Glenn County Groundwater Reliability and Recharge Pilot Project Summary Report

Prepared for

Glenn County Department of Agriculture

on behalf of

Glenn County Water Advisory Committee
Willows, CA

March, 2013

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List of Abbreviations

AF	acre-feet
Bureau	United States Bureau of Reclamation
CaSIL	California Spatial Information Library
cfs	cubic feet per second
CVP	Central Valley Project
DWR	Department of Water Resources
GCID	Glenn-Colusa Irrigation District
GIS	Geographic Information Systems
IRWMP	Integrated Regional Water Management Plan
NRCS	National Resource Conservation Service
Orland Unit	Orland Unit Water Users Association
Study	Glenn County Groundwater Reliability and Recharge Pilot Project
Sub-Area 8	Glenn County Basin Management Objective Sub-Area 8
TC Canal	Tehama Colusa Canal
WAC	Water Advisory Committee

Executive Summary

The purpose of the Glenn County Groundwater Reliability and Recharge Pilot Project (study) was to investigate the feasibility of delivering surface water to the northern portion of Basin Management Objective Sub-Area 8 (Sub-Area 8) to offset groundwater pumping through “in-lieu” recharge. In conjunction with the evaluation of in-lieu recharge, direct recharge alternatives were also evaluated. The desired result of a project would be to reduce the magnitudes of groundwater level fluctuations (see Figure ES-1) and long term declines in the northern portion of Sub-Area 8 caused by pumping groundwater for irrigation.

Sub-Area 8 is an unincorporated area located in the northeastern portion of Glenn County in the northern Sacramento Valley of California that relies primarily on groundwater for irrigation. Lands of Sub-Area 8 and surrounding areas in Glenn County are utilized primarily for growing animal feed crops, orchard crops, pasture, and truck crops.

Utilizing surface water for irrigation instead of groundwater is generally referred to “in-lieu” recharge because the groundwater that would have been used for irrigation is left stored in the groundwater aquifer. In contrast, direct groundwater recharge typically involves percolating surface water into the groundwater aquifer to replenish water that had been previously extracted.

Delivery of surface water to an area may be accomplished through the utilization of existing conveyance facilities, expansion of existing conveyance facilities, or the construction new conveyance facilities. This study included the collection of information on the study area, development of a conceptual surface water delivery system, and planning level analysis of the costs of a surface water delivery system for in-lieu recharge. Additional analysis was conducted to identify areas that may benefit from direct recharge (Section 2.5).

A field inventory of land use, irrigation practices, and existing drainages and canals was conducted in the study area to identify the lands that are able to utilize surface water and lands that can receive surface water without substantial pumping. Figure ES-2 presents the lands within the study area that are able to receive and utilize surface water. These lands are primarily flood or sprinkler irrigated and generally pasture and field crops. Figure ES-3 presents the existing drainages and canals in the study area that could potentially be used to convey surface water.

A conceptual canal layout for the potential surface water supply service area was prepared to evaluate the physical implementability of delivering surface water to the study area and to provide a basis for estimating costs of infrastructure. The conceptual layout uses surface water wheeled through the Tehama Colusa Canal (TC Canal), which is the preferred supply canal because it passes near the uphill (west) side of the study area. Some land in Tehama County was included in the service area because it would be easy to serve using some of the same infrastructure. The conceptual canal layout was developed using a number of considerations. The considerations included use of:

- Water supplied under Glenn-Colusa Irrigation District water rights,
- The Tehama Colusa Canal and Orland Unit Water Users Association (Orland Unit) canals for wheeling of the surface water to the uphill side of the study area,
- Existing topography, ditches, and infrastructure as much as possible to minimize capital costs,
- A conceptual layout to reach the majority of potential users, and
- An on-demand supply system.

The conceptual canal layout is presented in Figure ES-4. The conceptual layout serves 3,670 acres and was sized to deliver water for a peak demand of 0.42 inches per day over the entire area. The conceptual canal layout utilizes two diversions from the TC Canal into two major laterals. The northern lateral conveys 31 cubic feet per second (cfs), and the southern laterals convey 57 cfs. Spill at the bottom of the canal system from the southern lateral is measured and flows back to the Glenn-Colusa Irrigation District's canal. Turnouts in the canal system are based on location and topography. Turnouts for the conceptual design include 15 gravity turnouts, 11 low head pipe turnouts, and 30 pump turnouts.

The estimated cost of developing the infrastructure for the conceptual canal layout is presented in Table ES-1. Infrastructure costs include construction costs, engineering and design costs, and permitting costs, which are listed under "Other Overhead" in Table ES-1.

Table ES-1. Estimated Infrastructure Costs

Description	Quantity [a]	Units	Total Cost [a]
Ditch Earthwork	15,000	cubic yard	$110,000
Lining	163,000	square foot	$820,000
Culverts	440	feet	$160,000
Low Head Pipelines	12,100	feet	$1,060,000
Easements	457,000	square foot	$140,000
Turnouts	56	each	$290,000
Control Gates and Remote Sensors	12	each	$405,000
South Pumps	3	each	$810,000
North Pumps	2	each	$540,000
In-System Pumps	2	each	$300,000
Regulating Reservoir	1	each	$35,000
Miscellaneous	1	lump sum	$300,000
		Subtotal	**$4,970,000**
Engineering and Administration	20%		$990,000
Other Overhead	15%		$750,000
		Subtotal (rounded)	$6,700,000
Contingency (rounded)	30%		$2,000,000
		TOTAL (rounded)	**$8,700,000**

[a] *Numbers are estimated and rounded as necessary.*

Surface water costs will be driven by several factors including the original contracted cost of the water, institutional controls and fees, physical costs of conveyance including wheeling through canals, annualized capital costs, and anticipated maintenance and operations costs. These estimated costs are presented in Table ES-2 along with estimated total costs for groundwater pumping.

Table ES-2. Estimated Costs of Water per Acre-Foot

Cost	Groundwater	CVP Surface Water	Non-CVP Surface Water
Capital	$24	$42	$42
Power	$34	$6	$6
Operations and Maintenance	$8	$14	$14
Purchase and Fees	$0	$86	$51
TOTAL	**$66**	**$148**	**$113**

Total costs per acre-foot for delivered surface water were estimated at $113 to $148. Total costs of groundwater pumping for an irrigator in the vicinity of the study area were estimated at $66 per acre-foot. Because of the substantial extra cost to potential participants, the project is infeasible without a waiver of some water supply fees and other possible subsidies. Opportunities for fee waivers or subsidies should continue to be pursued and a smaller project study area should be considered.

Additional information on the study's development is available on the project's outreach website at: http://glennwac-eastcorning-recharge.org/

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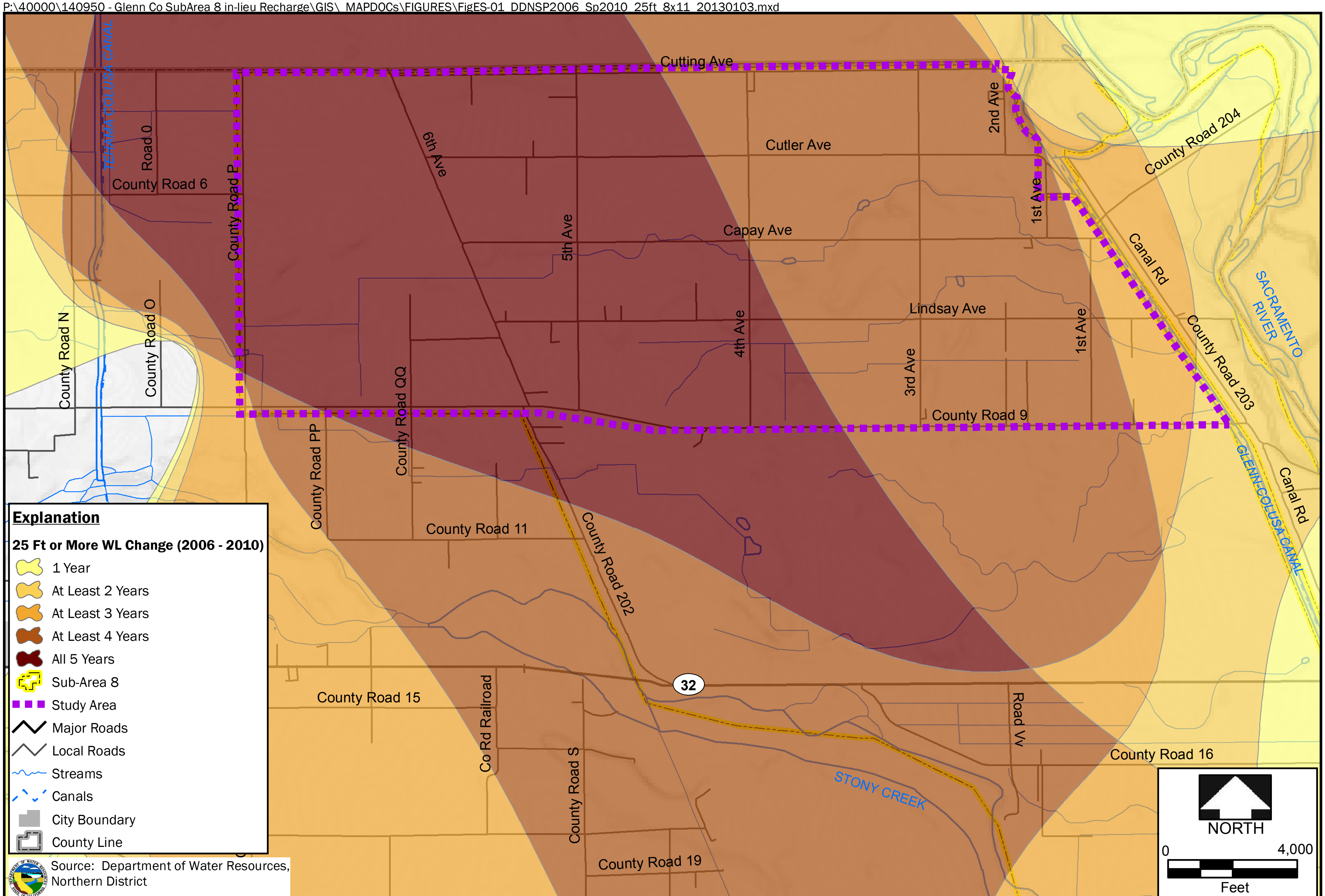

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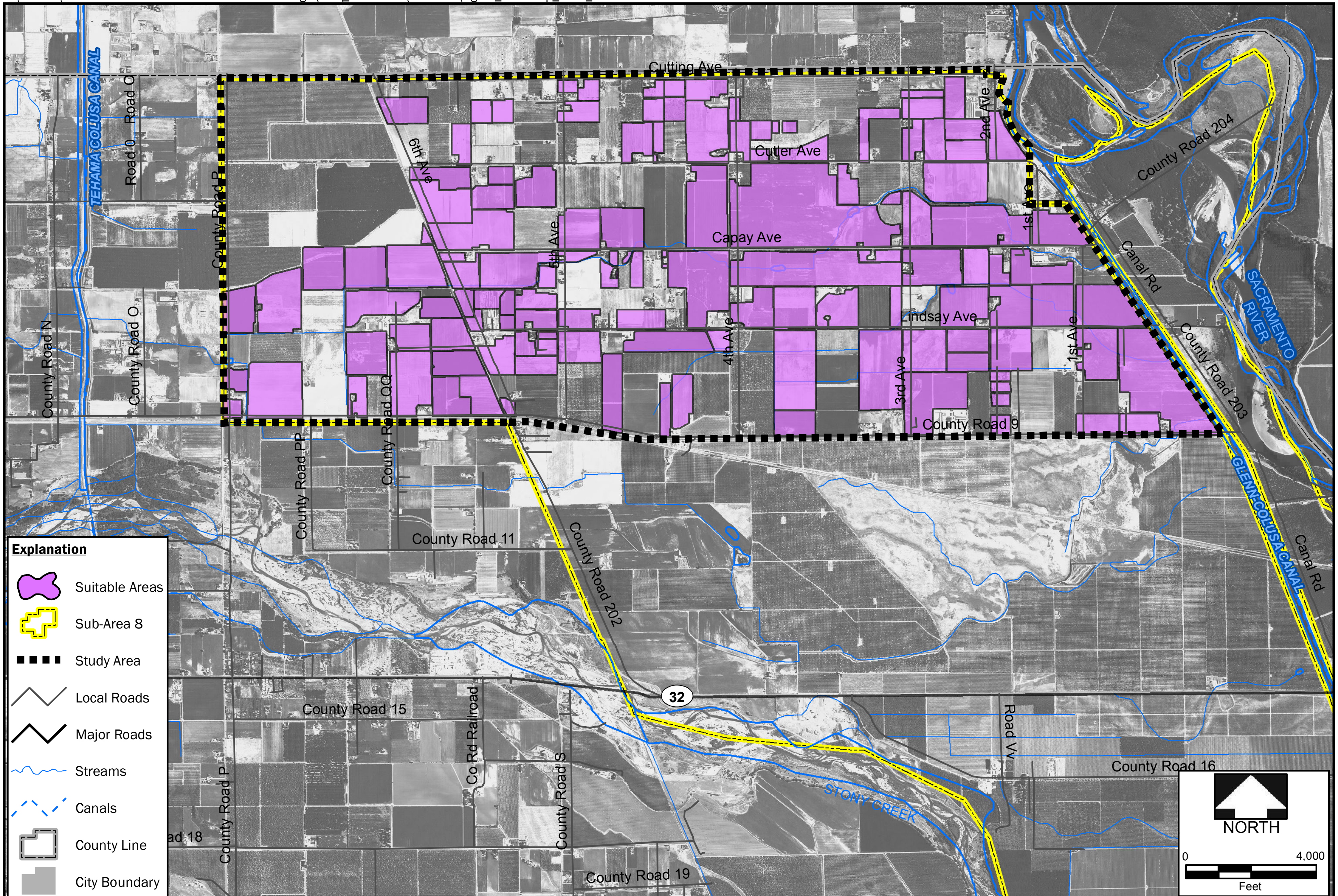
PROJECT	SITE
140950	Glenn County Groundwater Reliability and Recharge Pilot Project
DATE	TITLE
01/03/2012	Areas That Experienced Greater Than 25 Feet of Spring-Summer Drawdown Within 2006-2010

Figure ES-1

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\Fig1-2_Basemap_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure ES-2
	DATE 01/03/2012	TITLE Areas Suitable for Surface Water	

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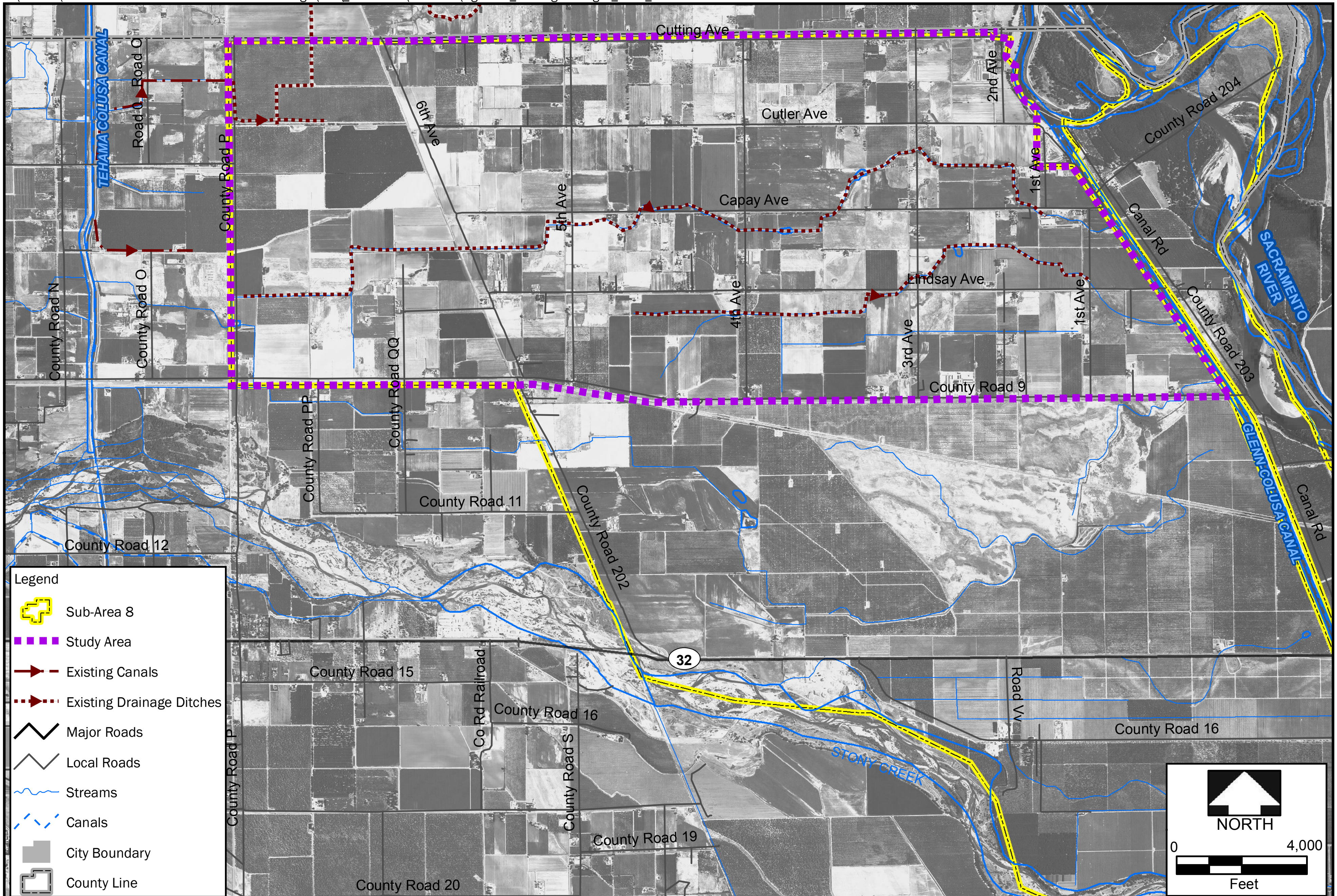
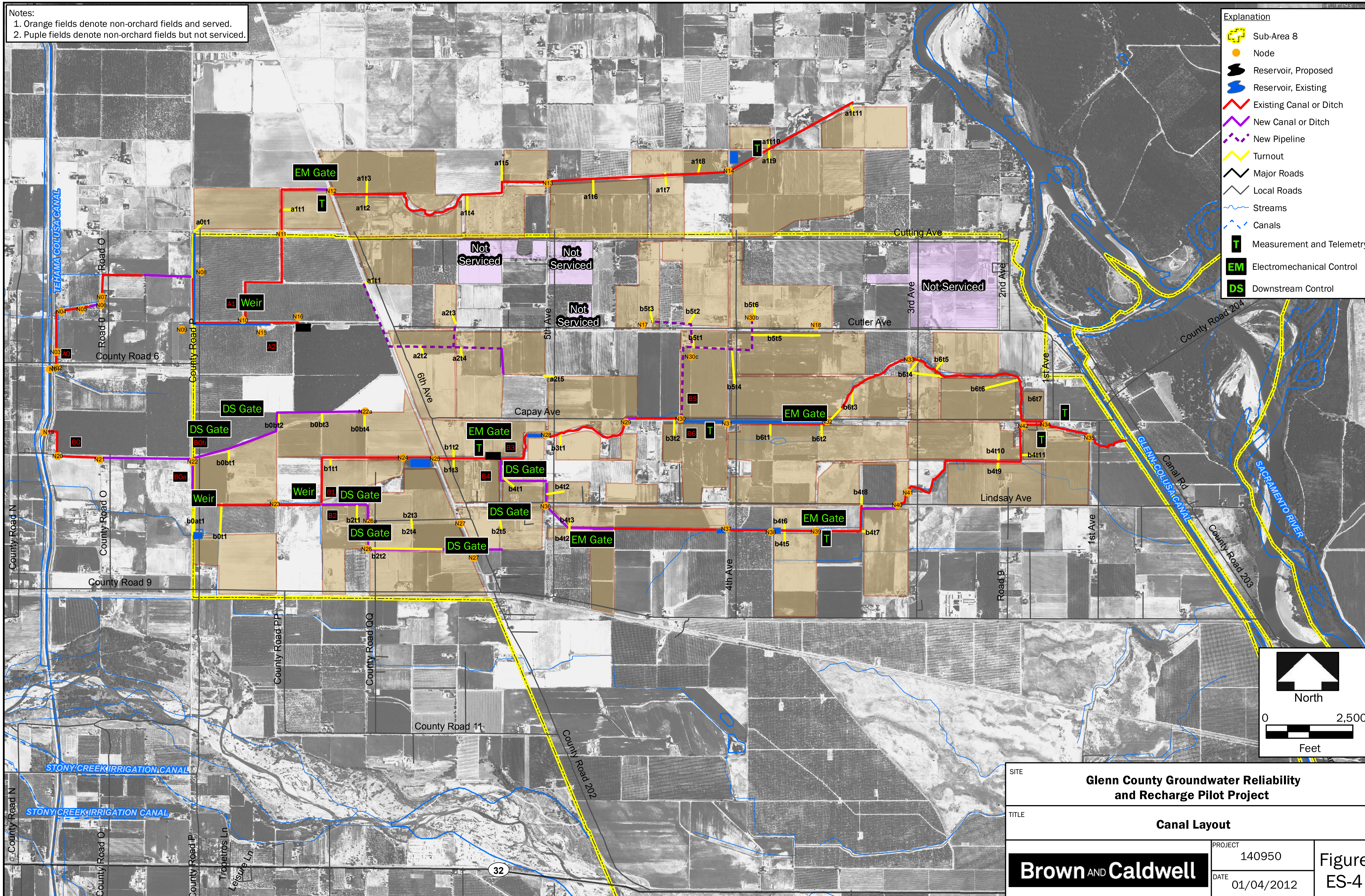


Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure ES-3**
	DATE 01/03/2012	TITLE **Existing Drainages and Canals**	



SITE

Glenn County Groundwater Reliability and Recharge Pilot Project

TITLE

Canal Layout

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PROJECT 140950

DATE 01/04/2012

Figure ES-4

Section 1

Introduction

The Glenn County Groundwater Reliability and Recharge Pilot Project (study) was conducted to investigate the feasibility of delivering surface water to the northern portion of Glenn County Basin Management Objective Sub-Area 8 (Sub-Area 8). Sub-Area 8 is an unincorporated portion of the County that relies almost entirely on groundwater for irrigation. This study included the collection of information on the study area, development of a conceptual surface water delivery system, and planning level analysis of the costs of a surface water delivery system for in-lieu use. Additionally, the study investigated potential sites for direct recharge.

1.1 Regional Setting

Sub-Area 8 is located in the northwestern portion of Glenn County (Figure 1-1). Glenn County is situated in the central portion of the northern Sacramento Valley of California. The valley portions of Glenn County are utilized for agriculture, with rice, orchard crops, and truck crops grown throughout the County.

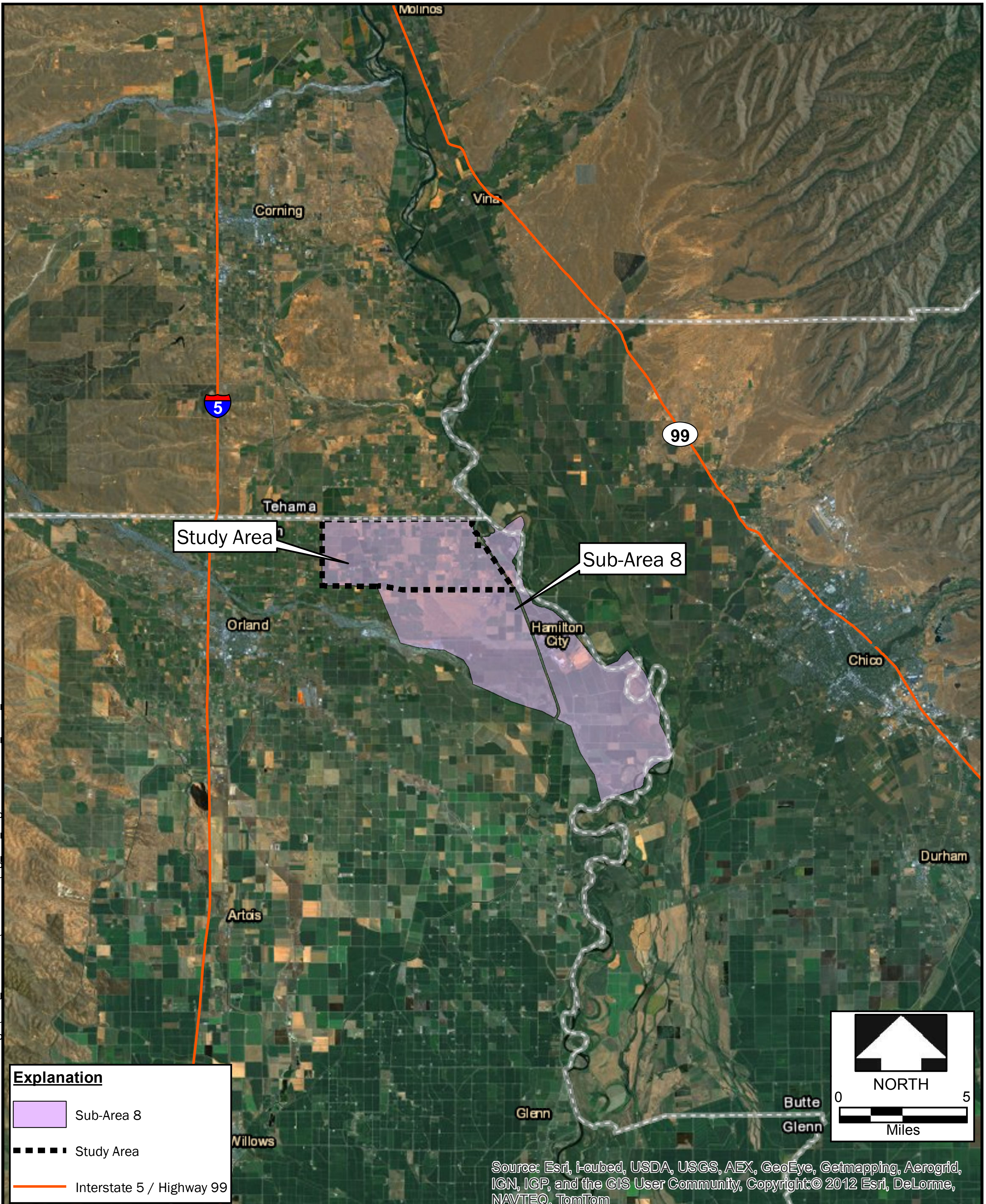
Glenn County's water supply planning is overseen by the Water Advisory Committee (WAC). The WAC is chartered under the following mission statement: "It is the desire of the people of Glenn County that sufficient and affordable water of good quality be available on a sustainable basis to meet the needs of agricultural, industrial, recreational, environmental, residential, and municipal users within the County, both now and in the future." The WAC is an advisory body to the Glenn County Board of Supervisors, and as such, is not authoritative.

Glenn County is part of the Northern Sacramento Valley Integrated Regional Water Management Plan development effort. The six counties of the Northern Sacramento Valley have been working together for over 10 years to lay the foundation for an integrated regional plan to address water-related issues such as economic health and vitality; water supply reliability; flood, stormwater and flood management; water quality improvements; and ecosystem protection and enhancement. The counties have committed to developing a valley-wide Integrated Regional Water Management Plan (IRWMP) by September 2013.

The IRWMP is a collaborative effort to enhance coordination of the water resources in a region. The IRWMP effort involves multiple agencies, stakeholders, tribes, individuals and groups to address water-related issues and offer solutions which can provide multiple benefits to the region. Representatives of the six counties are working in partnership with community stakeholders, tribes and the public to identify the water-related needs of the region. This information will be used to develop goals and objectives of the IRWMP, and ultimately lead to the identification of projects and programs to be included in the IRWMP. When it is adopted in September 2013, the IRWMP will better position the region and local partners to receive funding for high-priority projects.

1.2 Study Area

The study area is identified as the northern portion of Sub-Area 8, bounded by Cutting Avenue on the north, County Road P on the west, County Road 9 on the south, and the Glenn-Colusa Irrigation District (GCID) canal on the east. Land use in the study area is primarily agricultural, with a mixture of orchards, pastures, and other crops. Land use and irrigation methods are fully described in Section 2. Sub-Area 8 and the study area are shown in Figure 1-2.



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DATE	PROJECT	SITE	
10-17-12	140950	**Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 1-1**
Brown AND Caldwell		TITLE **Regional Location**	

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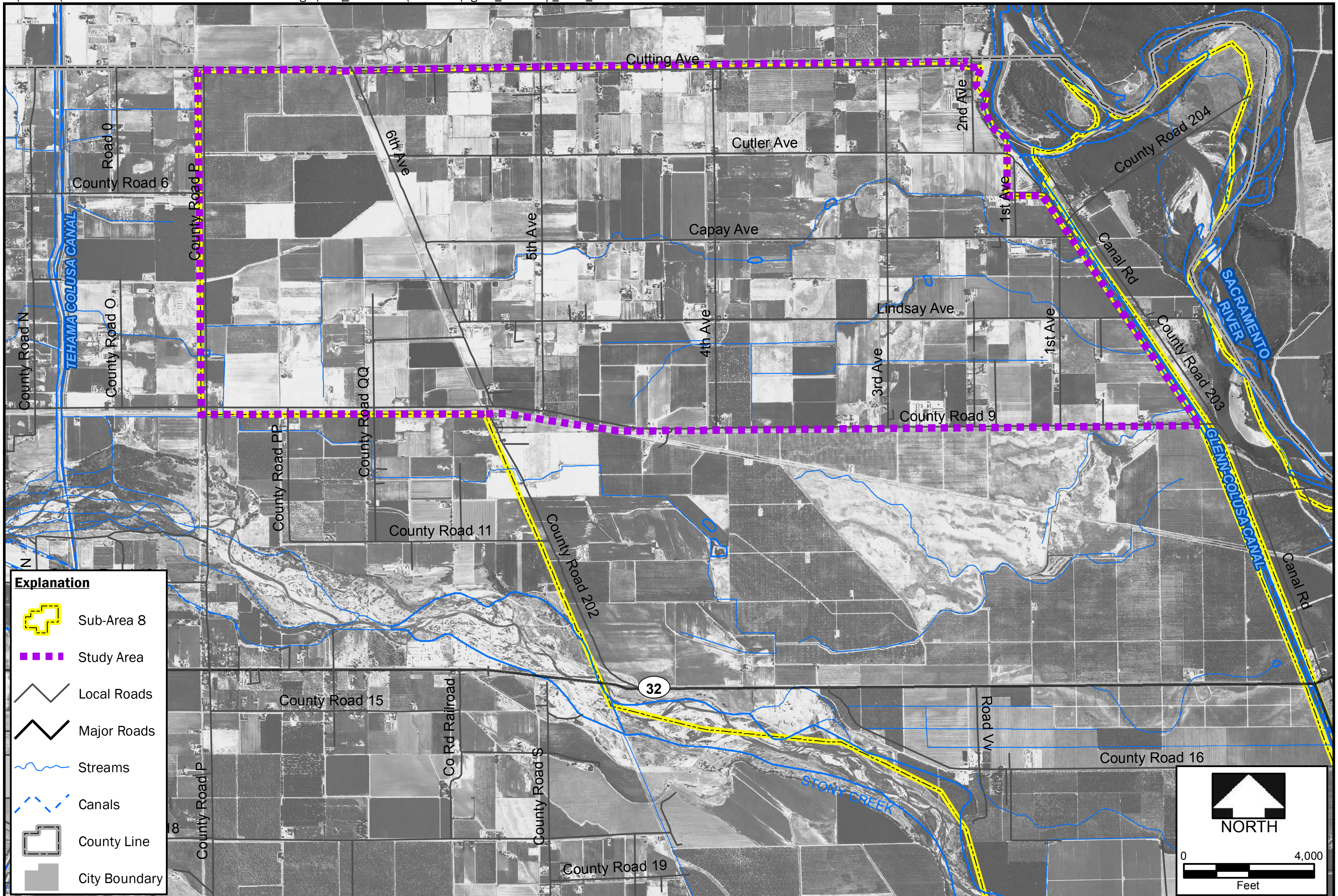

Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 1-2**
	DATE 01/03/2012	TITLE **Study Area**	

Sub-Area 8 has three major sections:

- The section between the GCID canal and the Sacramento River, which includes Hamilton City. This section was not studied because of the areas proximity to recharge from the canal and the river.
- The section south of County Road 9, and west of the GCID canal. This section was not studied because it is an area of orchards primarily irrigated with microsprinklers and drip systems that are incompatible with surface water use without additional costs.
- The section north of County Road 9. This section is the study area, and is identified in study maps as the area within a large purple rectangular shape.

The study area was selected because it is the area most susceptible to groundwater declines and also the area with crop types and irrigation methods most likely to be able to utilize surface water.

1.3 Project Need

Sub-Area 8 is an agricultural area that, except for a few small water rights on drainage water, is reliant upon groundwater for irrigation. Groundwater levels throughout the northern Sacramento Valley have been slowly declining over time, and may decline more rapidly in the future. During Geographic Information Systems (GIS) analysis of groundwater trends, the study area was identified to experience the largest spring to summer declines in groundwater level (Figure 1-3). Long term (2006 - 2010) groundwater level changes are shown in Figure 1-4. By acquiring a second source of water supply, irrigators would be able to leave more groundwater in storage for dry years.

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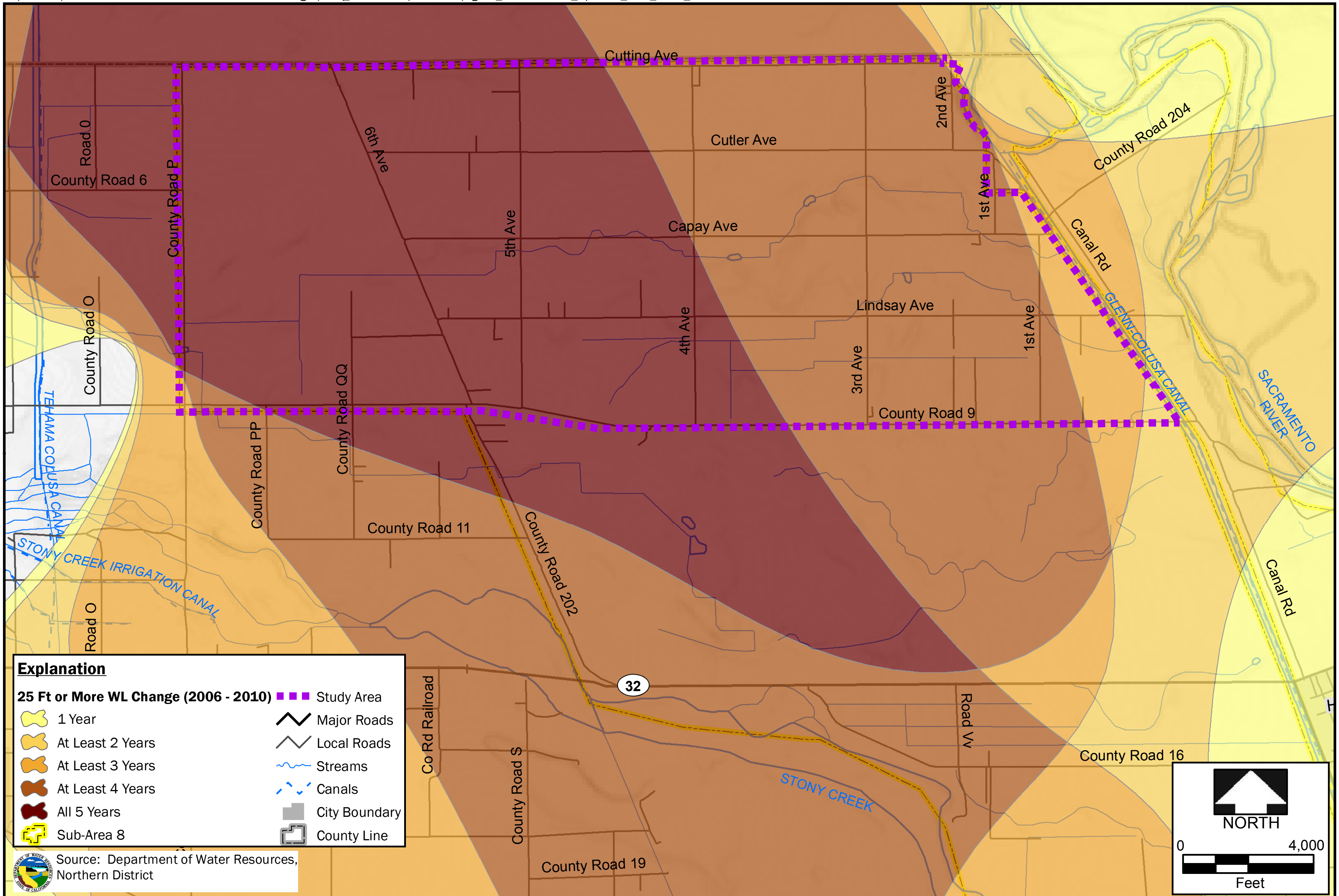

Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**
	DATE 01/03/2012	TITLE **Areas That Experienced Greater Than 25 Feet of Spring-Summer Drawdown Within 2006-2010**

Figure 1-3

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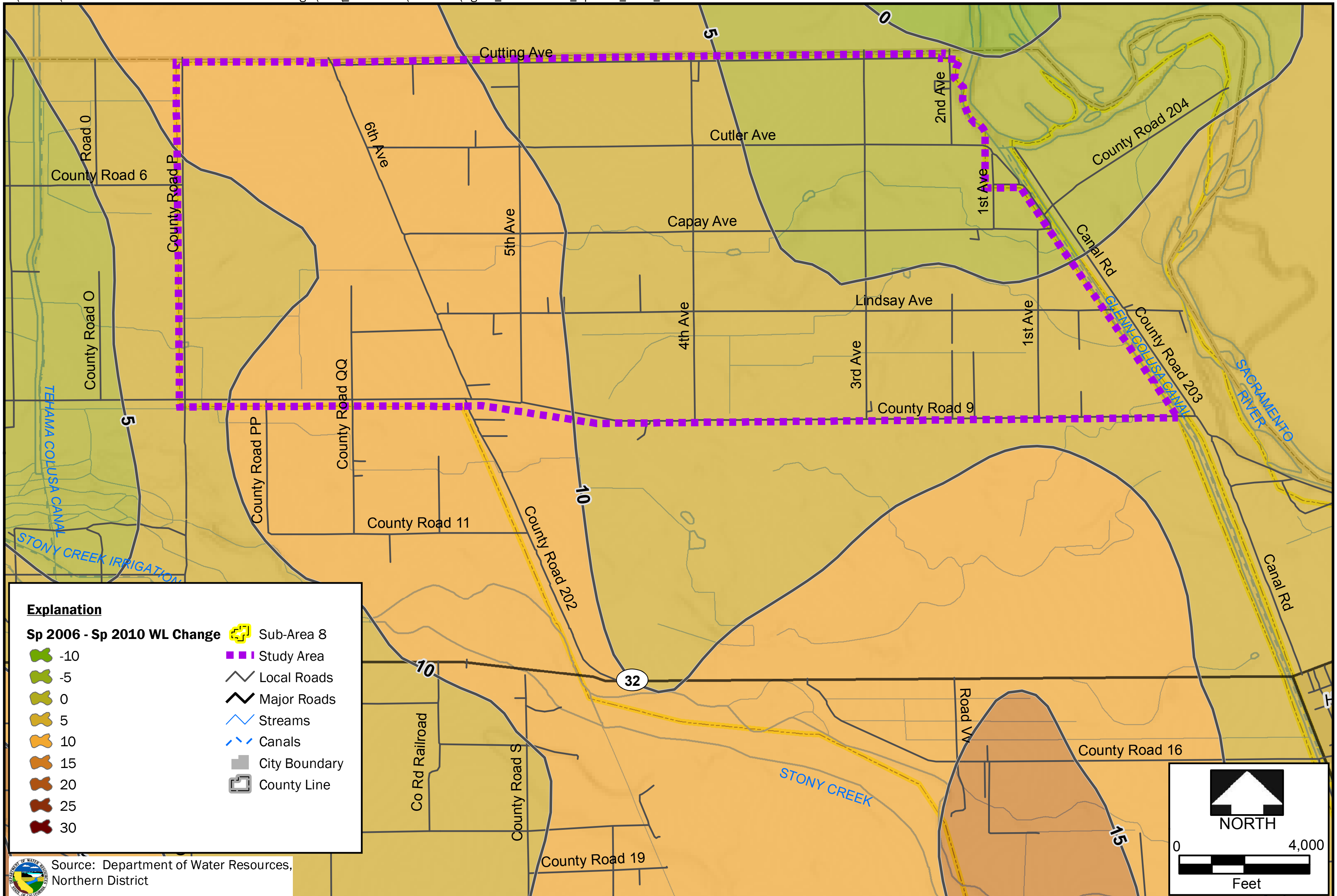

Brown AND Caldwell

PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 1-4**
DATE 01/03/2012	TITLE **Spring 2006 to Spring 2010 Decrease in Groundwater Elevation**	

1.4 Groundwater Law

This section of the report describes the context of California law as it relates to groundwater and water rights. During public outreach activities for this study, concerns were expressed by local irrigators that using surface water would create a situation where overlying irrigators may lose their groundwater rights.

Under the California Constitution, the use of water is limited to its beneficial use without waste; “The right to water or to the use or flow of water in or from any natural stream or water source in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water” (California Constitution, 1849).

There are three types of water under California law; surface water, “subterranean streams”, and percolating groundwater. Surface water and subterranean streams are both subject to oversight by the California State Water Resources Control Board, the entity which identifies and enforces water rights. Percolating groundwater does not fall under the jurisdiction of the California State Water Resources Control Board.

Without an oversight body, California does not have a statewide system to monitor groundwater pumping, nor to regulate or limit groundwater pumping. Local authorities such as cities and counties have been able to develop regulations about groundwater, and most of these ordinances have been intended to discourage groundwater exports from the local jurisdiction. Generally, groundwater is managed with a collaborative approach at the local, County level.

Groundwater rights in California are primarily decided during adjudication, a legal court determined process to establish groundwater rights in a basin that is in a state of overdraft. Adjudications are a civil action that determines and quantifies rights to the basin water supply (the safe yield). The court determines water rights (quantities) for each party, determines the "safe yield", and appoints a watermaster to administer the judgment. In legal terms, "Overdraft" is a chronic lowering of the groundwater in a groundwater basin, producing undesirable result(s); drought related lowering may not constitute overdraft in the court.

There are four kinds of groundwater rights in California that may be established during adjudication: overlying, appropriative, prescriptive, and "dormant" overlying:

- **Overlying**: Overlying rights apply to landowners who are using their groundwater to beneficial use, with the exception of most public utility use. Overlying rights are superior to appropriative rights, meaning an overlying right will be fully filled prior to any water going to an appropriative right in adjudication. If two or more overlying rights are in dispute, they are co-equal, and share the decrease in water proportionally.
- **Appropriative:** Appropriative rights describe groundwater that is pumped and used on a different parcel than the one where water is pumped. This applies to most aspects of most water districts and municipal suppliers. Appropriative rights are second to overlying, and during adjudication, don't receive water until the overlying rights are filled. Multiple appropriative rights under dispute are determined in a "First in Time, First in Right" methodology, so earlier established appropriative rights are filled in their entirety before the later established.
- **Prescriptive:** A prescriptive right is only documented during adjudication. A prescriptive right is established by utilizing an appropriative right in an "open and notorious", "adverse and hostile" manner, for a specific use, and during overdraft for five years. A prescriptive right is co-equal to overlying rights, so, during adjudication, a prescriptive right would share in the supply equally with overlying rights. Most of the legal maneuvering that occurs during adjudication is focused on whether a prescriptive right has been established or not.

- **Dormant Overlying:** A dormant overlying right is an overlying right that is not currently in use. Case law has not yet been conducted that establishes the court's direction in handling these rights in the case of adjudication, though it is likely that they could be placed at the lowest priority.

During adjudication, groundwater users sue each other to determine rights to the groundwater supply. Because of the complicated nature of a court decided adjudication, and the uncertainties of case law in California, it is not possible to determine a likely outcome of an adjudication in Glenn County, should one occur in the future.

Section 2

Inventory

This section describes information collected during the study for evaluating both direct recharge and in-lieu recharge opportunities. Information collected was focused on improving understanding of existing conditions in the study area, so that the conceptual surface water delivery system plan and overall feasibility study evaluation would be as accurate as possible.

2.1 Crop Types

Land use in Sub-Area 8 was inventoried as part of the study. Glenn County staff used GIS data, crop data from the County's pesticide permitting program. Site visits were conducted throughout Sub-Area 8. Based on crop types, determination was made to focus on the northern portion of Sub-Area 8 as the study area. Collected data was compiled into a GIS geodatabase and used during project analysis. The crop type inventory for the study area is presented in Figure 2-1. Agriculture in the study area includes a variety of land uses, including approximately:

- 1,300 acres of pasture,
- 540 acres of alfalfa and hay,
- 700 acres of row and field crops,
- 2,260 acres of orchard, and
- 930 acres of uncultivated land.

2.2 Irrigation Methods

Irrigation methods used in Sub-Area 8 were inventoried as part of the study. Glenn County staff used site visits within Sub-Area 8 to identify irrigation methods. Collected data was compiled into a GIS geodatabase and used during project analysis. The irrigation method inventory is presented in Figure 2-2. Agriculture in the study area is primarily flood irrigated, with some areas of micro sprinkler and drip, and many areas unirrigated or of unknown irrigation methodology. Irrigation methods include approximately:

- 480 acres of drip irrigation,
- 2,960 acres of flood irrigation,
- 1,140 acres of micro sprinkler irrigation,
- 290 acres of sprinkler irrigation, and
- 860 acres of no irrigation or unknown irrigation methodology.

2.3 Groundwater Well Inventory

Well depth, approximate location, and well use information was obtained from the Department of Water Resources (DWR)'s well completion report database and utilized to identify the existing well infrastructure in the study area. DWR's database contains information on the majority of wells drilled between 1950 and 2010. Wells drilled prior to 1950 are generally not included and some wells drilled after 1950 may not have been reported to DWR (potentially up to 30 percent), and therefore are not included in the database or this summary. Figure 2-3 presents the townships, ranges, and sections of the DWR well completion records that were queried for this analysis, this area is somewhat larger than the study area.

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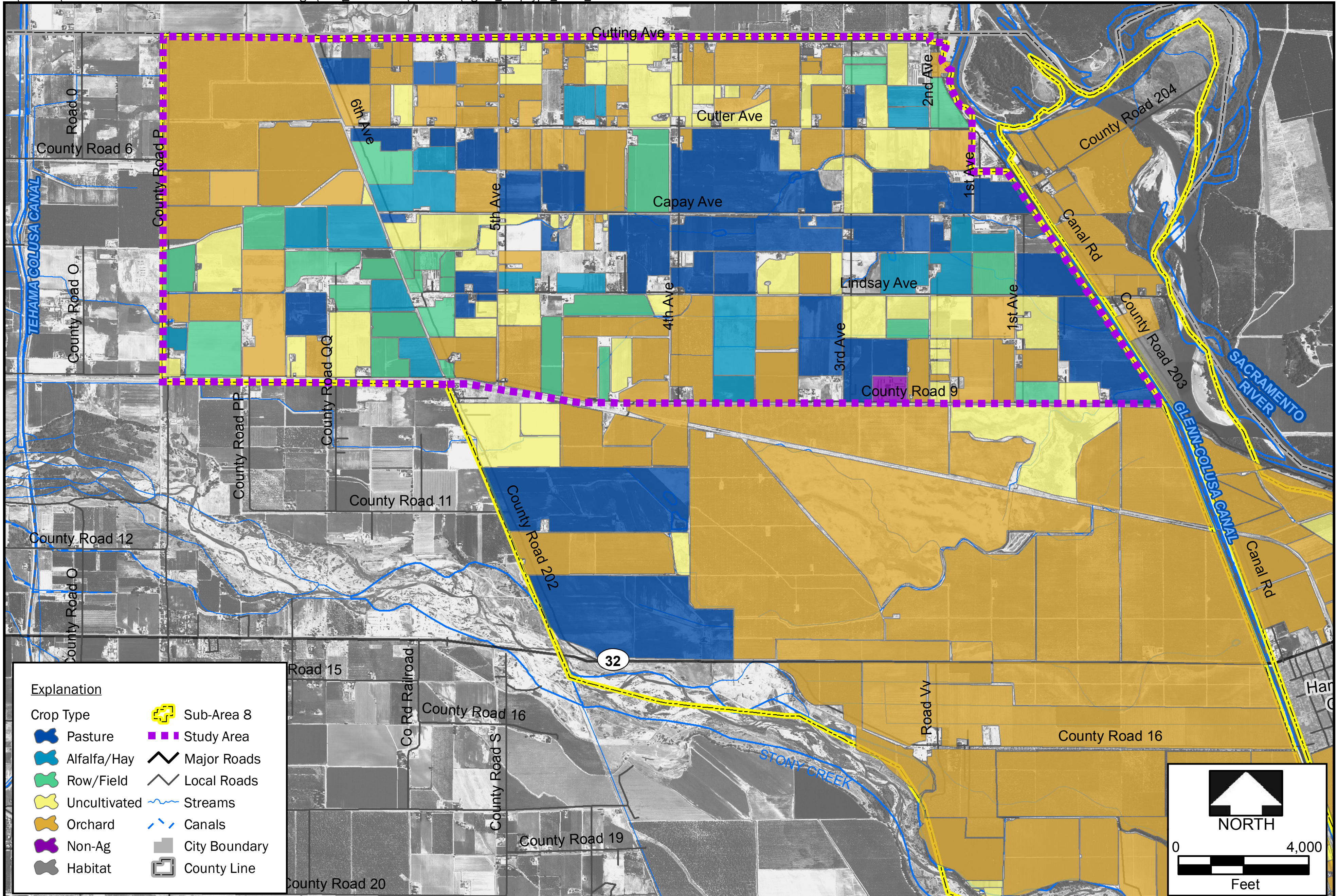

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PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 2-1**
DATE 01/03/2013	TITLE **Crop Type**	

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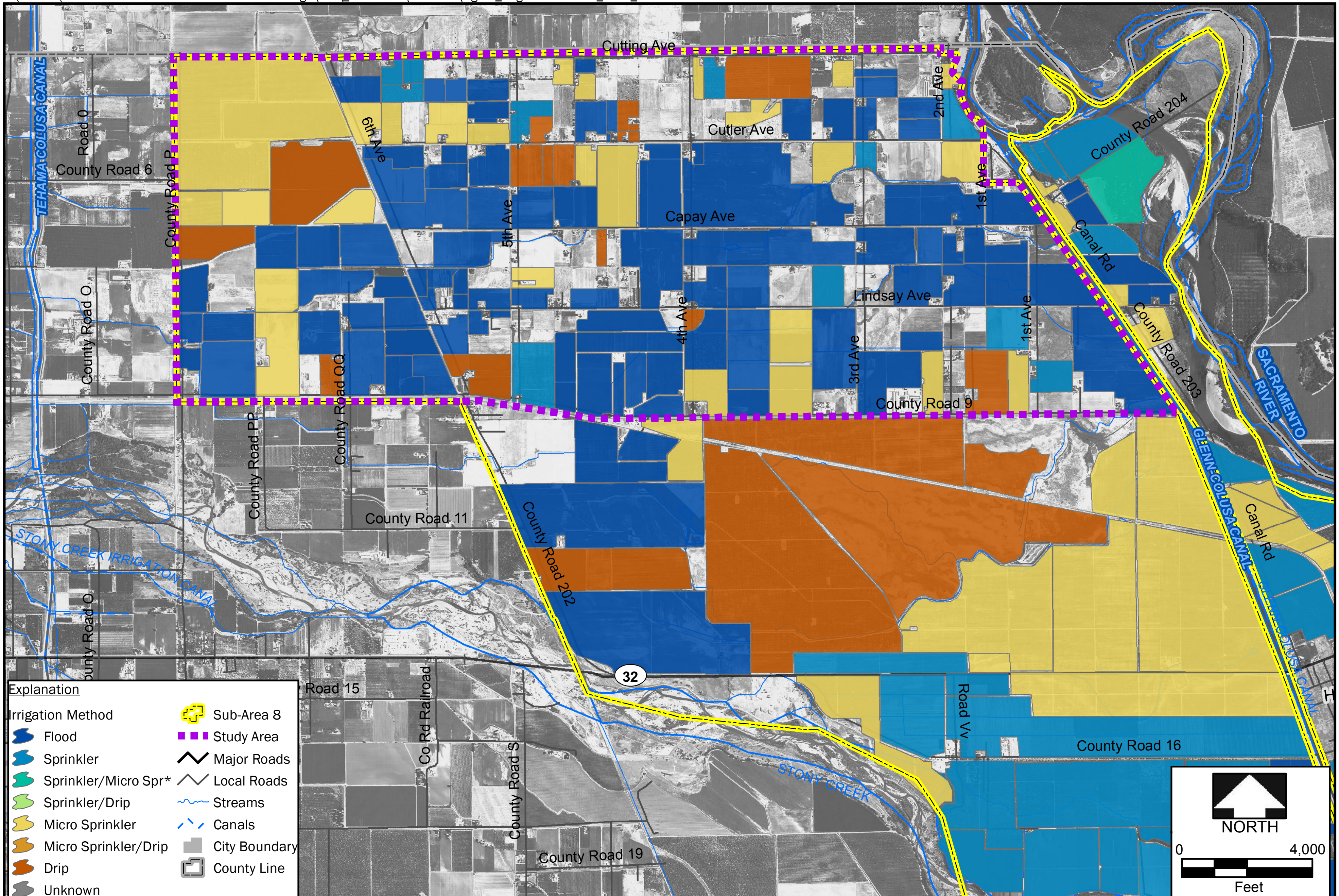

Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 2-2**
	DATE 01/03/2012	TITLE **Irrigation Methods**	

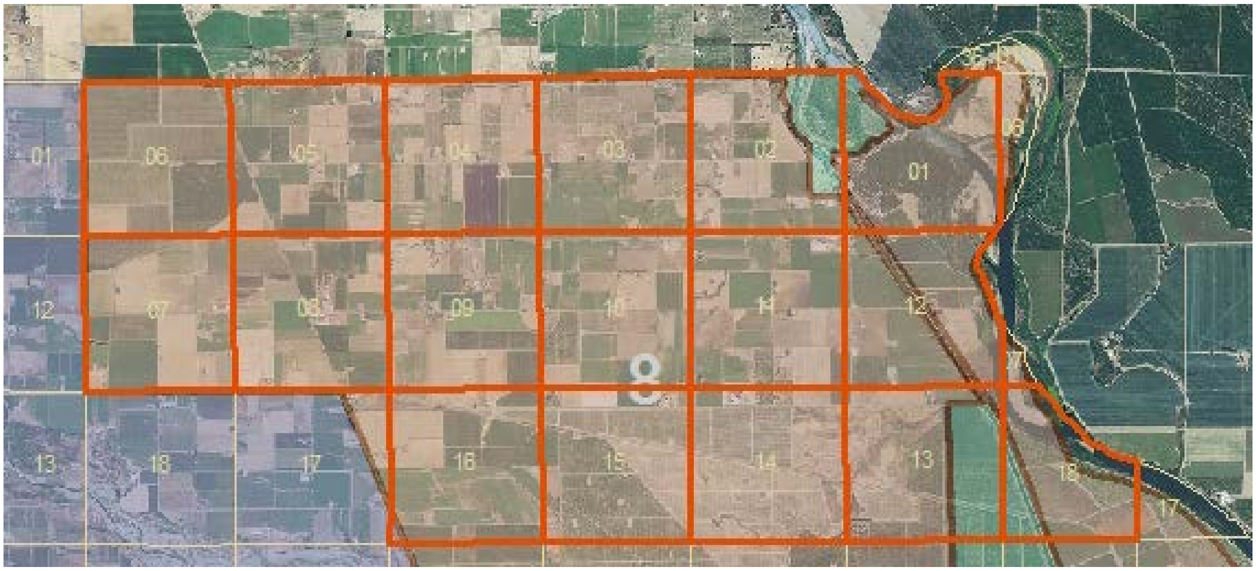

Figure 2-3. Township, Range, and Sections of DWR Well Log Database

The DWR database reports a total of 182 domestic wells within the study area. Figure 2-4 presents a graph that illustrates well depth range and cumulative frequency depth distribution for domestic wells in the study area. The left (vertical) axis, cumulative frequency, shows the percent of all wells that are shallower than the line. The right (horizontal) axis shows well depth. For example, this graph shows that the average depth of domestic wells in the study area is 100 feet, with minimum depth of 40 feet and maximum depth of 440 feet. The steep curve of the cumulative frequency line on this figure indicates that water has been available for domestic uses at depths shallower than 200 feet in the study area. The flat part of the curve at depths greater than 200 feet show that water at greater depths is not used frequently for domestic uses. Lastly, the cumulative frequency curve shows that:

– 30% of domestic wells in the area are 80 feet deep or shallower,
– 50% of domestic wells in the area are 100 feet deep or shallower, and
– 90% of domestic wells in the area are 180 feet deep or shallower.

The DWR database reports a total of 101 irrigation wells within the study area. Figure 2-5 presents a graph that illustrates well depth range and cumulative frequency depth distribution for irrigation wells in the study area. This graph shows that the average depth of irrigation wells in the study area is 220 feet, with minimum depth of 80 feet and maximum depth of 1,000 feet. The shallower curve of the cumulative frequency line on this figure indicates that water is being used for irrigation uses at a variety of depths. The flat part of the curve at depths greater than 480 feet show that water at greater depths is not used frequently for irrigation uses. Lastly, the cumulative frequency curve shows that:

– 30% of irrigation wells in the area are 200 feet deep or shallower,
– 50% of irrigation wells in the area are 220 feet deep or shallower, and
– 90% of irrigation wells in the area are 420 feet deep or shallower.

Figure 2-6 presents the spatial distribution of irrigation, domestic, monitoring, and other wells in the vicinity of SubArea-8. Figure 2-6 shows the majority of domestic wells in SubArea-8 are within the study area. Domestic wells are typically clustered along roadways, while irrigation wells are more spread out.

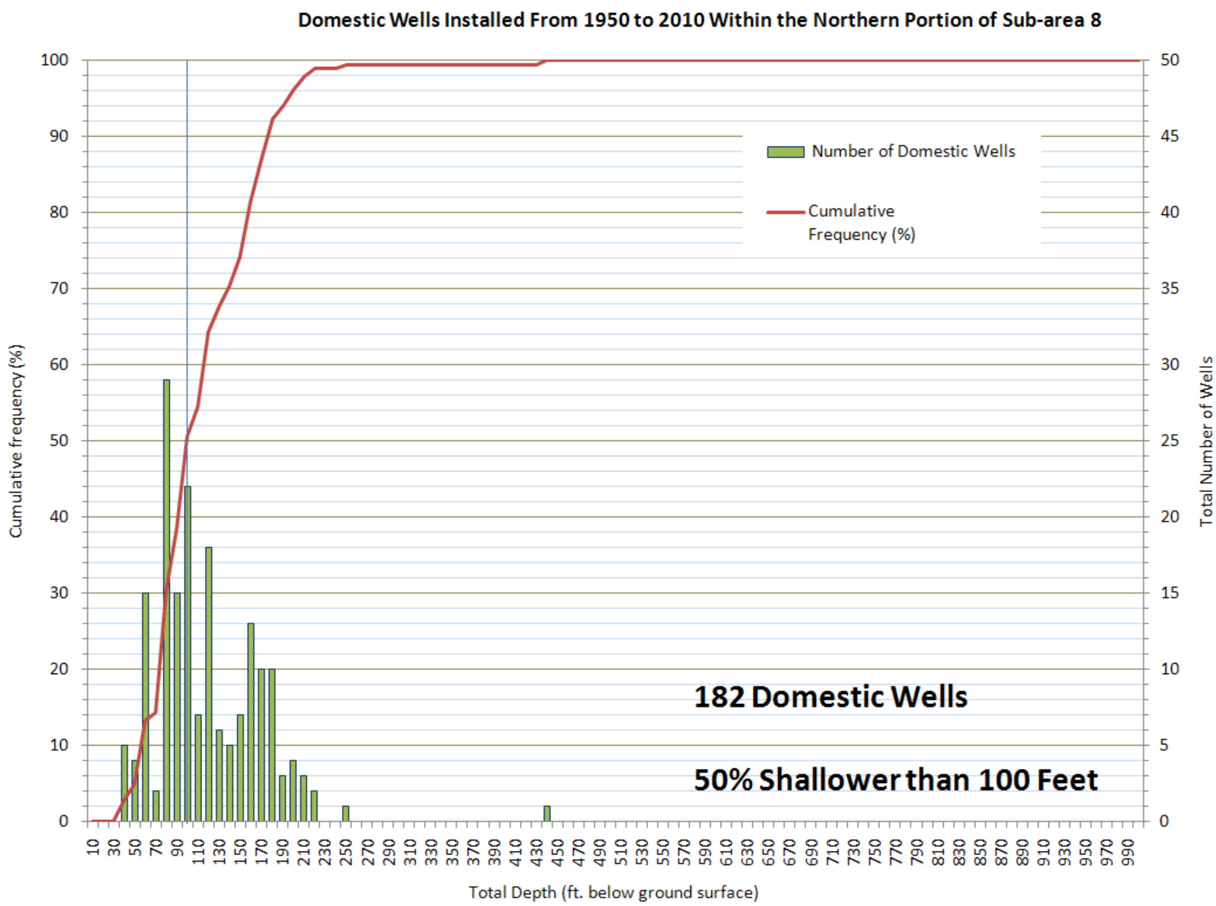

Figure 2-4. Domestic Well Cumulative Frequency Curve

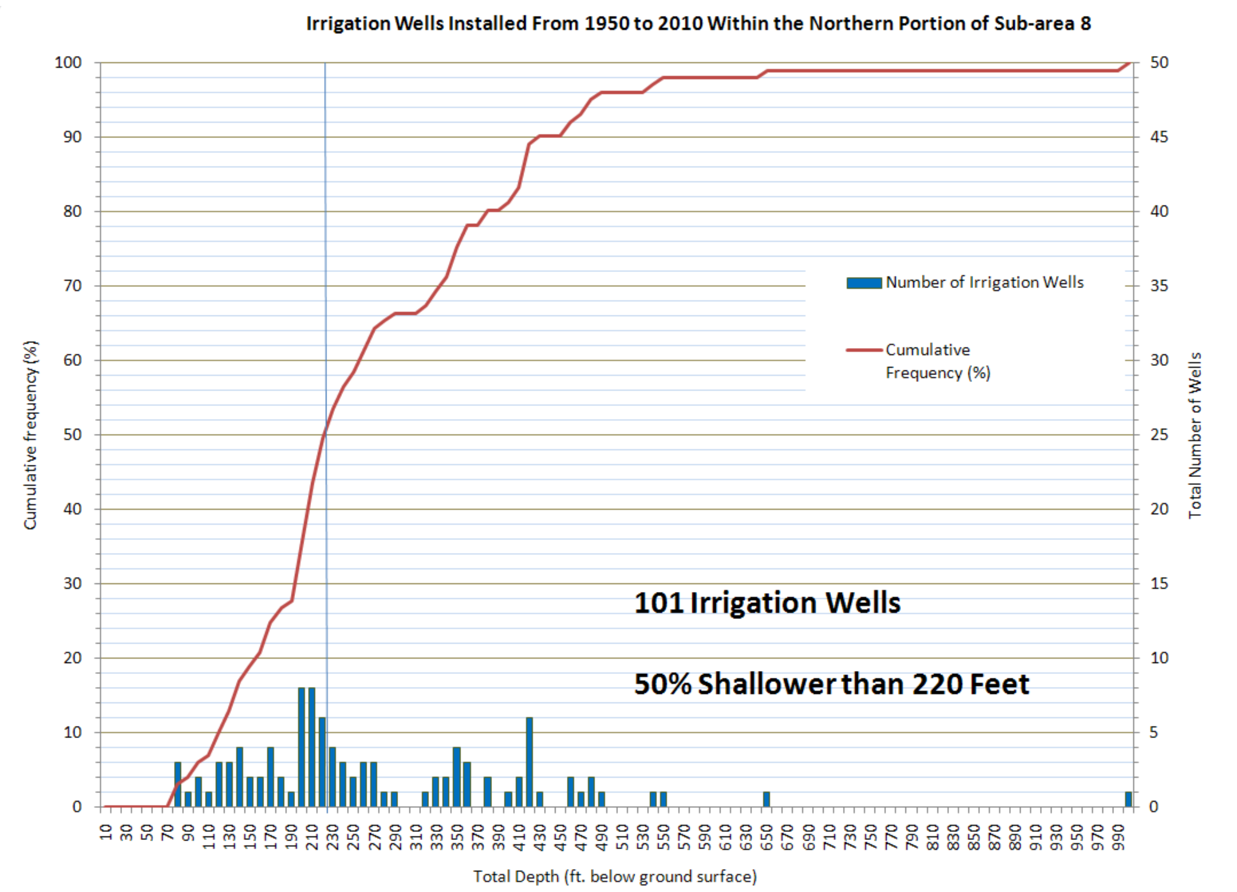

Figure 2-5. Irrigation Well Cumulative Frequency Curve

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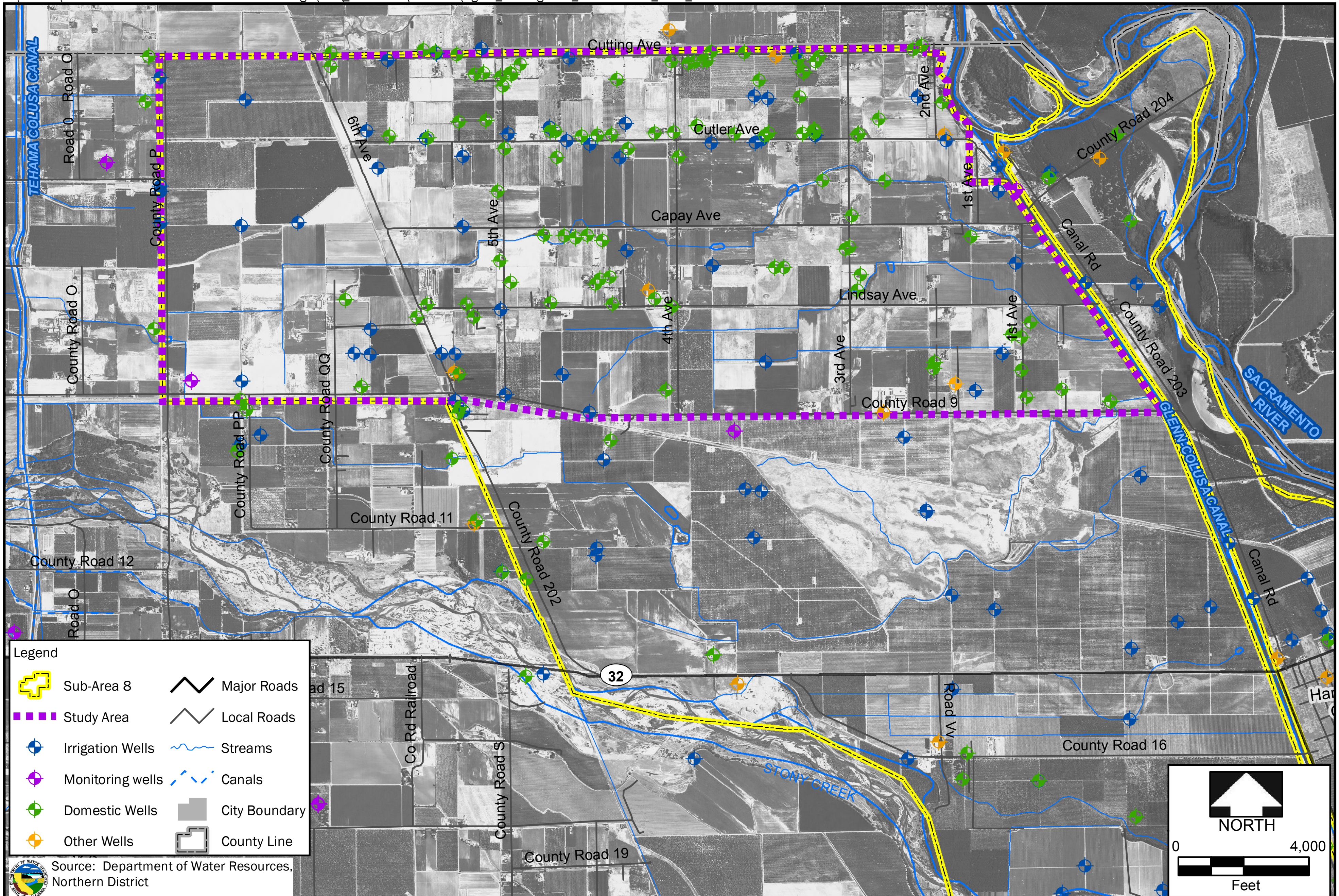

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PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 2-6**
DATE 01/03/2012	TITLE **Spatial Distribution of Wells**	

Figure 2-7 presents the number of wells drilled in the study area each year since 1970. Figure 2-7 shows that on average, less than five wells were drilled in the study area each year. Notable exceptions include 1977 and the early 2000's.

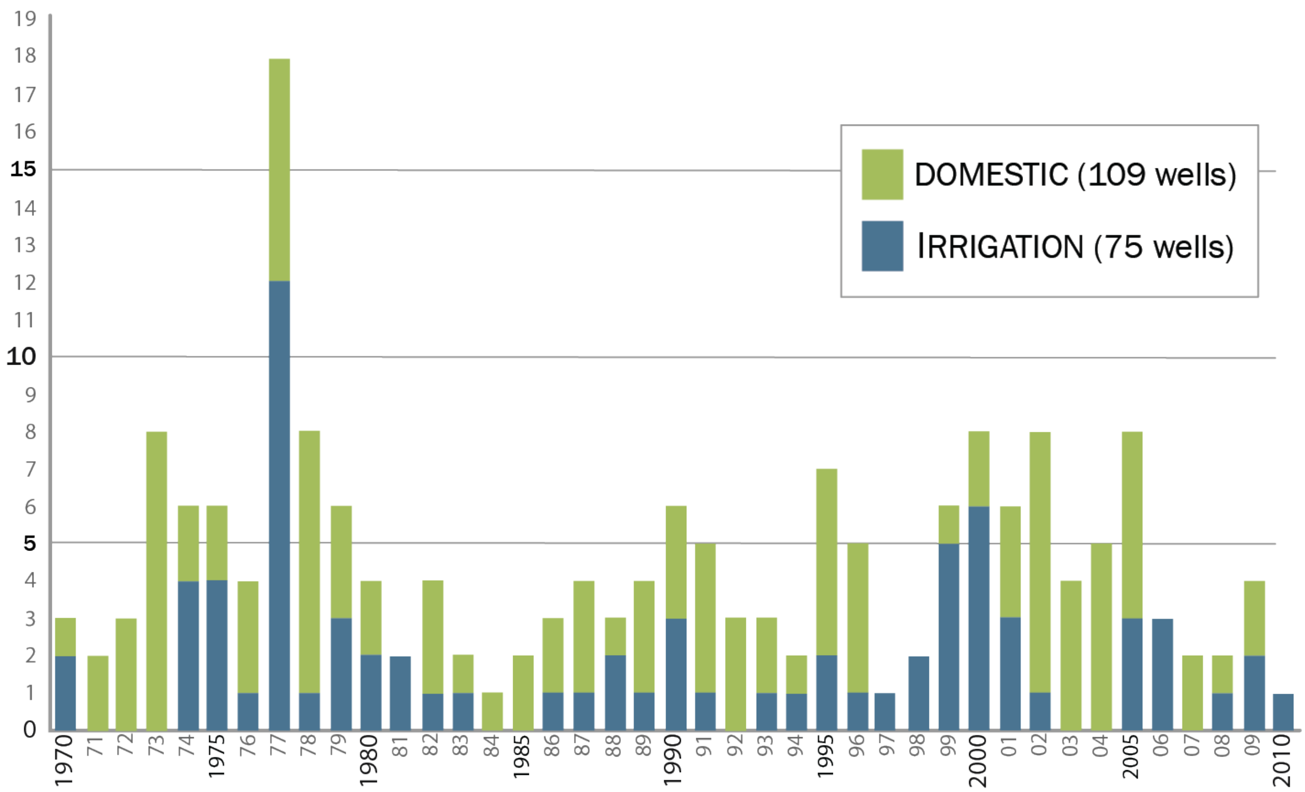

Figure 2-7. Wells Drilled by Year

2.4 Existing Drainages and Canals

A field inventory of existing drainages and canals was conducted in the study area. The results of the inventory are shown in Figure 2-8.

The Tehama Colusa Canal (TC Canal) flows north to south approximately 1 mile west of the study area. Directly west of the study area, canals delivering water to end users of the Orland Unit Water Users Association (Orland Unit) cross the TC Canal. One Orland Unit canal crosses the TC Canal at County Road 6 then branches into canals feeding areas from just south of County Road 6 up to Malton Switch Road. The Orland Unit canal crossing the TC Canal a quarter mile north of County Road 8 supplies water from the crossing point to canals south, including a moderately sized canal along part of the south side of County Road 8. The Orland Unit irrigation supply canals terminate roughly ½ mile west of County Road P.

The streams shown crossing the TC Canal on Figure 2-8 continue as unlined channels through the Orland Unit service area and into the study area. These streams carry irrigation tailwater during the irrigation season and stormwater runoff during the rainy season. West of County Road P, reaches of these channels are overgrown with blackberries and other vegetation.

In the southern portion of the study area, the main drainage channel carrying water from the upstream Orland Unit area flows generally eastward, ultimately merging with a smaller drainage channel near 1st Avenue and County Road 6 before emptying into the Glenn-Colusa Canal.

The smaller southern drainage channel in the study area begins south of County Road 8 about ¼ mile east of 5th Avenue. It also flows generally east until merging with the main drainage channel mentioned above. There are a few dams and existing pumped diversion facilities on the two southern drainage channels.

In the northern portion of the study area, there is a ½ mile long north-south level channel along the east side of County Road P from Malton Switch Road down to an eastward flowing unlined drainage ditch between orchards. This channel ultimately turns north, crosses Malton Switch Road, and merges with a major drainage channel flowing east about ¼ mile north of Malton Switch Road. This channel flows mostly east past farm fields in Tehama County that could be served by the project and ultimately empties into the Sacramento River. There are a few small retention dams and diversion facilities already existing on this channel.

Dimensions and hydraulic capacities of the canals and ditches in the study area that could be used for surface water delivery are discussed in Section 3.6.

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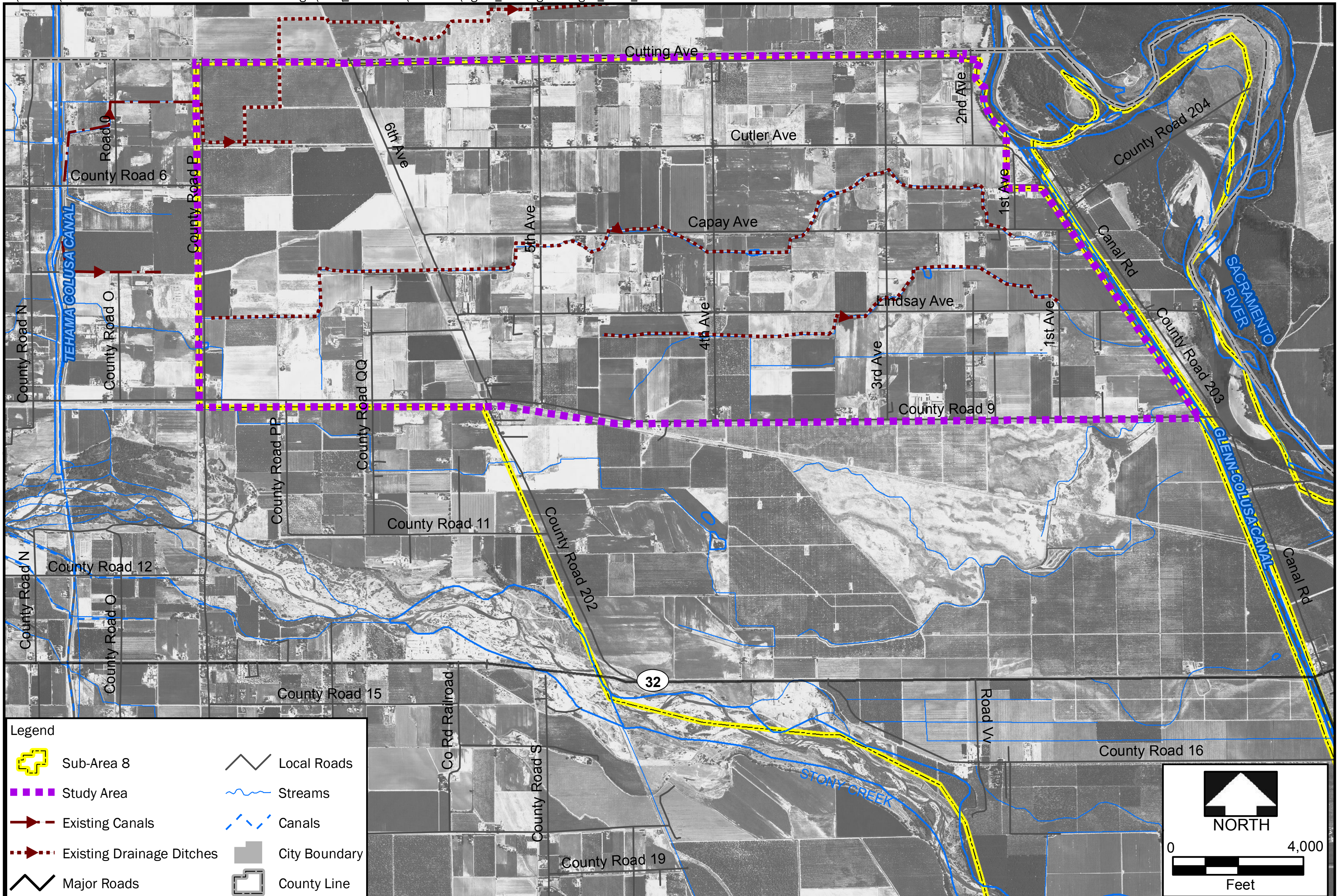

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DATE 01/03/2012

SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**

TITLE **Existing Drainages and Canals**

Figure 2-8

2.5 Advantageous Direct Recharge Areas

This portion of the study was conducted to identify areas where it would be advantageous to investigate potential locations for direct groundwater recharge. This section includes information about the study area, data collected for this task, analysis performed, and recommended areas for further investigation. The majority of figures referenced in this section are included in Appendix A, with key figures presented within the section. Figures presented in Appendix A are referred to in order as Figure A-1 through Figure A-25.

2.5.1 Data Collected

Data were collected for the direct recharge area portion of the study and compiled from existing GIS datasets, DWR provided groundwater information, and recommended data from Glenn County. Data were compiled in GIS format to facilitate analysis. This section presents and describes the data used in this study.

Geology

Geology in a GIS format was provided by DWR Northern District (Figure A-1). Geology was used in this study to identify surficial exposures of geologic formations that were more likely to have permeabilities that would be appropriate for recharge activities.

Soil

Soil data were acquired from the National Resources Conservation Service (Figure A-2). Soil data were sorted by textural class during analysis. Soil data were used in this study to identify more permeable soils appropriate for recharge activities.

Groundwater Contours

Contours of groundwater elevation for spring (usually measured in March) and summer (usually measured in July and August) measurements from the years 2006 to 2010 were collected from DWR Northern District (Figures A-3 through A-12). Contour information was analyzed to identify portions of the study area that would benefit from recharge activities.

Depth to Water Contour

A contour of average depth to water was provided by DWR Northern District and reported in feet below ground surface (Figure A-13). This map was created using information from shallow (less than 200 foot deep) groundwater wells. Depth to water information was used to identify portions of the study area that have enough aquifer space to receive water from recharge activities.

Two major criteria were identified as necessary for an area to qualify for further consideration as a potential site for direct recharge. These criteria included the physical potential for recharge (i.e. can water percolate into the ground), and areas of groundwater demand.

Collected data were reviewed and analyzed to identify areas where recharge efforts are likely to be successful, areas of groundwater use. Geologic and soil data were used to identify areas where water is likely to infiltrate. Groundwater contours were used to identify areas where groundwater demand was high. Criteria were developed for each data source used, which are described in Section 2.5.3. Figure 2-9 illustrates the general project approach.

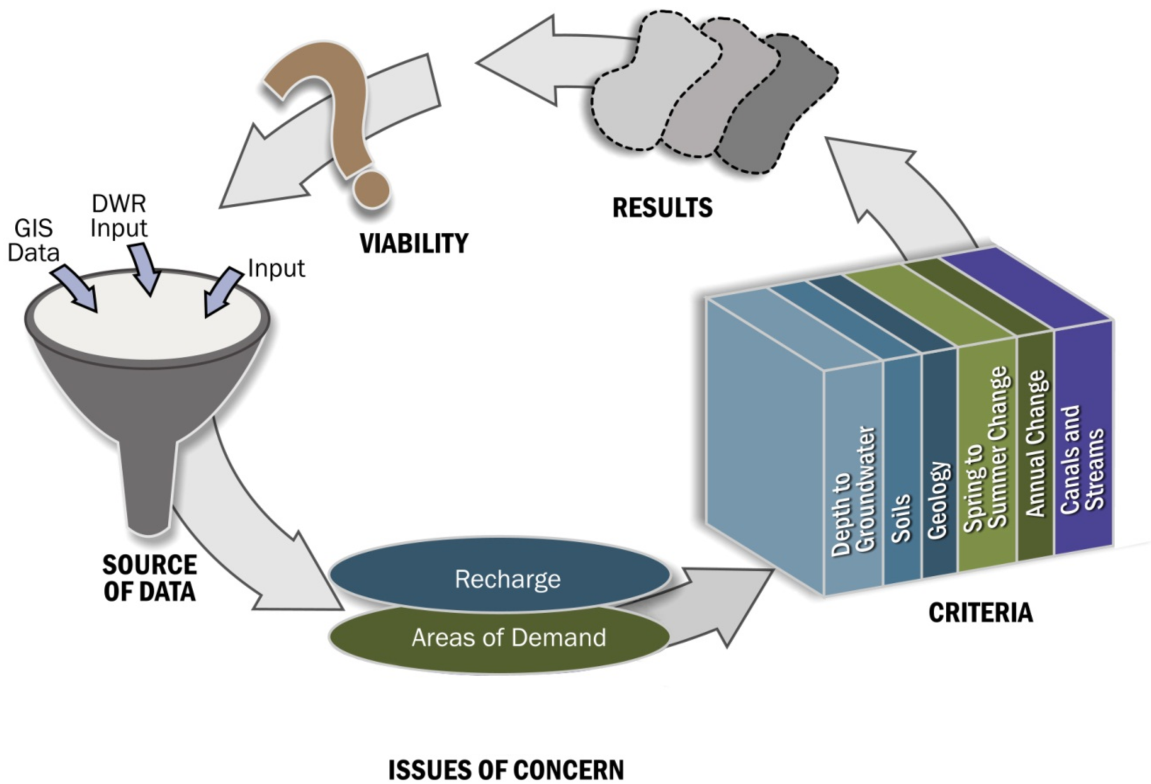

Figure 2-9. Generalized Approach

2.5.2 Groundwater Contour Analysis

Groundwater contours for spring and summer measurements from the years 2006 to 2010 (Figures A-3 through A-12) were used in this analysis to identify areas of the study area that would benefit from groundwater recharge activities. To identify those areas that would benefit, two analyses were performed on the contour data. The first analysis was of spring to summer groundwater change, and the second analysis was of spring to spring change over the period from 2006 to 2010. Analysis was performed using ArcGIS 10 to develop surfaces that represent the contours and then subtracting one surface from another surface. The difference between the surfaces was then contoured. The years 2006 through 2010 were the only years with readily available contour information.

Analysis of the change in groundwater levels between the spring and summer contours for the years 2006 to 2010 was performed to identify the portions of the study area that experienced drawdowns during the irrigation season. Areas that experienced regular spring to summer drawdowns are indicative of areas with established groundwater demand, and therefore are areas that could benefit from the increased groundwater made available through direct recharge or in-lieu recharge activities. Contours for spring to summer change in groundwater elevation are presented in Figures A-14 through A-18. Summer was used for this comparison instead of fall because summer measurements are typically when groundwater levels are the lowest for the year, and capture the drawdown due to pumping more clearly.

Figure 2-10, presents portions of the study area that experienced spring to summer drawdowns of over 25 feet between 2006 and 2010. Portions of the study area that experienced spring to summer drawdowns over 25 feet were considered areas of need that would benefit from groundwater recharge activities. Spring to summer drawdowns were largest in the northwestern portion of the study area.

Analysis of spring to spring change from 2006 to 2010 was performed to identify the portions of the study area that experienced a decline in groundwater levels over the five year period of spring measurements. This decline is possibly caused by dry periods over the period of analysis. If the decline is the result of dry periods, areas of decline are areas that are likely to decline first in future dry periods, and therefore are areas that could benefit from groundwater recharge activities. A contour map of the changes in groundwater elevations from spring 2006 to spring 2010 is presented in Figure 2-11. Portions of the study area that experienced a reduction in groundwater levels greater than 10 feet were considered areas of need that would benefit from groundwater recharge activities.

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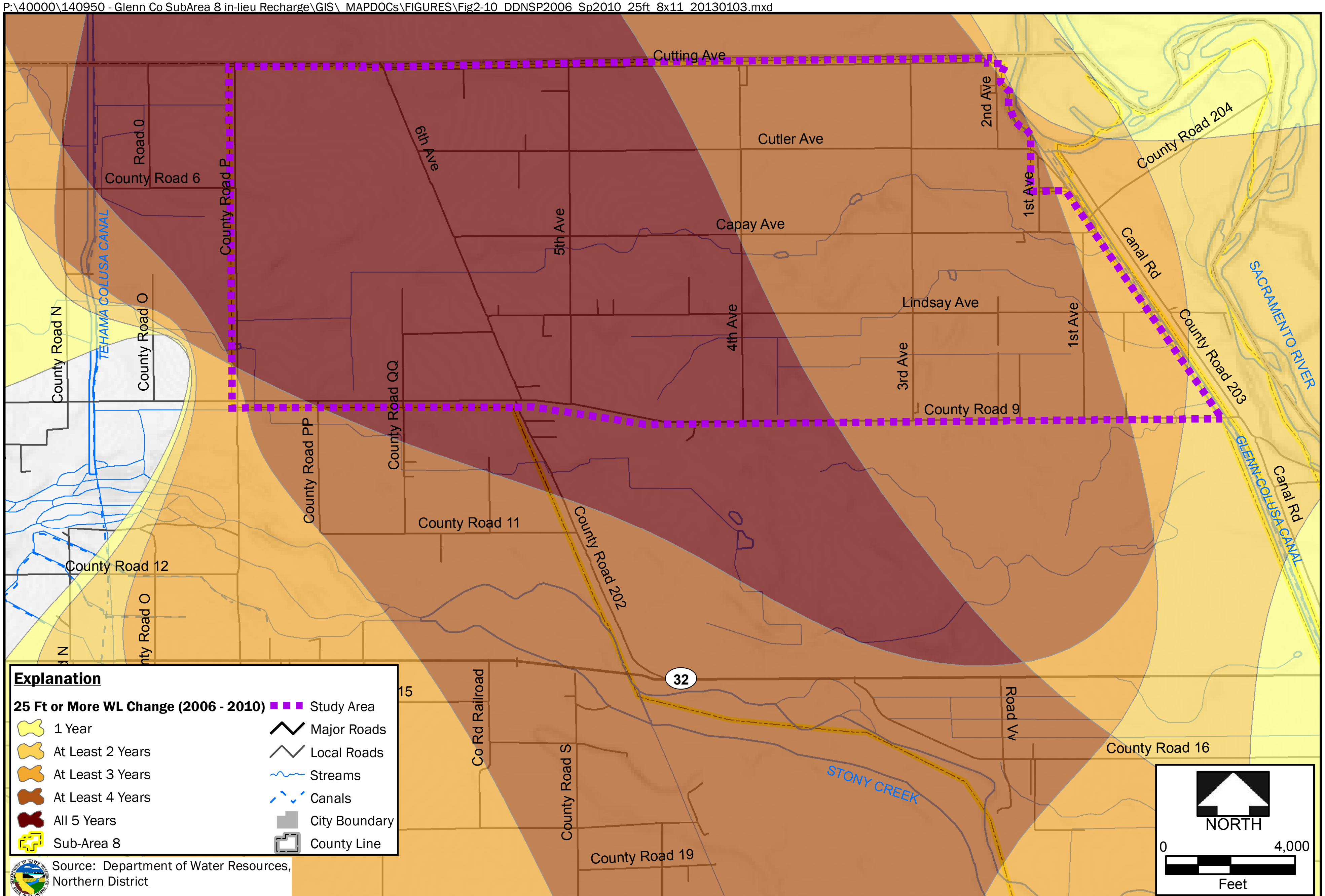

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PROJECT	SITE	
140950	**Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 2-10**
DATE 01/03/2012	TITLE **Areas That Experienced Greater Than 25 Feet of Spring-Summer Drawdown Within 2006-2010**	

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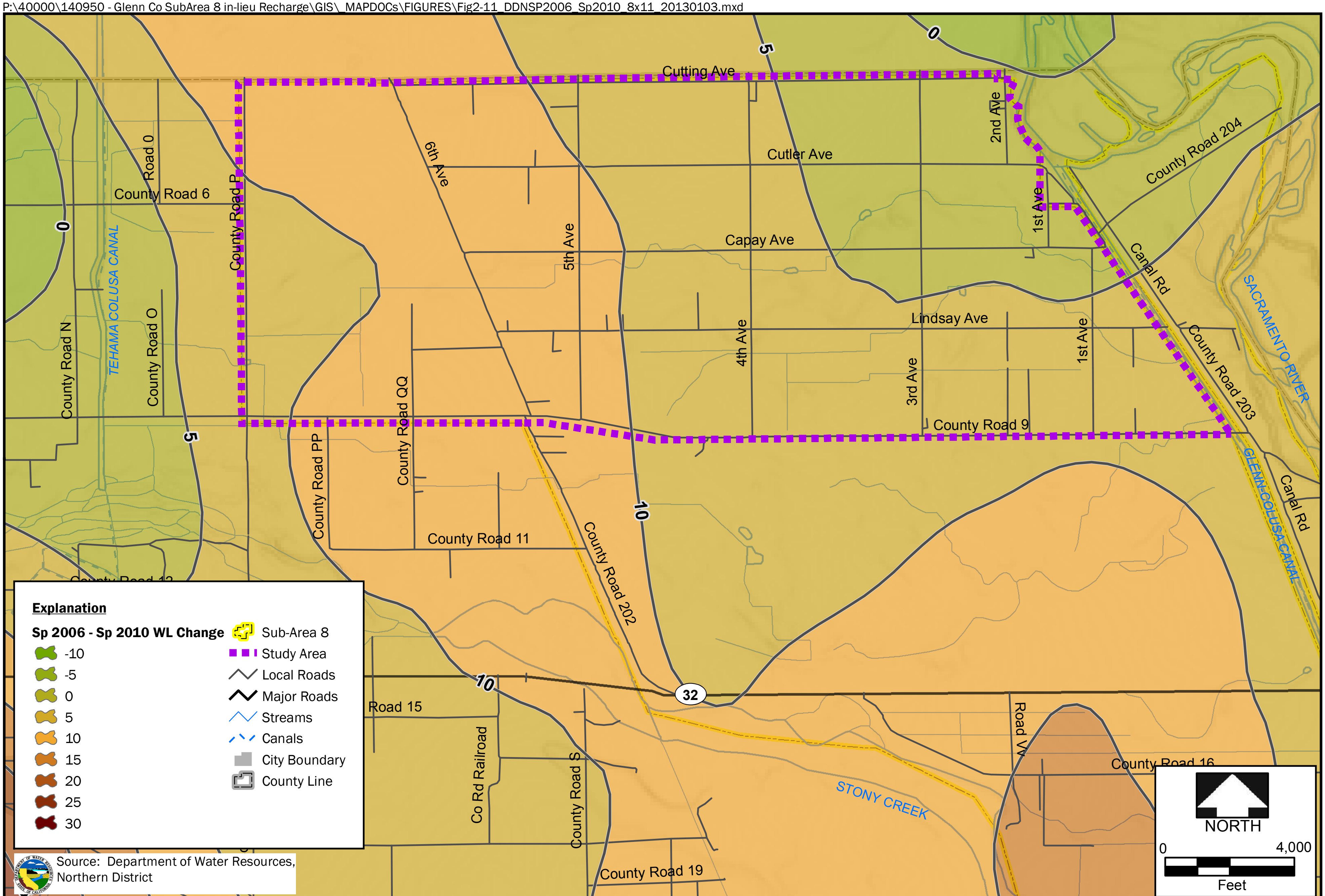


Brown AND Caldwell	PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure 2-11
	DATE 01/03/2012	TITLE Spring 2006 to Spring 2010 Decrease in Groundwater Elevation	

2.5.3 Selection Criteria

This section discusses the selection criteria used to identify potential groundwater recharge areas. The criteria list is organized by the screening order and summarized in Table 2-1.

Geology: There are several geologic formations within the study area and three of the formations are preferred because of higher probable permeability that will allow for faster water percolation from the surface to the water table. The Pleistocene/Holocene Riverbank and Modesto Formations and Alluvium units are the three geologic units used to identify suitable direct groundwater recharge areas.

Soils: Porous surface soils are needed for groundwater percolation. NCRS soil maps were used to identify non-silty loams and stream gravels as selection criteria. Soils containing silt or clay were screened out as fine grained materials will slow or prevent water percolation.

Areas of Need: Areas that experienced a decline in water levels of 25 feet or greater from spring to summer during two years from 2006 to 2010 or areas that experienced a 10 foot or greater decline in groundwater elevations from spring 2006 to spring of 2010 are areas that demonstrate that the area uses groundwater, and may benefit from recharge. Analysis indicates this area covers the entire study area.

Depth to water: There must be appropriate storage space in the water bearing unit so as not to cause water logging or nuisance seepage to overlying crops. A water level of greater than 30 feet below the surface during the summer of 2008 was selected to identify areas with enough storage for a groundwater recharge activity to be beneficial. Areas with less than 30 feet of space before the water table are more likely to experience undesirably high groundwater levels in the region of recharge. Depth to water contours for 2008 were the only depth to water contours available at the time of analysis.

Table 2-1. Data Type and Selection Criteria

Data Type	Issue of Concern	Selection Criteria
Geology	Potential for recharge	Riverbank, Modesto, Alluvium
Soils	Potential for recharge	Loam, Cobbly Loam, Sandy Loam, and Riverwash
Change in groundwater levels spring to summer	Areas of need	Areas that experienced a larger than 25 foot decline from spring to summer 2 or more times out of 5 years or areas that experienced a 10 foot or greater decline in groundwater elevations from spring 2006 to spring 2010
Depth to water	Potential for recharge	Depth to water in Summer 2008 estimated to be greater than 30 feet in shallow wells

2.5.4 Application of Selection Criteria

Selection criteria were applied to the data sets within the study area to identify the areas recommended for additional investigation and potential recharge activities. This section describes the application of selection criteria in a sequential manner.

Step 1 – Geology and Soil: The first application of criteria consisted of comparing geology and soil-type data. Figure A-19 presents portions of the study area that are both overlying Riverbank, Modesto, or Alluvium geologic formations and have overlying soils comprised of loam, cobbly loam, sandy loam, or riverwash soils.

Step 2 – Areas of Need: The second application of criteria was the comparison of the area identified in step 1 to areas of need. Areas of need are defined in this study as areas that experienced 2 or more years of a greater than 25 foot spring to summer groundwater elevation decline, or areas that experienced a 10 foot or greater decline in groundwater elevations from spring of 2006 to spring of 2010. Figure A-20 presents the portion of the County selected by comparison of step 1 with areas of need.

Step 3 – Depth to Groundwater: The third application of criteria was the comparison of the area identified in step 2 with areas that have an average depth to groundwater that is greater than 30 feet. Figure A-21 presents portions of the County that meet this criteria.

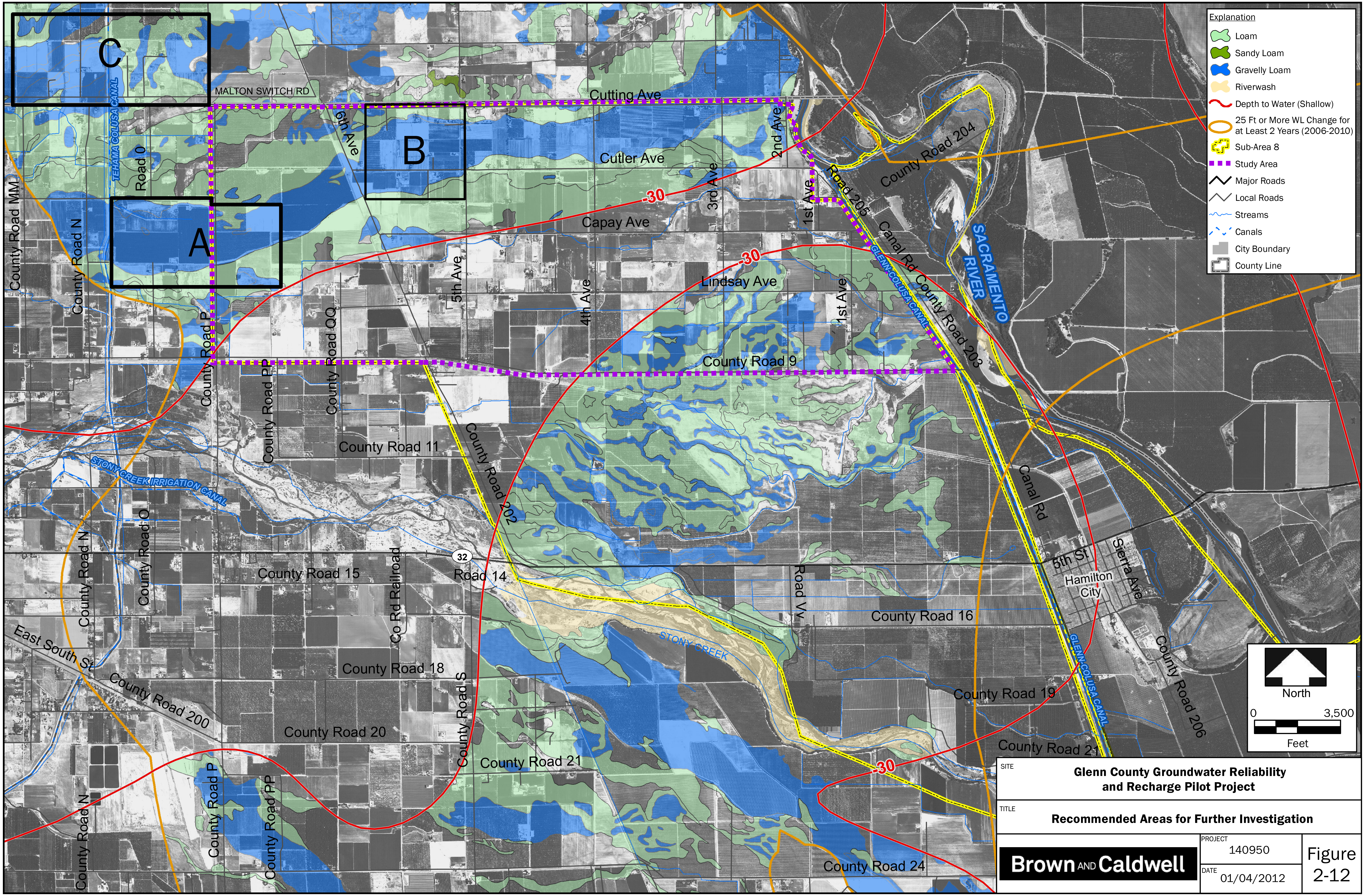
2.5.5 Recommended Areas for Potential Direct Recharge Programs

This section presents the recommended areas for further groundwater recharge investigation. After screening level analysis, any area in Figure A-21 that is green or blue is potentially worthy of further consideration as a potential recharge area. Additional focus on areas that are especially promising are included in this section, and are identified as recommended area A, B, and C. These recommended areas are presented in large scale in Figure 2-12. Specific maps of areas A, B, and C are presented in Appendix A as Figures A-23 through A-25 and are discussed below.

Recommended Area A: Recommended area A includes areas near the TC Canal, south of County Road 6, and on both sides of County Road P. Recommended area A is a strong candidate for a recharge project because it overlies a selected area that meets the selection criteria, and is located over a large area of gravelly soil. The long strip of gravelly soil runs from west to east, towards the Sacramento River (Figure A-22), and is likely a paleochannel, which is a prehistoric path of Stony Creek. Performing recharge operations in recommended area A would potentially put water into the paleochannel, which would provide a migration path for recharged water that moves through a significant portion of the study area. Recommended area A is presented in Figure A-23.

Recommended Area B: Recommended Area B includes area northeast of 6th Avenue, around Cutler Avenue, and is bounded on the north by Cutting Avenue, and on the east by 5th Avenue. Recommended area B is a strong candidate for a recharge project for similar reasons to area A, but is slightly less desirable because recharged water is likely to reach less of the study area. Recommended area B is presented in Figure A-24.

Recommended Area C: Recommended Area C is located north of Glenn County, along both sides of the TC Canal (Figure A-25). This area was identified in the report *Summary Report for Groundwater Recharge Area Location Study* (June 2011), which was prepared for Tehama County. The area identified in that report is restricted to the area immediately near the canal to ensure that water can reach possible direct recharge sites. This area is also suitable for in-lieu recharge activities because the land use in the area is primarily irrigated land that is irrigated with groundwater. A small portion of this recommended area is within the potential service area of the surface water delivery system described in Section 3.



SITE: Glenn County Groundwater Reliability and Recharge Pilot Project

TITLE: Recommended Areas for Further Investigation

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DATE 01/04/2012

Figure 2-12

2.5.6 Methods of Recharge

This section presents conclusions and describes the various methods available to perform groundwater recharge activities. The various methods of direct recharge have different benefits and constraints that make certain methods more beneficial for certain areas and less beneficial for others. Next steps for a direct recharge project would include finding a surface water supply, identifying specific parcels, review of water quality, pilot testing, and long term project implementation.

Direct recharge of groundwater is the process of adding water to an aquifer through human effort. Many different techniques and purposes exist for implementing direct recharge, but this discussion focuses on augmentation of a water supply for later use. Projects are varied but usually involve storing surplus surface water in an aquifer for later use. Recovery (withdrawal) of the stored underground water commonly is by wells.

Direct recharge requires some form of man-made structures and several techniques include:

- Flooded Fields,
- Spreading Basins,
- Excavated Recharge Pits,
- Dry Wells,
- Injection Wells,
- Enhanced Recharge through Streams or Unlined Canals, and
- Flood Detention Basins.

Each groundwater recharge technique is briefly described in the following sections.

Flooded Fields

This technique includes applying water to an undisturbed field and allowing it to infiltrate.

Depending on water availability, the field could be flooded quickly to a standing depth of about 10 inches, or water could be delivered continuously at a rate that nearly matches the infiltration rate. The field would be surrounded by a small (6 to 12-inch tall) berm and may also include several interior berms to regulate the water levels and flow across the field. Interior berms would be needed on gradually sloped sites. In addition to groundwater recharge, flooded fields would provide seasonal habitat opportunities and winter habitat for waterfowl.

Flooded fields are most appropriate in locations where cultivation has been practiced and vertical impediments to infiltration such as hardpan are not present or are shallow. If shallow hardpan exists at a depth of less than five feet below ground surface, the field would be ripped to increase infiltration characteristics. Before ripping could occur, the existing and potential habitat value of the site would need to be assessed. Field flooding may not be applicable at sites where hardpan is present at depths greater than five feet below ground surface. Deep ripping can result in the loss of potential vernal pool habitat (in the vernal pool zone) and potential losses of cultural resources.

Spreading Basins

Spreading basins are shallow ponds, excavated to relatively shallow depths (generally less than five feet), that are kept partially full with standing water for sustained periods. Spreading basins are commonly used in large-scale applications, such as those in the southern San Joaquin Valley, and in southern California and Arizona. In large applications, spreading basins provide storage capacity to accept peak flows and provide an efficient means to convey water throughout a site. Spreading basins are applicable in a variety of geologic and topographic conditions. At sites where shallow, vertical impediments, such as organic clay soils or a thin veneer of hardpan are present, the excavation of shallow basins can remove or reduce the effect of these materials thereby increasing infiltration effectiveness. Spreading basins may provide seasonal habitat opportunities and winter habitat for waterfowl.

Excavated Recharge Pits

This technique includes construction of pits to depths of 10 to 15 feet below ground surface.

This technique is most appropriate in areas where vertical impediments such as hardpan are thick and present at depths greater than five feet, and is otherwise similar to spreading basins.

Dry Wells

Dry wells, also known as vadose zone infiltration wells, are wells installed above the water table but below low permeability soils such as clay. The dry well typically contains a perforated pipe that extends from approximately 1 to 2 feet below ground surface to the bottom of the well. The entire well is filled with a permeable material, usually a gravel pack consisting of cobbles, which allows water to percolate through the well to lower more permeable underlying soils, such as sand and gravel. Dry wells would be installed with a direct water supply to each well.

Dry wells are prone to plugging from the accumulation of fine sediment in the coarse material and are only appropriate where the source water has low turbidity. As a dry well becomes plugged with sediment from turbid water, the recharge effectiveness of the well substantially decreases. Once a dry well is plugged, it must be redeveloped so that clogging materials may be removed. This cleaning process is not entirely effective because some fine material will have been carried into the formation and cannot be removed. This technique will therefore not be effective for recharging flood-season water unless a settling basin is constructed or filtration and chlorination is conducted before recharge, which would add significant costs. Pilot testing of this technique would be necessary to determine if such treatment was necessary.

Injection Wells

Injection wells are constructed to recharge water directly to the aquifer. The well contains an injection tube that terminates below the static water table in a well with a screen and filter pack so that positive pressure exists along its entire length. When water is discharged from an injection well, a cone of recharge will form similar in shape but the mirror image of a cone of depression surrounding a pumping well (Driscoll, 1986). In theory, an injection well can recharge as much as the pumping capacity allows. However, problems associated with water quality, high water temperature, biologic activity, and turbidity often reduce the recharge rate over relatively short periods of time (Driscoll, 1986). Injection wells are not well suited for use with floodwater or other sources with high dissolved or suspended solids because fine particles in the water can quickly plug the aquifer in the near vicinity of the well. Generally, water supplies for injection wells are either treated or obtained from high quality sources to assure that water quality requirements can be reliably and consistently met. Injection wells are often designed to operate as both injection and extraction wells. The dual use in this fashion can help keep the wells from clogging as quickly.

Enhanced Recharge in Streams or Unlined Canals

For this type of direct recharge, water is conveyed through stream channels, drainage channels, or unlined canals that lose water to deep percolation, thereby recharging the aquifer. This technique involves modifying existing surface water conveyance facilities to promote additional groundwater recharge where possible. This may be accomplished by deepening or widening an existing channel, or by the installation of temporary dams or check structures to increase in-stream water levels and maximize the wetted surface area to slow the movement of water, and therefore, increase the natural recharge through the streambed.

Costs and performance of this technique can vary significantly, depending on the modification considered. Installation of temporary dams or check structures could be expensive relative to the amount of water that would be recharged. However, this technique should be considered when changes or updates to water diversion facilities are contemplated, particularly those that involve relocation or enlargement. Modifications to the stream bed, such as excavation or widening to expose permeable soils may be cost prohibitive, create undesirable environmental impacts to aquatic species, and cause hydraulic impacts to downstream locations if excavated areas increase the potential for erosion.

Flood Detention Basins

Flood detention basins are designed to either reduce peak flows on neighboring streams during flood events, or to detain local runoff from newly developed areas. Modifications to flood detention basins would include changes to or the addition of diversion facilities for low-flow water deliveries; the addition of pumps from conveyance to detention basin; and changes in the operation of the basins. For each flood detention basin, the groundwater recharge operations would be possible only where the required amount of flood storage could be maintained. Potential modifications to detention basins may be possible to accommodate long-term groundwater recharge without reducing flood protection.

2.5.7 Additional Steps for Direct Groundwater Recharge

Section 2.5 presented the first steps of efforts to investigate the best areas within the study with potential for direct groundwater recharge. A number of activities are required before a direct groundwater recharge facility can be in operation, which include:

Identification of surface water: A surface water supply that can be dedicated to groundwater recharge is necessary to provide the water that will recharge the aquifer. Potentially available supplies include un-utilized surface water available during the flood season and the irrigation season. During flood season, water may be available from storm flows, and potentially available irrigation supplies include surface water purchased from irrigation districts, or surplus irrigation water during above average wet years.

Review of groundwater monitoring for trends: Review of hydrographs in recommended areas can reveal if trends identified during the 2006 to 2010 period are indicative of longer time scale declines. If declines have been occurring for longer periods, this makes these areas more desirable for recharge efforts.

Selection of specific parcels: Specific parcels to solicit participation in direct groundwater recharge activities will need to be selected. Considerations during selection of parcels should include: public or private ownership of the parcel, accessibility, space for recharge operations, local changes in land use patterns, existence of habitat zones, and owner willingness to participate.

Environmental review: An appropriate level of environmental review and analysis will be required when the specific project location is selected. The purpose of an environmental review is to disclose the potential impacts of a project, suggested methods to minimize those impacts, and to discuss project alternatives so that decision-makers will have full information upon which to base their decision.

Secure landowner participation: Landowner participation will need to be secured and documented with a written agreement. Agreements should include discussion of necessary geologic investigations, short term pilot testing, and eventual long term project implementation.

Review of water quality: Water quality is an important consideration during direct recharge activities. Site-specific soil and groundwater testing as well as assessments of the quality of source water will need to be conducted prior to project implementation.

Perform a pilot study: A pilot study needs to be conducted to determine specific sites for investigation and to perform investigation at selected sites to determine the feasibility of long term project implementation. A pilot study should include:

- Field investigation of soil characteristics. Investigation of shallow soils and geology will likely need to be performed through trenching and review of visible strata in the trench by geologists,
- Drilling at selected sites to provide information that will aid in recharge methodology selection, as well as to confirm porosity of subsurface materials,
- Installation of piezometers to monitor the effects of pilot testing on the water table,
- Short term operation of recharge methodologies. Effects of recharge activities on the aquifer will be measured in the installed piezometers, and
- Investigation of groundwater flow during recharge. This portion of the field study will identify retention time of water in the recharge area, and ascertain its flow direction.

Long term project implementation: A specific direct recharge methodology and project site will be selected based on the results of the pilot study, resulting in long term project implementation of the selected methodology at the recommended location.

2.6 In-Lieu Recharge

In-lieu recharge provides many of the same benefits as direct recharge without needing to have high permeability soils or needing to dedicate areas to direct recharge. The first task in the evaluation of in-lieu recharge is determining a service area that would receive surface water in-lieu of pumping groundwater. The study area for this project was identified in Section 1.2 as being the area most susceptible to groundwater declines and also having the crop types and irrigation methods most likely to be able to utilize surface water. The potential project service area is then further refined on a detailed field by field scale based on crop types such as those identified in Section 2.1 and irrigation methods such as those identified in Section 2.2.

Logistics of delivering surface water are the next limiting factor in further defining a potential surface water supply service area. The potential sources of surface water and the existing canals and drainage ways (such as those discussed in Section 2.4) are used to refine a service area to include only those fields which could be feasibly served in a relatively economical manner. Nearby areas that could also benefit and easily be incorporated into the potential service area can be included, even if they are outside the original study area.

The detailed development of a surface water supply service area, delivery option planning, conceptual layout of a system, and estimated costs are presented in Section 3.

Section 3

Analysis of Delivery Options

This section describes the delivery options considered for the potential surface water supply project service area and details the selected option, which includes a conceptual canal layout.

3.1 Basis of Delivery Option Planning

The overall objectives for delivery of surface water to the study area were:

- To reduce groundwater pumping in the study area, especially in the portions of the area with the greatest seasonal and long-term water level declines,
- To supply surface water to as many fields as possible that were not planted to orchards. It was assumed, based upon field surveys, that orchards would preferentially utilize groundwater and microirrigation,
- To take advantage of existing facilities and topography to the extent reasonable as a means to minimize delivery system capital costs, and
- To provide a delivery system with adequate capacity to meet irrigation needs and to provide on-demand supply capability for maximum flexibility and acceptance.

A service area, fields served, water source, and water distribution system layout had to be defined to determine project feasibility. Definition of these project components provides:

- A scenario for landowner/stakeholder feedback,
- A basis for estimating costs, and
- A reasonable starting point for future plans and actions.

3.2 Potential Surface Water Supply Project Service Area and Fields Served

This section describes the selection process used to identify lands that could utilize surface water. The land use and irrigation practices were important factors in determining which fields would be appropriate for surface water use. A field inventory of land use, irrigation practices, and existing drainages and canals was conducted in the study area to identify the crop types grown and the irrigation methods used, as detailed in Section 2. Within the study area, there are crops types and irrigation methods suitable for use with surface water, and crop types and irrigation methods that are not suitable for use with surface water.

Lands that have orchard crops are typically irrigated using microirrigation systems such as drip systems and microsprinklers that are more efficient while using groundwater. Microirrigation systems using groundwater require less filtration and maintenance than microirrigation systems using surface water, so groundwater is typically preferred for microirrigation. Areas using flood and sprinkler irrigation, pasture, alfalfa, hay, row and field crops, and uncultivated areas were selected as areas potentially suitable to use surface water.

Figure 3-1 presents the crop types and irrigation methods that are potentially suitable for utilizing surface water, which total 3,430 acres in the study area. These lands are primarily flood or sprinkler irrigated and generally pasture and field crops. Figure 3-2 presents the same lands as one color to facilitate ease of identification.

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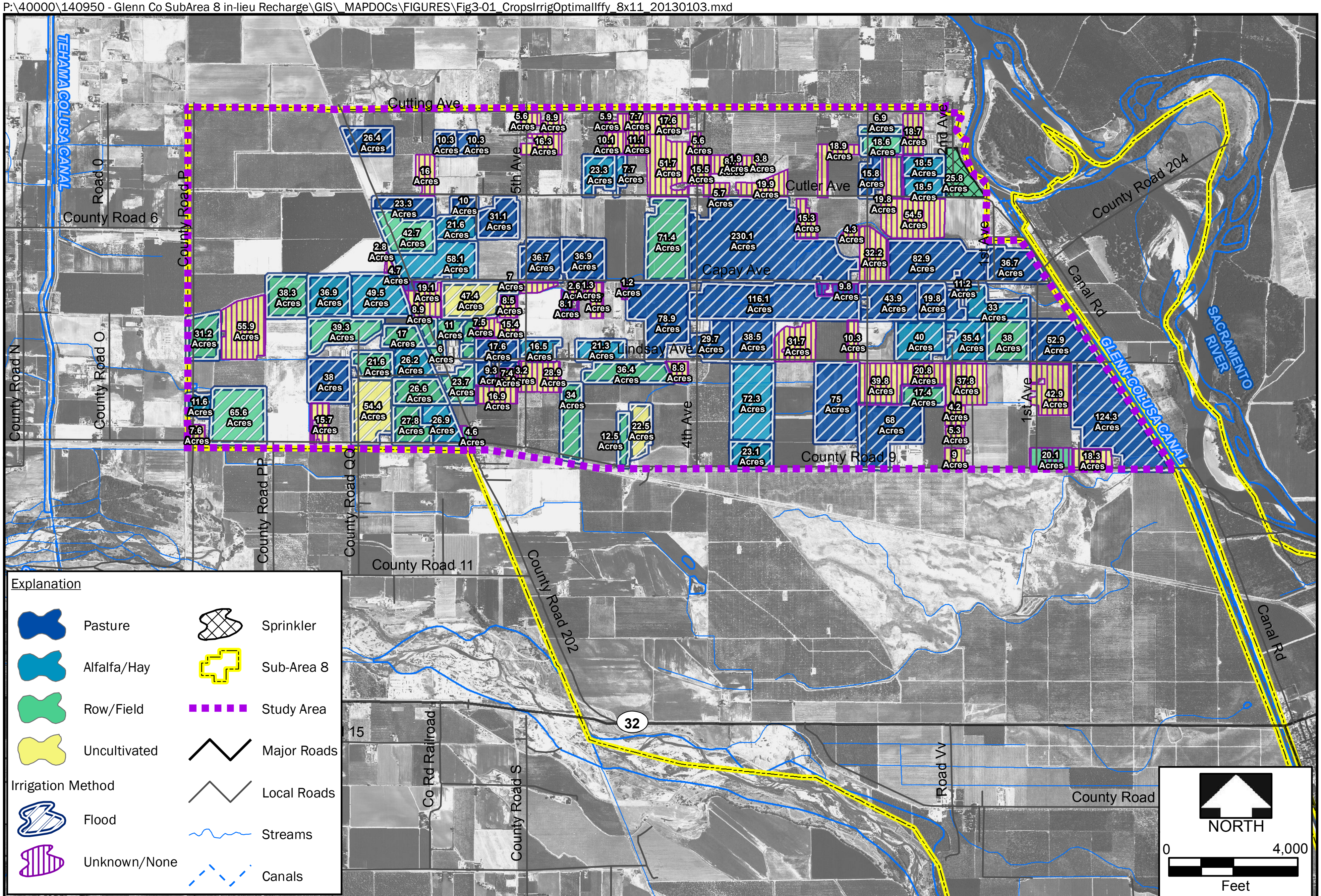

Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 3-1**
	DATE 01/03/2012	TITLE **Crop Types and Irrigation Methods Suitable for Surface Water Delivery**	

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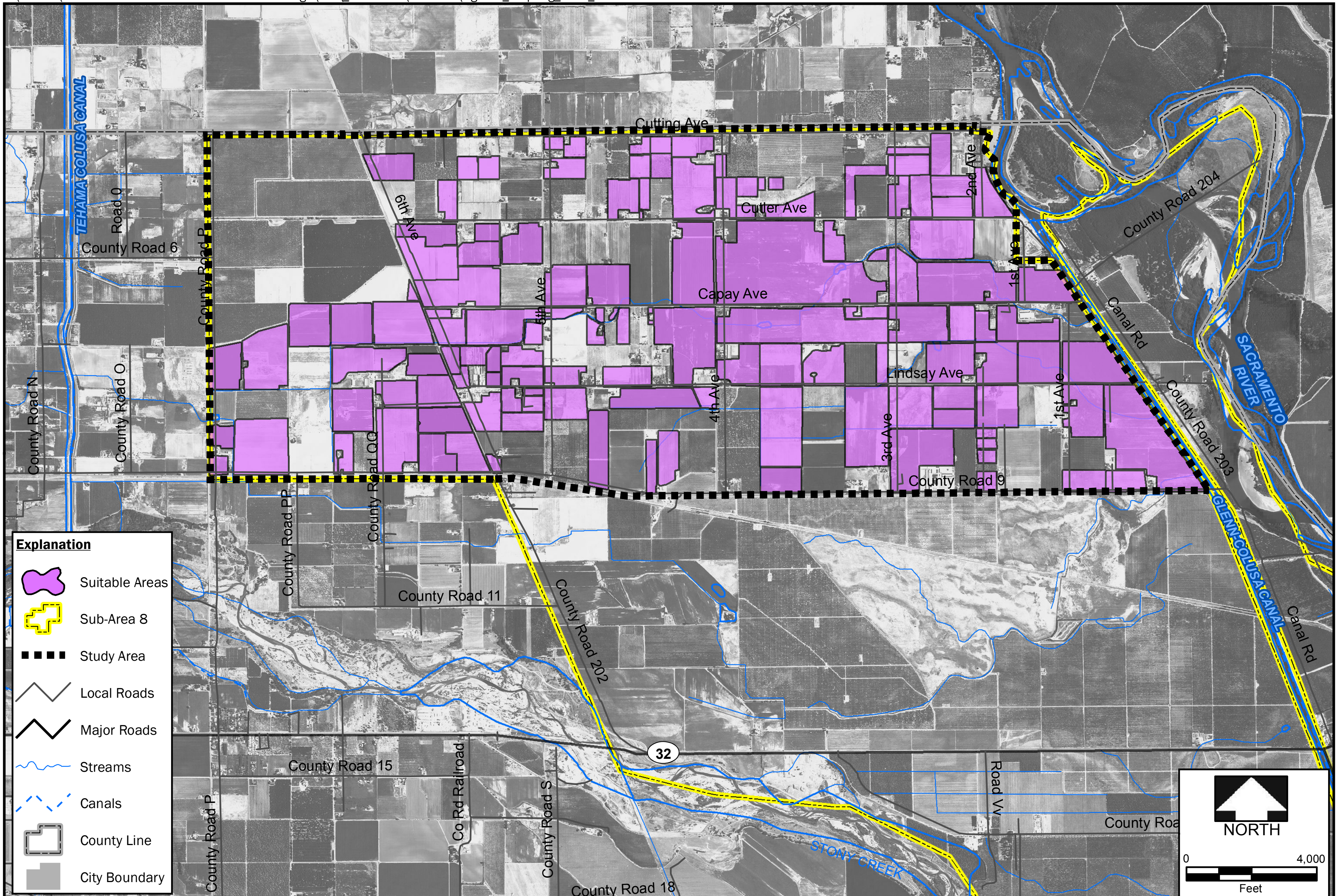

PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure 3-2**
DATE 01/03/2012	TITLE **Areas Suitable for Surface Water**	

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As the conceptual canal layout was developed, it became apparent that not all of the lands identified as able to use surface water could physically be reached with surface water without incurring significant pumping costs. Because of these considerations, some of the lands that met the criteria of crop type and irrigation method were removed from the conceptual canal layout's service area. At the same time, other nearby lands were identified in Tehama County that could be served relatively easily, and were included in the service area of the project. Between the lands that remained part of the service area in Glenn County plus the additional land identified for possible service in Tehama County, the system service area used for the feasibility evaluation totaled 3,670 acres.

3.3 Water Demand Assessment

To design the conceptual canal layout, the amount of water planned to be delivered needed to be determined. Maximum potential demand was calculated as if all fields with the specified crop types and irrigation methods (identified in Section 3.2) would participate in utilizing surface water. Should the project move forward after this study, the landowners would decide their participation, which would likely reduce the net acreage served by the project when compared with this feasibility evaluation.

The water demand assessment was based on the 3,670 acres potentially served by the project identified in Section 3.2. Crop irrigation water use estimates were based on evapotranspiration, crop water use coefficients, irrigation efficiency and rainfall. The reference evapotranspiration data used were average monthly values from the California Irrigation Management Information System (CIMIS) for Colusa Station #32. The crop coefficients used were estimated as a combined average of hay and summer grain crops. Average monthly rainfall data for the Orland Station was obtained from the Western Regional Climate Center. Irrigation efficiency was assumed to be 70%, and no additional water was assumed for leaching fraction for salt buildup prevention.

The resulting water balance and estimated average system delivery for the irrigation season is shown in Table 3-1. Table 3-1 reveals that monthly demand is highest in July, when system flow is 3,808 acre-feet (AF), and that total water demand per year is estimated to be 13,673 AF.

Table 3-1. Water Demand Calculations

Month	ETo (in./mo.)	Avg. Kc (system)	Etc (in./mo.)	Avg. Rain (in./mo.)	Net Etc (in./mo.)	Gross Irr. (in./mo.)	System Flow (ac-ft/mo)
April	5.03	0.50	2.52	1.30	1.22	1.74	531
May	6.43	0.80	5.14	0.73	4.41	6.31	1928
June	7.62	1.00	7.62	0.37	7.25	10.36	3,168
July	8.34	1.05	8.76	0.04	8.72	12.45	3,808
August	7.23	0.90	6.51	0.11	6.40	9.14	2,795
September	5.35	0.60	3.21	0.37	2.84	4.06	1,241
October	3.78	0.40	1.51	1.05	0.46	0.66	202
Season Totals	43.8	-	35.3	4.0	31.3	44.7	13,673

ETo from CIMIS for Colusa Station #32

System Irrigated Area 3,670 ac

Assumed Irrig. Efficiency 70%

3.4 Supply Options Considered

The potential sources of water for the project were GCID, Orland Unit, and other water districts with rights in the upper Sacramento River Watershed. GCID and Orland Unit were the only water suppliers evaluated in this study because of their proximity to the study area and because they had expressed interest in the project.

GCID holds rights to 720,000 AF of base water supply on the Sacramento River and 105,000 AF of project water supply. GCID can transfer water to users outside of their service area subject to additional costs and restrictions under the United States Bureau of Reclamation (Bureau), depending upon the classification and location of the final user. GCID base water could potentially be available during winter and irrigation season shoulder months. If GCID were to supply water to the project during the peak irrigation season months, it would likely have to come from GCID's project water supply. GCID water is assumed to be available in all years except critically dry years. Water supply costs are presented in Section 3.8

The Orland Unit is one of the oldest federal water projects in the country, with a storage capacity and rights for 100,000 AF of water in two reservoirs in the Stony Creek watershed. The Orland Unit also has direct diversion appropriative water rights for 85,000 AF. Because the capital costs of the major Orland Unit facilities were paid off decades ago, the cost of water in the Orland Unit service area is relatively low. Orland Unit cannot currently transfer water out of the district service area because of the restrictions by the federal government. The Orland Unit is gradually pursuing a possible buy-out of its remaining obligations to the federal government. Should that effort succeed, Orland Unit could be a source of water for the study area in the future.

3.5 Delivery Options Considered

The three physical sources of water considered were the GCID canal at the downhill boundary of the study area, the TC Canal uphill and west of the study area, and the Orland Unit canals which terminate near the western boundary of the study area.

3.5.1 GCID Canal

The GCID Canal is on the east boundary of most of the study area and downhill from all the fields in the study area. In order to utilize the GCID Canal as a physical water supply source, it would be necessary to construct a new pump station and new pipelines to reach all the fields in the study area with a pressurized water supply source. Alternatively, a single pipeline could be constructed to supply water to the uphill western edge of the study and water could then be distributed by a gravity water supply system. Either option would have high energy costs and would be relatively expensive.

3.5.2 TC Canal

The TC Canal is a large concrete-lined canal operated by the TC Canal Authority. It diverts water from the Sacramento River at its Red Bluff diversion and provides water to a number of water districts along the west side of the Northern Sacramento Valley. The TC Canal runs from north-to-south approximately one mile west of the western study area boundary as was shown in Figure 2-8. The canal water surface elevation is below grade, and there are currently no turnouts in the vicinity of the study area. The TC Canal Authority could convey water to near the project study area where new dedicated project diversion facilities would need to be constructed. From the TC Canal, water for the project could be conveyed through existing local Orland Unit canals and/or new or upgraded canals.

3.5.3 Orland Unit

The Orland Unit has both water supply canals and drainage channels crossing over the TC Canal and entering the area west of the study area as shown on Figure 2-8. The water supply canals provide irrigation water to a small service area on the west border of the study area. The drainage pipelines shown crossing the TC Canal on Figure 2-8 continue as unlined channels through the Orland Unit service area and into the study area. Some of the Orland Unit water canals and/or drainage channels could potentially be used to convey water from either the Orland Unit or the TC Canal part of the way to the study area.

3.5.4 Selected Delivery Option

Based on water supply availability and cost concerns, delivery from the TC Canal through Orland Unit canals and into existing drainages with appropriate modifications, ditches, pipelines, and other conveyance features was selected for detailed evaluation. Delivery from the GCID canal would involve much greater costs because of the location of the GCID canal at the bottom end of the study area.

Utilization of the TC Canal for wheeling water from the Sacramento River was determined to be physically feasible. Discussions with TC Canal Authority management established windows and capacities for conveyance of the relatively modest amounts of water required for the project. The only restrictions on delivery would be in narrow winter periods when maintenance is performed on the canal. These restrictions could affect winter season direct recharge, but would have no effect on the in-lieu recharge project supplying surface water during the irrigation season.

Because of these factors, wheeling GCID project water through the TC Canal, and then pumping water out of the TC Canal into the Orland Unit canal system, then using gravity to flow supplies into new canals and existing drainages was chosen.

3.6 Capacities of Existing Canals and Ditches

Figure 2-8 presents the existing drainages and canals in the study area that could be used for the proposed canal layout of the project. The dimensions of the existing Orland Unit canals, upstream reaches of the drainage channels, and culverts at road crossings were measured. Sizes of larger or more downstream drainage ditch reaches in the eastern portion of the study area were measured or visually estimated during field data collection activities. Ditch invert elevations at road crossings were estimated using a geographic positioning systems survey receiver. Invert elevations at other locations were estimated using Google Earth and ditch depth estimates. Using dimensions, slopes, and vegetative conditions, hydraulic capacities of the reaches of the ditches and canals of interest in the study area were estimated. These estimates are provided in Appendix B. Detailed measurements of drainage ditch reaches in the eastern portion of the study area were determined not to be needed because it was apparent that those ditches would have more capacity than would be needed for any proposed irrigation supply project.

3.7 Preliminary Irrigation Distribution System Layout

The preliminary irrigation distribution system layout is shown on Figure 3-3. The layout assumes water is diverted from the TC Canal by two pump stations with slant turbine pumps at County Road 6 and north of County Road 8. Short stretches of existing Orland Unit canals are used, then new lined canals are constructed to the west end of the study area. Existing drainage ditches are used for irrigation water distribution in the northern (branch A1) and southern portions (canal B0 and downstream branches) of the study area. The areas served by the major branches are 1,245 acres in the north and 2,440 acres in the south. Total flow capacities by major branch are 31 cfs for the north and 57 cfs for the south.

A new pipeline (branch A2) is shown to serve the middle ridge portion of the study area. A new highline ditch (branch B0b) serves fields in the middle-western portion of the study area. A new pump station and pipeline (branch B5) are also shown to serve the middle-eastern ridge portion of the study area.

The layout includes 15 gravity turnouts, 11 pipeline turnouts, and 30 pumped turnouts, with each turnout assumed to be capable of supplying 2 cfs of water. On-demand supply with 99% probability of no congestion was assumed for canal and pipeline sizing calculations. Water demand calculations by canal branch and reach are shown in Table C-1 in Appendix C. Turnout types, listed in Table C-2 in Appendix C, were dependent upon location.

New canal and pipeline sizes and capacities are provided in Table C-2. Lined canals were assumed for steeper reaches where velocities could exceed 2 feet per second. Earthen canals were assumed for flatter reaches.

The locations of irrigation water control gates and new regulating reservoirs are also shown on Figure 3-3. Downstream control would be used on as many reaches as practical. Upstream control, downstream control on sloping canals and constant volume control would be used in portions of the study area, depending upon location and elevations. Telemetry (shown as "T" on Figure 3-3) was assumed for control of diversion pumps and many of the main gates.

Low head Polyvinylchloride pipelines were assumed for the pipeline distribution portions of the study area. Corrugated pipes were assumed for new culverts, where needed, under roads. Additional details on distribution facilities and control strategies by canal branch and reach are provided in Table C-2.

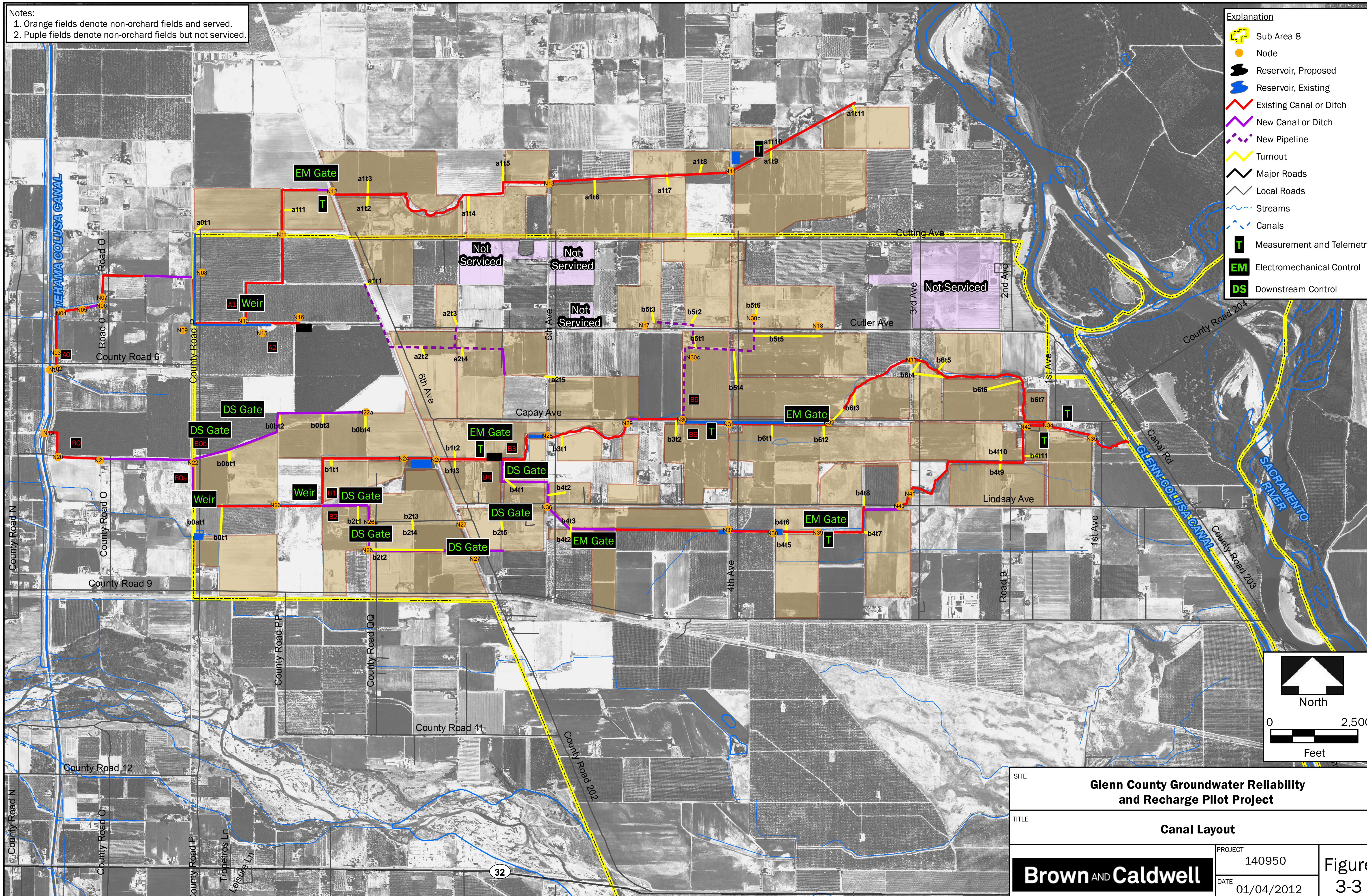
Spill water from the downstream end of the north supply/drainage channel would drain to the Sacramento River. Spill water for the two main southern supply/drainage channels would drain to the GCID canal. This southern drainage water that spills into the GCID canal would be measured, and the volume subtracted from any water purchased from GCID.

3.8 Preliminary Surface Water Cost Estimate

Costs were developed at a preliminary level for comparison with groundwater pumping costs.

3.8.1 Capital Costs

Capital costs were estimated based on unit costs for earthwork, lining, culverts, and other facilities. Capital costs include construction costs, engineering and design costs, and permitting costs, which are listed under "Other Overhead". Unit capital costs are given in Table D-1 in Appendix D. Pump station cost details are provided in Table D-2 in Appendix D. Costs for distribution system facilities were included in Table C-2. Capital costs are summarized in Table 3-2.



SITE

Glenn County Groundwater Reliability and Recharge Pilot Project

TITLE

Canal Layout

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DATE 01/04/2012

Figure 3-3

Table 3-2. Estimated Infrastructure Costs			
Description	Quantity	Units	Total Cost
Ditch Earthwork	15,000	cubic yard	$110,000
Lining	163,000	square foot	$820,000
Culverts	440	feet	$160,000
Low Head Pipelines	12,100	feet	$1,060,000
Easements	457,000	square foot	$140,000
Turnouts	56	each	$290,000
Control Gates and Remote Sensors	12	each	$405,000
South Pumps	3	each	$810,000
North Pumps	2	each	$540,000
In-System Pumps	2	each	$300,000
Regulating Reservoir	1	each	$35,000
Miscellaneous.	1	lump sum	$300,000
		Subtotal	$4,970,000
Engineering and Administration	20%		$990,000
Other Overhead	15%		$750,000
Subtotal (rounded)			$6,700,000
Contingency (rounded)	30%		$2,000,000
		Total (rounded)	$8,700,000

3.8.2 Annualized Costs

Capital costs were annualized to estimate the payment on the infrastructure by acre-foot. Annualized capital costs of the facilities for 30 years at 5% would calculate to be $566,000 per year. Operation and maintenance costs include system supervision, monitoring spillways and culverts for potential blockages, canal maintenance, other facilities maintenance, and pumping power costs. Telemetry based control was incorporated into the delivery system design to minimize operational labor requirements. Annualized capital and O&M costs are shown in Table 3-3. Total system costs per acre-foot delivered are shown as $62/AF assuming an annual water delivery of 13,670 AF.

Table 3-3. Estimated Annualized System Delivery Costs		
Item	Total Annualized Cost	Costs/AF
Capital	566,000	$42/AF
Operations and Maintenance (w/o power)	200,000	$14/AF
Power	83,300	$6/AF
	TOTAL	$62/AF

3.8.3 Delivered Water Costs

The cost of surface water to be delivered was estimated as a part of the feasibility study. The final cost of surface water was contingent on a number of factors, including: the original contracted cost of water, institutional costs and fees associated with transferring the water to the new area with the Bureau, physical costs to move the water to the area through wheeling, estimated costs to pay for the developed infrastructure, and anticipated maintenance and operations. Wheeling costs and charges levied by the Bureau vary by the type of water. Central Valley Project (CVP) water costs significantly more than non-CVP water. CVP water is water that is supplied by the federal government, and is stored in Shasta Lake and is historically used by irrigation districts with contracts with the federal government. Table 3-4 presents an itemized list of costs for both CVP and non-CVP water. A fee schedule from the Bureau is included in Appendix E. CVP water is defined in this study as any water purchased from the Bureau. Non-CVP water is any water from another source, including purchases from other agencies, wet season flows, and other sources.

The Bureau sets costs for CVP surface water supplies and transfers of the CVP supplies by the acre-foot (AF). The effective transfer rate is the base price of water, and an associated restoration fund charge is used by the Bureau for environmental protection. Because the study area is outside the CVP service area, the Bureau also charges a large ($40.80 AF) surcharge.

The conceptual canal layout requires that surface water be “wheeled” through existing canal systems. Wheeling means that the water is conveyed by a separate canal system before it is delivered to the study area. Surface water will need to be wheeled through the TC Canal, and Orland Unit canals and is subject to wheeling fees. An additional cost may be incurred from administrative costs incurred by GCID while managing the transfer, which are not known at this time.

Non-CVP water costs less in charges than CVP water, and is not subject to Bureau fees. An estimate of the base cost of non-CVP water is included in Table 3-4. To use a CVP facility to wheel non-CVP water causes imposition of a Warren Act charge, which replaces the wheeling fee for the TC Canal. Lastly, a potential wheeling fee from the Orland Unit canal system may apply, but was not included in the cost calculation.

Table 3-4. GCID Water Costs and Considerations

Item	Cost
CVP (Project) Water	
Effective transfer rate	$24.92/AF
Restoration Fund	$9.79/AF
Surcharge	$40.80/AF
Wheeling fee for Tehama Colusa Canal	$11.00/AF
TOTAL	$86.56/AF
Non-CVP (Base) Water	
Cost of water estimate	$30.00/AF
Warren Act charge	$21.39/AF
TOTAL	$51.39/AF

Costs of CVP water and non-CVP water delivered to the project were combined with the annualized costs of the surface water distribution system to determine the total estimated cost of surface water to potential users in the study area. The annualized distribution system cost described in Section 3.8.2 was estimated to be $62/AF. The cost of CVP (project) water from Table 3-4 is estimated to be $86.56/AF, for a total cost of $148.56/AF. Non-CVP (base) water is estimated to have a total delivered cost of $113.39/AF. These costs do not include any wheeling fees for the use of some of the uphill segments of Orland Unit canals, which, although not expected, could potentially be an additional $11/AF.

3.9 Groundwater Cost Estimate and Comparison

As part of the feasibility study, cost to produce groundwater was estimated. Groundwater cost estimating was necessary to provide a 'baseline' cost that estimated surface water costs could be compared against. The cost of pumping groundwater includes the annualized costs of a well, maintenance costs, and power costs. A summary of estimated costs to pump groundwater is presented in Table 3-5.

Table 3-5. Groundwater Costs

Item	Cost
Annualized Capital	$24/AF
Operations and Maintenance	$8/AF
Electricity	$34/AF
TOTAL	$66/AF

Cost estimates were generated using some general assumptions about well size, energy costs, and amount of water produced. A nominal 1,500 gpm well was used as the basis for estimating the cost of groundwater to users. Assuming the well would serve 167 acres (9 gpm/acre capacity), the groundwater produced would be 620 AF/yr. A capital cost of $250,000 was assumed, which would translate to an annualized capital cost of $14,600 for a 5% rate and a 40 year term, or $24/AF. Maintenance costs at 2% of capital cost would be $5,000 per year, or $8/AF. Power costs at $0.15/kwh for an estimated 140 feet of total pumping head (including 50 feet of discharge head) would be $34/AF. Total estimated costs for pumping groundwater would be $66/AF. Actual costs per AF may vary widely and would probably be lower for higher capacity wells and higher for lower capacity wells.

3.10 Indirect Benefits

The project would provide some indirect benefits to irrigators in the project vicinity. The main benefit would be leaving more groundwater in storage during times of surface water delivery. Each year of surface water use would equal up to 13,673 AF of in-lieu recharge, water that would have previously been pumped from groundwater supplies. There would also be some direct recharge from the deep percolation normally associated with surface irrigation practices and from infiltration from the unlined canals. The direct and in-lieu recharge would reduce pumping heads for groundwater wells in the vicinity of the study area, likely by 20 feet or more. This reduction in pumping heads would translate into lower power costs for groundwater pumpers in the area. The in-lieu and direct recharge would also increase the long term reliability of the groundwater aquifers in the study area. Lastly, the project would allocate more surface water to local users, which could reinforce the precedent for keeping surface water for beneficial use in the local area.

Section 4

Conclusions

4.1 Feasibility

The cost of water for the in-lieu recharge is estimated to be $148/AF for CVP supplies, and $113/AF for non-CVP supplies. It is likely that CVP supplies would be needed for in-lieu supply during the irrigation season due to supply availabilities. The cost for either surface water supply is double the cost to use groundwater supplies, which is estimated to be $66/AF. Because of this price difference, most irrigators would choose to use groundwater for economic reasons. This makes the project, if funded solely by irrigators, infeasible. Much of the differential is in the cost of the surface water supply. Without cost reductions or subsidies, it is apparent that the potential surface water supply project as envisioned is not feasible. Long term groundwater considerations or other local or political considerations could improve the feasibility of the project, but even then substantial subsidies would likely be required to achieve a reasonable level of participation.

For the project to be feasible, some of the components of water supply cost would need to be reduced, such as Bureau surcharges and Warren Act charges. Alternatively subsidies to pay for infrastructure to build the project could also make it more feasible. Fee waivers or subsidies would likely need to be identified before enough local interest could be generated to form a management entity such as formation of a new irrigation district or other institutional measures. Pursuit of planning grants, fee waivers, or subsidies could still be warranted on a limited basis to take advantage of the increased interest at the state and federal level on projects that increase water supply reliability.

Another alternative to the project as evaluated would be to pursue a smaller project that was more focused on areas of maximum benefit. This would be a project serving water only to the middle western portion of the study area, where groundwater declines have been greatest, soils and geology are most favorable to recharge, and crops are most amenable to surface water supply. These would be the areas served by branches A2 and B0b (570 acres total) as shown on Figure 3-3 plus a possible additional 65 acres in Tehama County (turnout a0t1). Water could possibly also be supplied directly from the Orland Unit or by siphon from the TC Canal. While an evaluation of a smaller project alternative was beyond the scope of this study, it could be worth considering if future circumstances warrant, especially if Orland Unit is successful in becoming independent from the federal government. Additional potential projects include evaluation of the feasibility of direct recharge in the recommended areas from Section 2.5.5.

Section 5

Next Steps

Although the project as evaluated is economically infeasible at this time, opportunities may arise that would help the economics of a surface water supply project for a portion of Sub-Area 8. It may be worthwhile to keep the need for the project prominent in regional planning activities moving forward to take advantage of these possible future opportunities.

5.1 Potential Actions and Schedule

Future actions should be focused on positioning key portions of Sub-Area 8 for potential surface water supply. These actions should leverage regional planning efforts and help focus a potential future project on the most feasible portion of Sub-Area 8. Some of the potential future actions could include:

1. Identify potential project advocates.
2. Identify interested participants.
3. Decide on strategy moving forward.
4. Include project in Regional IRWMP.
5. Discuss possible future service for some of the study area with Orland Unit.
6. Pursue additional planning grants if sufficient interest in the future.
7. Lobby for fee reductions and other water supply and capital cost subsidies to improve feasibility of project.

Actions 1 through 4 should be scheduled to occur in conjunction with the IRWMP timeline. Timing for actions 5 through 7 will be a function of whether there is sufficient interest for continuing to pursue a project and whether there are opportunities to significantly reduce costs to potential participants.

5.2 Potential Funding

Identification of and participating in funding opportunities as they arise will be key to the development of surface water supply. Potential sources of funding for future steps toward a project could include:

- IRWMP grants,
- Direct federal funding for water projects,
- Future state water bond funding,
- Bay-Delta Conservation Plan related funding,
- Other state funding for water projects, and
- Possible federal incentives to Orland Unit to include a portion of the project area.

Positioning for funding from any of the above sources will require one or more strong project advocates.

Section 6

References

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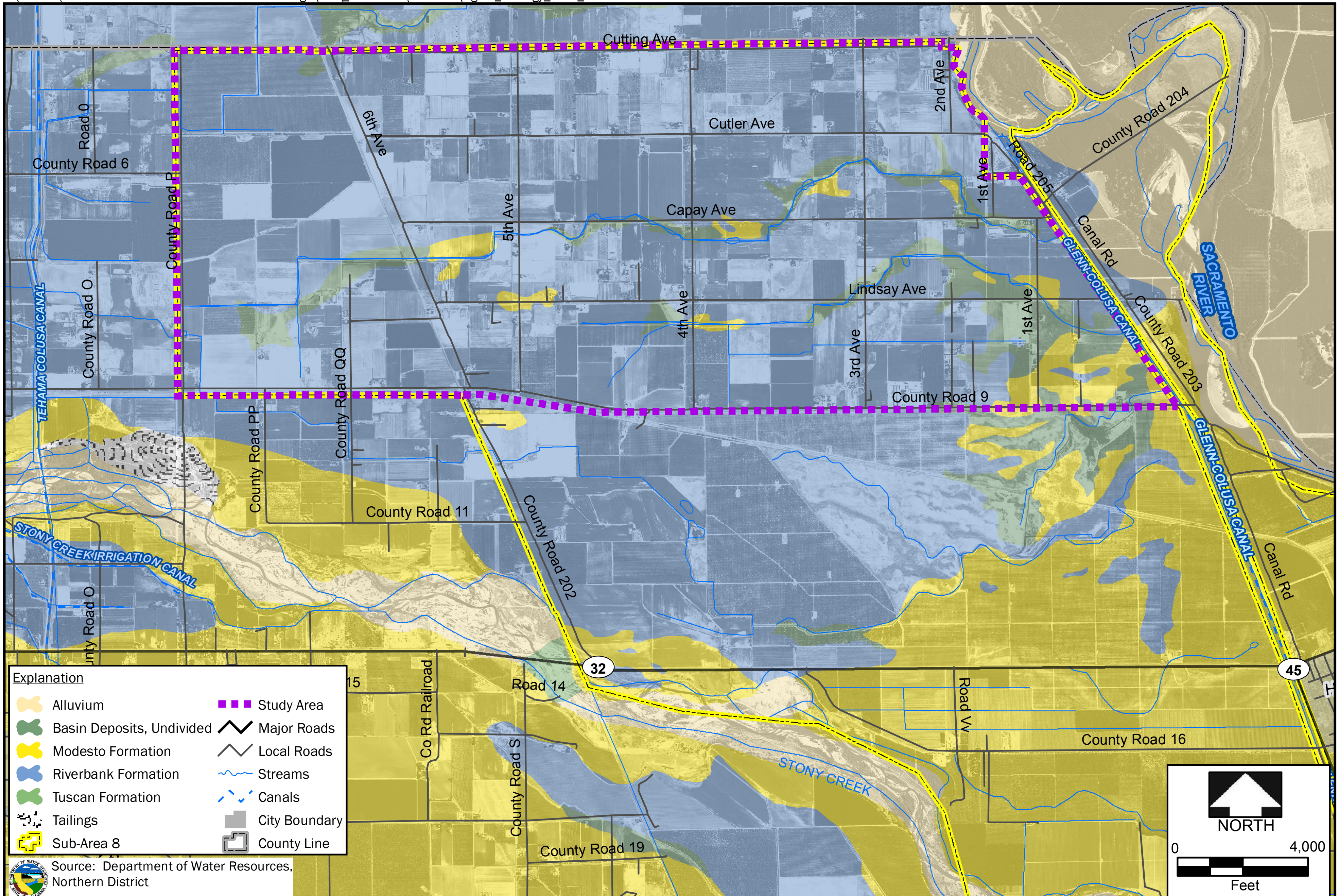
Appendix A

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-1_Geology_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-1**
	DATE 01/03/2012	TITLE **Geology**	

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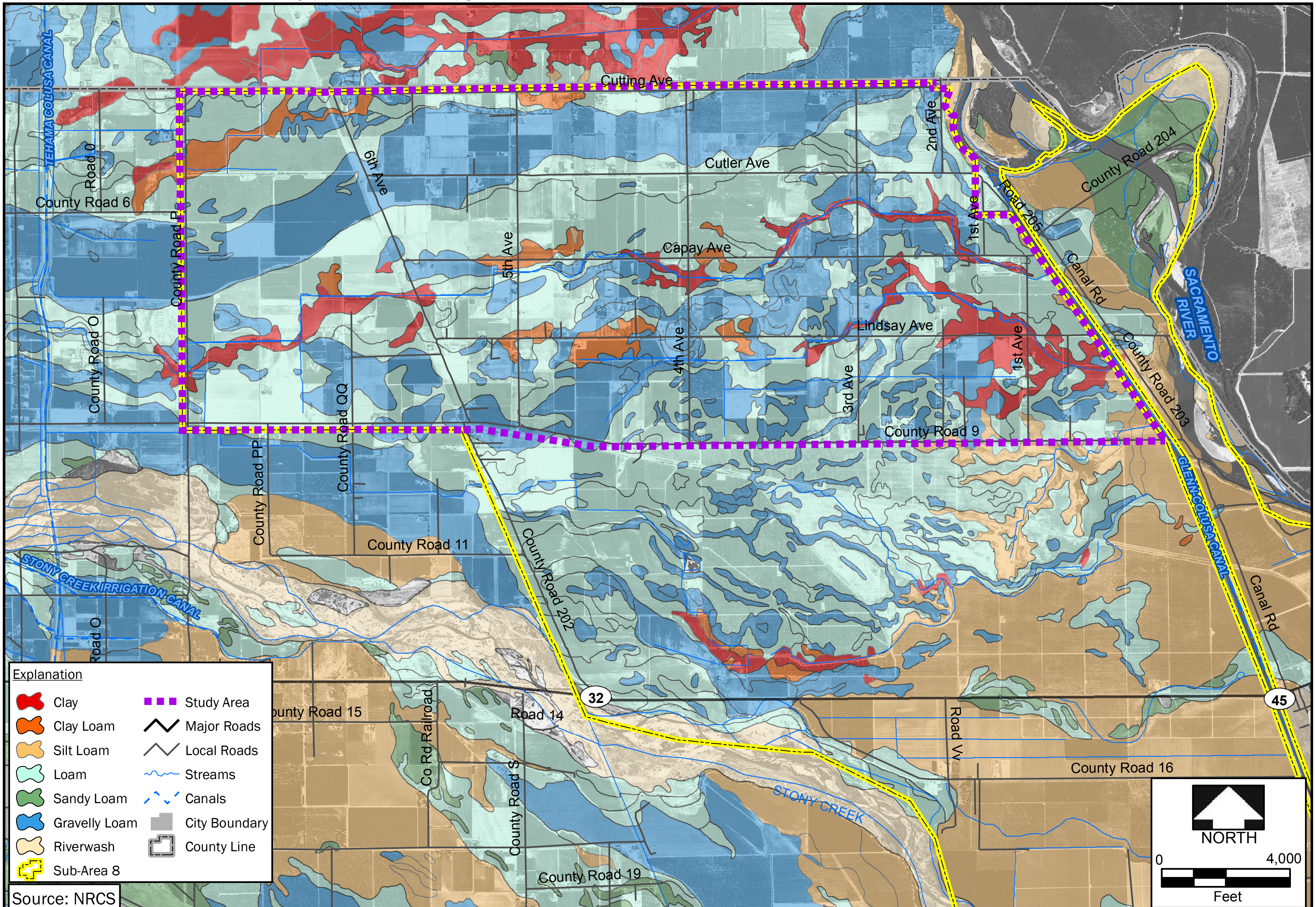

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PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure A-2
DATE 01/03/2012	TITLE Soils	

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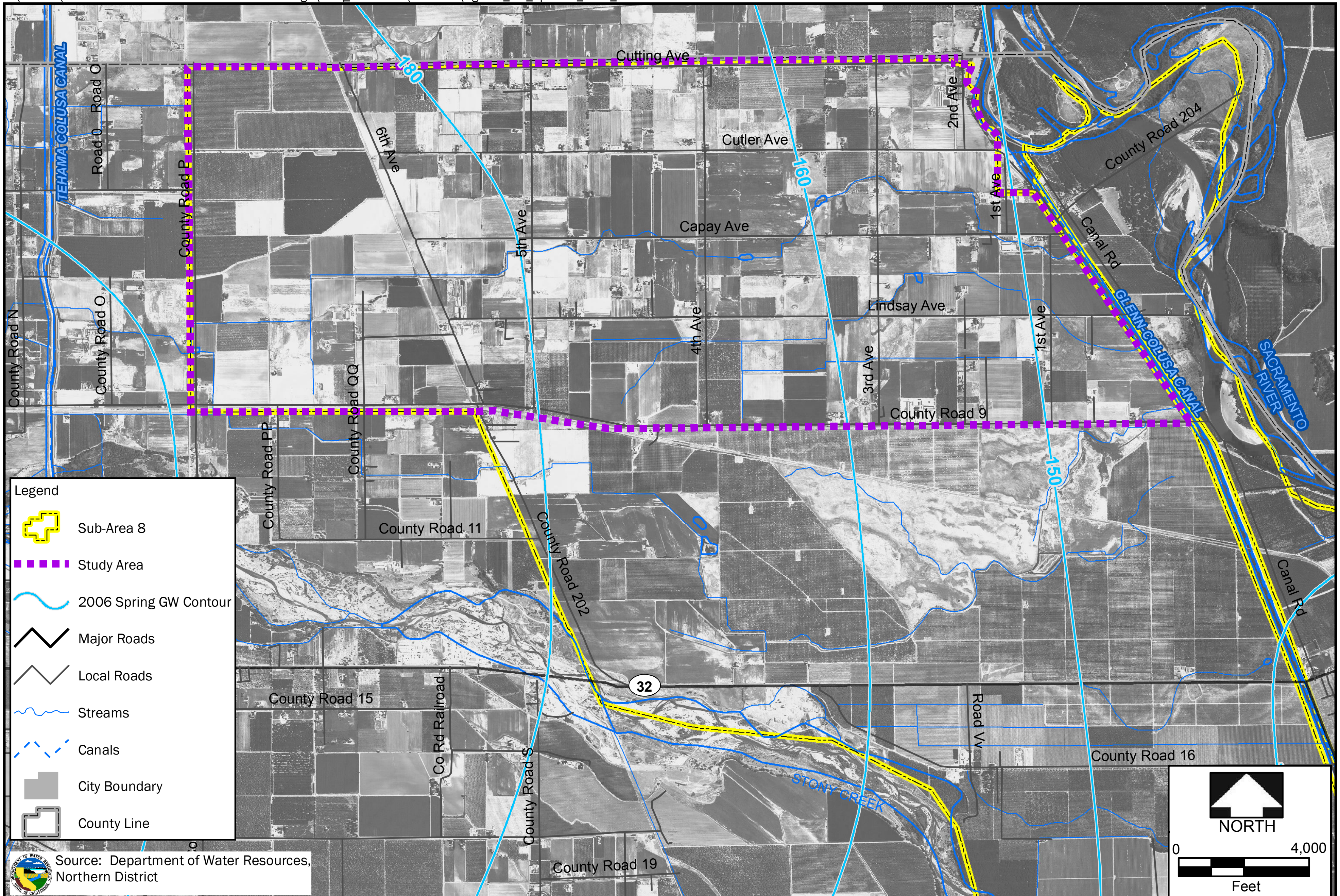

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PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-3**
DATE 01/03/2012	TITLE **Spring 2006 Groundwater Contour Map**	

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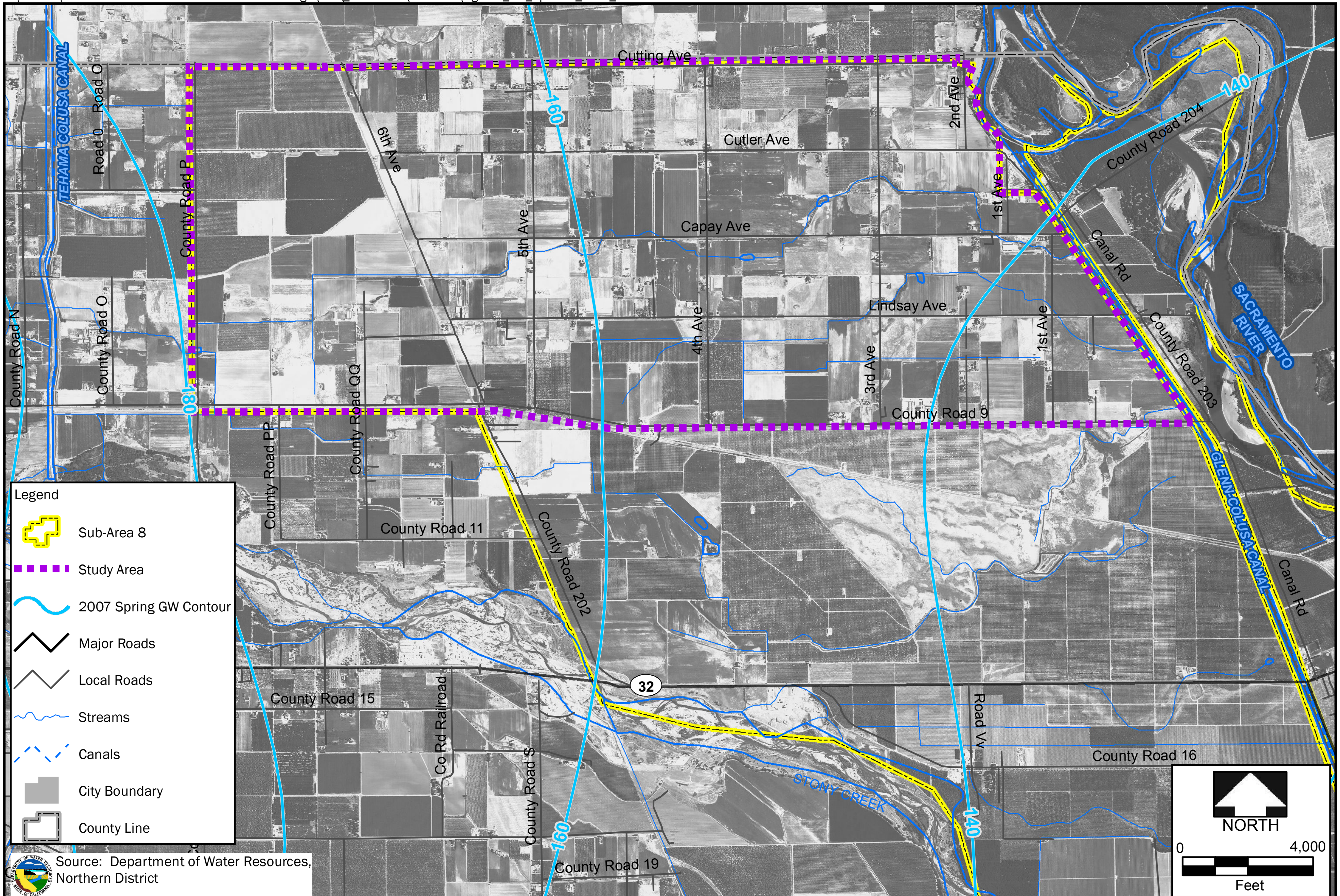

PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-4**
DATE 01/03/2012	TITLE **Spring 2007 Groundwater Contour Map**	

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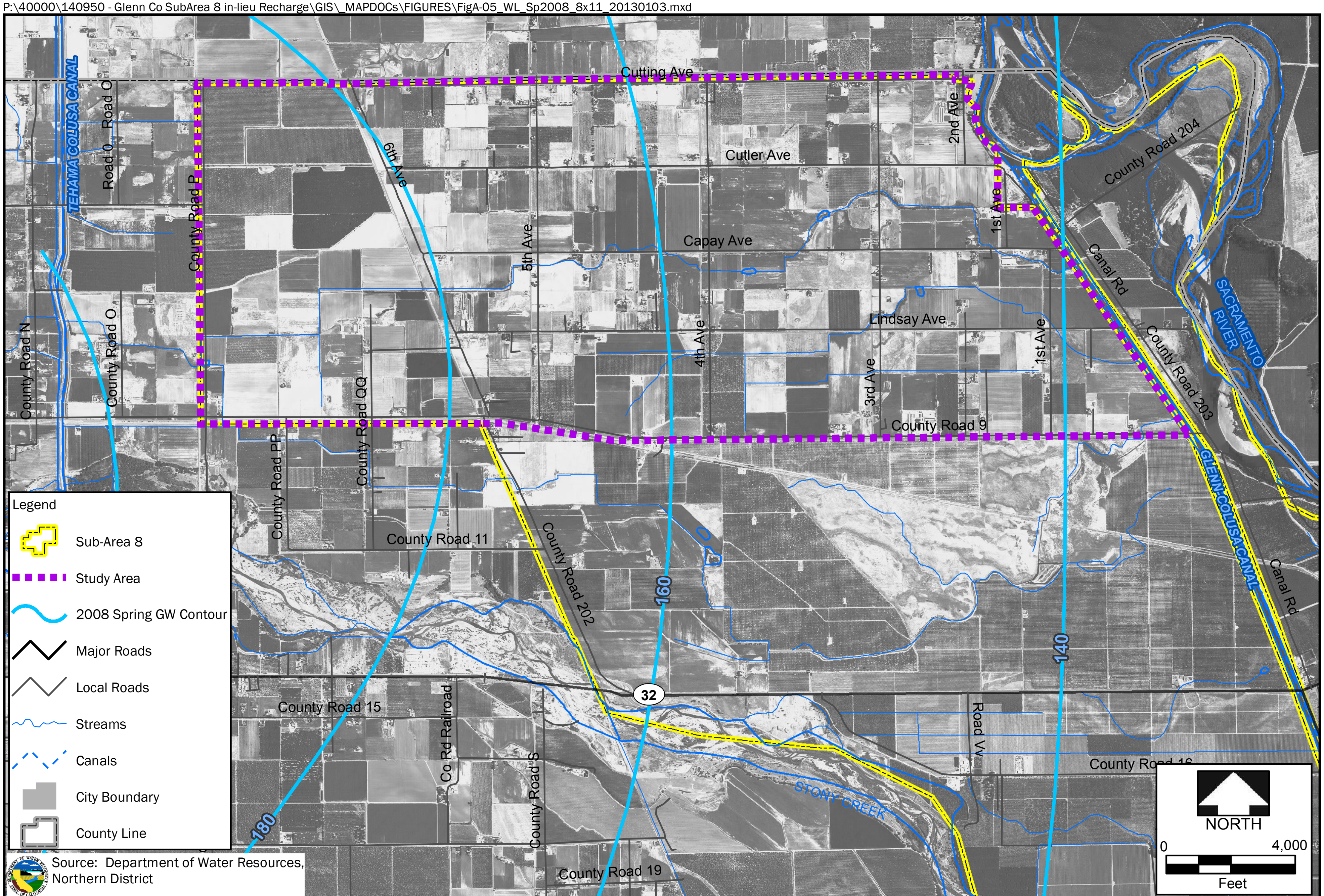

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	DATE 01/03/2012	TITLE **Spring 2008 Groundwater Contour Map**

Figure A-5

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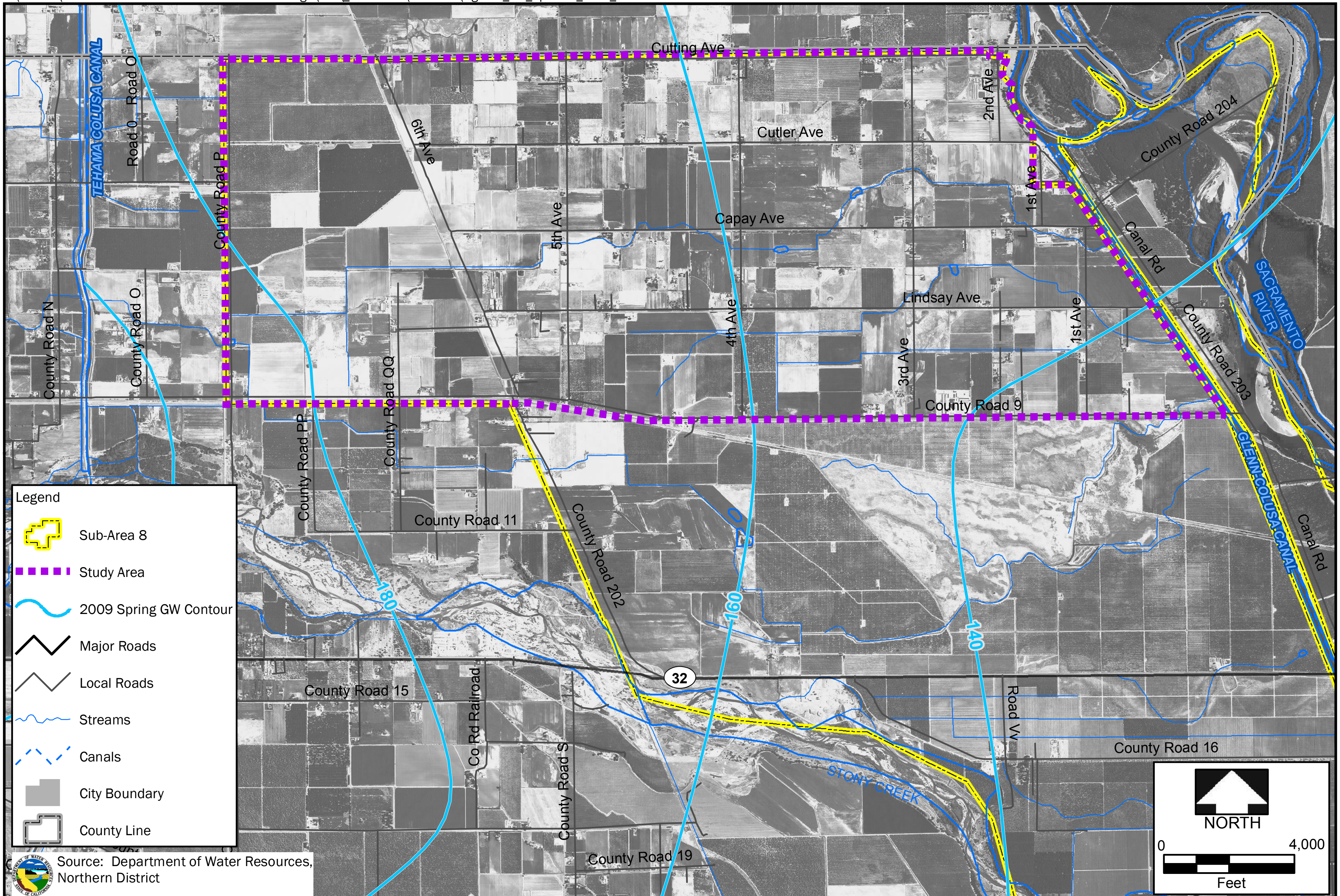

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PROJECT 140950

DATE 01/03/2012

SITE Glenn County Groundwater Reliability and Recharge Pilot Project

TITLE Spring 2009 Groundwater Contour Map

Figure A-6

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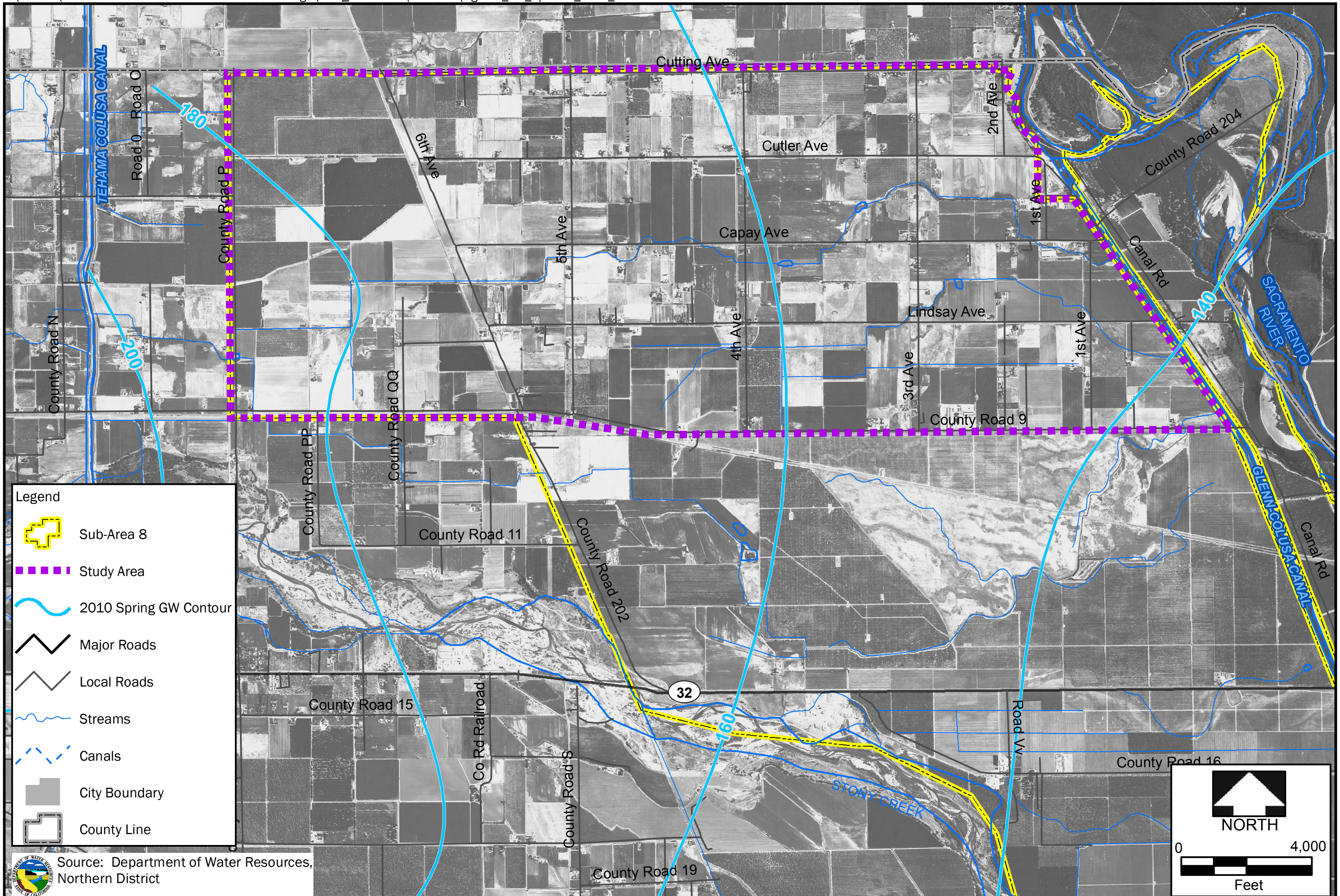

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PROJECT	SITE	
140950	**Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-7**
DATE 01/03/2012	TITLE **Spring 2010 Groundwater Contour Map**	

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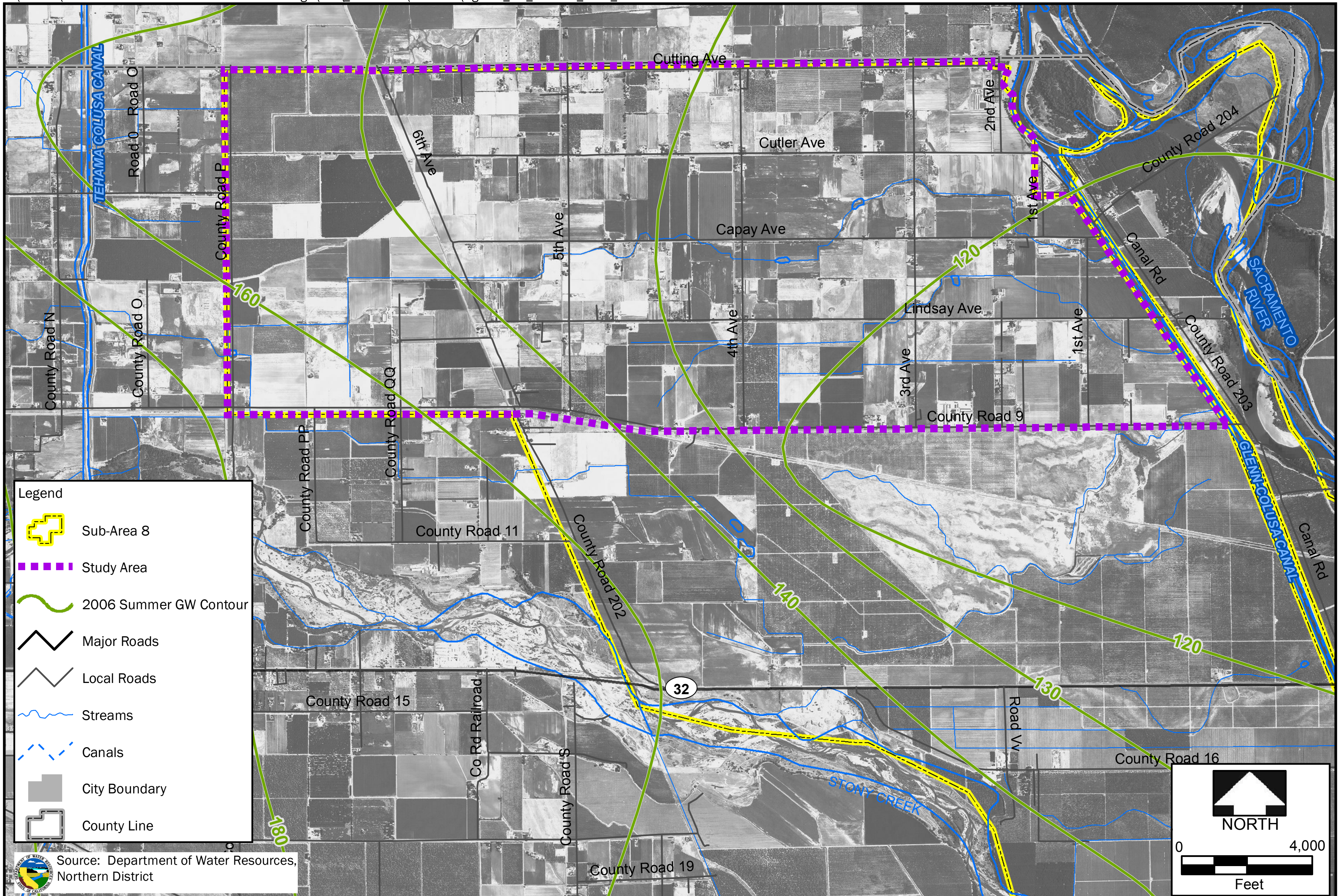

Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-8**
	DATE 01/03/2012	TITLE **Summer 2006 Groundwater Contour Map**	

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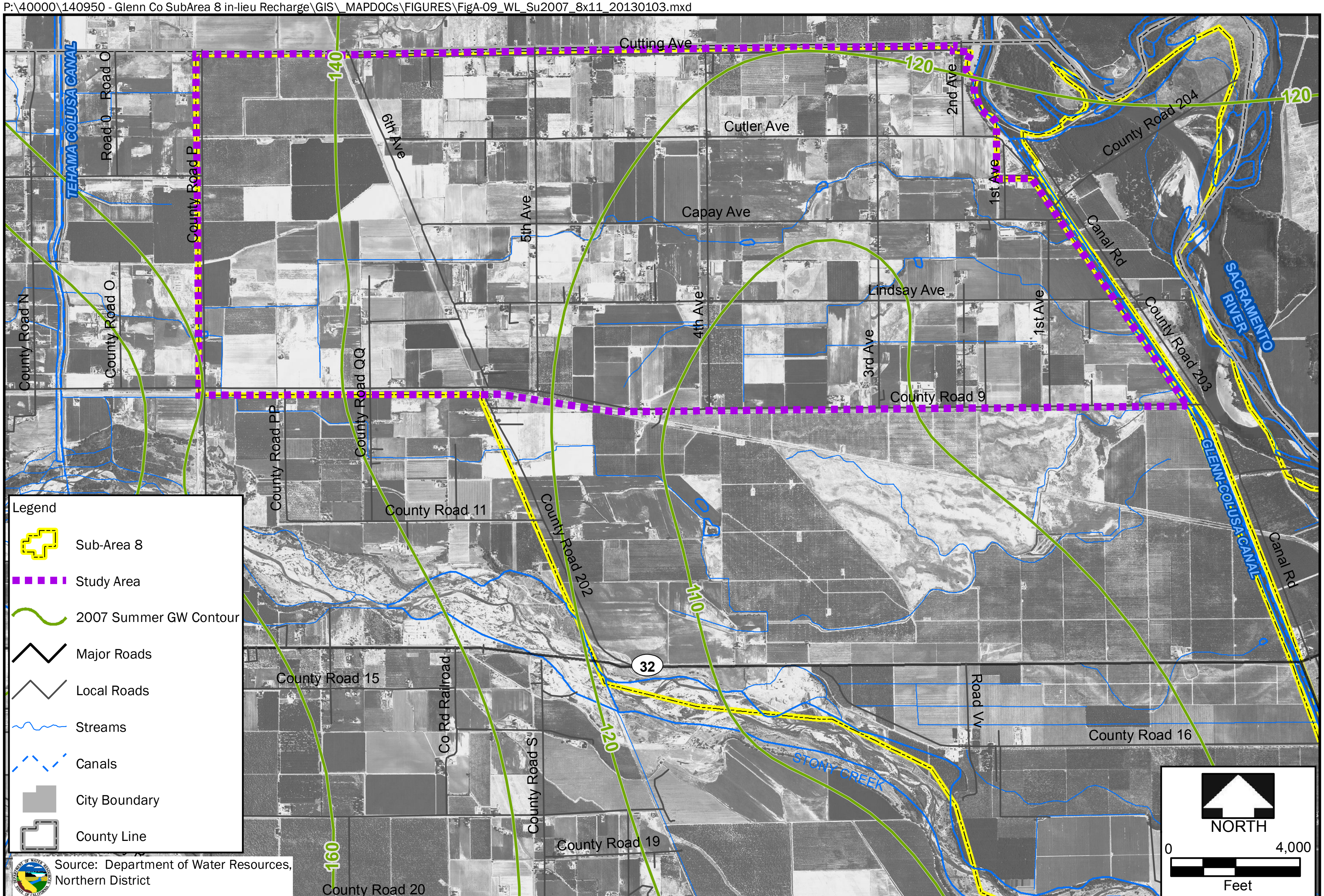

PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-9**
DATE 01/03/2012	TITLE **Summer 2007 Groundwater Contour Map**	

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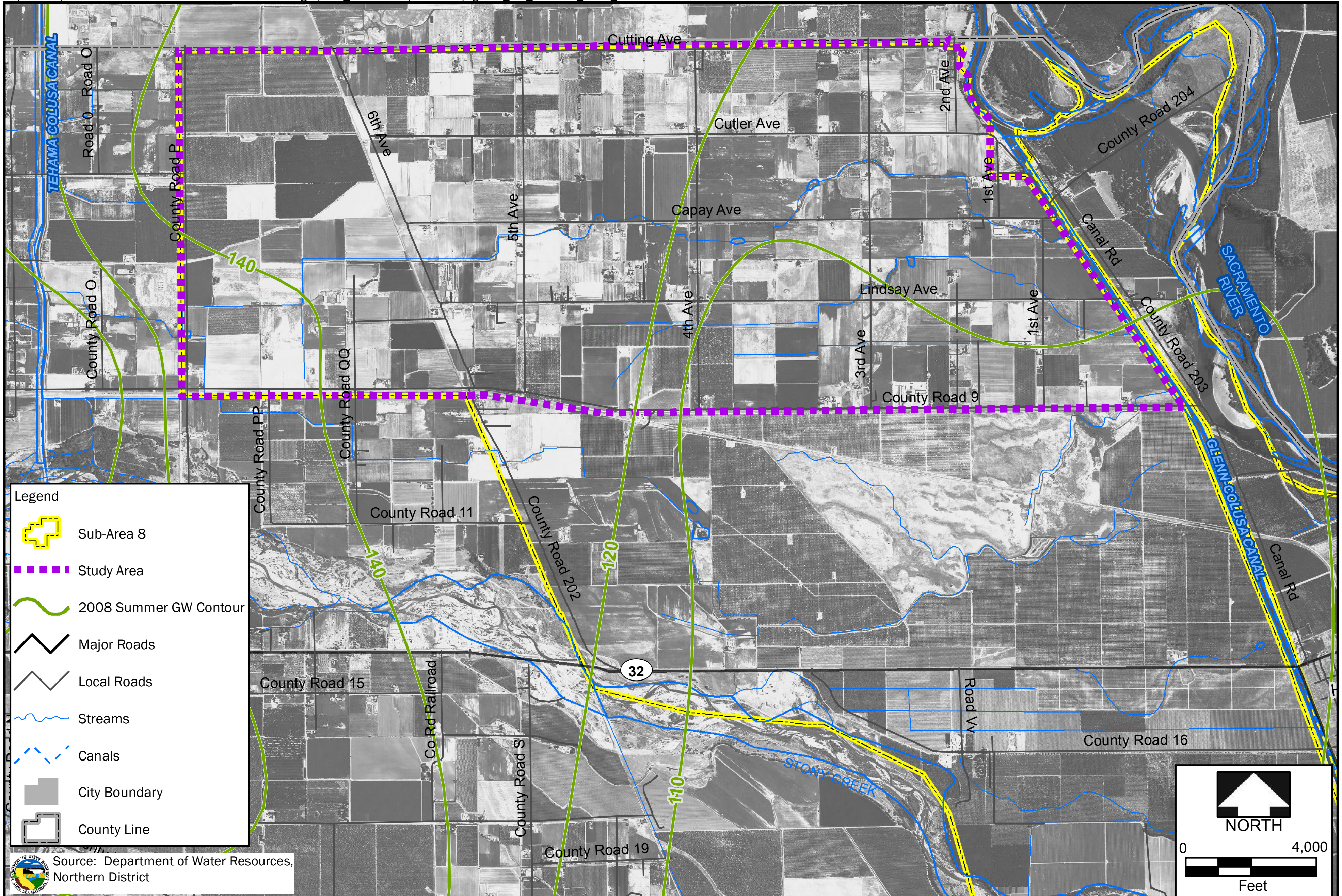

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PROJECT 140950

DATE 01/03/2012

SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**

TITLE **Summer 2008 Groundwater Contour Map**

Figure A-10

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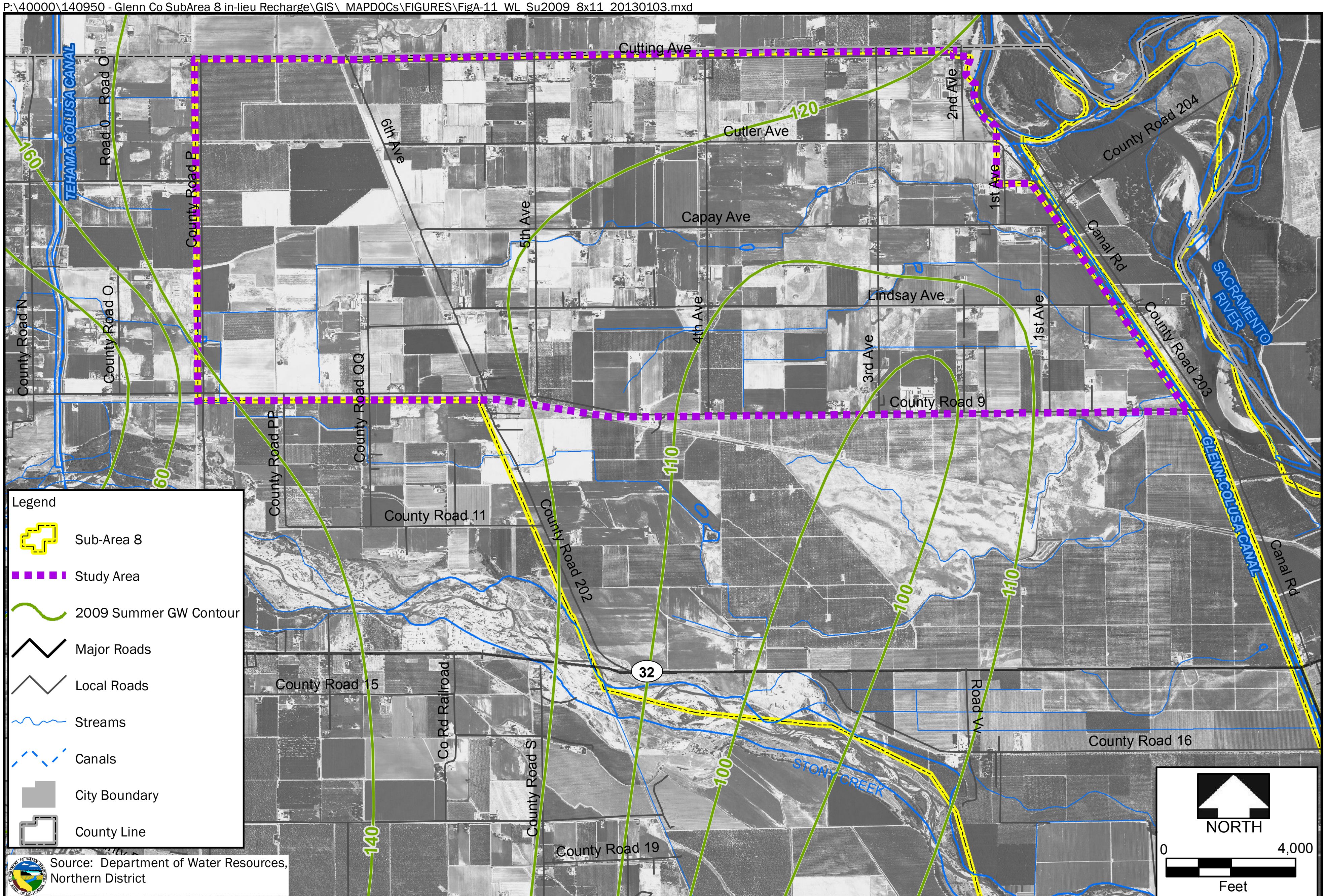

Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-11**
	DATE 01/03/2012	TITLE **Summer 2009 Groundwater Contour Map**	

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PROJECT	SITE	
140950	**Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-12**
DATE 01/03/2012	TITLE **Summer 2010 Groundwater Contour Map**	

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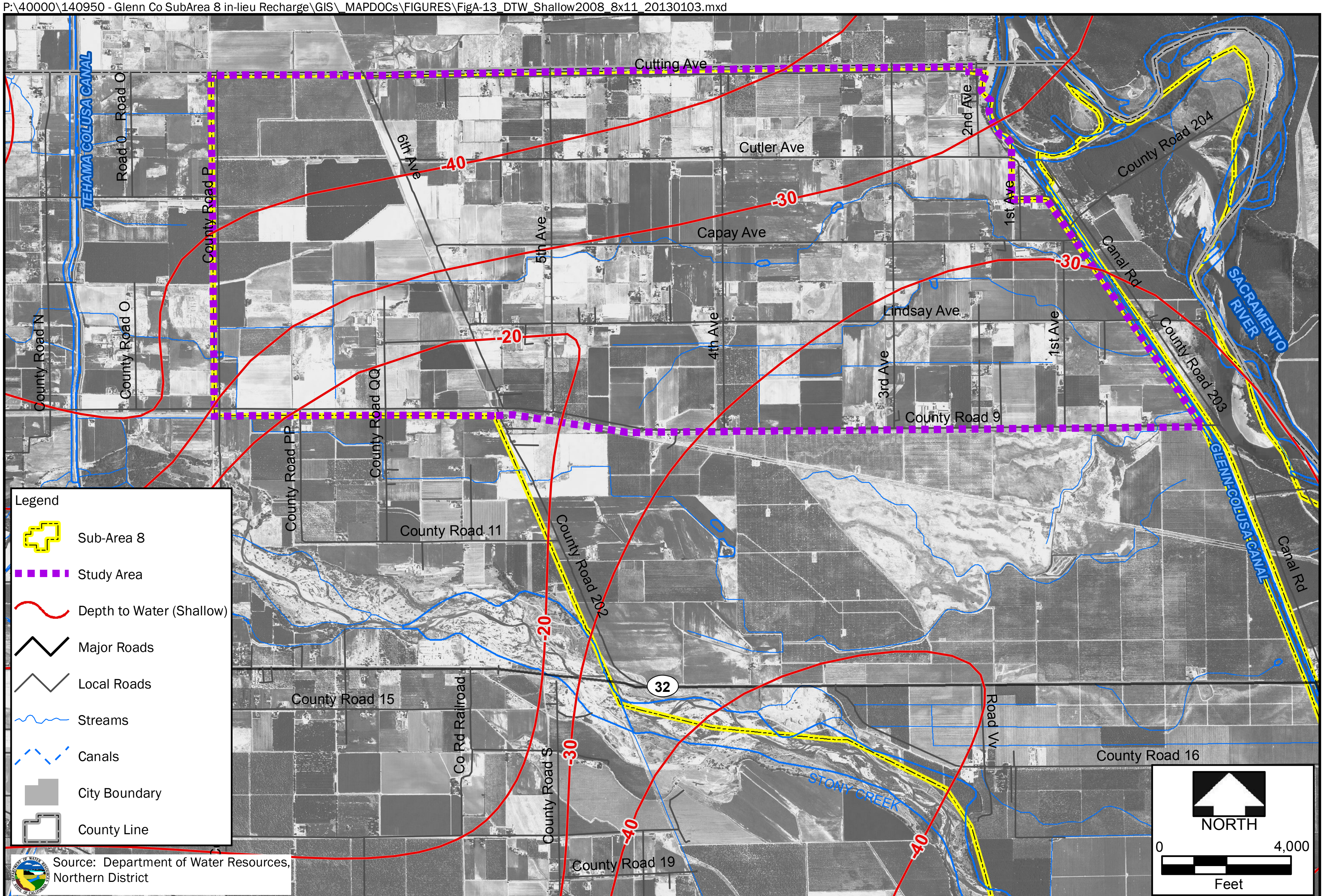

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PROJECT 140950

DATE 01/03/2012

SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**

TITLE **Depth to Water in Shallow Aquifer (2008)**

Figure A-13

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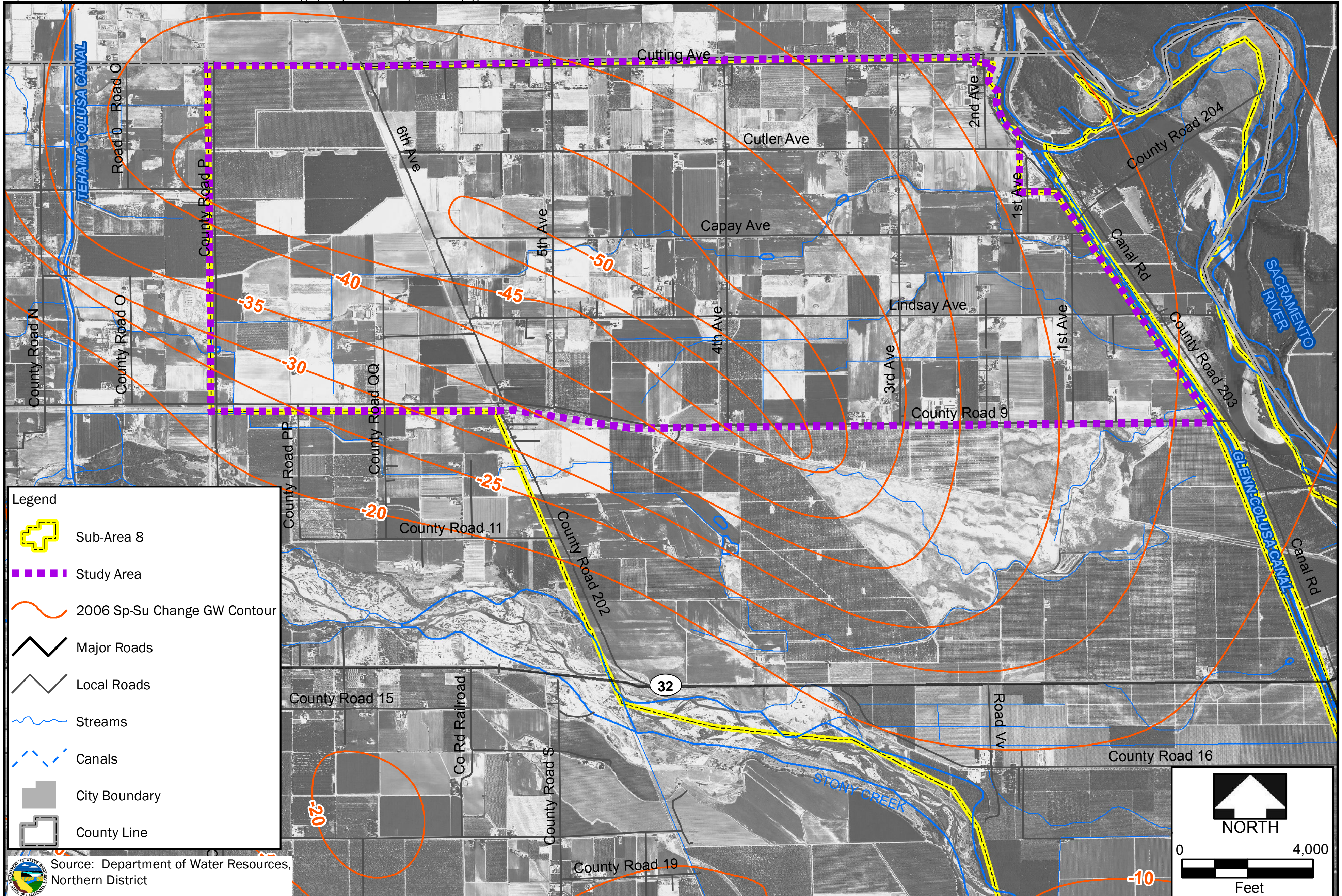

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PROJECT 140950

DATE 01/03/2012

SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**

TITLE **Spring - Summer 2006 Drawdown Groundwater Contour Map**

Figure A-14

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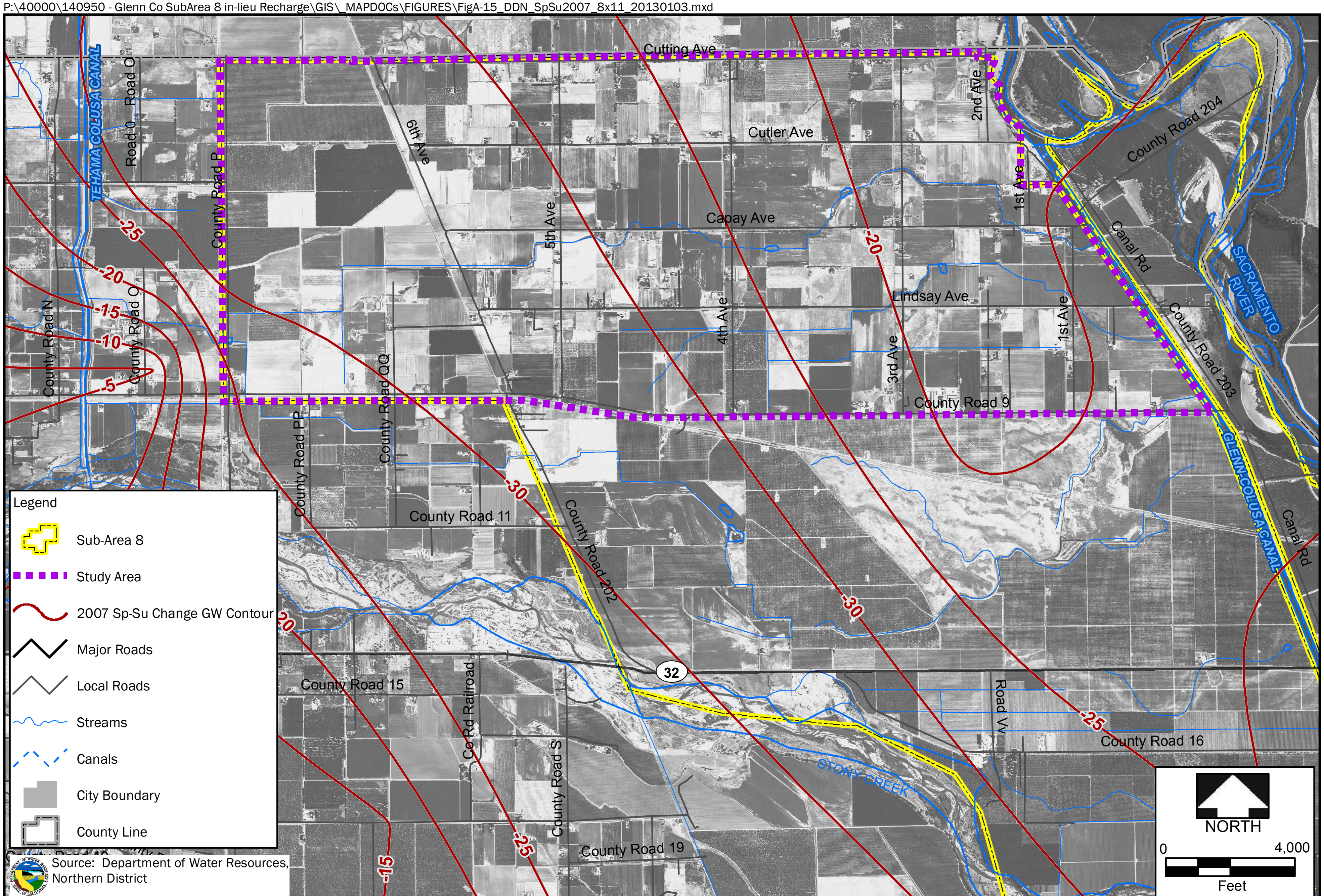
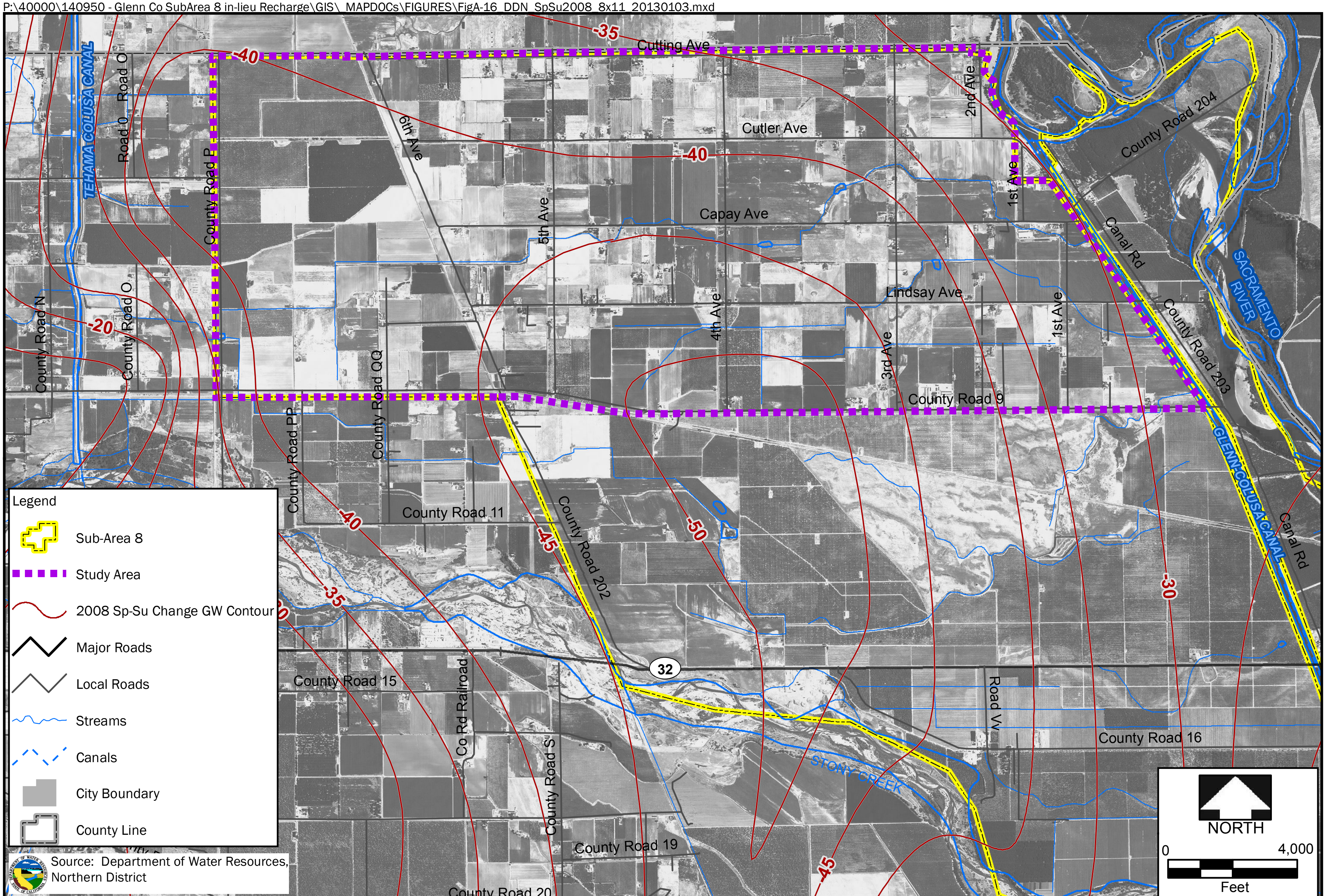


Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**
	DATE 01/03/2012	TITLE **Spring - Summer 2007 Drawdown Groundwater Contour Map**

Figure A-15

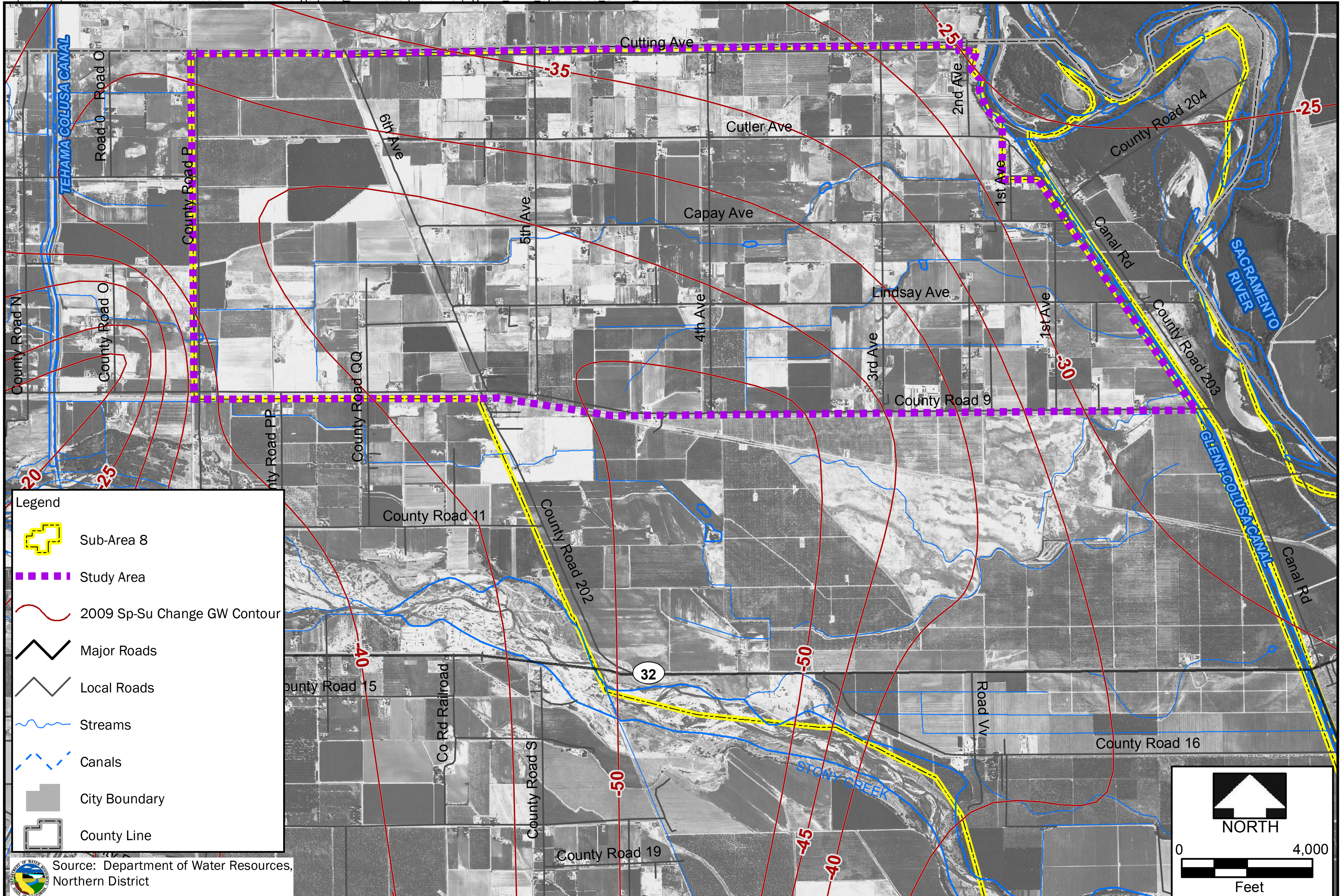
P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-16_DDN_SpSu2008_8x11_20130103.mxd



PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure A-16
DATE 01/03/2012	TITLE Spring - Summer 2008 Drawdown Groundwater Contour Map	

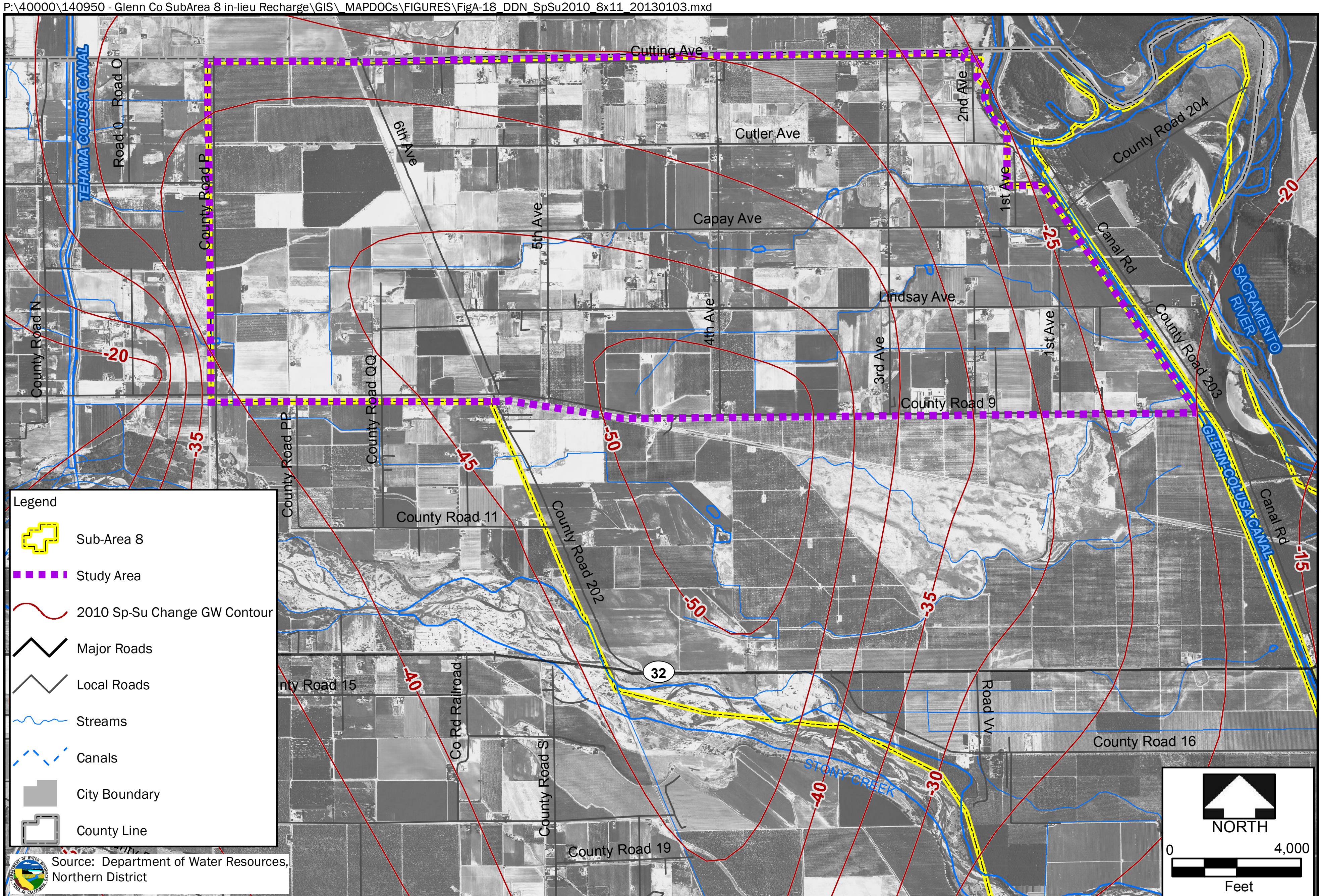
Brown AND Caldwell

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-17_DDN_SpSu2009_8x11_20130103.mxd



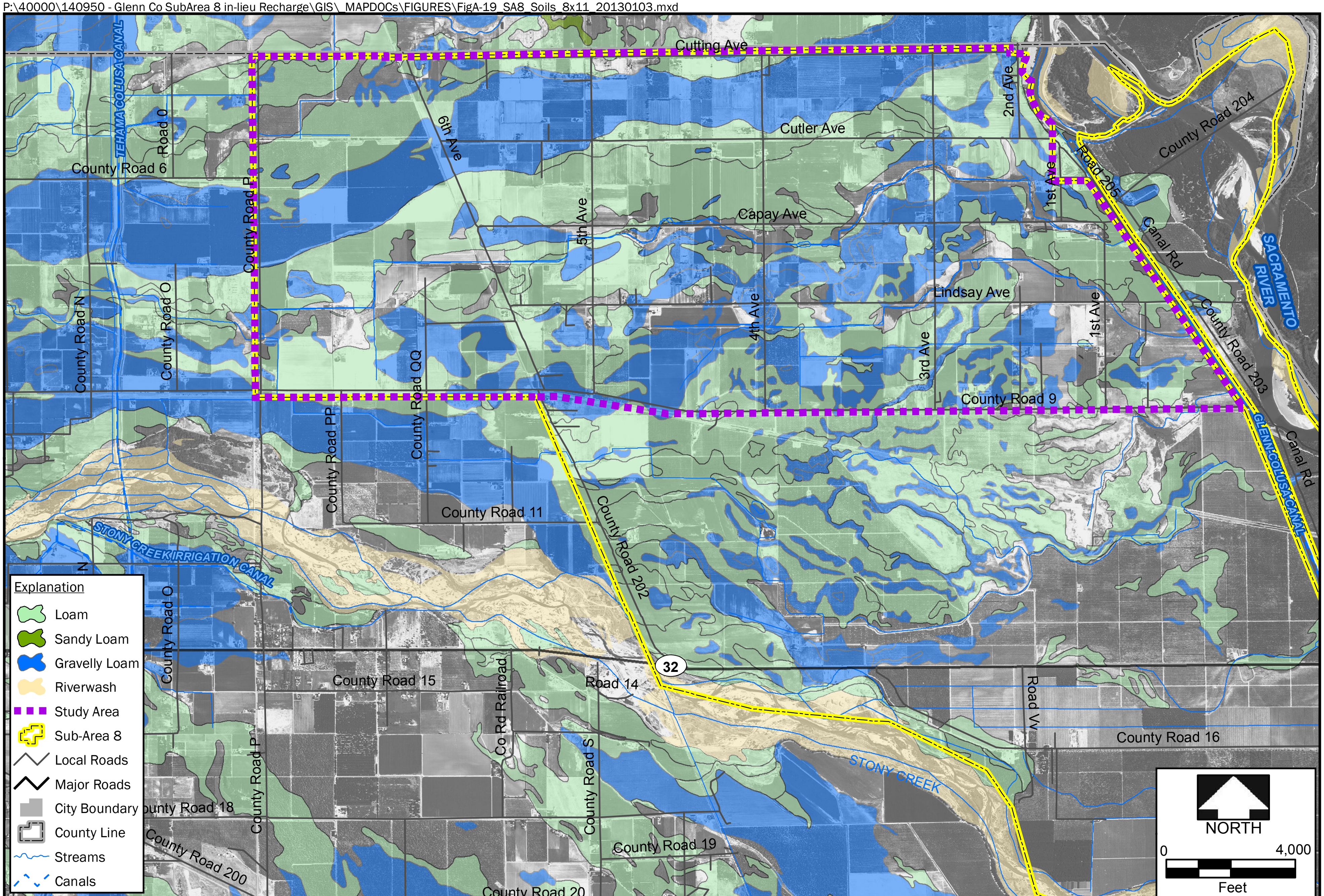
Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-17**
	DATE 01/03/2012	TITLE **Spring - Summer 2009 Drawdown Groundwater Contour Map**	

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-18_DDN_SpSu2010_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure A-18
	DATE 01/03/2012	TITLE Spring - Summer 2010 Drawdown Groundwater Contour Map	

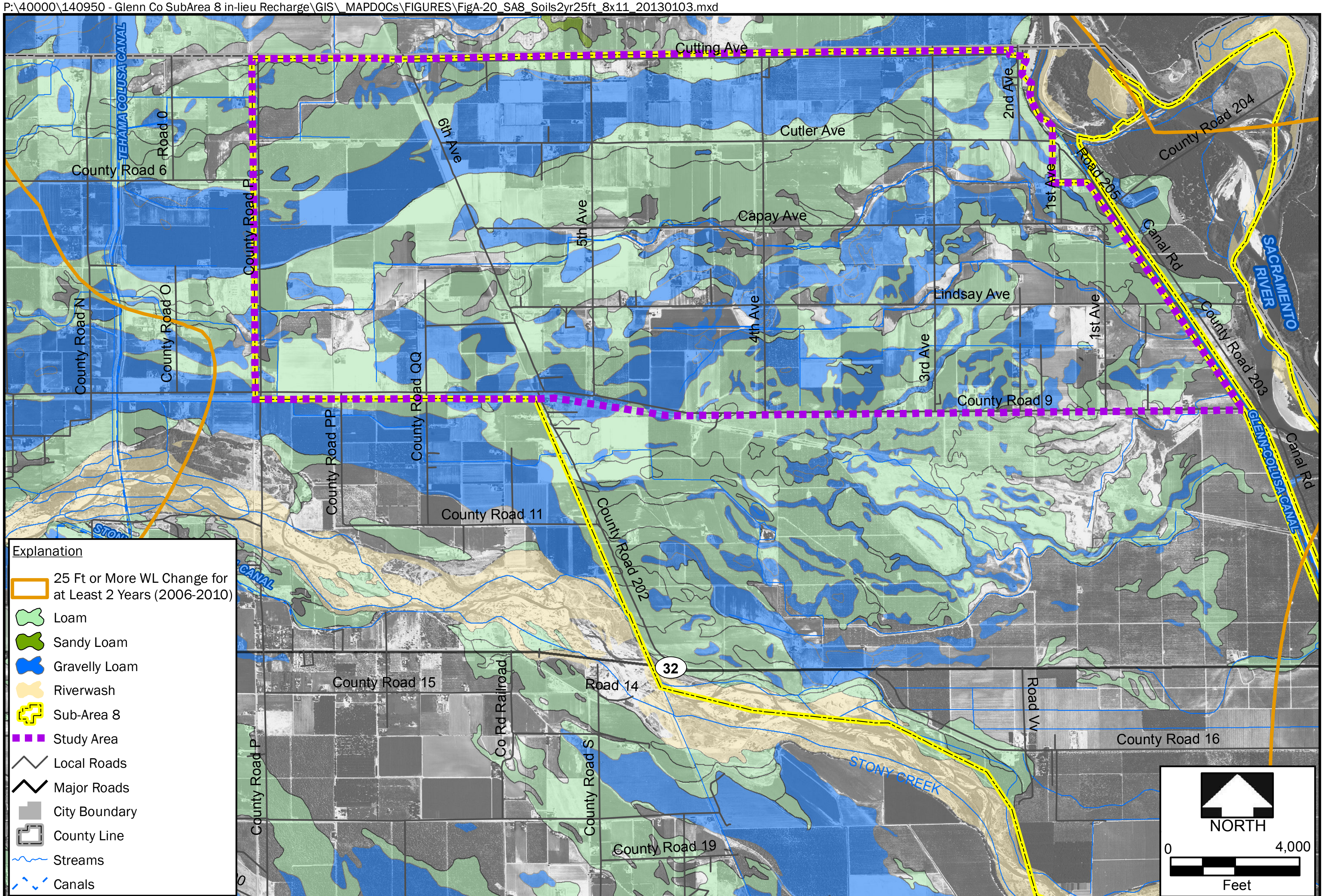
P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-19_SA8_Soils_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**
	DATE 01/03/2012	TITLE **Step 1 - Area Screened for Geology and Soil**

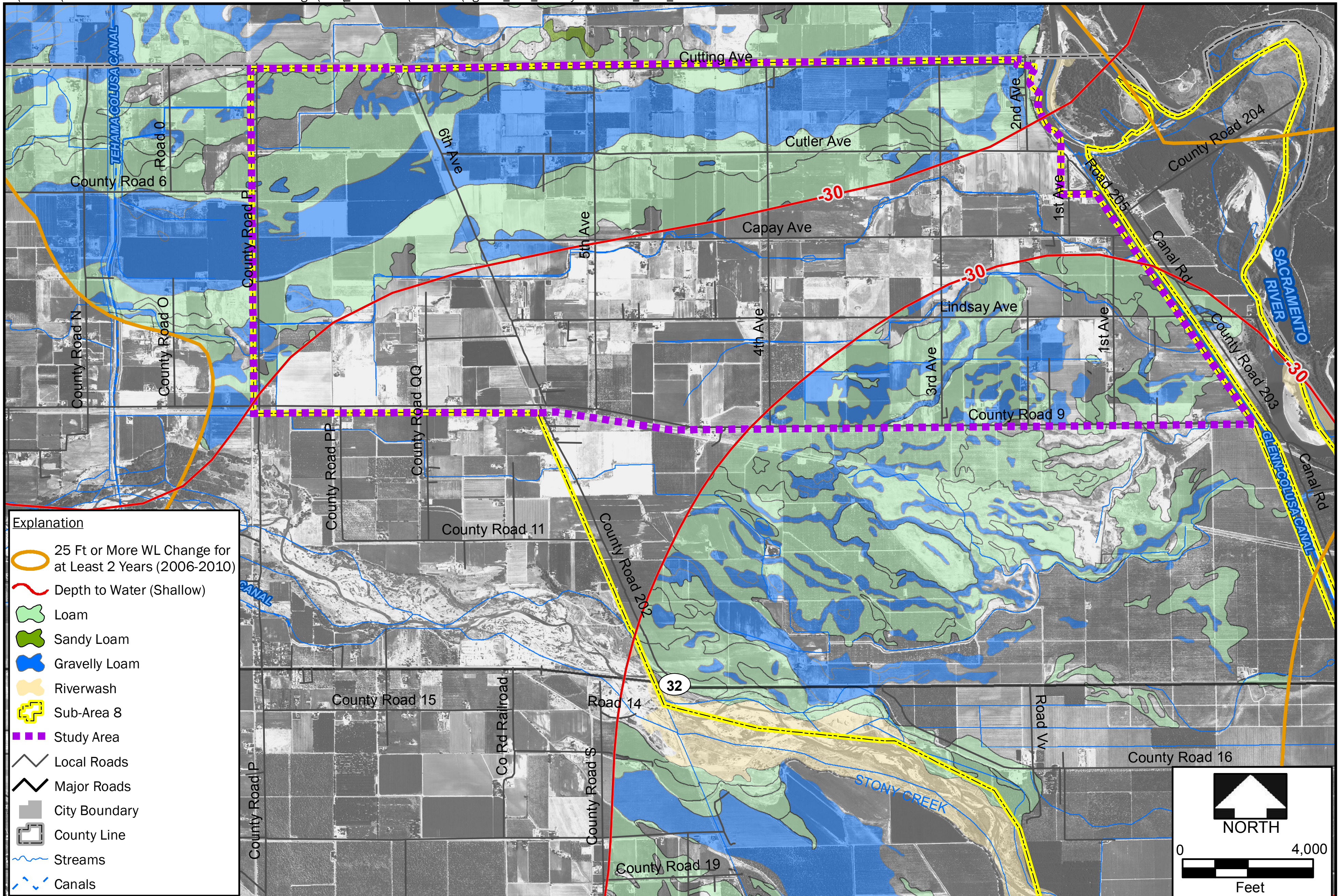
Figure A-19

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-20_SA8_Soils2yr25ft_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**	**Figure A-20**
	DATE 01/03/2012	TITLE **Step 2- Area Screened for Geology, Soil, and Areas of Need**	

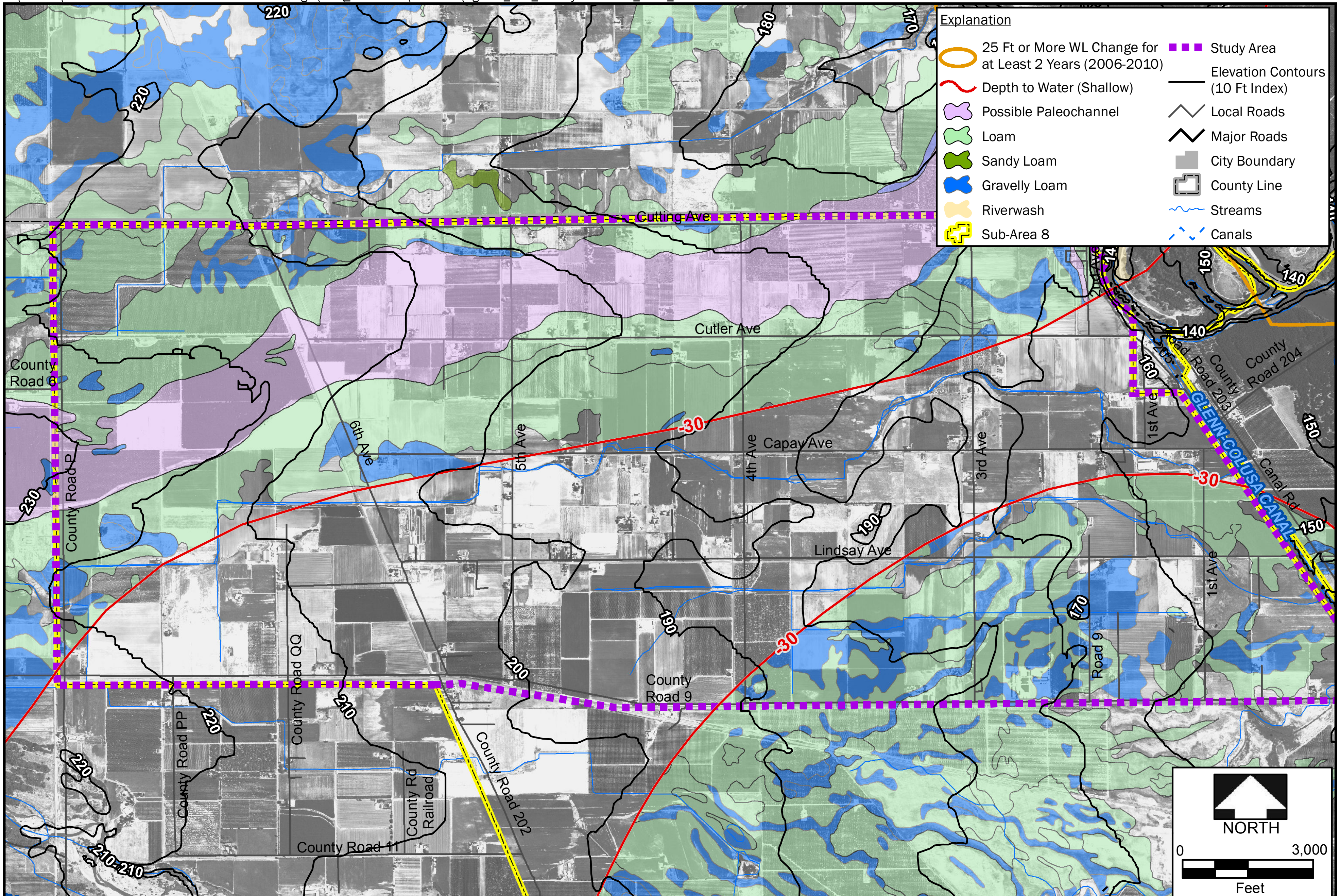
P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-21_SA8_Soils2yr25ftNo30_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE **Glenn County Groundwater Reliability and Recharge Pilot Project**
	DATE 01/03/2012	TITLE **Step 3 – Area Screened for Geology, Soil, Areas of Need, and Depth to Groundwater**

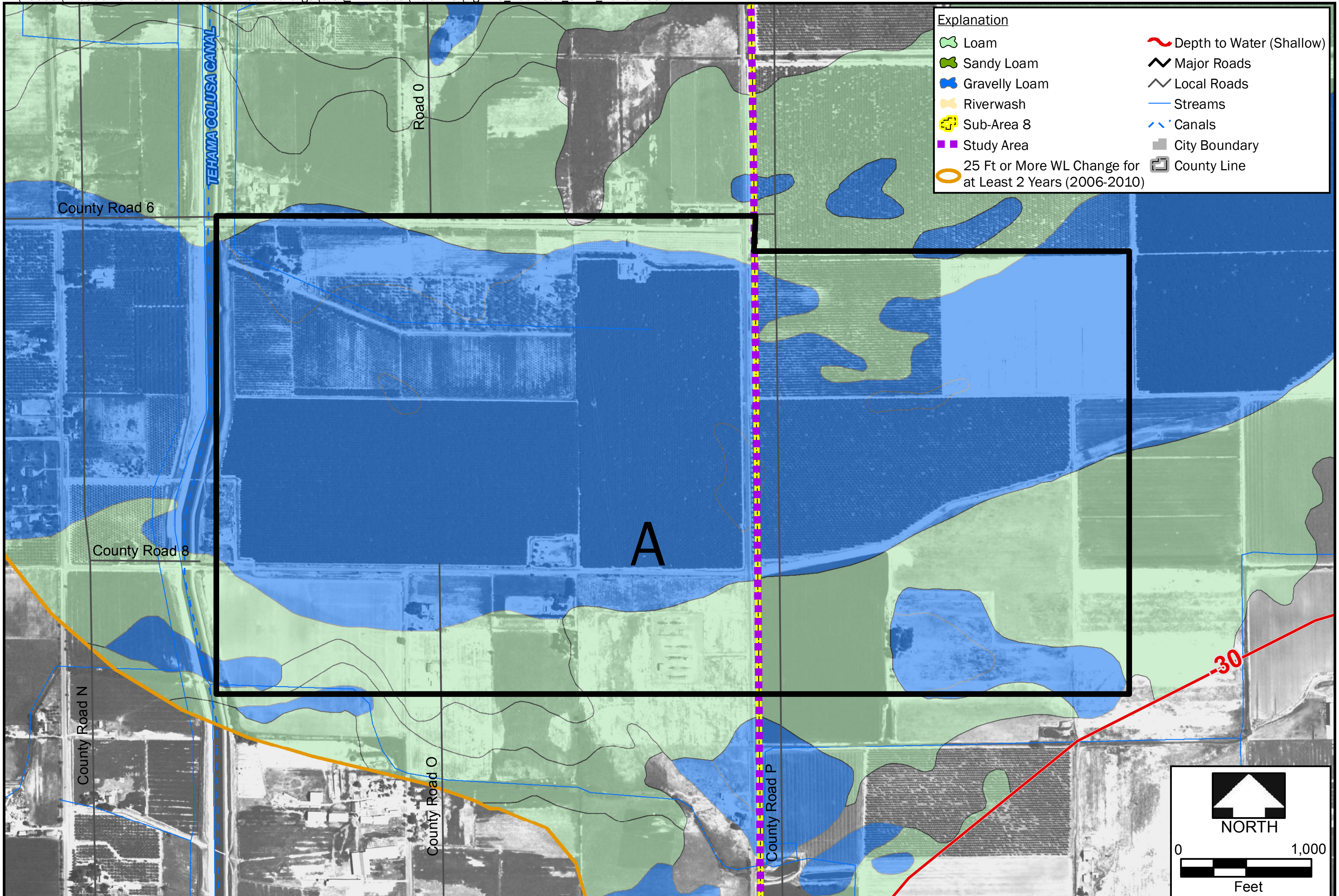
Figure A-21

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-22_SA8_Soils2yr25ftNo30_8x11_20130306.mxd



Brown AND Caldwell	PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure A-22
	DATE 03/06/2013	TITLE Location of Possible Paleochannel	

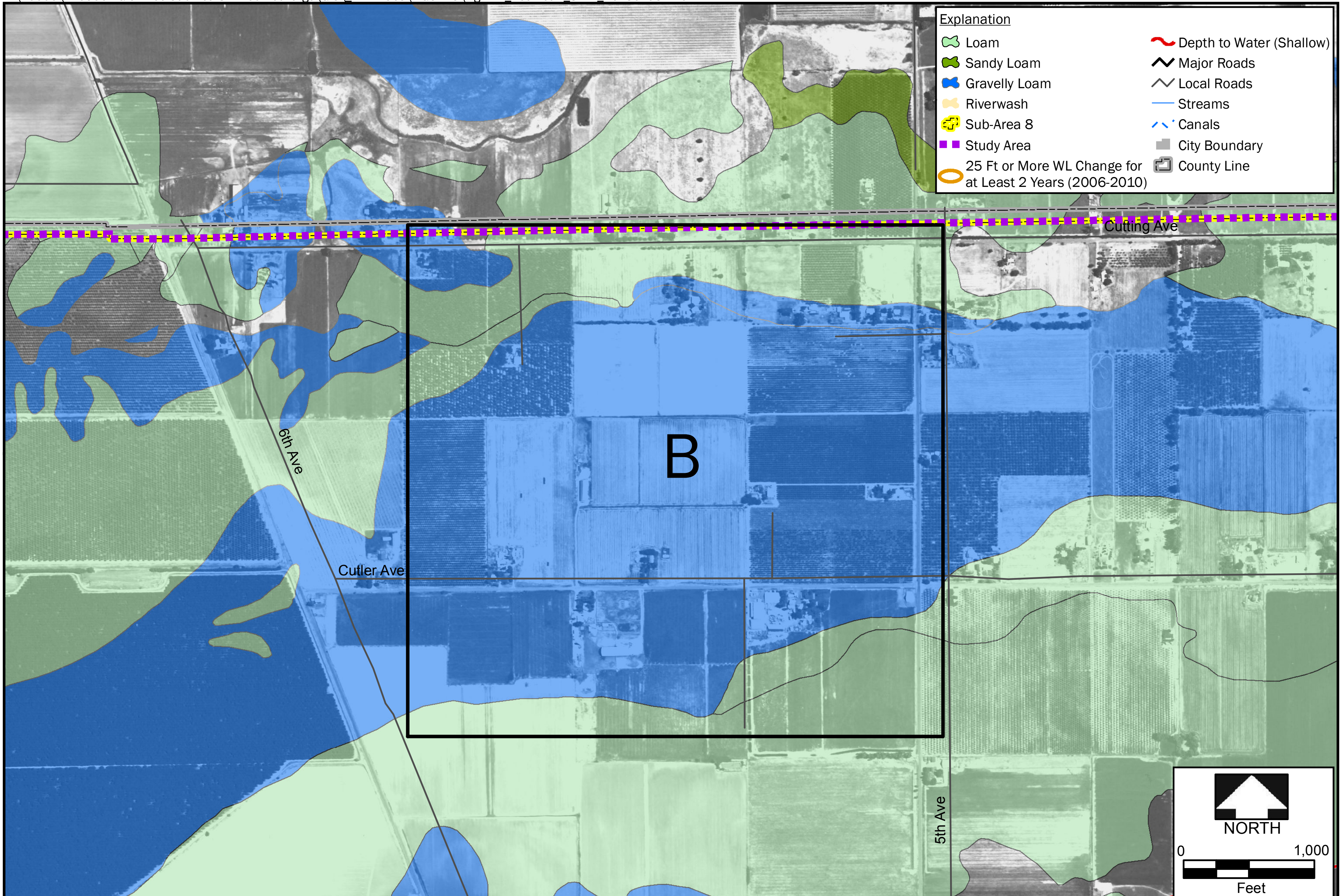
P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-23_RecAreaA_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project
	DATE 01/03/2012	TITLE Recommended Area A

Figure A-23

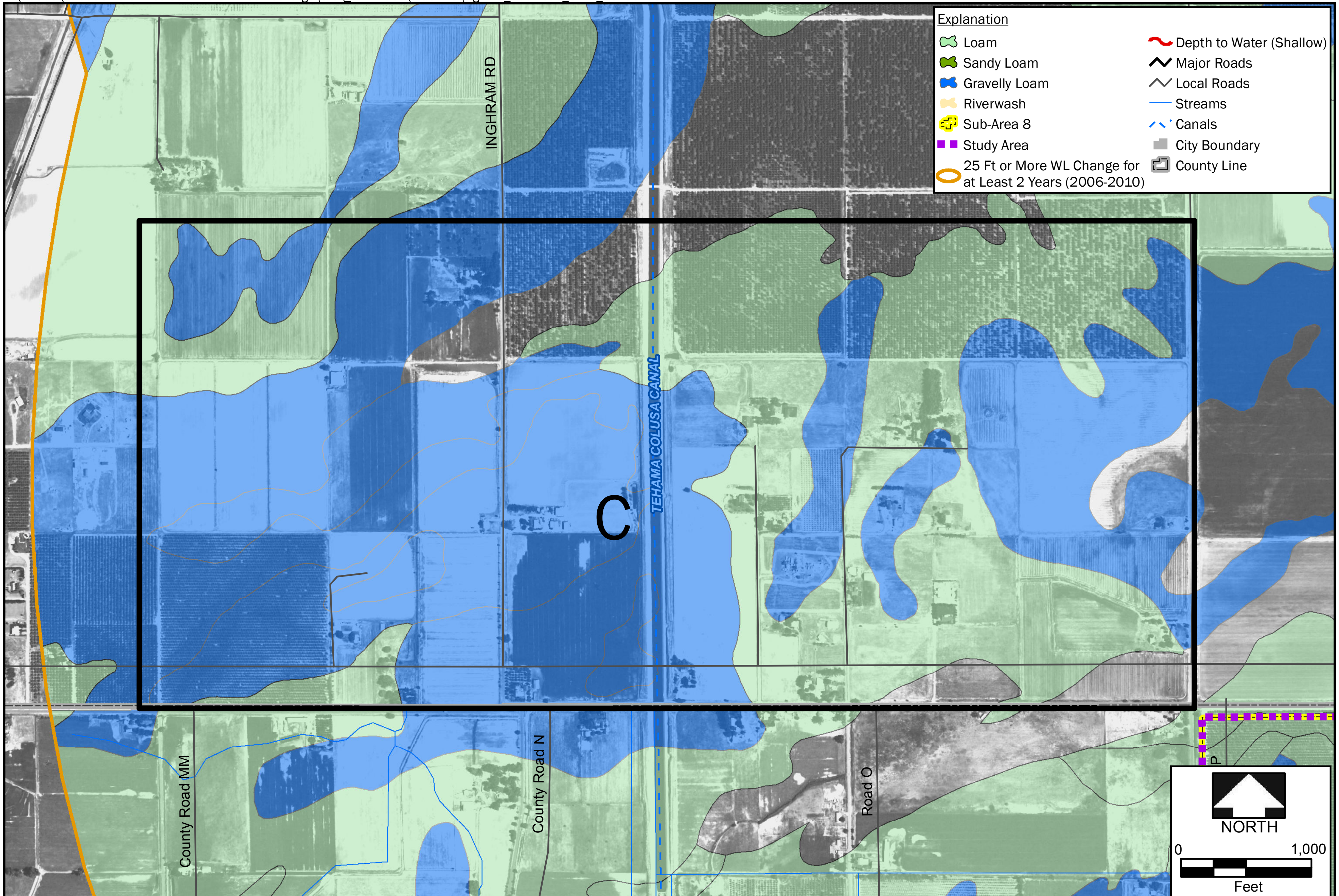
P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-24_RecAreaB_8x11_20130103.mxd



Brown AND Caldwell

PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure A-24
DATE 01/03/2012	TITLE Recommended Area B	

P:\40000\140950 - Glenn Co SubArea 8 in-lieu Recharge\GIS_MAPDOCs\FIGURES\FigA-25_RecAreaC_8x11_20130103.mxd



Brown AND Caldwell	PROJECT 140950	SITE Glenn County Groundwater Reliability and Recharge Pilot Project	Figure A-25
	DATE 01/03/2012	TITLE Recommended Area C	

Appendix B

Table B-1. Capacities of Existing Ditches and Culverts

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE B-1. Capacities of Existing Ditches and Culverts

Branch	Turn-outs	Node	Location	Coordinates	EL	Type (ditch/ Culvert)	Photo #	Slope	Length, ft	Cum Length	Existing Manning's n	Existing Culvert Size: Pipe Diameter, in	# Culverts	Existing Ditch Size: Bed Width, ft	Top Width, ft	Depth, ft	Water Depth, ft	Top Water Width, ft	Cross Section Area, sqft	Wetted Perimeter, ft	Velocity at Capacity, ft/s	Current Capacity, cfs	Required Flow	Good?	Lined ?
A0		N01	From over TC Canal		242	Pipe		0.01		0	0.013	32	1									48.72	31.0	YES	
A0			Through 48" Wooden Sliding Gate	39 47 12.39 N, 122 09 18.12 W		Gate																99999.00	31.0	YES	Yes
A0		N02	Through 2" culvert North, crossing Rd 6	39 47 12.90 N, 122 09 17.99 W	242	Culvert Pipe		0.1		63	0.013	24	1									71.54	31.0	YES	
A0			Large Ditch, intersection	39 47 13.41 N, 122 09 17.80 W		Ditch	Oversized	0.014492754	69		0.019												31.0	YES	yes
A0			Gate	39 47 13.41 N, 122 09 17.80 W	241	Gate				132												99999.00	31.0	YES	
A0			Lined Ditch going North	39 47 17.54 N, 122 09 17.83 W		Ditch		0.008152174	368		0.019			3	9	2.00	1.50	7.50	7.88	9.71	6.14	48.37	31.0	YES	yes
A0		N03	Culvert going N crossing farm road	39 47 17.54 N, 122 09 17.83 W	238	Culvert Pipe	235	0.027777778	18	500	0.013	24	1									37.70	31.0	YES	
A0			Large Ditch, half circle going N			Ditch		0.005	1200		0.019			3	12.5	3.00	2.50	10.92	17.40	13.74	6.47	112.62	31.0	YES	yes
A0		N04	Culvert	XXXXXX	232	Culvert Pipe		0.018518519	27	1700	0.013	24	1									30.79	31.0	NO	
A0			Ditch going East			Ditch		0.001428571	700		0.019			4	10	2.17	1.67	8.62	10.51	10.86	2.89	30.40	31.0	NO	
A0		N05	Culvert crossing Farm road	XXXXXX	231	Culvert Pipe		0.01	25	2400	0.013	24	1									22.62	31.0	NO	
A0			Ditch going East to Rd O			Ditch		0.005387931	556.8		0.08			4	10	2.17	1.67	8.62	10.51	10.86	1.33	14.02	31.0	NO	
A0		N06	Culvert Crossing Rd O	39 47 30.35 N, 122 09 00.89 W	228	Culvert Pipe	228	0.011111111	45	2956.8	0.013	24	1									23.85	31.0	NO	
A0			Gate at Turn (ditch going from east to North)	39 47 30.35 N, 122 09 00.89 W		Gate	P9/P10															99999.00	31.0	YES	Yes
A0			Ditch along Rd O going North	39 47 30.35 N, 122 09 00.89 W		Ditch	P9/P10	0.004734848	211.2		0.019			4	10	2.17	1.67	8.62	10.51	10.86	5.27	55.35	31.0	YES	Yes
A0		N07	Culvert for house	XXXXXX	227	Culvert		0.01	15	3168	0.024	24	1									12.25	31.0	NO	
A0			Ditch along Rd O going N and then turns East becoming a broken lined ditch	39 47 38.77 N, 122 09 00.58 W		Ditch	P1, P17	0.001832845	3273.6		0.08			4	10	2.17	1.67	8.62	10.51	10.86	0.78	8.18	31.0	NO	
A0		N08	Culvert crossing Rd P at	39 47 35.86 N, 122 08 19.54 W	221	Culvert	no photo	0.01	45	6441.6	0.024	0	0									0.00	31.0	NO	
A0	t1		Ditch along Rd P going south			Ditch	P14	0.000728438	1372.8		0.04			6	20	5.00	4.50	18.60	55.35	22.64	1.82	100.71	31.0	YES	
A0		N09	Culvert crossing farm road	XXXXXX	220	Culvert		0.01	25	7814.4		0	1									0.00	29.6	NO	
A0			Ditch going East to A1 and A2			Ditch		0.000676407	1478.4		0.04			6	20	5.00	4.50	18.60	55.35	22.64	1.75	97.04	29.6	YES	
			END A0		219					9292.8															
A1		N10	Culvert at split going North	39 47 23.99 N, 122 08 06.84 W	220	Culvert		0.01	18	0	0.024	24	1									12.25	21.7	NO	
A1			Ditch going North towards Malton Switch Rd			Ditch	NP15, P16	0.001646904	3643.2		0.04			6	15	4.00	3.50	13.88	34.78	17.40	2.39	83.20	21.7	YES	
A1		N11	Near Malton Switch Rd, one culvert (18")P16	39 47 51.44 N, 122 7 54.26 W	214	Culvert	P16	0.01	10	3643.2	0.024	18	1									5.69	21.7	NO	
A1			two culverts (30" and 32"), Malton Switch (undercrossing), the 18" culvert	39 47 51.44 N, 122 7 54.26 W	214	Culvert	P16	0.01		3643.2	0.024	30	2									44.44	21.7	YES	
A1	t1		Ditch going North to Capay Rd			Ditch	P16, P7	0.002272727	2640		0.04			6	15	4.00	3.50	13.88	34.78	17.40	2.81	97.74	21.7	YES	
A1		N12	Culvert crossing Country Rd 202	39 48 03.36 N, 122 07 36.07 W	208	Culvert	P7	0.01		6283.2	0.024	32	2									52.78	20.0	YES	
A1	t2 - t5		Ditch going east from Capay Rd to 5th Ave			Ditch	P7	0.002725093	7339.2		0.08			6	15	4.00	3.50	13.88	34.78	17.40	1.54	53.51	20.0	YES	
A1		N13	Culvert crossing 5th Ave		188	Culvert		0.01		13622.4	0.024	48	3									233.42	13.2	YES	
A1	t6 - t8		Ditch going east from 5th to 4th			Ditch		0.001893939	5280		0.08			3	15	2.50	2.00	12.60	15.60	15.65	0.81	12.58	13.2	NO	
A1		N14	Bridge Crossing		178	Bridge		0.01		18902.4	0.019	60	2									356.40	7.7	YES	
A1	t9 - t11		Ditch going east from 4th to Walch Ave ditch undercrossing			Ditch		0.003787879	1320		0.027			8	15	2.50	2.00	13.60	21.60	16.06	4.13	89.14	7.7	YES	
			Bridge crossing		173	Bridge		0.01		20222.4	0.019	60	2									356.40	3.5	YES	
			Ditch to River / Glenn-Colusa Canal			Ditch		0.001152833	6072		0.027			6	15	4.00	3.50	13.88	34.78	17.40	2.97	103.13	3.5	YES	
			END (GC Canal)		166					26294.4															
A2		**N15**	**Culvert going East**	**39 47 25 N 122 07 59.88 W**	**219**			**0.01**	**15**													**0.00**	**11.3**	NO	
A2			Ditch going East to transition into pipeline			Ditch	P15	0.01	0	0	0.025			6	20	5.00	4.50	18.60	55.35	22.64	10.79	597.01	11.3	YES	
A2	**Rd - t4**	**N16**	**Assume all pipeline**		**210**	**Pipeline**		**0.003214286**	2800	10243.2													**9.5**	NO	
	R - t1		**Pipeline**		**215**	**Pipeline**		**0.003333333**	1200														**2.0**	NO	
	t4 - end		**Pipeline**			**Pipeline**		**0.001875**	1600														**2.0**	NO	
			END @ Ditch		**207**																				

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE B-1. Capacities of Existing Ditches and Culverts

												Existing Culvert Size		Existing Ditch Size											
Branch	Turn-outs	Node	Location	Coordinates	EL	Type (ditch/ Culvert)	Photo #	Slope	Length, ft	Cum Length	Existing Manning's n	Pipe Diameter, in	# Culverts	Bed Width, ft	Top Width, ft	Depth, ft	Water Depth, ft	Top Water Width, ft	Cross Section Area, sqft	Wetted Perimeter, ft	Velocity at Capacity, ft/s	Current Capacity, cfs	Required Flow	Good?	Lined ?
B0		N19	Water flows out of the pipe crossing TC canal	39 46 53.40 N, 122 09 20.66 W	243	Pipe				0	0.013	?	1										58.0	YES	Yes
B0			Ditch to culvert at Rd 8			Ditch		0.003883495	1030		0.019			4	11.5	3.00	2.50	10.25	17.81	13.01	6.01	107.02	58.0	YES	Yes
B0		N20	Culvert Crossing Rd 8 (to south)	39 46 46.77 N, 122 09 16.02 W	239	Culvert Pipe		0.01	40	1030	0.019	24	1									15.48	58.0	NO	
B0			Ditch along Rd 8 to Co Rd O			Ditch		0.001650165	1212		0.019			3.5	11	2.50	2.00	9.50	13.00	12.00	3.35	43.57	58.0	NO	Yes
B0		N21	Culvert at County Rd O	39 46 45.99 N, 122 09 01.09 W	237	Culvert Pipe	15, 16	0.01	40	2242	0.019	24	1									15.48	58.0	NO	
B0			**Build Ditch to extend eastward to Co Rd P**			**Ditch**		0.003372808	2668.4														**58.0**	NO	
		N22	SPLIT																						
B0a		**N22**	**Culvert at Co Rd P**	**39 46 45.68 N, 122 08 27.34 W**	**228**	**Culvert**		**0.01**	**45**	**4910.4**													**53.3**	NO	
B0a			**Build Ditch to run south to Ditch going East**	**39 46 32.77 N, 122 08 26.57 W**		**Ditch**		0.00400128	1320														**53.3**	NO	Yes
B0a	t1		Ditch begins again at Co Rd P, going East	39 46 32.77 N, 122 08 26.77 W		Ditch	P21		2428.8		0.019			0	20	6.00	5.50	18.33	50.42	22.83	8.39	423.03	53.3	YES	
B0a		N23	Culvert crossing Rd PP	39 46 32.79 N, 122 07 55.44 W	213	Culvert	P13	0.01		8659.2	0.024	36	2									72.26	53.3	YES	
B0a			Ditch going East to split to B1/B2				P13	0.001515152	1320		0.08			0	20	6.00	5.50	18.33	50.42	22.83	1.23	61.83	53.3	YES	
			SPLIT		211					9979.2															
B0b		N22			226																				
B0b	t1 - t4		Ditch from culvert at N22 to N22a					0.000172414	5800					0	0	0.00	0.00	0.00	0.00	0.00			8.5	NO	
B0b		N22a	END of ditch		225																				
START B1					212					0															
B1	t1		Ditch going north			Ditch	No Photo	0.00226142	3537.6		0.08			4	16	3.00	2.50	14.00	22.50	17.00	1.06	23.96	45.2	NO	
B1		N24	Culvert in Farm	39 46 45.95 N, 122 07 21.86 W	204	Culvert	No Photo	0.01	15	3537.6		?	?									0.00	45.2	NO	
B1			Ditch passing Reservoir, very overgrown with Bullrush?			Ditch	P12	0.001	1003.2		0.08			4	16	3.00	2.50	14.00	22.50	17.00	0.71	15.93	45.2	NO	
B1		N25	Culvert crossing Co Rd 202	39 46 46.05 N, 122 06 56.84 W	202	Culvert	P12	0.01		4540.8	0.024	48	1									77.81	45.2	YES	
B1	t2 - t3		Ditch going East to B3/B4			Large Ditch, o	No Photo	0.002047502	1953.6		0.04			8	30	5.00	4.50	27.80	80.55	31.77	3.13	251.77	45.2	YES	
					198					6494.4															
New Segment @ Co Rd QQ and 6th Ave (dead end segment)					212					0															
B2	t1		**Build Ditch to run south, then east to Co Rd Qq**	**39 46 33.25 N, 122 07 38.67 W**		**Ditch**		0.0002	2640														**10.7**	NO	
B2		N26	**Culvert at Co Rd Qq**	**39 46 19.84 N, 122 07 21.44 W**	**212**	**Culvert**		**0.005**	**40**	**2640**													**9.0**	NO	
B2	t2 - t4		Existing Ditch runs Eastwards to Co Rd 202			**Ditch**		0.001959248	3062.4		**0.08**			2	10	2.00	1.50	8.00	7.50	10.54	0.66	4.91	**9.0**	NO	
B2		N27	**Culvert at Co Rd 202**	39 46 19.52 N, 122 07 42.56 W	**206**	**Culvert**		**0.01**	**45**	**5702.4**													**3.4**	NO	
B2	t5		**Build Ditch to run Eastwards to wells/dead end**	**39 46 19.57 N, 122 06 31.87W**		**Ditch**		0.002367424	844.8														**3.4**	NO	
			END		**204**					**6547.2**															
Split from B1					199					6494.4															
B3			Ditch from B3/B4 to N28			Ditch		0.001052189	1900.8		0.08			4	16	3.00	2.50	14.00	22.50	17.00	0.73	16.34	34.0	NO	
B3		N28	Culvert crossing Co Rd 5 (Adj to Jim's)	39 46 53.04 N, 122 06 15.11 W	197	Culvert	P23	0.01		8395.2	0.024	36	2									54537.36	34.0	YES	
B3	t1		Ditch					0.001856803	2692.8		0.08			3	16	4.00	3.50	14.38	30.41	17.76	1.15	34.82	34.0	YES	
B3		N29	Bridge crossing Rd 7		192		29, 30	0.01		11088	0.019	61	2									372.46	31.8	YES	
B3	t2		Ditch					0.001671123	1795.2		0.08			5	16	3.00	2.50	14.17	23.96	17.08	0.95	22.79	31.8	NO	
B3		N30	Bridge crossing Rd 7		189		31, 32, 33	0.01		12883.2	0.019	61	2									372.46	28.3	YES	
			TO B5 and B6																						

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE B-1. Capacities of Existing Ditches and Culverts

												Existing Culvert Size		Existing Ditch Size											
Branch	**Turn-outs**	**Node**	**Location**	**Coordinates**	**EL**	**Type (ditch/ Culvert)**	**Photo #**	**Slope**	**Length, ft**	**Cum Length**	**Existing Manning's n**	**Pipe Diameter, in**	**# Culverts**	**Bed Width, ft**	**Top Width, ft**	**Depth, ft**	**Water Depth, ft**	**Top Water Width, ft**	**Cross Section Area, sqft**	**Wetted Perimeter, ft**	**Velocity at Capacity, ft/s**	**Current Capacity, cfs**	**Required Flow**	**Good?**	**Lined ?**
New Segment @ Lindsay Av an Co Rd S (connect to B3)					198					0															
B4	t1 - t2		**Build Ditch to intersection of Rd 5 and Lindsay Ave**	**39 46 45.74 N, 122 06 31.62 W**		**Ditch**		0.0001	2607														**17.7**	NO	
B4		N36	**Culvert crossing diagonally at Rd 5 and Lindsay**	**39 46 32.39 N, 122 06 15.27 W**	**201**	**Culvert**		**0.005**	**45**	**2607**													**15.2**	NO	
B4	t3-t4		**Build ditch to run east to connect to existing ditches at:**	**39 46 25.81 N, 122 05 49.27 W**		**Ditch**		0.002715325	2250.6														**15.2**	NO	
B4			Ditch to run east to Rd T			Ditch		0.002715325	3273.6		0.08			8	16	3.00	2.50	14.67	28.33	17.43	1.34	37.91	12.5	YES	
B4		N37	Culvert crossing Rd T		186			0.01		8131.2	0.024	60	1									141.07	12.5	YES	
B4			Ditch					0.003642191	1372.8		0.04			8	16	3.00	2.50	14.67	28.33	17.43	3.10	87.81	12.5	YES	
B4		N38	Bridge crossing farm rd		181			0.01		9504	0.019	36	1									45.64	12.5	YES	
B4	t5 - t6		Dtitch					0.002367424	1267.2		0.04			0	14	8.00	7.50	13.13	49.22	20.52	3.24	159.42	12.5	YES	
B4		N39	Culver crossing farm rd		178			0.01		10771.2	0.024	32	1									26.39	9.7	YES	
B4	t7 -t8		Ditch, back end needs rebuild					0.001605033	3115.2		0.027			9	16	2.50	2.00	14.60	23.60	17.06	2.74	64.60	9.7	YES	
B4		N40	Bridge crossing Lindsay Ave		173			0.01		13886.4	0.019	61	2									372.46	6.8	YES	
B4			Ditch					0.001721763	580.8		0.08			4	10	3.00	2.50	9.00	16.25	11.81	0.95	15.49	6.8	YES	
B4		N41	Culvert (large) Crossing 3r Ave		172			0.01		14467.2	0.024	60	1									141.07	6.8	YES	
B4	t9 - t11		Ditch					0.002392344	5016		0.08			4	10	3.00	2.50	9.00	16.25	11.81	1.12	18.26	6.8	YES	
B4		N42	Culvert crossing farm road		160			0.01		19483.2	0.024	24	1									12.25	3.2	YES	
B4			Ditch to Creek					0.004370629	686.4		0.024			4	10	3.00	2.50	9.00	16.25	11.81	0.00			YES	
B4			Combine with B3 Creek to GC Canal		157					20169.6														YES	
B5		N30	**PIPELINE Split from B3 (PRZ'ed)**		189	**Culvert**																			
B5			Pipe 1 (N30 to N30c), EL 198 @ N30c			**Pipe**		-0.00422535	2130	10243.2													14.1	NO	
B5	t2-t3		Pipe 2 (N30c to N17) EL 200 @ N17			**Pipe**		-0.00070175	2850	10243.2													4.1	NO	
B5	t1, t4-t6		Pipe 3 (N30c to N30b) EL 195 @ N30b			**Pipe**		0.002	1500	10243.2													10.0	NO	
			END																						
		N30	**Split from B3**																						
B6			Ditch					0.001578283	1267.2		0.08			3	16	3.00	2.50	13.83	21.04	16.93	0.85	17.95	14.2	YES	
B6		N31	Culvert crossing Rd T		187		none	0.01		14150.4	0.019	48	2									196.56	14.2	YES	
B6	t1-t2		Ditch					0.004319511	3009.6		0.08			3	16	3.00	2.50	13.83	21.04	16.93	1.41	29.70	14.2	YES	
B6		N32	Culvert crossing Rd 7		174			0.01		17160	0.019	48	1									98.28	11.0	YES	
B6	t3		Creek					0.000642013	3115.2		0.08			20	25	1.00	0.50	22.50	10.63	25.10	0.27	2.82	11.0	NO	
B6		N33	Culvert crossing 3rd Ave		172			0.01		20275.2	0.024	16	4									16.62	9.2	YES	
B6	t4 - t7		Creek					0.002869605	5227.2					20	25	1.00	0.50	22.50	10.63	25.10			9.2	YES	
B6		N34	Culvert crossing intersection diagonally, Rd 7		157			0.01		25502.4	0.024	60	1									141.07	3.5	YES	
B6			Creek					0.002805836	1425.6					20	25	1.00	0.50	22.50	10.63	25.10			3.5	YES	
B6		N35	Bridge Crossing under 1st Ave		153			0.01		26928	0.019	61	2									372.46	3.5	YES	
			Creek					0	1320															YES	
			END (GC Canal)		153					28248															

TOTALS

Appendix C

Table C-1. Demand Calculations

Table C-2. In-Lieu Recharge Distribution System Facilities and Estimated Costs

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE C-1 - DEMAND CALCULATIONS

Equation from R. Clement (1965) for less than 100 Turnouts

N=Rp+2.32(Sqrt(Rpq))
N=# of open turnouts (TOs) d/s of design point
R=Total number of TOs both open and closed d/s of design point
d=mean flow of each delivery point when TO is open, assume constant
r=fraction of time irrigation system is in use (assume 1.0)
D= hypothetical flow rate needed for entire area (# ac/40)
p= (mean frequency of probability of operation of each delivery point)
p=D/(rRd)

Probabilty of no congestion U(Pq)	Pq
3.09	99.90%
2.32	99%
1.65	95%
1.28	90%

Total Demand: **89** cfs

Constants

Estimated Usage (cfs/ac):	0.018
r:	1
B0 - B3, B5 (cfs/TO):	2
A0 - A2, B4, B6 (cfs/TO):	2

Segment	Turnout #	Acres	R	p	q	# of TOs needed for rotation	# of extra TOs needed for flex	Total TOs needed	**Demand in Section, cfs**	Flow Subtotals	
A0											
	t1	65	17	0.643	0.357	10.92	4.58	15.51	**31.02**	Pumps	13896 gpm
	Frm A1, A2		16	0.647	0.353	10.34	4.44	14.78	**29.56**		
A1											
	t1	50	11	0.652	0.348	7.17	3.66	10.84	**21.68**		
	t2	80	10	0.652	0.348	6.52	3.49	10.02	**20.03**		
	t3	100	9	0.652	0.348	5.87	3.31	9.18	**18.37**		
	t4	70	8	0.652	0.348	5.22	3.13	8.34	**16.69**		
	t5	25	7	0.652	0.348	4.57	2.92	7.49	**14.98**		
	t6	100	6	0.652	0.348	3.91	2.71	6.62	**13.24**		
	t7	40	5	0.652	0.348	3.26	2.47	5.73	**11.46**		
	t8	40	4	0.652	0.348	2.61	2.21	4.82	**9.64**		
	t9	200	3	0.652	0.348	1.96	1.91	3.87	**7.74**		
	t10	25	2	0.652	0.348	1.30	1.56	2.87	**5.73**		
	t11	75	1	0.652	0.348	0.65	1.10	1.76	**3.51**		
A2 (Partially Pipelines)											
	t1	50	5	0.634	0.366	3.17	2.50	5.67	**11.34**		
	t2	100	4	0.634	0.366	2.54	2.24	4.77	**9.54**		
	t3	17.5	3	0.634	0.366	1.90	1.94	3.84	**7.68**		
	t4	105	2	0.634	0.366	1.27	1.58	2.85	**5.70**		
	t5	83.2	1	0.634	0.366	0.63	1.12	1.75	**3.50**	Area	1226 ac
B0											
	Frm B0a, B0b		39	0.559	0.441	21.79	7.19	28.98	**57.96**	Pumps	25966 gpm
B0b											
	t1	87.1	4	0.478	0.522	1.91	2.32	4.23	**8.46**		
	t2	40	3	0.478	0.522	1.43	2.01	3.44	**6.88**		
	t3	40	2	0.478	0.522	0.96	1.64	2.60	**5.19**		
	t4	47.5	1	0.478	0.522	0.48	1.16	1.64	**3.27**		
B0a											
	t1	77.2	35	0.568	0.432	19.87	6.80	26.67	**53.34**		
B1											
	t1	39.3	29	0.566	0.434	16.41	6.19	22.60	**45.21**		
	t2	71.2	28	0.566	0.434	15.84	6.08	21.93	**43.86**		
	t3	38.2	27	0.566	0.434	15.28	5.97	21.25	**42.51**		
B2											
	t1	53.7	5	0.555	0.445	2.77	2.58	5.35	**10.70**		
	t2	89.1	4	0.555	0.445	2.22	2.31	4.52	**9.05**		
	t3	61.4	3	0.555	0.445	1.66	2.00	3.66	**7.32**		
	t4	50	2	0.555	0.445	1.11	1.63	2.74	**5.48**		
	t5	57	1	0.555	0.445	0.55	1.15	1.71	**3.42**		
B3											
	t1	59.1	2	0.620	0.380	1.24	1.59	2.83	**33.99**		
	t2	80.1	1	0.620	0.380	0.62	1.13	1.75	**31.82**		
	Frm B5, B6								**28.33**		
B4											
	t1	45	11	0.458	0.542	5.04	3.83	8.87	**17.74**		
	t2	16.5	10	0.458	0.542	4.58	3.66	8.24	**16.47**		
	t3	48	9	0.458	0.542	4.12	3.47	7.59	**15.18**		
	t4	45.2	8	0.458	0.542	3.66	3.27	6.93	**13.87**		
	t5	52.3	7	0.458	0.542	3.21	3.06	6.26	**12.53**		
	t6	20	6	0.458	0.542	2.75	2.83	5.58	**11.16**		
	t7	75	5	0.458	0.542	2.29	2.58	4.87	**9.75**		
	t8	42	4	0.458	0.542	1.83	2.31	4.14	**8.29**		
	t9	75.4	3	0.458	0.542	1.37	2.00	3.38	**6.75**		
	t10	74.9	2	0.458	0.542	0.92	1.63	2.55	**5.10**		
	t11	71	1	0.458	0.542	0.46	1.16	1.61	**3.23**		
B5											
	t1	75	6	0.786	0.214	4.71	2.33	7.05	**14.09**	Pumps	6342 gpm
	t2	86	5	0.786	0.214	3.93	2.13	6.06	**12.11**		
	t3	57	4	0.786	0.214	3.14	1.90	5.05	**10.09**		
	t4	100	3	0.786	0.214	2.36	1.65	4.01	**8.01**		
	t5	115	2	0.786	0.214	1.57	1.35	2.92	**5.84**		
	t6	96	1	0.786	0.214	0.79	0.95	1.74	**3.48**		
B6											
	t1	154	7	0.585	0.415	4.09	3.02	7.12	**14.23**		
	t2	80	6	0.585	0.415	3.51	2.80	6.31	**12.62**		
	t3	50	5	0.585	0.415	2.92	2.56	5.48	**10.96**		
	t4	32.2	4	0.585	0.415	2.34	2.29	4.62	**9.25**		
	t5	60	3	0.585	0.415	1.75	1.98	3.73	**7.47**		
	t6	60	2	0.585	0.415	1.17	1.62	2.79	**5.57**		
	t7	22.9	1	0.585	0.415	0.58	1.14	1.73	**3.46**	Area	2444 ac

2444.3 ac for B0
3670 ac total

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE C-2. In-Lieu Recharge Distribution System Facilities and Estimated Costs

								Earthwork		Lining		Culvert					Pipeline					Easement	Turnout				Control				
Reach	Turnouts	Node	Location	Type (ditch/ Culvert)	New Capacity, cfs	Lining Req'd?	Action	Fill/Cut (yd^3)	Earthwork Cost	sf	Lining Cost	size	Length	Road Crossing	cost/ft	cost	size	Length	cost/ft	Cost	Road Crossing Cost	Cost	#	Type	Unit Cost	Cost	Control	Gate Type	# of Gates	Cost	Comments
A0			Ditch going East	Ditch	66.7	Yes	Deepen	203	$ 1,419	9,800	$ 49,000																				
A0		N05	Culvert crossing Farm road	Culvert Pipe	44.4							2 @ 30"	25	farm road	$360	$9,000															
A0			Ditch going East to Rd O	Ditch	129.5	Yes	Deepen and Clean	161	$ 1,129	7,795	$ 38,976																				
A0		N06	Culvert Crossing Rd O	Culvert Pipe	46.8		Expand					2 @ 30"	45	Yes	$404	$18,180															
A0		N07	Culvert for house	Culvert	44.4		Expand					2 @ 30"	15	driveway	$404	$6,060															
A0			Ditch along Rd O going N and then turns East becoming a broken lined ditch	Ditch	75.5	Yes	Rebuild/clean/line	948	$ 6,637	45,830	$ 229,152																				
A0		N08	Culvert crossing Rd P at	Culvert	**44.4**		**New**					2 @ 30"	45	Yes	$404	$18,180															
A0	t1		Ditch along Rd P going south	Ditch																			1	Gravity	10000	$10,000	downstream				fed out of long, narrow N-S impoundment
A0		N09	Culvert crossing farm road	Culvert	72.3		Rebuild																								
			END A0																												
A1		N10	Culvert at split going North	Culvert	44.4		Expand					2 @ 30"	18	No	$360	$6,480															
A1		N11	Near Malton Switch Rd, one culvert (18")P16	Culvert	44.4		Expand					2 @ 30"	10	No	$360	$3,600															
A1	t1		Ditch going North to Capay Rd	Ditch																			1	Pump	3000	$3,000					
A1	t2 - t5		Ditch going east from Capay Rd to 5th Ave	Ditch																			4	Pump	3000	$12,000	BIVAL	EM	1	$40,000	gate
A1	t6 - t8		Ditch going east from 5th to 4th	Ditch	37.3		Assume it requires cleaning	0	$ -														3	Pump	3000	$9,000					
A1	t9 - t11		Ditch going east from 4th to Walch Ave ditch	Ditch																			3	Pump	3000	$9,000	ELFLO	EM	1	$30,000	telemetry back to gate at N12 and diversion pumps
			END (GC Canal)																												
A2		**N15**	**Culvert going East**		**12.3**		**New**					1 @ 24"	15	No	$144	$2,160															
A2	**Rd - t4**	**N16**	**Assume all pipeline**	**Pipeline**	**12.8**		**New**										24	2800	$108	$302,400	5000	$10,080	3	Pipe	5000	$15,000	const. head	weir	1	$15,000	float off weir to A1 system
	R - t1		**Pipeline**	**Pipeline**	**3.7**		**New**										15	1200	$68	$81,000	5000	$4,320	1	Pipe	5000	$5,000					
	t4 - end		**Pipeline**	**Pipeline**	**2.8**		**New**										15	1600	$68	$108,000		$5,760	1	Pipe	5000	$5,000					
			END @ Ditch																												
B0		N19	Water flows out of the pipe crossing TC canal	Pipe			Could not reach, assume good																								
B0			Ditch to culvert at Rd 8	Ditch																											
B0		N20	Culvert Crossing Rd 8 (to south)	Culvert Pipe	72.3							2 @ 36"	40	Yes	$498	$19,920															
B0			Ditch along Rd 8 to Co Rd O	Ditch	71.7	Yes	Rebuild	239	$ 1,676	16,968	$ 84,840																				
B0		N21	Culvert at County Rd O	Culvert Pipe	72.3		Rebuild					2 @ 36"	40	Yes	$498	$19,920															
B0			**Build Ditch to extend eastward to Co Rd P**	**Ditch**	**102.5**	**Yes**	**New**	1812	$ 12,683	37,358	$ 186,788											$19,212									
		N22	SPLIT																												
B0a		**N22**	**Culvert at Co Rd P**	**Culvert**	72.3		**New**					2 @ 36"	45	**Yes**	$498	$22,410															
B0a			**Build Ditch to run south to Ditch going East**	**Ditch**	**99.5**	**Yes**	**New**	794	$ 5,561	16,481	$ 82,403											$8,712									
B0a	t1		Ditch begins again at Co Rd P, going East	Ditch																			1	Gravity	10000	$10,000	downstream f	weir	1	$15,000	keep farm reservoir full
			SPLIT																												
B0b	t1 - t4		Ditch from culvert at N22 to N22a		14.0	No	Need to Measure	3759	$ 26,315														4	Gravity	10000	$40,000	downstream	DS	1	$30,000	level top canal
B0b		N22a	END of ditch																												
B1	t1		Ditch going north	Ditch	71.0		Clean moderately	0															1	Pump	3000	$3,000	n/a				there should always be sufficient flow
B1		N24	Culvert in Farm	Culvert	72.3		Assume insufficient					2 @ 36"	15	No	$432	$6,480															
B1			Ditch passing Reservoir, overgrown	Ditch	70.2		Clean, Slightly deepen	279	$ 1,951																						
B1	t2 - t3		Ditch going East to B3/B4	Large Ditch, overgrown																			2	Pump	3000	$6,000	n/a				there should always be sufficient flow
New Segment @ Co Rd QQ and 6th Ave (dead end segment)																															
B2	t1		**Build Ditch to run south, then east to Co Rd Qq**	**Ditch**	15.1	**No**	**New**	1711	$ 11,978													$7,033	1	Gravity	10000	$10,000	downstream	weir	1	$20,000	level top canal, need weir for branch to B1
B2		N26	**Culvert at Co Rd Qq**	**Culvert**	**25.5**		**New**					1 @ 36"	40	yes	$249	$9,960															
B2	t2 - t4		Existing Ditch runs Eastwards to Co Rd 202	**Ditch**	20.6	**No**	Clean and enlarge	241	$ 1,687														3	Gravity	10000	$30,000	downstream	DS	1	$30,000	level top canal
B2		N27	**Culvert at Co Rd 202**	**Culvert**	**12.3**		**New**					1 @ 24"	45	yes	$177	$7,965															
B2	t5		**Build Ditch to run Eastwards to wells/dead end**	**Ditch**	16.0	**No**	**New**	235	$ 1,643													$20,592	1	Gravity	10000	$10,000	downstream	DS	1	$15,000	level top canal
			END																												
Split from B1																											ELFLO	EM	1	$50,000	downstream sensor at N31, level telemetry controlling gate to B3
B3		N28	Culvert crossing Co Rd 5 (Adj to Jim's)	Culvert																							n/a				
B3	t1		Ditch																				1	Pump	3000	$3,000					ELFLO at N31
B3		N29	Bridge crossing Rd 7																												
B3	t2		Ditch		67.5		Clean	0															1	Pump	3000	$3,000	n/a				ELFLO at N31
			TO B5 and B6																												
New Segment @ Lindsay Ave and Co Rd S (connect to B3)																											ELFLO	DS	1	$80,000	regulating reservoir sensor back to diversion pumps plus DS gate to B4 plus bypass
B4	t1 - t2		**Build Ditch to intersection of Rd 5 and Lindsay**	**Ditch**	26.5	**No**	**New**	3126	$ 21,882													$21,899	2	Gravity	10000	$20,000	downstream				level top canal
B4		N36	**Culvert crossing diagonally at Rd 5 and Lindsay**	**Culvert**	**25.5**		**New**					1 @ 36"	45	yes	$249	$11,205															
B4	t3-t4		**Build ditch to run east to connect to existing ditches at:**	**Ditch**	26.7	**Yes**	**New**	875	$ 6,127	29,132	$ 145,662											$16,204	2	Gravity	10000	$20,000	downstream				level top canal
B4			Ditch to run east to Rd T	Ditch																											
B4		N37	Culvert crossing Rd T																									EM	1	$40,000	gate downstream of t3/t4, sensor at N42
B4	t5 - t6		Dtitch																				2	Pump	3000	$6,000		ELFLO			
B4		N39	Culvert crossing farm rd																												
B4	t7 -t8		Ditch, back end needs rebuild																				2	Pump	3000	$6,000		ELFLO			
B4	t9 - t11		Ditch																				3	Pump	3000	$9,000		ELFLO			sensor at N42
B4			Combine with B3 Creek to GC Canal																												
B5		N30	**PIPELINE Split from B3 (PRZ'ed)**	**Culvert**																											
B5			Pipe 1 (N30 to N30c), EL 198 @ N30c	**Pipe**			**New**										24	2130	$108	$230,040	8000	$7,668									
B5	t2-t3		Pipe 2 (N30c to N17) EL 200 @ N17	**Pipe**			**New**										15	2850	$68	$192,375	7000	$10,260	2	Pipe	5000	$10,000	n/a				ELFLO sensor at N31 controlling gate at B3 split
B5	t1, t4-t6		Pipe 3 (N30c to N30b) EL 195 @ N30b	**Pipe**			**New**										21	1500	$95	$141,750	7000	$5,400	4	Pipe	5000	$20,000	n/a				ELFLO sensor at N31 controlling gate at B3 split
			END																												
		N30	**Split from B3**																												
B6			Ditch																												
B6		N31	Culvert crossing Rd T																									ELFLO	1	$40,000	gate controlled by sensor at N34
B6	t1-t2		Ditch																				2	Pump	3000	$4,000		ELFLO			sensor at N34 controling gate at N31
B6		N32	Culvert crossing Rd 7																												
B6	t3		Creek		13.0	**No**	Deepen/clean/narrow	812	$ 5,687														1	Pump	3000	$2,000		ELFLO			
B6		N33	Culvert crossing 3rd Ave																												
B6	t4 - t7		Creek				Assume good																4	Pump	3000	$8,000		ELFLO			
			END (GC Canal)																												
							Quantity Totals	15,196		163,364			443					12,080					56						12		
							Dollar Totals		$ 106,374		$ 816,821					$ 161,520				$ 1,055,565		$ 137,141				$288,000				$ 405,000	$2,970,421

Appendix D

Table D-1. Estimated Unit Costs for Potential Surface Water Supply Project

Table D-2. Pump Stations and Reservoir Estimated Base Costs

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE D-1. Estimated Unit Costs for Proposed Service Area Improvements

Earthen Canal Deepening	$7.00	$/cy
Shotcrete Lining	$6.00	$/sf
Gravity Turnout	$10,000	ea
Pipe Turnout	$5,000	ea
Pump Turnout	$3,000	ea
Easements	$0.30	$ per sf
Low head PVC	$4.50	$/ft per inch-dia
CMP Culverts	$7.50	$/ft per inch-dia
Pavement Replacement	$5.50	$/sf

Glenn County Groundwater Reliability and Recharge Pilot Program
TABLE D-2. Pump Stations and Reservoir Estimated Base Costs

Item	Quantity	Units	Unit Cost	Extended
South Pump Station				
100 HP Pumps (14000 gpm)	3	ea	$70,000	$210,000
Electrical, structural, installation	3	ea	$200,000	$600,000
Total				**$810,000**
North Pump Station				
100 HP Pumps (14000 gpm)	2	ea	$70,000	$140,000
Electrical, structural, installation	2	ea	$200,000	$400,000
Total				**$540,000**
In-System Pump Station				
6300 gpm, 35' lift; 75 HP	2	ea	$50,000	$100,000
Pump electrical, structural, installation	2	ea	$100,000	$200,000
Total				**$300,000**
Regulating Reservoir				
Earthwork	1185	cy	$7	$8,295
Spillway	1	ea	$15,000	$15,000
Regulating Gate	already included in Table C-2			
Misc.	1	ls	$12,000	$12,000
Total				**$35,300**

Appendix E

United States Bureau of Reclamation Fee Schedules

Central Valley Project
Transfer Form
2012
Transferor, Renewed Contract

Use the Business Practice Guidelines for Accounting for CVP Water Transfers, Exhibits A and C.

Transferor: Irrigation, Renewed — Water Contractor: Glenn-Colusa ID - Sac. River
Transfer Purpose: Irrigation — Water Contractor: Non-CVP - TCC

	Rates
Identify the Transferor's Cost of Service Rate **(Schedule A-2A)**	**21.86**
Reduce Rate for Transferor's Direct Pumping O&M	
Reduce Rate for Transferor's Ability to Pay Capital Relief (Cost to Power) **(Schedule A-2A)**	
Add Additional Services to Transferee that Apply	
Storage Capital	
San Felipe Unit	
All Others	
Conveyance Pumping Capital	
Corning PP	
Dos Amigos PP	
O'Neill PGP	
Tracy PP	
FK/Madera Exchange	
All Other Contractors	
Conveyance Capital **(Schedule A-2Bb)**	3.06
Direct Ppg Capital	
Ability to Pay Capital Relief (Cost to Power)	
Storage O&M	
Direct Pumping O&M	
Effective Transfer Rate	**24.92**

Identify Transferor's Tiered Water Rates (Begin with the Transferor's Full Cost 202(3) Rate)

Full Cost==> ______ *

Tier 2: Applicable to > 81 <= 90% of transferor's entitlement

Tier 3: Applicable to > 90% of transferor's entitlement

Identify Applicable Full Cost (FC) Interest Water Rate for Transferee.

		Full Cost Water Rate		Additional Interest from Eff. Rate	Tier 2	Tier 3
202(3) Interest Rate?	Total FC Rate==>		<==Total FC Rate			
205(a)(3) Interest Rate?	Total FC Rate==>		<==Total FC Rate			

Irrigation Restoration Fund Charge **(Schedule A-1)**	
Restoration Fund Charge	**9.79**
Ability to Pay Restoration Fund Charge Relief (Cost to Power)	**-**
Applicable Restoration Fund Charge for Transfer Water	**9.79**
M&I Surcharge (Transfer of CVP water to Non-CVP Contractor)	**40.80**
Trinity Public Utilities District Assessment **(Schedule A-1)**	**0.05**
Friant Surcharge: Water being diverted from the Friant-Kern Canal or Millerton Reservoir	-
Total = Effective Transfer Rate + Restoration + Surcharge + Trinity PUD Assessment	**75.56**

* If Applicable, Distribution System interest identified on Irrigation water ratebook, Schedule A-3A is excluded.

EXHIBIT B
GLENN-COLUSA IRRIGATION DISTRICT
YEAR 2012 CONVEYANCE RATES
(Per Acre-Foot)

Cost Component	(1) Irrigation Cost of Service	(2) RRA Full Cost 202(3)	(3) RRA Full Cost 205(a)(3)	(4) Incremental Fee	(5) M&I Cost of Service
Water Marketing	$6.43	$6.43	$6.43	$6.43	$3.13
Conveyance					
O&M	$0.00	$0.00	$0.00	$0.00	$0.00
Capital	$5.81	$11.52	$13.93	$13.93	$4.58
Other Cost	$0.43	$0.85	$1.03	$1.03	$1.75
Total	$12.67	$18.80	$21.39	$21.39	$9.46

(1) The Irrigation Cost of Service Rate is applicable to Eligible Lands that are entitled to receive Irrigation Water at other than a Full-Cost Rate.

(2) The RRA Section 202(3) Full Cost Rate is applicable to a Qualified Recipient or to a Limited Recipient (as those terms are defined in Section 202 of the RRA) receiving Irrigation Water on or before October 1, 1981.

(3) The RRA Section 205(a)(3) Full Cost Rate is applicable to a Limited Recipient (as that term is defined in Section 202 of the RRA) that did not receive Irrigation Water on or before October 1, 1981, and those prior law landholders leasing land in excess of their entitlement.

(4) The Incremental Fee is applicable to Ineligible Lands pursuant to subdivision (b) of Article 9 of this Contract. (Incremental Fee requirements for Ineligible Lands are set forth in 43 CFR 426.15.)

(5) The M&I Cost of Service Rate is applicable to Non-Project Water delivered for municipal and industrial purposes. See definition of "Municipal and Industrial Water" in subdivision (j) of Article 1 of this Contract.

*Conveyance operation and maintenance costs were removed for ratesetting purposes and are billed directly by the Operating Non-Federal Entity.

NOTE: If the Non-Project Water is being conveyed through the Contractor's 9(d) distribution system, a separate rate will be developed for that system.

Additional details of rate components are available on the Internet at http://www.usbr.gov/mp/cvpwaterrates/ratebooks/index.html.