ROADWAY CROSSING VAN BIBBER CREEK AND CONNECTING TWO EXISTING ROADWAYS

9. ARE A 22: CHURCH DITCH WITHIN WEST WOODS GOLF COURSE

This area consists of a length of open ditch that runs through the West Woods Golf Club. It includes pedestrian bridge crossings, road crossings and the Ralston Creek crossing. Active erosion is occurring on many of the ditch banks and has led to bank undercutting and sedimentation along the ditch bottom. Concern was raised during the inspection that the embankment along the Church Ditch's ditch left as it crosses over Ralston Creek may not be adequate and may fail during a large storm event.

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PHOTO 37 - EROSION TYPICAL OF THIS LENGTH OF THE DITCH

PHOTO 38 – DOWNDITCH VIEW OF THE RALSTON CREEK CROSSING

10. AREA 28: EXISTING BRIDGE ON TOM CAMPBELL PROPERTY

A 10'x4.5' bridge crossing was constructed without CDWA's consent or the determination of its impact on the Church Ditch. This area is located on private property owned by Tom Campbell.

PHOTO 39 – BRIDGE CONSTRUCTED OVER CHURCH DITCH ON THE TOM CAMPBELL PROPERTY

11. AREA 34: EXISTING RAIL ROAD CROSSING

A railroad track owned by the Burlington Northern Santa Fe Railway crosses the Church Ditch in this area. The Ditch flows south east and then turns northeast to flow under the crossing. It then turns southeast as it leaves the crossing and continues southeast. Debris has been deposited by residents on both banks updtich of the crossing. Heavily vegetated banks and sedimentation is apparent on both the updtich and the downditch ends of the crossing. There are concerns that the crossing may cause capacity issues. A more in depth analysis, including a HEC-RAS model, may be needed to determine the full impact of the alignment on ditch capacity.

PHOTO 40 – DEBRIS HAS BEEN DISCARDED BY RESIDENTS ONTO THE DITCH BANKS UPDITCH OF THE RAILROAD CROSSING

PHOTO 41 – UPDITCH END OF RAILROAD CROSSING

PHOTO 42 – DOWNDITCH END OF RAILROAD CROSSING

PHOTO 43 – VIEWING THE DITCH FROM THE DOWNDITCH END OF THE RAILROAD CROSSING THE EXCESS VEGETATION LOCATED IN THE FLOW AREA IS APPARENT

12. AREA 37: DOUBLE 55" CONCRETE BOX CULVERT UNDER W. 74TH AVENUE

This area consists of a double 55" concrete box culvert that crosses under W. 74th Avenue. A wall is located between the two pipe openings on the updtich side and splits the flow between them. The ditch flows east until taking an approximately 90° turn to flow south through the culvert. Upon leaving the culvert, the ditch takes another approximately 90° turn and again flows east. Some active erosion is occurring updtich and downs ditch of the culvert and has caused bank undercutting. In the past, blockages have occurred at the updtich end of the culvert primarily when the Ditch is brought online on if someone was not there before the flow reached it to remove debris. The blockage has been large enough to stop flow in the ditch completely. A more in depth analysis, including a HEC-RAS model, may be needed to determine the full impact of the culvert alignment.

PHOTO 44 – UPDITCH END OF 55" DOUBLE CULVERT UNDER W. 74TH AVENUE

PHOTO 45 – DOWNDITCH END OF 55" DOUBLE CULVERT UNDER W. 74TH AVENUE

PHOTO 46 – A SHARP BEND, LIKE THIS ONE SEEN LEAVING THE DOWNDITCH END OF THE CULVERT, CAN ALSO BE FOUND ON THE UPDITCH END OF THE CULVERT

13. AREA 42: DOUBLE 44" CMP CULVERT UNDER W. 80TH AVENUE AT NEWMAN STREET

This area consists of a double 48" CMP culvert under W. 80th Avenue. The double culvert design may cause capacity and blockage issues. There is some erosion along the banks of the ditch on both the updtich and downditch sides. Although the erosion is not severe now it may need to be addressed in the future.

PHOTO 47 – UPDITCH END OF 44" DOUBLE CULVERT UNDER W. 80TH AVENUE AT NEWMAN STREET

PHOTO 48 – DOWNDITCH END OF 44" DOUBLE CULVERT UNDER W. 80TH AVENUE AT NEWMAN STREET

V. RECOMMENDED IMPROVEMENTS

A. INTRODUCTION

The CDWA's stated objectives for this project were to define master plan improvements:

- Identify areas of concern likely requiring repairs, maintenance or modification
- Develop costs associated with recommended improvements where applicable

After ERC completed its evaluation of the Ditch system through site assessment and review of background data, recommended improvements were defined. Improvements presented herein are intended to address problems identified in a consistent manner establishing a roadmap for future implementation. Improvements presented include all AOCs identified as part of this evaluation. It is recommended that AOCs not identified as Inspection Areas by the CDWA and that require further inspection or analysis should receive a more detailed evaluation to determine which specific improvements, if any, are required. An example of this, are AOCs that are stormwater entry points. It is envisioned that recommended improvements would be phased in and it is likely that some improvements may never be implemented. It is also likely that as areas which are not included as specific areas for this report will become important issues in the future and need to be addressed and incorporated into this CDMP.

Recommended improvements presented in this CDMP are described at a conceptual level of detail and are intended to provide the CDWA with a budgetary planning cost for implementing improvements. Prior to implementation, a more detailed site-specific investigation and design will need to be completed to verify the appropriateness and suitability of the respective technique for a given area as well as provide refinement in the recommended improvements made in this report.

The sections below describe the typical improvement techniques that were considered as part of the CDMP improvements. Possible treatments are broken out below to correspond to the categories of concerns observed and discussed above. For each treatment method, means of implementing the treatment along with pros and cons are discussed. Where appropriate, a graphical example of the typical treatment is presented. Locations within the project reach where specific improvements are recommended are shown on Drawings 1 – 5 in Appendix B. A table describing the recommended improvement for each AOC can be found in Appendix C.

B. CAPACITY CONCERNS

Many factors can cause a loss of capacity within the Ditch. Capacity may be lost through the change in longitudinal slope from sedimentation, an inadequately sized structure, and an inadequate ditch cross section or alignment. Recommended improvements for capacity losses due to sedimentation and an inadequately sized structure can be found below. Recommended improvements for capacity concerns due to ditch cross section and alignment will be discussed here.

- Improvement technique
    a) Pipe length of Ditch
        - Description
            - Length of ditch is replaced with an adequately sized pipe
        - Where Appropriate
            - In areas where the straightening of the ditch is desired
        - Implementation
            - Grade ditch to ensure positive flow
            - Place pipe and required headwall and endwall
        - Advantages
            - Prevents seepage
            - Prevents bank erosion
            - Improves water quality by decreasing turbidity that may occur through bank erosion
            - Improves water quality by eliminating potential contamination inflow points
            - Improves ditch capacity by not allowing sediment to enter the ditch through bank erosion
            - Allows for the construction of a roadway on top of the piped ditch length to allow for ditch access

- Disadvantages
  - Maintenance may be required
  - Expensive to construct

b) Grade ditch
- Description
  - Ditch is regraded to ensure capacity
- Where Appropriate
  - In areas where the lack of capacity is a concern
  - In areas where the lack of capacity is a concern and piping is not feasible or desired
- Implementation
  - Grade ditch to ensure positive flow
- Advantages
  - Improves flow in ditch by ensuring a positive slope
- Disadvantages
  - Maintenance may be required as the ditch may again change shape after grading
  - Solution may be temporary
  - The natural seal that forms along the bottom of the ditch may degrade as a result of excessive or repeated grading

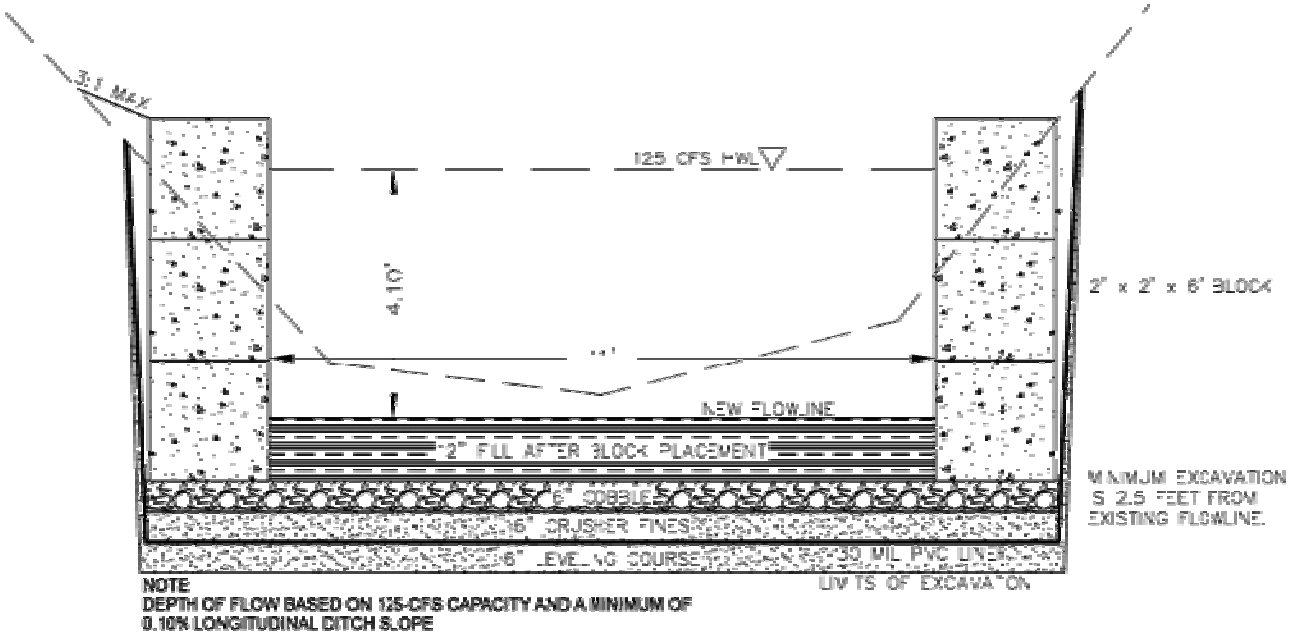
c) Straighten ditch alignment
- Description
  - Ditch is regraded to ensure no bends exist within the ditch length
- Where Appropriate
  - In areas where the straightening of the ditch is desired
  - In areas where the easement issues are amenable to this activity
- Implementation
  - Grade ditch to ensure positive flow and to ensure that no bends exist in the ditch
- Advantages
  - Improves ditch capacity by creating a straight ditch alignment
- Disadvantages
  - Maintenance may be required to ensure alignment remains straight
  - May be expensive to maintain since the ditch may naturally want to bend
  - Straight channels have higher velocity therefore erosion potential is expected to increase

C. SEEPAGE CONCERNS

Before ditch lengths are lined the intensity of seepage should be investigated to determine if lining is required. Areas where seepage is occurring can be identified visually by the presence of down gradient flooding or by quantifying the amount of seepage that may occur with a seepage meter or a pondage test. A pondage test requires a section of the channel to be blocked off with barriers to form a pond. The water level within the constructed pond is made up to or higher than it is when the channel is operating. The rate of the drop of the water level is measured by a gauge. The seepage rate is calculated making any necessary corrections for rainfall and evaporation. Or, water can be added over time to maintain the initial water level. The rate of the addition of water is equal to the seepage rate.

Due to space constraints along the Ditch, lining the Ditch without blocks may not be possible. In areas where a 3:1 minimum side slope is possible lining the ditch without blocks may be considered.

- Improvement technique
    a) Line length of Ditch



* TYPICAL LINING CROSS SECTION TAKEN FROM THE RECENT IMPROVEMENT THAT LINED THE DITCH FROM 6TH STREET TO ILLINOIS STREET.

FIGURE 10 – IMPROVEMENT EXAMPLE, TYPICAL DITCH LINING CROSS SECTION

- Description
    - Ditch is lined to prevent seepage
- Where Appropriate
    - In areas where seepage occurs
    - In areas where room for 3:1 side slopes does not exist
- Implementation

- Grade ditch banks to allow for the placement of the typical ditch lining cross section
- Construct ditch lining along entire ditch length
- Construct transitions between lined and unlined sections of ditch where necessary

▪ Advantages
- Prevents seepage
- Prevents bank erosion
- Improves water quality by decreasing turbidity that may occur through bank erosion
- Improves ditch capacity by not allowing sediment to enter the ditch through bank erosion
- Many alternatives of ditch lining are available therefore this option is typically available and can be customized to the specific problem
- Reduces the risk of litigation and subsequent costs due to damage caused by seepage

▪ Disadvantages
- Maintenance may be required
- May be expensive to construct

D. EROSION AND SEDIMENTATION CONCERNS

Bank stabilization is recommended in locations throughout the project reach where instabilities were noted.

- Improvement techniques
  a) Stabilize Ditch bank with armoring

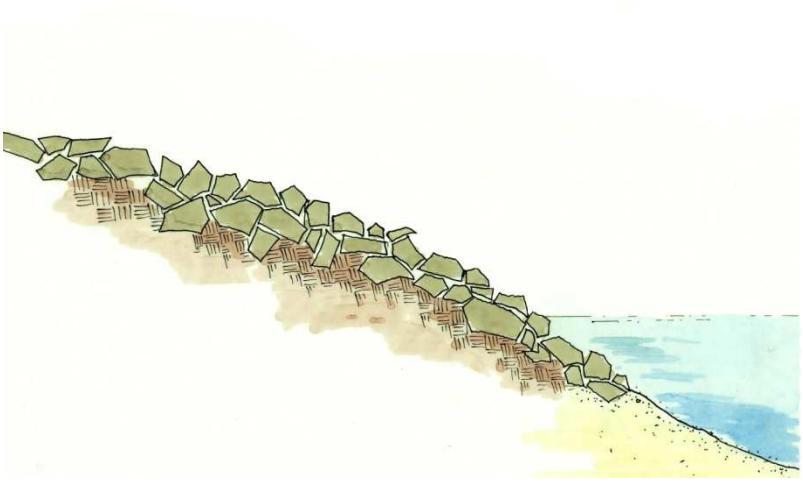


FIGURE 11 – IMPROVEMENT EXAMPLE, RIP RAP IS PLACED ONTO DITCH

▪ Description
- Bank is stabilized by the addition of riprap or other armoring

- Where Appropriate
  - In areas where adequate structural bank armoring does not exist
- Implementation
  - Grade ditch banks where appropriate and possible
  - Place riprap or other armoring onto ditch banks
- Advantages
  - Increases structural bank stabilization
  - Improves water quality by decreasing turbidity
  - Improves ditch capacity by not allowing sediment to enter the ditch through bank erosion
- Disadvantages
  - Maintenance may be required

b) Regrade Ditch bottom and remove excess sediment

- Description
  - The ditch bottom is regraded to allow for positive flow and any excess sediment is removed
- Where Appropriate
  - In areas where ditch slope has reversed or flow has become impeded as a consequence of sedimentation
- Implementation
  - Ditch bottom is regraded to provide for positive flow
  - Excess sediment is removed from ditch bottom
  - Sediment is either hauled away or used to build updtich banks
- Advantages
  - Ensures positive flow through ditch
  - Ensures that flows moves easily through ditch
  - Improves water quality by decreasing turbidity from loose sediment on ditch bottom
- Disadvantages
  - Adequate access to ditch may not be possible
  - Disposing of sediment may be costly or not easily completed
  - The natural seal that forms along the bottom of the ditch may degrade as a result of excessive or repeated grading

b) Stabilize Ditch bank with a geo-synthetic

- Description
  - Bank is stabilized by the addition of a geo-synthetic
- Where Appropriate
  - In areas where adequate structural bank armoring does not exist
- Implementation
  - Grade ditch banks where appropriate and possible

- Place a geo-synthetic onto ditch banks
- Advantages
  - Increases structural bank stabilization
  - Improves water quality by decreasing turbidity
  - Improves ditch capacity by not allowing sediment to enter the ditch through bank erosion
- Disadvantages
  - Requires vegetative growth within the channel for stabilization which may decrease ditch capacity
  - Anchoring vegetation will require maintenance to ensure the capacity of the ditch does not decrease
  - Not suitable in ditches with steep sides
  - May require maintenance during ditch operation and after large flows

E. PRESCRIPTIVE EASEMENTS

No improvements for prescriptive easements are recommended.

F. STORMWATER ENTRY POINTS

It is recommended that a more in depth analysis should be completed for areas with stormwater entry points. This analysis should include the identification of the responsible storm system and its caretaker and the preparation of construction documents required to divert the stormwater to ensure that it no longer enters the ditch. The solution for stormwater entry points would likely either include removing the updtich water source through retention/detention facilities or conveying the stormwater under or over the Ditch.

G. EXISTING STRUCTURE CONCERNS

Recommended improvements for areas with existing structure concerns include the replacement of the structure, needed structural repairs and the addition of a trash rack(s) where needed.

- Improvement technique
  a) Replace double culvert with a concrete box culvert or span structure
    - Description
      - Existing double culvert is replaced with an adequately sized concrete box culvert or span structure
    - Where Appropriate
      - In areas where a double culvert is causing blockages or a decrease in capacity
    - Implementation
      - Remove existing double culvert
      - Install adequately sized concrete box culvert or span structure
    - Advantages
      - Ensures adequate capacity

- Lessens possibility of blockages due to debris in the ditch
- Should lessen on-going maintenance

- Disadvantages
  - May be expensive to construct
  - May require the installation of a trash rack to ensure blockages do not occur within the structure due to debris in the ditch

b) Repair concrete structure to prevent leakage
   - Description
     - Repairs necessary to prevent leakage are completed
   - Where Appropriate
     - In structures where leaking is an issue
   - Implementation
     - Repair areas where leaking occurs
   - Advantages
     - Keeps more water in the ditch
     - Minimizes potential seepage damage
   - Disadvantages
     - Maintenance may be required
     - May be expensive to complete
     - May not permanently solve leaking issues

c) Install trash rack(s)
   - Description
     - A trash rack(s) is installed along the updtich side of a structure or within the ditch
   - Where Appropriate
     - In areas where blockages due to debris is a concern
   - Implementation
     - Install trash rack(s)
   - Advantages
     - Prevents blockages of flow in structures and the ditch
     - When properly maintained, will lessen amount of debris within the ditch
   - Disadvantages
     - Requires frequent maintenance of the trash rack

d) Remove and replace structure
   - Description
     - Existing structure is removed and replaced
   - Where Appropriate
     - In areas where the structure has become ineffective and cannot be improved through repair

- Areas where the existing structure requires more than minor modifications to function properly

- Implementation
  - Existing structure is removed
  - A new replacement structure is constructed in its general location
- Advantages
  - Ineffective or damaged structures are removed
  - Higher quality feature can be implemented
- Disadvantages
  - May be costly

e) Install new structure

- Description
  - A structure such as a flush structure is installed where currently one does not currently exist
- Where Appropriate
  - In areas where a structure such as a flush structure is desired
- Implementation
  - Desired structure is designed and installed
- Advantages
  - It will enhance the usability and efficiency of the ditch
- Disadvantages
  - May be costly

H. ACCESS CONCERNS

In many instances where ditch access is a concern the ditch either lies on private property or its proximity to private property prohibits the construction of adequate ditch access. Areas with access concerns that were not included in the Inspection Areas should be further evaluated for the possibility of access construction.

In areas where an access easement or property procurement is possible it is recommended that a 15' wide roadway be constructed adjacent to the ditch, preferably on the downditch side. In areas where this is not possible and access is deemed necessary, it may be beneficial to pipe the ditch and construct an access roadway on top of the piped sections with manholes placed at reasonable distances to provide ditch access. An example of this was completed in the Narrows pipeline project.

- Improvement technique

a) Construct 15' wide roadway adjacent to the ditch

- Description
  - A 15' wide roadway is constructed adjacent to the ditch providing access along the ditch length
- Where Appropriate
  - In areas where adequate room to construct a 15' wide roadway exists

- Implementation
  - Grade area adjacent to ditch to allow for roadway construction
  - Construct roadway
- Advantages
  - Provides access to ditch for maintenance
- Disadvantages
  - May require an access easement or procurement of property which may be costly or impossible

b) Construct 15' wide roadway on top of a piped section of ditch

- Description
  - A 15' wide roadway is constructed on top of a piped section of ditch providing access along the ditch length
- Where Appropriate
  - In areas where access is currently not possible and judged to be required for continued operations of the system.
- Implementation
  - Determine appropriate size pipe for the ditch and install piped section with updtich trashrack
  - Construct roadway on top of piped section of the ditch
  - Place pipe backfill to allow for continued vehicular traffic
- Advantages
  - Connects updtich and downditch access points for maintenance of the ditch
- Disadvantages
  - Cost of piping the ditch

I. RECOMMENDED IMPROVEMENTS FOR INSPECTION AREAS

The CDWA requested improvement recommendations for specific areas within the project area that required further inspection. These recommended improvements are discussed below.

1. AREA 1: CHURCH DITCH HEADWORKS

The recommended improvements for this area are to replace the existing structure with a new system that is fully automated. This would include replacing the existing gates for the Church Ditch and the Clear Creek river return system with new overshot gates. Since the municipal gates are not part of the CDWA system their replacement is not an improvement recommended in this report.

Fully automating the headworks is also recommended to allow the gates to be controlled from CDWA's main office. This will eliminate the need for the manual opening and closing of the gates when the Ditch is brought online and taken offline. It would also allow for any emergency shutoff that may be desired.

The cost and feasibility of automating the entire Ditch canal with a SCADA system is currently being determined.

Area	Recommended Improvement
1	Replace existing headgate structure and river return flow system with overshot gate and automated system

TABLE 1 - INSPECTION AREA 1: RECOMMENDED IMPROVEMENTS

2. AREA 4: DOUBLE 48" CMP CULVERT UNDER 8TH STREET

The replacement of the existing double culvert with a 9'x4' concrete box culvert is recommended for this area. This will lessen the possibilities of blockages occurring at this location and will provide adequate capacity.

Area	Recommended Improvement
4	Replace with a 9'x4 ' concrete box culvert

TABLE 2 - INSPECTION AREA 4: RECOMMENDED IMPROVEMENTS

3. AREA 5: CHURCH DITCH BETWEEN ILLINOIS STREET AND CHEYENNE STREET

Due to the Ditch's close proximity to private property in this area and the concern that the ditch is not easily accessible for maintenance two improvements are recommended, each dependent upon the method of ditch access.

The first recommended improvement includes the lining of the ditch and determining the potential of an access roadway located adjacent to the ditch.

The second recommended improvement includes the piping of the ditch and the construction of an access roadway along the piped ditch. Although considerably more costly than the first recommended improvement, this improvement will eliminate most ditch concerns by providing a constant and adequate closed ditch cross section. It will also provide ditch access in an area where it may not be possible due to space constraints. This improvement will also lessen the amount of maintenance required since it will eliminate bank erosion in this area.

Area	Recommended Improvement
5a	Line ditch with stacked blocks and determine the potential for access and determine the potential for the construction of an access roadway.
5b	Pipe ditch and create access on top of piped length

TABLE 3 - INSPECTION AREA 5: RECOMMENDED IMPROVEMENTS

4. AREA 7: DOUBLE 48" CMP CULVERT UNDER CHEYENNE STREET

The replacement of the existing double culvert with a 9'x4' concrete box culvert is recommended for this area. This will lessen the possibilities of blockages occurring at this location and will provide adequate capacity.

Area	Recommended Improvement
7	Replace with a 9'x4 ' concrete box culvert

TABLE 4 - INSPECTION AREA 7: RECOMMENDED IMPROVEMENTS

5. AREA 8: CHURCH DITCH BETWEEN ARAPAHOE STREET AND WASHINGTON AVENUE

The piping of the ditch in this area is recommended to eliminate the capacity concerns along this ditch length. The replacement of the existing double culvert under Arapahoe Street with a 9'x4' concrete box culvert and a trash rack on the updtich side is also recommended for this area. This will lessen the possibilities of blockages occurring at this location and will provide adequate capacity.

Area	Recommended Improvement
8	Replace with a 9'x4 ' concrete box culvert and a trash rack on the updtich end
8	Pipe ditch from Arapahoe to Washington

TABLE 5 - INSPECTION AREA 8: RECOMMENDED IMPROVEMENTS

6. AREA 15: CHURCH DITCH BETWEEN W. 50TH AVENUE AND W. 54TH AVENUE

Due to the Ditch's close proximity to private property in this area and the concern that the ditch is not easily accessible for maintenance two improvements are recommended, each dependent upon the method of ditch access.

The first recommended improvement includes the grading of the ditch to remove any excess sediment and debris and the armoring of the banks to decrease the amount of sediment settling along its bottom and the amount of erosion taking place along its banks. The grading of the ditch to a standard cross section that allows for the passage of the design flow (125-cfs) plus two feet of freeboard will ensure capacity. Since many ditch crossings exist along this length of ditch, the analysis of their impacts on capacity is recommended. The potential of constructing an access roadway adjacent to the Ditch should also be determined.

The second recommended improvement includes the piping of the ditch, the construction of an access roadway along the piped ditch and the installation of a trash rack on the updtich side of the culvert under W. 50th Avenue. Although considerably more costly than the first recommended improvement, this improvement will eliminate all ditch concerns by providing a constant and adequate ditch cross section. It will also provide ditch access in an area where it may not be possible due to space constraints. This improvement will also lessen the amount of maintenance required since it will eliminate bank erosion in this area.

Area	Recommended Improvement
15a	Grade ditch to remove excess sediment and riprap ditch banks. Inspect channel for capacity issue. Determine the potential for the construction of an access roadway.
15b	Pipe ditch and construct an access roadway on top of piped length. Install a trash rack on the updtich side of the culvert under W. 50th Avenue.

TABLE 6 - INSPECTION AREA 15: RECOMMENDED IMPROVEMENTS

7. AREA 19: STRUCTURE OVER VAN BIBBER CREEK

Since the main concern in this area is that the concrete structure that allows the Ditch to cross over Van Bibber Creek leaks, it is recommended that the areas where leaking is occurring be repaired.

Area	Recommended Improvement
19	Repair leaking concrete joints

TABLE 7 - INSPECTION AREA 19: RECOMMENDED IMPROVEMENTS

8. AREA 20: PROPOSED ROADWAY OVER VAN BIBBER CREEK

The construction of a roadway that crosses over Van Bibber Creek and connects the two existing roadways that terminate in this area are recommended. A detailed analysis of the impacts of this structure on Van Bibber Creek and its floodplain will need to be completed prior to roadway construction. Also, this area lays on private property thus the attainment of the approval of the property owner and an access easement will need to occur prior to roadway construction.

Area	Recommended Improvement
20	Construct a road crossing over Van Bibber Creek to connect existing roadways

TABLE 8 - INSPECTION AREA 20: RECOMMENDED IMPROVEMENTS

9. ARE A 22: CHURCH DITCH WITHIN WEST WOODS GOLF COURSE

The recommended improvements for this area include the grading of the ditch to remove any excess sediment and debris and the armoring of the banks to decrease the amount of sediment settling along its bottom and the amount of erosion taking place along its banks. The grading of the ditch to a standard cross section that allows for the passage of the design flow (125-cfs) plus required two feet of freeboard will also ensure capacity.

The failure of the embankment along the Ralston Creek crossing during a large event was a concern that was introduced while inspecting the site. If this is a concern of the CDWA, it is recommended that a more detailed analysis be conducted to determine the possibility of embankment failure and potential mitigation measures.

Area	Recommended Improvement
22	Remove excess sediment from ditch bottom, grade channel and armor ditch banks

TABLE 9 - INSPECTION AREA 22: RECOMMENDED IMPROVEMENTS

10. AREA 28: EXISTING BRIDGE ON TOM CAMPBELL PROPERTY

An analysis of the impacts of this bridge crossing on the Ditch has been completed and it was determined that the bride does not provide the 2’ of freeboard required by the CDWA at design flow (125-cfs). Thus, ERC has recommended that this bridge be removed and raised by the property owner. These calculations and recommendations were provided to the land owner and the CDWA under separate cover.

Area	Recommended Improvement
28	The bridge will be removed or raised at the expense of the property owner.

TABLE 10 - INSPECTION AREA 28: RECOMMENDED IMPROVEMENTS

11. AREA 34: EXISTING RAIL ROAD CROSSING

The impacts of the railroad crossing on the ditch were analyzed using Flowmaster and a design flow of 125-cfs. It was determined that at the current bridge height the requisite 2' of freeboard is present at the design flow. This indicates that the railroad crossing itself does not deleteriously impact ditch capacity.

Although the railroad crossing does not inhibit ditch flow, the amount of excess sediment and debris within the ditch and along its banks is a contributing factor. To ensure positive and adequate flow through this area, it is recommended that the ditch be cleaned out and regraded. If ditch capacity is still a concern after the ditch has been cleaned out and regraded it is recommended that this area receive a more detailed analysis that includes the bends and a greater length of ditch located both updtich and downditch of the railroad crossing.

Area	Recommended Improvement
34	The ditch, both updtich and downditch of the crossing, should be cleaned to address excess sediment and debris and regraded to ensure positive flow. If capacity is still a concern after excess sediment and debris is removed, a more detailed analysis of the bridge crossing and the impacts of the bends may be required.

TABLE 11 - INSPECTION AREA 34: RECOMMENDED IMPROVEMENTS

12. AREA 37: DOUBLE 55" CMP CULVERT UNDER W. 74TH AVENUE

It is recommended that the ditch, both updtich and downditch of the culvert be regraded to ensure positive flow and that any excess sediment and debris should be removed. Due to the erosion seen along the ditch banks, it is also recommended that the banks be armored at the inlet and outlet sides of the culvert. And, to ensure adequate capacity and decrease the possibility of blockages from debris, the double culvert, including the concrete dividing wall, should be replaced with a 10'x5' concrete box culvert.

The placement of a trash rack(s), a debris dam(s) or another debris collection/diversion structure updtich of the culvert is also a recommended possibility. We would recommend that the structure be replaced and initially operated without a debris collection/diversion structure. If it is then deemed necessary, a debris collection/diversion structure could be added. The number and location of the structures will need to be determined prior to their installation. The in-depth analysis this requires was not part of the scope of this report.

Before any construction begins in this area, it is recommended that a more detailed analysis of the impact of the existing culvert alignment on ditch capacity and blockage potential occur. The current alignment requires flows to make two approximately 90^{o} turns, one entering the culvert and one leaving the culvert. These abrupt turns may create a backwater condition and may cause an overflow of the ditch banks and may increase the likelihood of blockages.

Area	Recommended Improvement
37	Both upditch and downditch of the culvert, the ditch should be regraded to ensure positive flow and to remove any excess sediment and debris. The double culvert should be replaced with a 10'x5' concrete box culvert. Riprap should be placed along the ditch banks that lead into and out of the culvert. Trash racks capable of removing debris from the ditch before flow reaches the structure should be installed.

TABLE 12 - INSPECTION AREA 37: RECOMMENDED IMPROVEMENTS

13. AREA 42: DOUBLE 44" CMP CULVERT UNDER W. 80TH AVENUE AT NEWMAN STREET

The replacement of the existing double culvert with a 9'x4' concrete box culvert is recommended for this area. This will lessen the possibilities of blockages occurring at this location and will provide adequate capacity.

Area	Recommended Improvement
42	Replace with a 9'x4 ' concrete box culvert

TABLE 13 - INSPECTION AREA 42: RECOMMENDED IMPROVEMENTS

VI. IMPROVEMENT COSTS

Cost estimates were developed for the individual AOC improvements. These costs included those associated with the Inspection Areas. As the improvements presented herein are conceptual in nature, all costs should be considered budgetary level costs. More detailed costs can be developed as part of the final design for improvements as they occur.

Costs contained in this Plan are based on 2009 prices. Estimates were generated from known material costs, cost data provided by the CDWA, costs for completed Ditch improvement projects and engineering judgment.

Unit construction costs (per linear foot, per square foot, per each, etc) were prepared for each specific area improvement. Estimated costs to implement any specific improvement can be determined by scaling the unit cost to the number or size of a particular problem area. A table summarizing unit costs for each improvement type is shown in Appendix E.

A. UNIT COST

Unit costs used for this evaluation included major construction items only. Costs were not intended to identify all minor components and costs associated with the recommended improvements. Minor components were included in the overall costs by assuming a set percentage of the cost of the major ditch improvement components. Minor costs assumed when generating the capital costs for ditch improvements includes the following:

o Site Preparation	10% of major construction items
o Erosion, Water and Sediment Control	5% of major construction items
o Incidentals	20% of major construction items
o Mobilization/Demobilization	5% of major construction items
o Design and Permitting	15% of major construction items
o Construction Management	8% of major construction items
o Contingencies	20% of major construction items
o **Total**	**83% of major construction items**

B. COST ASSUMPTIONS

Quantity assumptions were made in determining recommended improvement costs. The assumptions used were:

- In areas where the recommendation is to pipe a considerable length of ditch (more than a road crossing) a trash rack would be installed on the updtich side of the proposed piped ditch length
- A minimum of one manhole would be installed for every 300 LF of piped ditch
- In areas where the recommended improvement was to pipe the ditch or line the ditch with blocks it was assumed that the entire ditch length required this improvement
- In areas where the recommended improvement was to line the ditch it was assumed that the typical ditch lining cross section shown above would be used

C. IMPROVEMENT COSTS

Costs were developed for each of the recommended improvements. They include the repair or replacement costs for structures and any ditch grading, lining or piping recommended to ensure adequate flow throughout the ditch. Recommended improvement costs can be found below. Please note that for all AOCs, it is assumed that the entire length of Ditch identified in the area will require the recommended improvement. The recommended improvement cost for these AOCs may be decreased when a more detail design is completed. For instance, in area 15b it may be determined that the space

required for 3:1 bank slopes is possible thus, the typical ditch lining cross section discussed above will not be needed. This will decrease the cost to implement the recommended improvement considerably.

Area	Location Description	Recommended Improvement Cost
1	Church Ditch Headworks	$201,300
2	Stormwater entry point from US Hwy 6, located by the Headworks	-
3	Prescriptive easement beginning at the Headworks located by the Headworks	-
4	Under 8th Street west of Illinois Street	$77,550
5a	Illinois Street to Cheyenne Street	$183,732
5b	Illinois Street to Cheyenne Street	$293,003
6	Stormwater entry point located at Cheyenne Street	-
7	Under Cheyenne Street at 7th Street	$87,492
8	Capacity issue from Arapahoe to Washington	$682,229
9	Culvert under Washington Avenue	-
10	Siphon located at Ford Street	-
11	Open section of ditch between 2 piped sections	$1,603,397
12	Length of ditch from Hwy 58 to Easley Way	$6,503,092
13	Stormwater entry point at Easley Road	-
14	Length of ditch along Easley Road	$24,348
15a	Length of ditch from W. 50th Avenue to W. 54th Avenue	$252,898
15b	Length of ditch from W. 50th Avenue to W. 54th Avenue	$2,203,016
16	Length of ditch from W. 50th Avenue to south of W. 54th Avenue	-
17	Length of ditch from south of W. 54th Avenue to north of W. 60th Avenue	-
18	Stormwater entry point at Holly Gulch	-
19	Structure over Van Bibber Creek	$27,450
20	Located at emergency overflow structure that outfalls into Van Bibber Creek	$89,670
21	Located at emergency overflow structure that outfalls into Van Bibber Creek	$73,200
22	Length of ditch from north of W. 60th Avenue to W. 64th Avenue	-
23	West Woods Golf Club	$280,998
24	72nd and Quaker Street Drainage	-
25	South of Leyden Lake	-

Area	Location Description	Recommended Improvement Cost
26	Along southwest side of Leyden Lake	-
27	Stormwater entry point at Barbara Gulch	-
28	Length of ditch located south of W. 82nd Avenue and west of Indiana Street	-
29	Leyden Lake Flushing Structure	$175,680
30	On Tom Campbell's property	-
31	Under Indiana street south of the intersection of Indiana Street and W. 80th Avenue	$197,470
32	Stormwater entry point located east of Indiana Street and between W. 82nd Avenue and W. 80th Avenue	-
33	Length of ditch by Ralston Valley High School	-
34	Length of ditch east of Ralston Valley High School	$49,166
35	Under West 80th Avenue, near intersection of 80th Ave and Simms, west of intersection of 80th and RR	$131,647
36	Railroad crossing near W. 80th Avenue and W. 76th Avenue, west of Simms Street	$4,911
37	Length of ditch along W. 76th Drive	-
38	Length of ditch along W. 76th Drive	-
39	Length of ditch east of the intersection of W. 74th Avenue and Jellison Street	$422,511
40	Length of ditch that begins east of the intersection of W. 74th Avenue and Jellison Street and ends at Club Crest Park	$9,150
41	Length of ditch along Club Crest North Park	-
42	Length of ditch along Club Crest North Park	$9,150
43	Length of ditch between Kipling Street and the intersection of W. 80tn Avenue and Newman Street	-
44	Under West 80th Avenue at West 80th Avenue and Newman Street	$46,397
45	Length of ditch along Michael Northey Park	$510,367
46	at Little Dry Creek crossing	-
47	West of Standley Lake between W. 86th Pkwy and W. 100th Avenue	-
48	West of Standley Lake between W. 86th Pkwy and W. 100th Avenue	-

Area	Location Description	Recommended Improvement Cost
48	West of Standley Lake between W. 86th Pkwy and W. 100th Avenue	-
Area	Location Description	Recommended Improvement Cost
49	West of Standley Lake between W. 86th Pkwy and W. 100th Avenue	-
50	West of Standley Lake between W. 86th Pkwy and W. 100th Avenue	-
	Total	$11,643,804

* Total includes total for 5a and 15a and not 5b and 15b.
Note: These costs include the contingency costs for each area.

TABLE 14 –IMPROVEMENT COSTS

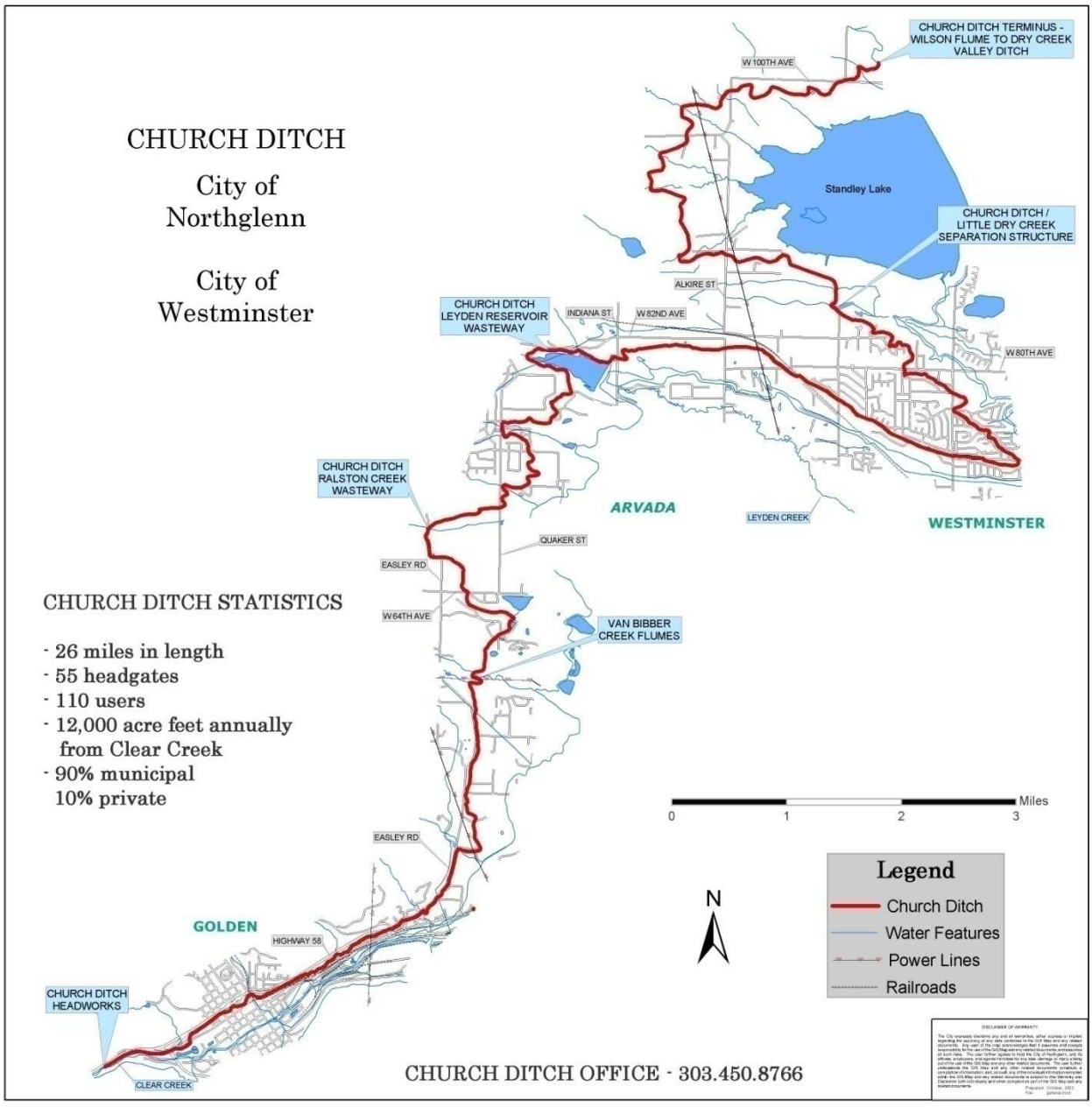
VII. PRIORITIZATION OF IMPROVEMENTS

Given the high cost to implement the recommended improvements, the recommendations within this CDMP will need to be prioritized. Final prioritization should factor in the relative need for the improvement and available financial resources. It is recommended that the recommended improvements that improve ditch access and increase ditch efficiency are implemented first.

VIII. REFERENCES

Water Resources Consultants, Inc. (1983). Plans for Major Maintenance and Repair of the Church Ditch. Water Resources Consultants, Inc.

APPENDIX A – CITY MAPPING AND BACKGROUND INFORMATION USED


CHURCH DITCH
City of Northglenn
City of Westminster
CHURCH DITCH TERMINUS - WILSON FLUME TO DRY CREEK VALLEY DITCH
W 100TH AVE
Standley Lake
CHURCH DITCH / LITTLE DRY CREEK SEPARATION STRUCTURE
ALKIRE ST
CHURCH DITCH LEYDEN RESERVOIR WASTEWAY
INDIANA ST
W 82ND AVE
W 80TH AVE
CHURCH DITCH RALSTON CREEK WASTEWAY
ARVADA
LEYDEN CREEK
WESTMINSTER
QUAKER ST
EASLEY RD
W 64TH AVE
VAN BIBBER CREEK FLUMES
CHURCH DITCH STATISTICS
- 26 miles in length
- 55 headgates
- 110 users
- 12,000 acre feet annually from Clear Creek
- 90% municipal 10% private
Miles
0
1
2
3
EASLEY RD
GOLDEN
HIGHWAY 58
CHURCH DITCH HEADWORKS
CLEAR CREEK
N
Legend
Church Ditch
Water Features
Power Lines
Railroads
CHURCH DITCH OFFICE - 303.450.8766

APPENDIX B – AREAS OF CONCERN MAPS

SHEET 2

Easley Rd

CHURCH DITCH

DITCH

12

14

150+00

W 44th Ave

13

11

Peery Pkwy

Plateau Pkwy

Hwy 58

CHURCH DITCH

2

Ford St

Washington Ave

100+00

10

Coors Brewing Company

Hwy 93/Foothills Rd

5

6

7

9

8

Hwy 58

50+00

CHURCH DITCH

Cheyenne St

4

1

3

0+00

2

LEGEND

- Stormwater Entry Point
- Access
- Capacity
- Erosion and Sedimentation
- Prescriptive Easements
- Seepage
- Structure

No.	DATE	REVISIONS	APPR.

PROJECT No. 375-061

PLAN
DRAWN ERC
DESIGNED ERC
CHECKED ERC

UTILITIES
RESEARCHED
DRAWN
CHECKED

N

Ecological Resource Consultants, Inc.
35715 U.S. Highway 40, Suite D-204
Evergreen, CO 80439
(303) 679-4820
www.ercolorado.net

Church Ditch Water Authority
Capital Improvement Plan
Areas of Concern

DATE
MARCH 2009

SHEET
1

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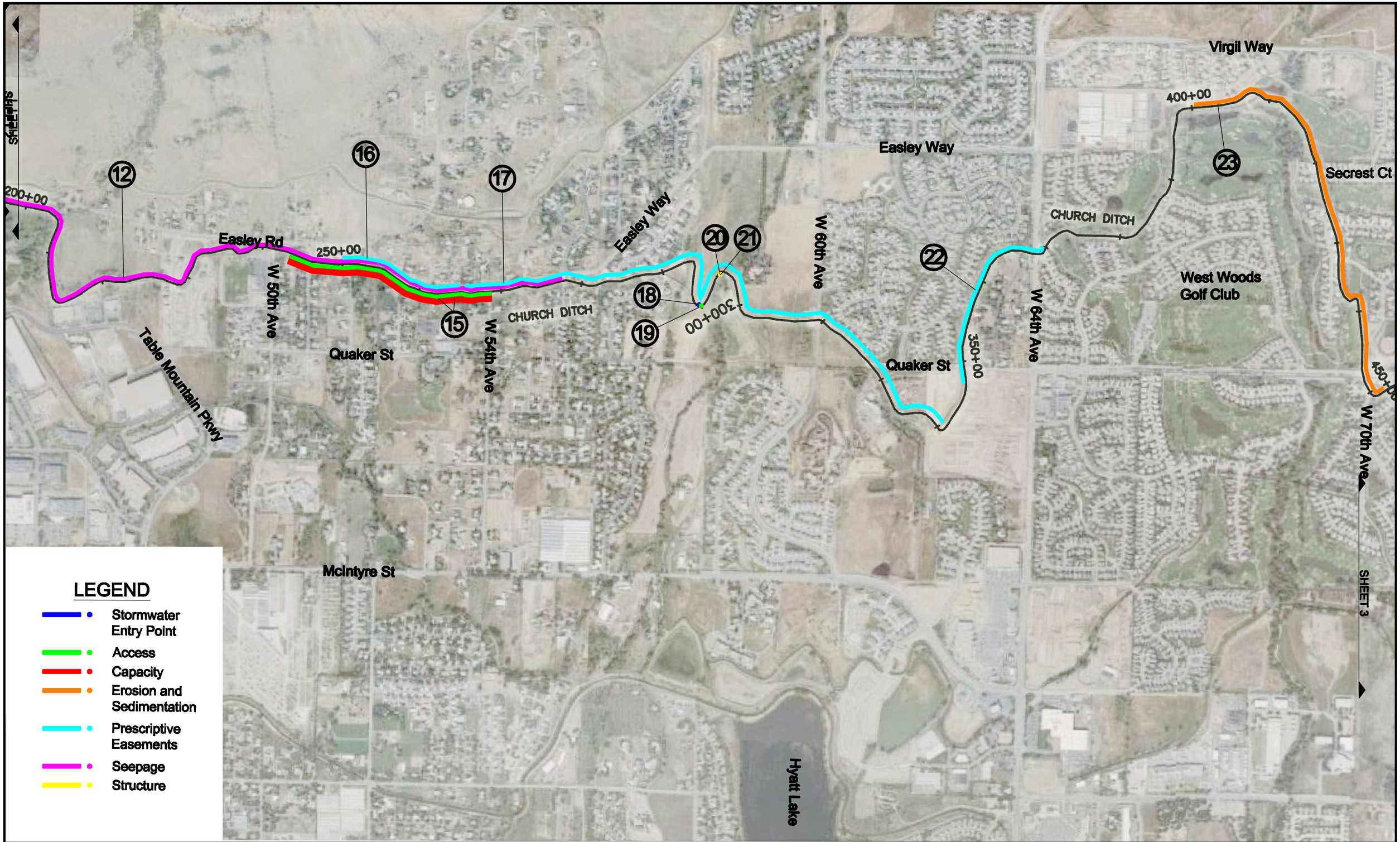

No.	DATE	REVISIONS	APPR.

PROJECT No. 376-081

PLAN DRAWN ERC DESIGNED ERC CHECKED ERC

UTILITIES RESEARCHED DRAWN CHECKED

500' 0' 250' 500' 1000'

SCALE: 1"=1000'

N

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(303) 679-4820
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Church Ditch Water Authority
Capital Improvement Plan
Areas of Concern

DATE MARCH 2009

SHEET 2

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LEGEND

- Stormwater Entry Point
- Access
- Capacity
- Erosion and Sedimentation
- Prescriptive Easements
- Seepage
- Structure

W 86th Pkwy

W 82nd Ave

W 78th Ave

W 76th Ave

W 74th Ave

W 72nd Ave

W 80th Ave

W 70th Ave

Indiana Street

Quaker St

Secrest Ct

Alkire Street

Leyden Lake

CHURCH DITCH

CHURCH DITCH

CHURCH DITCH

600+00

650+00

700+00

550+00

500+00

450+00

25

26

27

28

29

30

31

32

33

34

35

SHEET 2

SHEET 4

No.	DATE	REVISIONS	APPR.

PROJECT No. 375-081

PLAN
DRAWN ERC
DESIGNED ERC
CHECKED ERC

UTILITIES
RESEARCHED
DRAWN
CHECKED

N

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Church Ditch Water Authority
Capital Improvement Plan
Areas of Concern

DATE
MARCH 2009

SHEET
3

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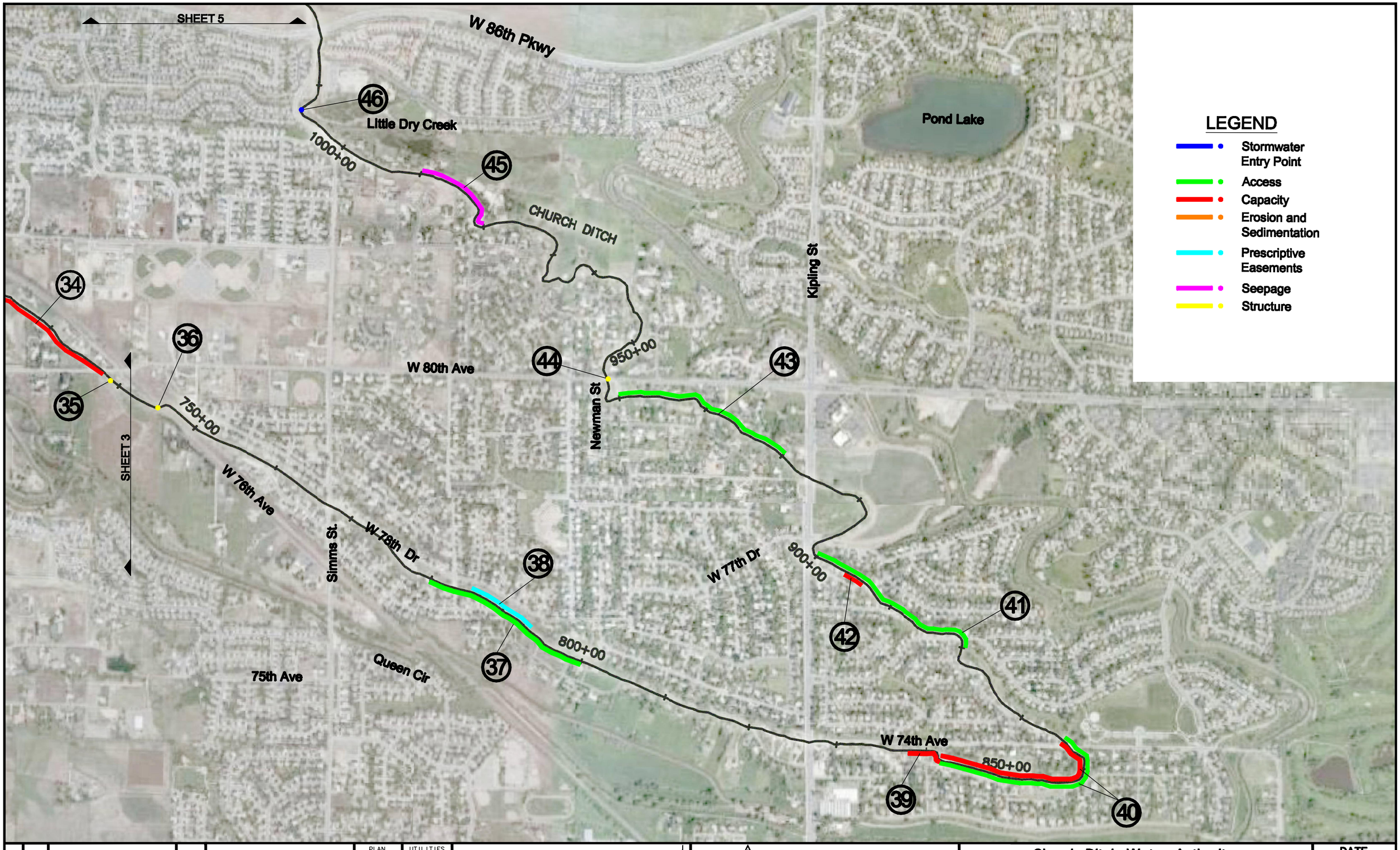

No.	DATE	REVISIONS	APPR.

PROJECT No. 375-081

PLAN DRAWN ERC DESIGNED ERC CHECKED ERC

UTILITIES RESEARCHED DRAWN CHECKED

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SHEET 4

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No.	DATE	REVISIONS	APPR.

PROJECT No. 375-081

PLAN	UTILITIES
DRAWN ERC	RESEARCHED
DESIGNED ERC	DRAWN
CHECKED ERC	CHECKED

Ecological Resource Consultants, Inc.
35715 U.S. Highway 40, Suite D-204
Evergreen, CO 80439
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Church Ditch Water Authority
Capital Improvement Plan
Areas of Concern

DATE MARCH 2009

SHEET 5

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APPENDIX C – AREAS OF DESCRIPTIONS, RECOMMENDED IMPROVEMENTS AND COST

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
1	STR	The Church Ditch headworks consists of gates that allow water to flow into the Church Ditch, a gate to return flow to Clear Creek and 2 gates designated for municipal use. The entire headworks system is operated manually. The Church Ditch gates do not seal properly and leak. The Clear Creek return gate also leaks but has been retrofitted to seal properly. It does not easily open. This gate is rarely used.	Replace existing headgate structure and river return flow system with overshot gate and automated system	$201,300
2	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-
3	SWP	This area has been identified as an area where stormwater is entering the ditch. A more detailed analysis of the issue was not a part of this report.	Divert water from Hwy 6	-
4	STR	In an effort to ensure capacity and to decrease blockage issues, all double culverts will be replaced with a concrete box culvert or a single span.	Replace with a 9'x4 ' concrete box culvert	$77,550
5a	SEEP, CAP, ACC	The CDWA has received complaints of seepage from local residents. Ditch capacity concerns have been raised by the CDWA. Heavy vegetation is present along both banks of the ditch and debris is present within the ditch. The heavily vegetated banks combined with the ditch's close proximity to the adjacent roadway makes maintenance access very difficult. The extent of the seepage for this area has not been measured.	Line ditch with stacked blocks and determine the potential for the construction of an access roadway.	$183,732

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
5b	SEEP, CAP, ACC	The CDWA has received complaints of seepage from local residents. Ditch capacity concerns have been raised by the CDWA. Heavy vegetation is present along both banks of the ditch and debris is present within the ditch. The heavily vegetated banks combined with the ditch's close proximity to the adjacent roadway makes maintenance access very difficult. The extent of the seepage for this area has not been measured.	Pipe ditch and create an access roadway on top of piped length	$293,003
6	SEP	The construction of system that diverts water from Hwy 58 to a Golden storm system was completed in 2008	No Recommendations at this Time	-
7	STR	In an effort to ensure capacity and to decrease blockage issues, all double culverts will be replaced with a concrete box culvert or a single span.	Replace with a 9'x4 ' concrete box culvert	$87,492
8	CAP, ACC	Ditch capacity issues have been raised by the CDWA for this length of ditch. The area begins with a double 48" CMP culvert under Arapahoe Street. From here it enters an open ditch that is very close to an existing dwelling on ditch right. It then enters a concrete box culvert (11'-8" x 5' at its updtich end and 8' x 4'-7" at its downditch end). It then enters another open ditch that is partially lined with stone before entering a 14'-5"x5' open span under Washington Avenue. The heavily vegetated banks combined with the ditch's close proximity to the adjacent roadway makes maintenance access very difficult. The extent of the seepage for this area has not been measured.	Pipe ditch from Arapahoe to Washington and replace double culver under Arapahoe Street with a 9'x4' Concrete Box Culvert	$682,229

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
9	STR	This area was not analyzed as part of this report.	Assess the integrity of the structure and determine its adequacy	-
10	STR	This area consists of a siphon structure that allows the Church Ditch to pass under an agricultural ditch and proceed downditch. This structure was not inspected as part of this report.	Assess the integrity of the structure and determine its effectiveness	-
11	CAP	This area consists of a length of open ditch between 2 piped sections. The piping of this section has been identified as a future project.	Pipe ditch	$1,603,397
12	SEEP	Complaints of seepage in this area have been received by the CDWA from local residents. The area consists of a length of open ditch that typically has vegetated banks and runs adjacent to private property. A portion of this length has already been lined. The extent of the seepage for this area has not been measured.	Quantify seepage and line ditch	$6,503,092
13	SWP	This area has been identified as an area where stormwater is entering the ditch. A more detailed analysis of the issue was not a part of this report.	Divert stormwater from Easley Road	-
14	ES	Erosion resulting in the undercutting of the ditch banks has occurred in this area. Indication that seepage may be occurring in this area has been reported by staff of the CDWA. The possibility and extent of seepage for this area has not been measured.	Quantify seepage and riprap ditch banks	$24,348

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
15a	ACC, CAP	This area begins at W. 50th Avenue and proceeds north to W. 54th Avenue. The bank is actively eroding and bank undercutting is present along most of the ditch. Sedimentation from the eroding banks is present. Debris is collecting along the bottom of the ditch. The ditch's close proximity to private property makes maintenance access impossible. Historically, maintenance has required employees walking the ditch and manually removing debris.	Determine the potential for the construction of an access roadway. Grade ditch to remove excess sediment and riprap ditch banks. Inspect channel for capacity issue.	$252,898
15b	ACC, CAP	This area begins at W. 50th Avenue and proceeds north to W. 54th Avenue. The bank is actively eroding and bank undercutting is present along most of the ditch. Sedimentation from the eroding banks is present. Debris is collecting along the bottom of the ditch. The ditch's close proximity to private property makes maintenance access impossible. Historically, maintenance has required employees walking the ditch and manually removing debris.	Pipe ditch and construct an access roadway on top of piped length. Install a trash rack on the updtich side of the culvert under W. 50th Avenue.	$2,203,016
16	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-
17	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-
18	SWP	This area has been identified as an area where stormwater is entering the ditch. A more detailed analysis of the issue was not a part of this report.	Divert water from Holly Gulch	-

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
19	STR	This area consists of a double concrete box culvert structure that allows the Church Ditch to cross over Van Bibber Creek. There have been complaints of the structure leaking from local residents. Visual indications of leaking at the joints are present.	Repair leaking concrete joints	$27,450
20	STR	A flush structure is desired in this area. It would allow the CDWA to flush the ditch when needed.	Construct and automated flush structure	$89,670
21	ACC	A road crossing over Van Bibber Creek is desired in this area. It would provide a connection between 2 existing roadways that currently terminate at Van Bibber Creek.	Construct a road crossing over Van Bibber Creek to connect existing roadways	$73,200
22	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-
23	ES	This area consists of a length of open ditch that runs through the West Woods Golf Club. It includes pedestrian bridge crossings, road crossings and the Ralston Creek crossing. Active erosion is occurring along several sections of ditch bank in this area, leading to bank undercutting and sedimentation along the ditch bottom. Concern was raised on the inspection trip that the embankment along the Church Ditch's ditch left as it crosses over Ralston Creek may not be adequate and may fail during a large event. The adequacy of the embankment was not analyzed as part of this report.	Remove excess sediment from ditch bottom and armor ditch banks	$280,998

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
24	SWP	This area has been identified as an area where stormwater is entering the ditch. A more detailed analysis of the issue was not a part of this report.	Divert stormwater from 72nd and Quaker Street	-
25	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-
26	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-
27	SWP	This area has been identified as an area where stormwater is entering the ditch. A more detailed analysis of the issue was not a part of this report.	Divert water from Barbara Gulch	-
28	ACC	This area is located on private property. Access has not been granted by the property owner at the time of this report.	Determine the potential for the construction of an access roadway.	-
29	STR	The Leyden Lake flush structure needs to be replaced. It is currently manually operated.	Replace the existing flush structure with new gates and an automated system.	$175,680
30	CAP	A 10' x 4.5' bridge crossing was constructed without CDWA's consent or the determination of its impact on the Church Ditch. This area is located on private property owned by Tom Campbell.	The bridge will be removed and raised at the expense of the property owner.	-
31	STR	In an effort to ensure capacity and to decrease blockage issues, all double culverts will be replaced with a concrete box culvert or a single span.	Replace with a 7.5'x5 ' concrete box culvert	$197,470
32	SWP	This area has been identified as an area where stormwater is entering the ditch. A more detailed analysis of the issue was not a part of this report.	Divert stormwater	-

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
33	ACC	This area is located on private property. Access has not been granted by the property owner at the time of this report.	Determine the potential for the construction of an access roadway.	-
34	CAP	Bridge crossings in this area may be an issue. The ditch needs to be cleaned out and straightened.	Analyze the impacts of the bridge crossings. Regrade the ditch to remove excess sediment and bends.	$49,166
35	STR	In an effort to ensure capacity and to decrease blockage issues, all double culverts will be replaced with a concrete box culvert or a single span.	Replace with a 7.5'x5 ' concrete box culvert	$131,647
36	ES	A railroad crosses the Church Ditch in this area. The Ditch flows south east and then turns northeast to flow under the crossing. It turns southeast and continues southeast after leaving the crossing. Debris has been deposited by residents on both banks updditch of the crossing. Heavily vegetated banks and sedimentation is apparent on both the updditch and the downditch sides of the crossing. There are concerns that the crossing may cause capacity issues.	The ditch, both updditch and downditch of the crossing, should be cleaned out of excess sediment and debris and regraded to ensure positive flow. If capacity is still a concern after excess sediment and debris is removed, a more detailed analysis of the bridge crossing and the impacts of the bends may be required.	$4,911
37	ACC	This area is located on private property. Access has not been granted by the property owner at the time of this report.	Determine the potential for the construction of an access roadway.	-
38	PE	This area has been identified as an area with prescriptive easements. Further analysis was not a part of this report.	No Recommendations at this Time	-

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
39	CAP, STR	This area consists of a double concrete box culvert that crosses under W. 74th Avenue. A wall is located between the 2 pipe openings on the updtich side and splits the flow between them. The ditch flows east until taking an approximately 90o turn to flow south through the culvert. Upon leaving the culvert the ditch takes an approximately 90o turn left and again flows east. Some active erosion is occurring updtich and downditch of the culvert and has caused bank undercutting. In the past, blockages have occurred at the updtich end of the culvert if someone was not there before the flow reached it to remove debris. The blockage has been large enough to stop flow in the ditch completely.	Both updtich and downditch of the culvert, the ditch should be regraded to ensure positive flow and to remove any excess sediment and debris. The double culvert should be replaced with a 10'x5' concrete box culvert. Riprap should be placed along the ditch banks that lead into and out of the culvert. Trash racks capable of removing debris from the ditch before it reaches the structure should be installed.	$422,511
40	ACC, CAP	This area consists of an area of open ditch that runs through a neighborhood. There are concerns that the ditch may not have adequate capacity. The ditch's close proximity to private property may have a negative impact on maintenance access.	Determine the potential for the construction of an access roadway. Inspect channel for capacity issue.	$9,150
41	ACC	The ditch's close proximity to private property may have a negative impact on maintenance access.	Determine the potential for the construction of an access roadway.	-
42	ACC, CAP	The ditch's close proximity to private property may have a negative impact on maintenance access.	Determine the potential for the construction of an access roadway. Inspect channel for capacity issue.	$9,150
43	ACC	The ditch's close proximity to private property may have a negative impact on maintenance access.	Determine the potential for the construction of an access roadway.	-

AREA	AREA CATEGORY	AREA PROBLEM DESCRIPTION	RECOMMENDED IMPROVEMENT	IMPROVEMENT COST
44	ES	In an effort to ensure capacity and to decrease blockage issues, all double culverts will be replaced with a concrete box culvert or a single span.	Replace with a 9' x4 ' concrete box culvert	$46,397
45	SEEP	Indication that seepage may be occurring in this area has been reported by staff of the CDWA. The possibility and extent of seepage for this area has not been measured.	Quantify seepage and line the ditch with blocks	$510,367
46	SWP	Bypass construction drawings completed in 2008. Construction to commence in 2009.	No Recommendations at this Time	-
47	CAP	A detailed capacity study of this area had begun at the time of this report and will be completed by ERC, Inc.	Inspect the channel for capacity issues.	-
48	SWP	This area is a Last Chance Drainage approved point.	No Recommendations at this Time	-
49	SWP	This area is a Big Dry Creek Drainage approved point.	Improvements to be made by JCMD	-
50	SWP	This area is a Smart Ditch Drainage approved point.	Improvements to be made by JCMD	-

CAP = Capacity Concern

SEEP = Seepage Concern

ES = Erosion and Sedimentation Concern

PE = Prescriptive Easement

SWP = Stormwater Entry Point

STR = Existing Structure Concern

ACC = Access Concern

APPENDIX D- AREA COSTS

*Please note that the following AOC costs do not include the contingency costs. Those are added after the AOC costs are subtotaled.

Area	Improvement	Unit	Unit Cost	Quantity	Cost	AOC Cost
1	Headworks	LS	110,000.00	1	110,000.00	110,000.00
2	No Recommendation at this Time	-	0.00	1	0.00	0.00
3	Divert Stormwater	EA	0.00	1	0.00	0.00
4	9'x4' Concrete Box Culvert	LF	724.39	39	28,251.26	42,376.89
	Remove existing double culvert	LS	removal cost	1	14,125.63	
5a	Lining	LF	278.89	360	100,400.00	100,400.00
	Determine potential for formal access	LS	0.00	1	0.00	
5b	Piping	LF	421.42	360	151,711.20	160,111.20
	60" Manhole	EA	5,000.00	1	6,000.00	
	Construct Roadway	LF	6.67	360	2,400.00	
6	No Recommendation at this Time	-	0.00	1	0.00	0.00
7	9'x4' Concrete Box Culvert	LF	724.39	44	31,873.21	47,809.82
	Remove existing double culvert	LS	removal cost	1	15,936.61	
8	9'x4' Concrete Box Culvert	LF	724.39	311	225,285.66	372,802.71
	9'x4' Concrete Box Culvert	LF	724.39	44	31,873.21	
	60" Manhole	EA	1.00	1	1.00	
	Trash Rack	EA	3,000.00	1	3,000.00	
	Remove existing double culvert	LS	removal cost	1	112,642.83	
	Determine potential for formal access	LS	0.00	1	0.00	
9	Inspect	EA	0.00	1	0.00	0.00
10	Inspect	EA	0.00	1	0.00	0.00
11	Piping	LF	421.42	2,000	842,840.00	876,173.33
	60" Manhole	EA	5,000.00	7	33,333.33	
12	Lining	LF	278.89	12,742	3,553,602.22	3,553,602.22
13	Divert Stormwater	EA	0.00	1	0.00	0.00
14	Rip Rap	LF	44.35	300	13,305.06	13,305.06
15a	Inspect	EA	0.00	1	0.00	138,195.51
	Grade channel	LF	6.83	2,700	18,450.00	
	Rip Rap	LF	44.35	2,700	119,745.51	
	Determine potential for formal access	LS	0.00	1	0.00	

Area	Improvement	Unit	Unit Cost	Quantity	Cost	AOC Cost
15b	Piping	LF	421.42	2,700	1,137,834.00	1,203,834.00
	60" Manhole	EA	5,000.00	9	45,000.00	
	Trash Rack	EA	3,000.00	1	3,000.00	
	Construct Roadway	LF	6.67	2,700	18,000.00	
16	No Recommendation at this Time	-	0.00	1	0.00	0.00
17	No Recommendation at this Time	-	0.00	1	0.00	0.00
18	Divert Stormwater	EA	0.00	1	0.00	0.00
19	Repair Concrete Joints	LS	15,000.00	1	15,000.00	15,000.00
20	Install Automated Flush Structure	LS	49,000.00	1	49,000.00	49,000.00
21	Construct Road Crossing	LS	40,000.00	1	40,000.00	40,000.00
22	No Recommendation at this Time	-	0.00	1	0.00	0.00
23	Grade channel	LF	6.83	3,000	20,500.00	153,550.57
	Rip Rap	LF	44.35	3,000	133,050.57	
24	Divert Stormwater	EA	0.00	1	0.00	0.00
25	No Recommendation at this Time	-	0.00	1	0.00	0.00
26	No Recommendation at this Time	-	0.00	1	0.00	0.00
27	Divert Stormwater	EA	0.00	1	0.00	0.00
28	Determine potential for formal access	LS	0.00	1	0.00	0.00
29	Replace Flush Structure and Automate	LS	40,000.00	1	80,000.00	96,000.00
	Remove existing flush structure	LS	removal cost	1	16,000.00	
30	No Recommendation at this Time	-	0.00	1	0.00	0.00
31	7.5'x5' Concrete Box Culvert	LF	685.13	105	71,938.13	107,907.19
	Remove existing double culvert	LS	removal cost	1	35,969.06	
32	Divert Stormwater	EA	0.00	1	0.00	0.00
33	Determine potential for formal access	LS	0.00	1	0.00	0.00
34	Analyze	EA	5,000.00	1	5,000.00	26,866.67
	Grade channel	LF	6.83	3,200	21,866.67	
35	7.5'x5' Concrete Box Culvert	LF	685.13	70	47,958.75	71,938.13
	Remove existing double culvert	LS	removal cost	1	23,979.38	
36	Remove debris	LS	2,000.00	1	2,000.00	2,683.33
	Grade channel	LF	6.83	100	683.33	
37	Determine potential for formal access	LS	0.00	1	0.00	0.00
38	No Recommendation at this Time	-	0.00	1	0.00	0.00

Area	Improvement	Unit	Unit Cost	Quantity	Cost	AOC Cost
39	10'x5' Concrete Box Culvert	LF	890.58	169	150,508.02	230,880.38
	Remove existing double culvert	LS	removal cost	1	75,254.01	
	Grade channel	LF	6.83	100	683.33	
	Rip Rap	LF	44.35	100	4,435.02	
40	Determine potential for formal access	LS	0.00	1	0.00	5,000.00
	Analyze	EA	5,000.00	1	5,000.00	
41	Determine potential for formal access	LS	0.00	1	0.00	0.00
42	Determine potential for formal access	LS	0.00	1	0.00	5,000.00
	Analyze	EA	5,000.00	1	5,000.00	
43	Determine potential for formal access	LS	0.00			0.00
44	9'x4' Concrete Box Culvert	LF	724.39	35	25,353.69	25,353.69
	Remove existing double culvert	LS	removal cost	1	12,676.85	
45	Lining	LF	278.89	1,000	278,888.89	278,888.89
46	No Recommendation at this Time	-	0.00	1	0.00	0.00
47	Inspect	EA	0.00	1	0.00	0.00
48	No Recommendation at this Time	-	0.00	1	0.00	0.00
49	No Recommendation at this Time	-	0.00	1	0.00	0.00
50	No Recommendation at this Time	-	0.00	1	0.00	0.00
					SUBTOTAL	**6,314,734.38**
Total	Site Preparation	LS	10% of total cost	1	636,273.44	636,273.44
Total	Erosion, Water and Sediment Control	LS	5% of total cost	1	318,136.72	318,136.72
Total	Incidentals	LS	20% of total cost	1	1,272,546.88	1,272,546,88
Total	Mobilization/Demobilization	LS	5% of total cost	1	318,136.72	318,136.72
Total	Design & Permitting	LS	15% of total cost	1	954,410.16	954,410.16
Total	Construction Management	LS	8% of total cost	1	509,019.75	509,018.75
Total	Contingency	LS	20% of total cost	1	1,272,546.88	1,272,546.88
					Total	**11,643,803.92**

**Please note that the AOC costs do not include contingencies.

APPENDIX E - COST BREAKDOWN

Improvement	Improvement break down	Unit	Cost/Unit	Quantity	Cost/Improvement Unit
No Recommendation at this Time	No Recommendation at This Time	-	0.00	-	0.00
Determine potential for formal access		LS			0
	Determine potential for formal access	LS	5,000.00	1.0000	
Construct Roadway		LF	AVG W*AVG D	7.5	6.67
	6" Base Course	CY	8.00	1.0000	8.00
Construct Road Crossing		LS	roadway length	50	40,000.00
	Construct road crossing	LF	800.00	1.0000	800.00
Analyze		EA			5,000.00
	Analyze	EA	5,000.00	1.0000	
Divert Stormwater		EA			0
	Divert Stormwater	EA	-	1.0000	
Inspect		EA			0
	Inspect	EA	-	1.0000	
Rip Rap		LF	AVERAGE WIDTH	4	44.35
	Rip Rap	SF	7.22	1.0000	7.22
	Vegetation Removal	SF	0.25	1.0000	0.25
	Filter Fabric	SF	3.00	1.0000	3.00
	Hay mulch	AC	1,600.00	0.000023	0.04
	Bank grading	CY	10.00	0.0400	0.40
	Stabilization blanket	SY	3.20	0.0550	0.18
Grade channel		LF	AVERAGE WIDTH	25	6.83
	Channel excavation	CY	25.00	0.0200	0.50
	Channel grading	CY	16.00	0.0200	0.32
Remove debris		LS			2,000.00
	Remove debris	LS	2,000.00	1.0000	2,000.00
Lining		LF			278.89
	Lining	LF	278.89	1.0000	278.89
Incidentals		LS			20% of total cost
	Incidentals	LS	20% of total cost	1.0000	

Improvement	Improvement break down	Unit	Cost/Unit	Quantity	Cost/Improvement Unit
Site Preparation		LS			10% of total cost
	Site preparation	0	10% of total cost	1.0000	
Construction Management		LS			8% of total cost
	Construction Management	LS	8% of total cost	1.0000	
Contingency		LS			20% of total cost
	Contingency	LS	20% of total cost	1.0000	
Design & Permitting		LS			15% total cost
	Design & Permitting	LS	15% total cost	1.0000	
Mobilization/Demobilization		LS			5% of total cost
	Mobilization/Demobilization	LS	5% of total cost	1.0000	
Erosion, Water and Sediment Control		LS			5% of total cost
	Erosion, Water and Sediment Control	LS	5% of total cost	1.0000	
Piping		LF			421.42
	81"x59" 12 gauge CMP	LF	389.82	1.0000	389.82
	Mirafi Filter	SY	1.60	1.0000	1.60
	Class 6 Road Base	CY	30.00	1.0000	30.00
Remove existing double culvert		LS			removal cost
	Remove existing double culvert	LS	removal cost	1.0000	
Remove existing flush structure		LS			removal cost
	Remove existing flush structure	LS	removal cost	1.0000	
60" Manhole		EA			5,000.00
	60" Manhole	EA	5,000.00	1.0000	
Concrete Headwall		CY			300.00
	Concrete Headwall	CY	300.00	1.0000	
Concrete Wingwall		CY			300.00
	Concrete Wingwall	CY	300.00	1.0000	
Trash Rack		EA			3,000.00
	Trash Rack	EA	3,000.00	1.0000	

Improvement	Improvement break down	Unit	Cost/Unit	Quantity	Cost/Improvement Unit
Repair Concrete Joints		LS			15,000.00
	Repair concrete joints	LS	15,000	1.0000	
Headworks		LS			110,000.00
	Headgate	EA	14,000.00	5.00	70,000.00
	Tellemetry	LS	30,000.00	1.00	30,000.00
	Bring power to the site	LS	10,000.00	1.00	10,000.00
Replace Flush Structure and Automate		LS			80,000.00
	Motor Operated Slide Gate	EA	3,000.00	2.00	6,000.00
	Tellemetry	LS	30,000.00	1.00	30,000.00
	Bring power to the site	LS	10,000.00	1.00	10,000.00
	Piping and water control	LS	40,000.00	1.00	40,000.00
Install Automated Flush Structure		LS			49,000.00
	Motor Operated Slide Gate	EA	3,000.00	3.00	9,000.00
	Tellemetry	LS	30,000.00	1.00	30,000.00
	Bring power to the site	LS	10,000.00	1.00	10,000.00
7.5'x5' Concrete Box Culvert		LF			685.13
	7.5' X 5' CBC, Furnish and Install	LF	685.13	1.0000	
9'x4' Concrete Box Culvert		LF			724.39
	9' X 4' CBC, Furnish and Install	LF	724.39	1.0000	
10'x5' Concrete Box Culvert		LF			890.58
	10' X 5' CBC, Furnish and Install	LF	890.58	1.0000	