Final

Remedial Investigation/ Feasibility Study Report B.F. Goodrich Superfund Site Rialto, California

Prepared for:

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January 25, 2010

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ES110209152559SCO/LW3289.DOC/100220001

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Acronyms

°F	degrees Fahrenheit
1,1,1-TCA	1,1,1-trichloroethane
1,1-DCA	1,1-dichloroethane
AFY	acre-feet per year
AHPA	Archaeological and Historic Preservation Act
AOP	advanced oxidation process
ARAR	applicable or relevant and appropriate requirement
ARPA	Archaeological Resources Protection Act
BACT	best available control technology
bgs	below ground surface
BOD	biological oxygen demand
CAA	Clean Air Act
Caltrans	California Department of Transportation
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COD	chemical oxygen demand
COPC	contaminant of potential concern
CT	concentration time
DIP	ductile iron pipe
DLR	Detection Limit Requirement
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FBR	fluidized bed reactor
FS	feasibility study
ft/day	feet per day
ft/ft	feet per foot
gpm	gallons per minute

H&SC	Health and Safety Code
HDD	horizontal directional drilling
HDPE	high-density polyethylene
HHRA	human health risk assessment
HI	hazard index
HWL	high water level
I	Interstate
ISB	in situ bioremediation
lb	pound
LGAC	liquid-phase granular activated carbon
MCL	maximum contaminant level
µg/L	micrograms per liter
MP	multi-port well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NHPA	National Historic Preservation Act
NPL	National Priorities List
NPV	net present value
NRHP	National Register of Historic Places
O&M	operations and maintenance
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
OU	operable unit
Ox	oxidant
PCE	tetrachloroethene
PFD	process flow diagram
psi	pounds per square inch
PVC	polyvinyl chloride
PW	permanent monitoring well
RA	remedial action
RAO	remedial action objective
RASP	Rialto Ammunition Backup Storage Point
RCB	Rialto-Colton Groundwater Basin
RCRA	Resource Conservation and Recovery Act

RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RMS/range	root-mean squared range
RO	reverse osmosis
ROD	Record of Decision
RSL	regional screening level
RWQCB	Regional Water Quality Control Board, Santa Ana Region
SCADA	supervisory control and data acquisition
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SDWA	Safe Drinking Water Act
Site	B.F. Goodrich Superfund Site
STLC	soluble threshold limit concentration
T-BACT	best available control technology for toxics
TBC	to be considered
TCE	trichloroethylene
TDS	total dissolved solids
TTLC	total threshold limit concentration
U.S.C.	U.S. Code
USGS	U.S. Geological Survey
UV	ultraviolet
VFD	variable frequency drive
VGAC	vapor-phase granular activated carbon
VOC	volatile organic compound
WCLC	West Coast Loading Corporation
WVWD	West Valley Water District

SECTION 1

Introduction

The United States Environmental Protection Agency (EPA) is conducting a remedial investigation and feasibility study (RI/FS) to address groundwater contamination at the B.F. Goodrich Superfund Site (B.F. Goodrich Site or Site). Most or all of the Site is located in the Rialto-Colton Groundwater Basin (RCB) in western San Bernardino County, California. The RCB and adjacent groundwater basins are important sources of drinking water to residents and businesses in the cities of Rialto, Colton, and Fontana. In recent years, more than 10,000 acre-feet of water have been pumped each year from the RCB, enough to serve more than 50,000 people.

The Site includes the 160-Acre Area where volatile organic compounds (VOCs) and perchlorate have contaminated soil and groundwater, and downgradient areas of groundwater contamination. This RI/FS Report addresses groundwater contamination in a portion of the Site that includes the 160-Acre Area and an area extending approximately 1.5 miles downgradient to the southeast from the 160-Acre Area. The report provides detailed evaluations of actions intended to remediate this area. The information considered or used in the report is from RI activities completed by EPA and other parties during the past 6 years.

EPA has designated this area as the Interim Source Area Operable Unit. The term "operable unit" (OU) defines a discrete action that is an incremental step toward a comprehensive remedy for a site.

The RI/FS is being conducted under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended. EPA added the Site to the National Priorities List (NPL) in September 2009.

Enough RI work has been completed to develop, evaluate, and select a remedial alternative. Additional data collection and analysis are anticipated during remedial design to further define project details. Additional data collection and analysis are also underway to better define the nature and extent of perchlorate and VOC contamination in downgradient areas to determine what additional remedial action is needed.

1.1 Remedial Investigation and Feasibility Study Purpose and Overview

The purpose of the RI and FS described in this report is to develop and evaluate remedial alternatives that mitigate threats to human health and the environment from the continued spread of contaminated groundwater from the 160-Acre Area. In accordance with CERCLA, remedial alternatives must be appropriate to site-specific conditions and protective of human health and the environment. In the RI, data were collected to characterize site conditions, evaluate the nature of the contamination, and assess risks to human health and the environment. In the FS, information gathered during the RI was used to develop, screen, and evaluate alternative remedial actions. The RI/FS process typically results in EPA proposing a preferred alternative (described in a "proposed plan") and then, after considering state and community input, preparing a Record of Decision (ROD). In a ROD, EPA selects an environmental cleanup action to mitigate threats to human health and the environment.

This RI/FS has been carried out in accordance with the guidelines set forth in the *Guidance for Conducting Remedial Investigations and Feasibility Study Under CERCLA* (EPA, 1988). Pursuant to these guidelines, the remedial alternatives are evaluated in the RI/FS according to their ability to meet the following criteria:

1. Overall protection of human health and the environment.
2. Compliance with federal and more stringent state standards, requirements, criteria, or limitations that are determined to be Applicable or Relevant and Appropriate Requirements (ARARs).
3. Long-term effectiveness and permanence of the remedial action to minimize risks.
4. Reduction of toxicity, mobility, and volume through treatment.
5. Ability to meet short-term remediation goals, including minimization of adverse health, safety, and environmental impacts during remedial activities.
6. Technical viability, reliability, and implementability.
7. Cost-effectiveness and economic feasibility.

Alternatives will be evaluated against two additional criteria, state acceptance and community acceptance, after state review of, and public comment on, the RI/FS Report and the proposed plan.

1.2 RI/FS Report Organization

This RI/FS Report is organized as follows:

- Section 1.0 — Introduction: Summarizes site location, site history, site setting, hydrogeologic conditions, previous soil and groundwater investigations, and the nature and extent of contamination at the Site.
- Section 2.0 — Remedial Action Objectives and Applicable or Relevant and Appropriate Requirements: Describes the remedial action objectives (RAOs) and ARARs.
- Section 3.0 — Identification and Screening of Response Actions: Identifies general response actions and remedial technologies likely to satisfy the RAOs, and screens the remedial technologies based on effectiveness, implementability, and cost.
- Section 4.0 —Remedial Alternatives Development: Develops remedial alternatives by combining remedial technologies.

- Section 5.0 — Detailed Analysis of Remedial Alternatives: Provides detailed analysis of remedial alternatives based on the seven criteria listed in Section 1.1.
- Section 6.0 — References: Lists the documents referenced in this RI/FS Report.

1.3 Site Background

The following sections provide brief descriptions of the location, topography, land use, and geology of the RCB, the Site, and the 160-Acre Area. They also provide a summary of past soil and groundwater investigations at the Site.

1.3.1 Site Description

Most or all of the Site lies within the RCB. The 40-square-mile RCB is located in western San Bernardino County, California, about 60 miles east of Los Angeles, as shown in Figure 1-1. It is bounded on the northwest and southeast by the San Gabriel Mountains and the Badlands (a series of hills located at the margin of the basin), respectively. The San Jacinto Fault and a subsurface geologic feature known as Barrier E form the northeastern boundary, and the Rialto-Colton Fault forms the southwestern boundary. The Santa Ana River cuts across the southeastern part of the basin, and Warm and Lytle Creeks join the Santa Ana River near the eastern edge of the basin. Except in the southeastern part of the basin, the San Jacinto and Rialto-Colton faults appear to restrict groundwater flow into and out of the basin (USGS, 1997). Barrier E generally does not impede groundwater flow into the basin.

The 160-Acre Area, which is a portion of the Site and wholly located within the RCB, is in the southwest quadrant of Section 21, Township 1 North, and Range 5 West, of the USGS 7.5 minute series "Devore, California" quadrangle map. Figures 1-1 and 1-2 show its location. The 160-Acre Area is square-shaped and bounded by West Casa Grande Drive on the north, Locust Avenue on the east, Alder Avenue on the west, and an extension of Summit Avenue on the south. Various buildings and structures are located throughout the 160-Acre Area and several roadways run through it, including West Lowell Street and several unimproved roads. Portions of the site are used for commercial and/or industrial purposes, and other areas are vacant or open space. The County of San Bernardino's Mid-Valley Sanitary Landfill is located immediately southwest of the 160-Acre Area. Adjacent properties to the north, east, west and south are either undeveloped or developed with industrial facilities or residential buildings. An extension of State Route 210 was recently constructed approximately 0.5-mile to the south of the 160-Acre Area, Interstate (I) 15 is located approximately 1.5 miles to the northwest, and I-215 is located approximately 3 miles to the northeast. The Rialto Municipal Airport is located approximately 1.5 miles south-southeast of the 160-Acre Area.

The Site is larger than the area addressed by this Interim Source Area Operable Unit. The full extent of contamination is not yet known, but the area of groundwater contamination is at least several miles long.

1.3.2 Site History

In aerial photographs taken in the 1930s, irrigated and non-irrigated agriculture appear to be the main land uses in developed areas of the Site.

In 1942, the U.S. Army acquired 2,822 acres of mostly undeveloped land for use as the "Rialto Ammunition Backup Storage Point" (RASP). The U.S. Army subsequently developed and operated on approximately 740 of the 2,822 acres. The 740-acre area includes most or all of the 160-Acre Area. The RASP included a network of rail spurs to store rail cars, bunkers adjacent to the rail spurs, approximately 20 earthen-covered concrete igloos, approximately four magazines used to store ammunition consisting of fuses and gun powder, and assorted buildings. The RASP was an inspection, consolidation, and storage facility for railcars transporting bombs, ammunition, and other ordnance to the Port of Los Angeles, California. The materials handled at the RASP likely included flares and other pyrotechnics containing perchlorate salts (SAIC, 2004).

In 1946, after World War II ended, the United States government sold the RASP property. Since then, a portion of the former RASP property has been used by a variety of defense contractors, fireworks manufacturers, and others who used perchlorate salts in their manufacturing processes or in their products.

From about 1952 to 1957, the West Coast Loading Corporation (WCLC) tested and manufactured pyrotechnic devices. In 1955 and 1956, WCLC manufactured two products, photoflash flares and "ground-burst simulators," containing potassium perchlorate, and used its facility to dry ammonium perchlorate.

In 1957, B.F. Goodrich Corporation (Goodrich) purchased the West Coast Loading property. From about 1957 to 1962, Goodrich conducted research, development, testing, and production of solid-fuel rocket propellant and solid-fuel missile and rocket motors containing ammonium perchlorate, used chlorinated solvents in its operations, and disposed of wastes in one or more onsite pits. Goodrich sold the property in 1966.

Since the 1960s, the 160-Acre Area has been used by a number of companies that manufactured or sold pyrotechnics, including Pyrotronics, Pyro Spectaculars, and American Promotional Events. Pyrotronics reportedly manufactured pyrotechnics containing potassium perchlorate and disposed of wastes in an impoundment later known as the "McLaughlin Pit." Pyro Spectaculars describes itself as a public display fireworks operator, wholesaler, and importer/exporter of fireworks, and is also believed to have disposed of materials into the "McLaughlin Pit." American Promotional Events has tested and stored fireworks containing potassium perchlorate and, in the past, burned defective and off-spec fireworks.

To the southwest of the 160-Acre Area were the storage igloos constructed as part of the RASP (known as the "former bunker area") shown in Figure 1-1. After closure of the RASP, the igloos were used by a variety of parties for storage. Most of the igloos were demolished in 1998 after the County of San Bernardino purchased the property for expansion of the Mid-Valley Sanitary Landfill. From 1999 through 2003, the County contracted with Robertson's Ready Mix, Inc. to perform "gravel washing operations" in the former bunker area. The County believes that the gravel washing operations contributed to a release of perchlorate to the groundwater system separate from the Site (GeoLogic, 2007a).

1.3.3 Site Investigations

Between 2003 and 2009, numerous investigations were conducted to characterize potential releases of contaminants at the Site. Table 1-1 summarizes investigations that included collection and analysis of soil samples, soil gas samples, installation of groundwater monitoring wells, and/or collection and analysis of groundwater samples.

The groundwater investigations include a 2004 investigation by Geosyntec Consultants on behalf of Goodrich (Geosyntec, 2005), which included the installation of 18 temporary groundwater wells, four permanent groundwater monitoring wells, and three groundwater piezometers. The four permanent monitoring wells are on or bordering the 160-Acre Area, including one upgradient well (PW-1) and three downgradient wells (PW-2 through PW-4). Well locations are shown in Figure 1-2. These wells were all completed in the variably saturated intermediate aquifer. Site hydrogeology is described in Section 1.5. Three deeper piezometers (PW-2A, PW-3A, and PW-4A) were installed into the deeper regional aquifer. The intermediate and regional aquifers are separated by an aquitard ranging in thickness from a few feet to more than 30 feet, and significant groundwater elevation differences (over 150 feet) were observed between the two aquifers. The four wells and three piezometers were periodically sampled between 2004 and 2008, and the results were summarized in monthly reports prepared between May 2004 and March 2008 (Geosyntec, 2004 to 2008). EPA also sampled three of the wells in January 2008 and March 2009. The downgradient wells contain elevated concentrations of perchlorate and trichloroethylene (TCE), as discussed further in Section 1.6.

In 2006, Geosyntec Consultants performed a second groundwater investigation, (Geosyntec, 2006). The 2006 investigation built upon previous investigations in and around the 160-Acre Area. It was designed to further investigate hydrogeologic conditions in the vicinity and downgradient of the 160-Acre Area and to evaluate the areal and vertical extent of contaminants in groundwater, including perchlorate and TCE. The investigation consisted of the installation of five multi-screen or multi-port (MP), permanent groundwater monitoring wells (PW-5 through PW-9, see Figure 1-2 for locations). The deepest screened intervals in these MP wells range from 667 to 817 feet below ground surface (bgs). The furthest downgradient well (PW-9) is more than 3 miles downgradient (that is, southeast) of the 160-Acre Area and contains elevated concentrations of perchlorate and TCE. The five wells were periodically sampled between August 2006 and February 2007, and the results were summarized in monthly reports (Geosyntec, 2004 to 2008). EPA also sampled the five wells in January 2008 and again in March 2009 (results are summarized in Table 1-2).

In 2006, Environ International Corp. and Adverus carried out a groundwater investigation at the Site on behalf of Emhart Industries and Pyro Spectaculars (Environ, 2008). The investigation included the installation of five monitoring well clusters (CMW-01 through CMW-05), each containing three wells (for example, CMW-01A, CMW-01B, and CMW-01C) completed at different depth intervals, in the middle portion of the 160-Acre Area. Groundwater sampling results from these well clusters confirm the presence of elevated perchlorate and TCE concentrations in groundwater in the middle of the 160-Acre Area. The five wells have been periodically sampled since 2006, and the results summarized in laboratory reports prepared by Test America Laboratory and submitted to EPA by Environ (2008) and Adverus. EPA sampled two of the five three-well clusters (wells CMW-2 and CMW-5) in January 2008 and the results are summarized in Table 1-2.

In February 2008, DPRA (2008) investigated groundwater at the Site on behalf of the City of Colton, California. The investigation included the installation of two additional monitoring wells (CPW-16 and CPW-17, see Figure 1-2). The two wells were sampled initially in February and March 2008, again in April 2008, and by EPA in March/April 2009. During the 2009 sampling event, perchlorate was measured in one zone of the furthest downgradient well (CPW-17) at a concentration of 4 micrograms per liter (μg/L). Well CPW-16 contained perchlorate concentrations in excess of the State of California Primary Maximum Contaminant Level (MCL) of 6 μg/L in five of the seven zones monitored, at a maximum concentration of 45 μg/L.

In 2008 and 2009, EPA sampled selected U.S. Geological Survey (USGS) monitoring wells and water supply wells near or potentially downgradient of the 160-Acre Area for VOCs and perchlorate. Water purveyors, including the City of Rialto, West Valley Water District, City of Colton, and Fontana Water Company, routinely monitor production wells they own and operate in the RCB.

In 2009, EPA installed six MP groundwater monitoring wells (EPA MW-1 through EPA MW-6) to further investigate hydrogeologic conditions downgradient of the 160-Acre Area and to evaluate the areal and vertical extent of contaminants in groundwater.

Although not part of the Site, several investigations that focused on contamination at or downgradient of the former bunker area (Figure 1-1) have been completed. The results of many of those investigations are summarized in a September 2005 report prepared by GeoLogic Associates (GeoLogic, 2005). At the time the GeoLogic (2005) report was prepared, three phases of field investigation had been completed, including installation and sampling of a total of 18 groundwater monitoring wells. The GeoLogic (2005) report indicates that groundwater downgradient of the former bunker area is affected by elevated concentrations of perchlorate and multiple VOCs, including TCE (GeoLogic, 2005). The GeoLogic (2005) report documented groundwater impacts approximately 1.6 miles downgradient of the former bunker area to depths down to 600 feet bgs (200 feet below the water table). Data from more recent investigations conducted to further refine the extent of contamination and hydrogeologic conditions downgradient of the former bunker area are described in various reports prepared by GeoLogic (for example, GeoLogic, 2007a and GeoLogic, 2008).

The GeoLogic (2005) report evaluated remedial alternatives to mitigate impacts to City of Rialto production well Rialto-03 (Figure 1-2) from contamination believed to originate at the former bunker area. The report recommended intercepting the groundwater contaminant plume with a groundwater extraction system, ex situ treatment of the water, and delivery of treated water to the City of Rialto's municipal supply system (GeoLogic, 2005). Section 1.3.4 describes the status of this system.

1.3.4 Site Remediation

There has not been significant remediation of groundwater on or downgradient of the 160-Acre Area. In 2006 San Bernardino County installed a remediation system downgradient of the former bunker area (GeoLogic, 2007b) as a first phase of remediation.

This remediation system included installation of an ion exchange treatment plant at the Rialto-03 well site, resumption of pumping of the Rialto-03 well, and supply of the treated water to the City of Rialto. In 2008 additional extraction wells (as described in GeoLogic

2007b) were installed to supplement pumping in the Rialto-03 well. Treatment plant upgrades, including the addition of VOC treatment, were also completed in September 2009. The new extraction wells and VOC treatment system were permitted for operation in January 2010 by the California Department of Public Health (CDPH).

Planning for a remediation project downgradient of this OU is ongoing. The currently proposed plan is to construct a 1,000– to 2,000-gallon-per-minute (gpm) bioreactor that would treat water extracted from the Rialto-06 well. The treated water would initially be recharged to the aquifer and then, after permitting by CDPH, used as a drinking water supply. In addition, ion exchange treatment installed by the City of Rialto, West Valley Water District, and the City of Colton at several water supply wells used for drinking water supply purposes may contribute to remediation of the Site.

1.4 Site Setting

This section briefly describes the site setting including population, topography, climate and ecological resources. According to the City of Rialto website, as of 2006 the approximate population of Rialto was just over 100,000. The elevation of the 160-Acre Area gently slopes to the southeast from elevations of approximately 1,700 feet to 1,610 feet above mean sea level (Geosyntec, 2005). The site and surrounding areas have a semiarid Mediterranean climate with hot dry summers and mild, wetter winters. Most of the rainfall occurs during the rainy season from December through April, although in summer occasional thundershowers occur in the nearby mountains. Mean annual precipitation for San Bernardino, located approximately 7 miles east of the Site, from 1871 to 1994 was 16.45 inches (USGS, 1997). The temperature ranges from an average maximum of approximately 96 degrees Fahrenheit (°F) during the summer to an average minimum of 40°F in the winter (Geosyntec, 2005).

The predominant natural ecological community of the area is mixed chaparral shrub lands, which include Broom series, California annual grass series, Cheat grass series, Giant reed series, Eucalyptus series, Introduced perennial grassland series, Kentucky bluegrass series, and Tamarisk series. Fauna expected on the Site include coyotes, ground squirrels, snakes, lizards, mice, hawks, crows, owls, and other birds.

1.5 Hydrogeologic Setting

1.5.1 Regional Hydrogeology

The following discussion of regional hydrogeology is based on three studies of the Rialto-Colton Groundwater Basin (Anderson et al., 2004; USGS, 1997 and 2001). The RCB is an elongated northwest-southeast trending alluvial basin located southwest of the San Bernardino Mountains. The basin is approximately 10 miles long and ranges from 3.5 miles wide in the northwest to 1.5 miles wide in the southeast. The deepest portion of the basin is the northeastern area between the San Jacinto Fault Zone and a parallel unnamed fault; the total sediment thickness in this area ranges between 0.5 and 1 mile. The remainder of the RCB is approximately 500 to 1,000 feet deep.

Groundwater flow in the RCB is strongly influenced by the presence of several faults that act as partial barriers to groundwater flow (see Figure 1-2). The San Jacinto and Rialto-Colton Faults comprise the northeastern and southwestern boundaries of the basin, respectively. Barrier E forms the northwestern portion of the northeastern boundary of the RCB. The northwest-trending unnamed fault is present in the northeast portion of the RCB. The unnamed fault has a significant effect on groundwater flow and acts as a barrier that essentially creates a separate sub-basin to the northeast of the unnamed fault within the RCB. Groundwater chemistry and elevation are substantially different on opposite sides of the unnamed fault. Barrier H is another northwest-trending barrier located west of the Rialto-Colton Airport and south of the Mid-Valley Sanitary Landfill. Barrier H extends from the intersection of Baseline Road to the Rialto-Colton Fault. Barrier H may be associated with the Rialto-Colton Fault and likely obstructs groundwater flow.

The unconsolidated alluvial material that fills the RCB consists of sand, gravel, and boulders interbedded with lenticular deposits of silt and clay. The unconsolidated alluvium is underlain by partly consolidated continental deposits formed as lenticular bodies consisting of somewhat compacted gravel, sand, silt, and clay. These continental deposits outcrop in the Badlands, which form the southeastern boundary of the basin, and also outcrop at the base of the San Gabriel Mountains, which form the northeastern boundary of the basin. The consolidated continental deposits consist primarily of clay that contains lenses of compacted, cemented sand. These deposits underlie the partly consolidated alluvial deposits. The alluvial and consolidated continental deposits are underlain by the basement complex consisting of metamorphic and igneous rocks, which outcrop out in the San Gabriel Mountains.

The fine-grained beds within the basin do not separate the groundwater system into well-defined aquifers and confining beds. The groundwater system is divided into the following four water-bearing units: river-channel deposits, and upper, middle, and lower water-bearing units. Some or all of these water-bearing units contain more than one stratigraphic unit. Lithologic logs indicate that subsurface materials are largely heterogeneous alluvium that consists of varying thicknesses of interbedded gravel, sand, silt and clay. In the RCB, the water-bearing units are generally unconfined to partly confined and are in hydraulic connection with one another. However, in the key area of interest for this site (at and downgradient of the 160-Acre Area), there is an aquitard present locally that limits direct hydraulic communication into the deeper aquifers (see Section 1.5.3).

The river-channel deposits underlie the present channels of Warm Creek and the Santa Ana River in the southeastern part of the basin (Figures 1-1 and 1-2). The deposits consist of coarse sand and gravel interbedded with lower permeability deposits of medium to fine sand and clay. The thickness of the river-channel deposits ranges from about 150 feet to about 200 feet.

The upper water-bearing unit is present throughout the RCB. The unit consists of alluvial fan deposits that grade into older river-channel deposits near the Santa Ana River and Warm Creek. The upper water-bearing unit underlies the river-channel deposits and is the uppermost unit throughout the rest of the basin. The alluvial fan deposits consist of coarse sand and gravel, cobbles, and boulders. In some areas, the upper water-bearing unit contains clay lenses. The upper water-bearing unit ranges in thickness from about 120 feet to about 300 feet. It is unsaturated throughout most of the basin except for the southeast portion near the Santa Ana River and Warm Creek. The unit is highly permeable and freely allows infiltration to the underlying units.

The middle water-bearing unit is present throughout the basin and primarily consists of coarse- to medium-grained sand and interbedded fine sand and clay. The deposits of the middle water-bearing unit are finer in the southeastern portion of the basin. The clay beds are more extensive in the northwestern part of the basin near the Rialto-Colton Fault. The middle water-bearing unit ranges in thickness from about 240 feet to about 600 feet, and is the thickest in the northwestern portion of the basin, south of Barrier J.

The extensive lower water-bearing unit consists mainly of interbedded sand and clay. The thickness of this unit ranges from about 100 feet in the southeastern part of the basin to about 400 feet in other parts of the basin. Relatively impermeable consolidated deposits underlie the lower water-bearing unit and form the lower boundary of the groundwater system.

Groundwater generally moves from east to west in the river-channel deposits and upper water-bearing unit in the southeast part of the basin, and from northwest to southeast in the middle and lower water-bearing units. Two structural features, Barrier J and the unnamed fault, affect groundwater movement in the interior of the basin. Groundwater moves across Barrier J in the unfaulted part of the groundwater system. The unnamed fault is a partial barrier to groundwater movement in the middle water-bearing unit and an effective barrier in the lower water-bearing unit. Water flows laterally across the unnamed fault above the saturated zone. Water levels in wells located north of Barrier J are not affected by production well pumping stresses on the groundwater system south of Barrier J, indicating that these two parts of the groundwater system are not well-connected.

Sources of recharge to the groundwater system are: underflow/subsurface inflow, seepage loss from the Santa Ana River and Warm Creek, and infiltration of rainfall and irrigation return flow. The primary component of discharge from the groundwater system is pumping of production wells by water purveyors. Additional components of discharge include underflow across the Rialto-Colton Fault to the Chino Basin and seepage to the Santa Ana River and Warm Creek during wet years when the water levels in the upper water-bearing unit and the river-channel deposits rise above the base of the streambed.

Long-term water levels in production wells reflect recharge cycles. Historical measurements indicate that groundwater elevations in the RCB have varied significantly in response to extended periods of drought and municipal and agricultural pumping. Extended drought conditions in the region and operation of new municipal supply wells in the basin have resulted in pronounced reductions in groundwater levels within the RCB, with levels declining steadily from 2001 to 2009. Even after heavy rainfall during the winter of 2004-2005, groundwater levels in the regional aquifer increased by only a small amount.

The RCB yield has not been formally determined in any legal documents. However, USGS studies (USGS, 1997 and USGS, 2001) suggest that from the early 1950s through late 1990s the RCB yielded no more than about 9,000 to 10,000 acre-feet per year (AFY), on average. Recent pumping in the portion of the RCB upgradient (northwest) of Colton Avenue (Figure 1-2) has approached 18,000 AFY (Figure 1-3), suggesting that current groundwater production may not be sustainable.

1.5.2 Local Hydrogeology

Data collected by GeoLogic suggest that groundwater in the northern portion of the RCB occurs in three laterally continuous water-bearing units. These units are part of the middle and lower water-bearing units described in Section 1.5.1. The Upper Aquifer is currently dry. The Intermediate Aquifer (also known as the B Aquifer), first encountered at a depth of approximately 400 to 450 feet, is approximately 100 feet thick beneath the 160-Acre Area and thins to the southeast. The Intermediate Aquifer is variably saturated and perched on top of a laterally extensive aquitard (termed the BC Aquitard) that separates the Intermediate Aquifer from the deeper Regional Aquifer (also known as the C Aquifer). As observed during installation of the "PW" monitoring wells, the Intermediate or B Aquifer is comprised of a number of thin water-bearing units separated by thin aquitards and dry intervals. Beneath the 160-Acre Area, potentiometric head differences between the Intermediate Aquifer and Regional Aquifer are as great as 150 feet, resulting in a downward hydraulic gradient between the two aquifers. Based on geophysical logs and groundwater level data collected by GeoLogic (GeoLogic, 2005) as part of their characterization of conditions in the vicinity of the Rialto-03 well, it appears that the BC Aquitard diminishes or disappears (that is, the BC Aquitard "pinches out") just upgradient of monitoring well M-3. Downgradient of well M-3, the Intermediate and Regional Aquifers are indistinguishable (based on groundwater elevation data) and have effectively merged. Downgradient of the 160-Acre Area, it appears that the BC Aquitard "pinches out" between EPA MP well MW-4 and the Rialto-02 well (Figures 1-5 and 1-6).

In the northwestern and central portions of the RCB that are the focus of this report, groundwater flows to the south and southeast under a gradient of 0.003 foot per foot (ft/ft) to 0.012 ft/ft (USGS, 1997; USGS, 2001). The gradient in the Regional Aquifer is 0.003 ft/ft near Rialto-03 (GeoLogic, 2007a).

GeoLogic conducted aquifer pumping tests as part of the characterization of the contamination downgradient of the former bunker area. These tests provided hydraulic conductivity estimates for Intermediate Aquifer materials that range from 10 to 60 feet per day (GeoLogic, 2007a). Data collected by GeoLogic during startup of the treatment system at the Rialto-03 well indicated that the Regional Aquifer materials have hydraulic conductivities in the range of 80 to 90 feet per day (GeoLogic, 2007a). Using an effective porosity of 0.25 for the area, GeoLogic calculated groundwater flow velocities of 2 to 4 feet per day in the Intermediate Aquifer and 1 foot per day in the Regional Aquifer near the Rialto-03 well.

Water level data collected during Spring 2009 as part of EPA's groundwater sampling efforts in the RCB, supplemented by data collected by the USGS and GeoLogic (as part of the San Bernardino County cleanup efforts), have been used to prepare a water level contour map that provides details on apparent flow directions in the Regional Aquifer (Figure 1-4). As shown in Figure 1-6, the Regional Aquifer gradients appear to be relatively flat in the upgradient (northwest) and downgradient (southeast) portions of the RCB, with increased gradients in the central portion.

1.6 Nature and Extent of Groundwater Contamination

1.6.1 B.F. Goodrich Site

Groundwater contamination from perchlorate and VOCs has been detected throughout a large portion of the RCB downgradient of the 160-Acre Area, as shown in the cross-sections in Figures 1-5 and 1-6. Perchlorate is an inorganic ion present in various salts, including potassium perchlorate and ammonium perchlorate. Perchlorate salts have been used in solid rocket propellant, munitions, explosives, pyrotechnics and other applications. TCE is a chlorinated solvent that was widely used for degreasing and cleaning. Perchlorate salts are highly soluble and mobile in both surface water and groundwater. Perchlorate does not readily degrade when released to the environment. TCE is also mobile and, although it is a volatile constituent, can persist in groundwater for decades.

Figure 1-7 presents maximum perchlorate and TCE concentrations detected in groundwater samples analyzed in 2007 and 2008 from monitoring and production wells located at and downgradient of the 160-Acre Area. The figure includes a contour that delineates the approximate extent of contamination in excess of drinking water MCLs that EPA interprets as being associated with the B.F. Goodrich site.

There are monitoring wells at nine locations on or immediately adjacent to the 160-Acre Area. These wells include one upgradient well (PW-1), six locations on the 160-Acre Area (PW-2 and CMW-01 through CMW-05), and two wells on the downgradient perimeter of the 160-Acre Area (PW-3 and PW-4). The PW wells monitor one depth interval, and the CMW wells are cluster wells that each monitor three depth intervals. Both perchlorate and TCE have been detected at all eight downgradient monitoring locations at concentrations substantially higher than those seen in the upgradient well. Perchlorate has been detected in the upgradient well in 3 of 17 sampling events, at concentrations ranging from 1.2 to 6.3 µg/L. TCE has never been detected in the upgradient well. The highest perchlorate concentration detected in groundwater at the 160-Acre Area was 10,000 µg/L at PW-2 in April 2006 (previously at 43 µg/L in July 2005). This peak concentration was detected after Intermediate Aquifer water levels rose dramatically in response to record rainfall early in 2005. The peak TCE concentration of 420 µg/L was also detected in PW-2, in June 2006 (compared to 36 µg/L in October 2005). The two order of magnitude increase in perchlorate concentration (and the order of magnitude increase in TCE concentration) indicates that there is substantial contaminant mass remaining in the Intermediate Aquifer.

Approximately 4,000 feet downgradient of the 160-Acre Area is West Valley Water District (WVWD) well WVWD-22, which was used as a water supply well until 1990. It was later converted into a monitoring well with screens in both the Intermediate and Regional Aquifers. Well WVWD-22 is the location where TCE and perchlorate contamination were first detected at the Site. TCE was detected first, in 1989, then perchlorate in 1997. Perchlorate concentrations in well WVWD-22 have been as high as 1,000 µg/L; TCE concentrations have been as high as 76 µg/L. Perchlorate has also been detected in all of the City of Rialto groundwater wells that pump from the RCB, except the Rialto-05 well. The 160-Acre Area is believed to be the source of contamination in Rialto-01, Rialto-02, Rialto-04, and Rialto-06 (see Figure 1-7).

The groundwater contamination at the 160-Acre Area is believed to be limited to the Intermediate Aquifer and portions of the BC Aquitard. The contaminated groundwater in the Intermediate Aquifer probably first migrates downward into the Regional Aquifer downgradient of the 160-Acre Area. This could be from leakage through the BC Aquitard or, more likely, from downward movement through wells screened in both aquifers. At the WVWD-22 well site, monitoring wells confirm that groundwater in both the Intermediate and Regional Aquifers is contaminated. Further downgradient, between wells WVWD-22 and Rialto-02, the BC Aquitard "pinches out" and the Intermediate and Regional aquifers merge (Figures 1-5 and 1-6).

Contaminated groundwater originating at the 160-Acre Area has been detected further downgradient of WVWD-22 at monitoring well PW-5, located approximately 2 miles from the 160-Acre Area; well PW-7, located another 0.5-mile downgradient; and well PW-9, located 1 mile further downgradient. At well PW-5, perchlorate concentrations have been as high as 1,400 µg/L. This concentration is more than 230 times the California MCL of 6 µg/L. TCE in well PW-5 has reached 32 µg/L, well above the MCL of 5 µg/L. At well PW-9, recent perchlorate concentrations have been as high as 370 µg/L, exceeding the California MCL by a factor of 60. TCE also exceeds the MCL at this well location, which is adjacent to the Rialto-06 well. At well PW-9, perchlorate concentrations in March 2009 were 230 µg/L in the deepest monitoring port, located at a depth of 815 feet bgs. These data confirm that the full vertical extent of contamination has not been delineated, although it should be noted that this monitoring port is located near the base of the alluvial aquifer.

Perchlorate concentrations at the two City of Rialto water supply wells (Rialto-04 and Rialto-06) that are located in the vicinity of these downgradient monitoring wells have steadily increased over the last several years. Figure 1-8 shows a time-series graph of perchlorate concentrations in the Rialto-06 well. The Rialto-06 well is located approximately 3 miles downgradient of the 160-Acre Area and, in late 2008, had a perchlorate concentration greater than 300 µg/L (Figure 1-8).

The downgradient (to the south or southeast) extent of this contamination has not been delineated, and groundwater flow directions in downgradient areas are not well-understood. These data gaps do not limit or interfere with the evaluation of remedial alternatives in this RI/FS, but need to be evaluated as additional remedial actions in the downgradient portions of the Site are considered.

1.6.2 Former Bunker Area

Figure 1-7 presents maximum perchlorate and TCE concentrations detected in groundwater samples analyzed in 2007 and 2008 from monitoring and production wells located at and downgradient of the former bunker area. As described in Section 1.3, the former bunker area is not part of the Site. The following description of the nature and extent of groundwater contamination downgradient of the former bunker area is summarized from GeoLogic (2007a).

Plume migration has occurred to the southeast, consistent with the primary groundwater flow direction. Perchlorate concentrations have varied from as high as 1,000 µg/L at the upgradient end of the plume to approximately 10 µg/L in the downgradient portion of the plume near the Rialto-03 well. TCE is the VOC that has been detected at the highest concentrations (730 μg/L adjacent to the former bunker area). Other VOCs frequently detected at low or trace concentrations include 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), 1,2-dichloropropane, chloroform, dichlorofluoromethane, methylene chloride, tetrachloroethene (PCE), and trichlorofluoromethane.

The BC Aquitard is relatively effective at limiting impacts to the Regional Aquifer at or immediately downgradient of the former bunker area. Significant concentrations of perchlorate and VOCs have been detected in the Regional Aquifer in the vicinity of the Rialto-03 well near where the BC Aquitard is no longer effective and the Intermediate Aquifer merges into the Regional Aquifer. Contamination extends about 200 feet into the Regional Aquifer (or to approximately 630 feet bgs) near the downgradient end of the plume. The plume is approximately 3,000 feet wide near the downgradient end in the vicinity of the Rialto-03 well.

1.7 Risk Evaluation

This section presents the methods and results of an initial screening-level human health risk assessment (HHRA) conducted as part of the RI/FS for the Interim Source Area OU of the Site. An ecological risk assessment was not completed as part of this interim action because no ecological receptors are expected to be exposed to Site contaminants.

The RI groundwater sampling conducted by EPA in January 2008 and March/April 2009 is the source of the water quality data used in this risk evaluation. Risk estimates were developed for both the Intermediate and Regional aquifers.

The risk evaluation was conducted to assess whether the contaminated groundwater poses a significant risk to human health if human receptors (for example, local residents) are exposed to untreated groundwater. For this assessment, drinking water MCLs and EPA's regional screening levels (RSLs) for tap water were used to evaluate risks. Because federal and state drinking water regulations make it unlikely that residential consumers would actually be exposed to the contaminated groundwater, this health risk evaluation is considered conservative and likely overestimates the actual exposures and risks.

This risk evaluation covers the following topics:

- Contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Uncertainties
- Conclusions

1.7.1 Contaminant Identification

Perchlorate and all detected VOCs have been identified as contaminants of potential concern (COPCs). Detected VOCs are benzene, carbon tetrachloride, chloroform, methylene chloride and TCE. Constituents detected in the January 2008 and March/April 2009 groundwater samples are compared to EPA and California MCLs and EPA RSLs in

Table 1-2. For the wells that were sampled both in 2008 and 2009, only the most recent (2009) data were used.

1.7.2 Exposure Assessment

Receptors that could potentially be exposed to the contaminated groundwater include current and future residents that receive drinking water from groundwater wells near the 160-Acre Area. Exposure could occur through inhalation (VOCs only) or ingestion (VOCs or perchlorate) of the contaminants present in the groundwater. Inhalation can occur during showering or other activities that enhance the movement of volatile chemicals from water to air. Exposure through dermal contact is not expected to be a significant pathway for these constituents.

For each multi-port monitoring well or monitoring well cluster, results from the same aquifer (either Intermediate or Regional) are averaged together. This provides a single concentration for each aquifer at each well location. The maximum concentrations from the Intermediate and Regional aquifers are then compared to MCLs and the EPA RSLs to estimate cancer risks and noncancer hazards (Table 1-3).

In keeping with EPA guidance for a baseline HHRA (EPA, 1989), federal and state drinking water regulations that prohibit the use of contaminated water are not considered in this risk assessment.

1.7.3 Toxicity Assessment

Exposure estimates are compared to primary California MCLs, EPA MCLs, and EPA tap water RSLs (EPA, 2009). For chemicals that exceed MCLs or RSLs, MCL exceedance ratios, lifetime cancer risk, and/or hazard quotients are estimated. For MCL exceedance ratio estimates, maximum chemical concentrations are divided by the primary MCL. Lifetime cancer risks and hazard quotients are estimated by direct comparison to the EPA RSLs.

- For cancer risk estimates, the maximum exposure estimate is divided by the RSL concentrations designated for cancer evaluation. The resulting ratio is multiplied by 1E-06 to estimate chemical-specific risk for a reasonable maximum exposure. For multiple chemicals, the risks for the chemicals are summed to estimate a total (ELCR) cancer risk for groundwater from that aquifer.

- For noncancer health hazard estimates, the maximum exposure estimate is divided by the noncancer RSL concentration to estimate the hazard quotient. Because perchlorate is the only constituent that exceeds a noncancer RSL, the hazard quotient equals the hazard index (HI).

1.7.4 Risk Characterization

This section summarizes cancer risks and health hazards associated with exposure to contaminated Intermediate and Regional Aquifer groundwater. The potential for unacceptable cancer risk or human health hazard was identified using the following criteria:

- ELCR values were compared to EPA's general risk management range of 1E-06 to 1E-04.

- An HI greater than 1 indicates that there is potential for adverse noncancer health effects associated with exposure to the contaminants of potential concern (EPA, 1991).

As shown in Table 1-3, the total cancer risk in both aquifers is between 2E-05 and 6E-05, which falls within EPA's risk management range and warrants further consideration of remedial actions. The HIs are 5 (Intermediate Aquifer) and 11 (Regional Aquifer), further confirming the potential health impacts from exposure to the contaminated groundwater.

In addition to the risk estimates, MCL exceedance ratios are presented in Table 1-3. Primary MCL exceedance ratios in the Intermediate Aquifer include 1.2 times the MCL for carbon tetrachloride, 19 times the MCL for TCE, and 20 times the MCL for perchlorate. In the Regional Aquifer, TCE (1.2 times the MCL) and perchlorate (48 times the MCL) exceeded MCLs.

1.7.5 Uncertainties

In keeping with EPA guidance for a baseline HHRA (EPA, 1989), drinking water regulations that limit distribution of contaminated water are not considered in this risk evaluation. This is likely to lead to an overestimation of actual exposures and associated risks and hazards. In addition, there are no known extraction wells in the Intermediate Aquifer, so direct exposure to Intermediate Aquifer water is not currently possible.

1.7.6 Conclusions

The objective of this risk evaluation is to assess whether groundwater contamination at the B.F. Goodrich Site poses a significant risk to human health. Based on the results of the January 2008 and March/April 2009 sampling events and this risk evaluation, the following conclusions can be made:

- Maximum concentrations exceeded primary MCLs for carbon tetrachloride, TCE, and perchlorate in the Intermediate and/or Regional Aquifer.
- Excess cancer risks and HI values support the evaluation of remedial actions to address the contaminated groundwater.

1.8 Data Usability/Data Quality

For this RI/FS, two primary uses of the water quality data are generated from sampling groundwater wells at the Site: 1) risk evaluation, and 2) definition of the nature and extent of contamination (including definition of the target areas described in Section 3.2.2).

As described in Section 1.3.3, the groundwater sampling conducted by EPA in January 2008 and March/April 2009 is the source of the water quality data used in the risk evaluation. These groundwater samples were obtained and analyzed in accordance with procedures detailed in field planning documents (Field Sampling Plans [FSPs] and Quality Assurance Project Plans [QAPPs]) approved by the EPA Region 9 Quality Assurance Office.

The water quality analyses were performed at the EPA Region 9 laboratory (for perchlorate) and at a laboratory participating in EPA's Contract Laboratory Program (CLP) (for VOCs). All of the data generated by EPA's Region 9 laboratory are verified by EPA chemists at the laboratory according to Tier 1A manual data review procedures and Region 9 laboratory standard operating procedures (SOPs). For analyses performed by the CLP, all data undergo a Tier 1B automated review.

A minimum of 10 percent of the Region 9 Laboratory's perchlorate analytical results were selected for Tier 3 validation. The samples for Tier 3 review were selected at random.

For the 2008 sampling, 100 percent of the VOC analytical results from the CLP were selected for Tier 3 validation. Similar to the perchlorate data, a minimum of 10 percent of the 2009 CLP VOC results underwent Tier 3 validation.

The Tier 3 data validation that EPA conducted followed EPA Contract Laboratory Program National Guidelines for Data Review as described in *USEPA Contract Laboratory Program National Functional Guidelines for Low Concentration Organic Data Review* (EPA-540-R-00-006, June 2001). The data validation efforts resulted in no rejections of any perchlorate or VOC results. Data validation flags have been added to some of the water quality results.

The extent of perchlorate and TCE contamination as shown in Figure 1-7 is based, in part, on the EPA 2008 sampling results. However, there are also several other data sources, including sampling of potentially responsible party (PRP) monitoring wells, water purveyor production wells, and San Bernardino County monitoring wells. Although the sample results generated by the other data sources are not collected under as stringent quality assurance/quality control (QA/QC) procedures as the EPA sampling, each of these other data sources uses standard EPA-approved analytical methods and the analyses are conducted by laboratories certified by the State of California.

Although the overall QA/QC procedures are less stringent, all of the data points generated by these other data sources are from wells that have been sampled numerous times over the years; therefore, there is a significant data history to support the contaminant concentrations shown in Figure 1-7. Minor variations in the extent of contamination would not have a meaningful impact on the target areas identified in Section 3 and used in the description and evaluation of the remedial alternatives.

The water quality data used in this RI/FS is of adequate quality to support the uses described.

SECTION 2

Remedial Action Objectives and Applicable or Relevant and Appropriate Requirements

This section describes the RAOs for the remedial alternatives described and evaluated in Sections 4 and 5 of this document.

2.1 Remedial Action Objectives

Remedial action objectives (RAOs) are narrative statements that specify the goals of a remedial effort and identify the extent to which a site or OU requires cleanup to protect human health and the environment. RAOs can be divided into general RAOs that can be applied to all CERCLA sites and specific RAOs that reflect site-specific conditions.

2.1.1 General Remedial Action Objectives

Generally applicable RAOs include the following:

- Protect human health and the environment by reducing the potential for exposure to contaminants
- Expedite site cleanup and restoration
- Use permanent solutions to the maximum extent possible
- Consider innovative technologies to reduce the duration and cost of remedial actions
- Use solutions that support existing and proposed land uses
- Achieve compliance with ARARs
- Be compatible with other actions
- Be flexible to respond to changing reuse priorities

2.1.2 Site-Specific Remedial Action Objectives

The RAOs for the Interim Source Area OU of the B.F. Goodrich Site are to:

- Protect water supply wells and groundwater resources by limiting the spread of contaminated groundwater from the 160-Acre Area
- Remove the contaminants from the groundwater

The RAOs do not address contaminated soil at the Site or contaminated groundwater in downgradient portions of the Site, and RAOs do not include in situ cleanup goals for contaminated groundwater at the site (for example, allowable TCE or perchlorate concentrations in the aquifer). Additional actions may be needed to address contaminated soil, set in situ cleanup goals, and/or address downgradient areas of groundwater contamination.

2.2 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA, 42 U.S. Code (U.S.C.) § 9621(d) requires that remedial actions at CERCLA sites attain (or justify the waiver of) any federal or state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. These applicable or relevant and appropriate requirements are referred to as "ARARs." Federal ARARs may include requirements promulgated under any federal environmental laws. State ARARs may only include promulgated, enforceable environmental or facility-siting laws that are more stringent than federal requirements and that are identified by the state in a timely manner.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. If there is no specific federal or state ARAR for a particular chemical or remedial action or if the existing ARARs are not considered sufficiently protective, then other guidance or criteria "to be considered" (TBC) may be identified and used to ensure the protection of public health and the environment. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300, defines "applicable," "relevant and appropriate," and "to be considered" as follows:

- **Applicable requirements** are those cleanup standards, standards of control, or other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.
- **Relevant and appropriate requirements** are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.
- **TBCs** consist of advisories, criteria, or guidance that EPA, other federal agencies, or states have developed that may be useful in developing CERCLA remedies. The TBC values and guidelines may be used as EPA deems appropriate. Once a TBC is adopted (as a performance standard), it becomes an enforceable requirement.

ARARs are identified on a site-specific basis from information about the chemicals at the site, the remedial actions contemplated, the physical characteristics of the site, and other appropriate factors. ARARs include only substantive, not administrative, requirements, and pertain only to onsite activities.

Section 121(e) of CERCLA, U.S.C. 9621(e) states that no federal, state, or local permit is required for remedial actions conducted entirely onsite. Offsite activities, however, must comply with all applicable federal, state, and local requirements, including both substantive and administrative requirements that are in effect when the activity takes place. There are three general categories of ARARs:

- **Chemical-specific ARARs** are health- or risk-based concentration limits, numeric values, or methodologies for various environmental media (that is, groundwater, surface water, air and soil) that are established for a specific chemical that may be present in a specific media at the site, or that may be discharged to the site during remedial activities. These ARARs set limits on concentrations of specific hazardous substances, pollutants, and contaminants in the environment. Examples of this type of ARAR include state and federal drinking water standards.
- **Location-specific ARARs** restrict certain types of activities based on site characteristics. Federal and state location-specific ARARs are restrictions placed on the concentration of a contaminant or the activities to be conducted because they are in a specific location. Examples of special locations possibly requiring ARARs include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.
- **Action-specific ARARs** are technology- or activity-based requirements that are triggered by the specific type of remedial activity. Examples of this type of ARAR include the Resource Conservation and Recovery Act (RCRA) regulations for waste treatment, storage, or disposal.

CERCLA Section 121(d)(4), 42 U.S.C. 9621(d)(4), provides that in certain limited circumstances EPA may waive an ARAR. The circumstances include interim measures, greater risk to health and the environment, technical impracticability, equivalent standard of performance, inconsistent application of state requirements, and fund balancing.

2.2.1 Potential Chemical-Specific ARARs

Potential chemical-specific ARARs for this remedy were identified on the basis of the COPCs at the Site and the media affected (groundwater). The primary COPCs identified in groundwater at the Site are perchlorate and TCE; however, other VOCs are also present in selected wells.

Potential ARARs and TBC criteria for drinking water include the federal Safe Drinking Water Act (SDWA) and the California Safe Drinking Water Act as discussed in the following sections.

Safe Drinking Water Act

The federal SDWA establishes national primary drinking water standards (that is, MCLs) to protect the quality of water in public water systems. MCLs are enforceable standards and represent the maximum concentrations of contaminants permissible in a public water system. Because the remedial alternatives evaluated in this RI/FS include treatment of groundwater that may be used as drinking water, MCLs are considered relevant and appropriate.

California SDWA MCLs, found in 22 CCR 64435 and 64444.5, have been promulgated for some chemicals for which there are no federal MCLs (for example, perchlorate). Some California MCLs are more stringent than the federal MCLs. The more stringent limit is determined on a chemical-by-chemical basis.

2.2.2 Potential Location-Specific ARARs

Location-specific ARARs are requirements that relate to the geographical position or physical condition of the site. These requirements may limit the type of remedial action that can be implemented, or may impose additional constraints on a remedial alternative. For the groundwater control remedial alternatives being considered in this RI/FS, location-specific ARARs may influence construction of extraction wells, pipelines, and the treatment plant. The major location-specific ARARs that could affect the remedial alternatives are briefly described in the following sections.

National Historic Preservation Act, National Historic Landmarks Program, and National Register of Historic Places

The National Historic Preservation Act (NHPA), 16 U.S.C. 470, requires federal agencies to take into account the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places (NRHP) (36 CFR 60). Criteria for evaluation are included in 36 CFR 60.4. The Site is not designated as having historic value to warrant inclusion in the NRHP. If an eligible structure were encountered, the procedures for protection of historic properties set forth in Executive Order 11593 "Protection and Enhancement of the Cultural Environment" and in 36 CFR 63, 36 CFR 800, and 40 CFR 6.301(b) are potentially applicable.

Archaeological and Historic Preservation Act and Archaeological Resources Protection Act

The Archaeological and Historic Preservation Act (AHPA), 16 U.S.C. 469, and the Archaeological Resources Protection Act (ARPA), 16 U.S.C. 470, establish procedures to preserve and protect archaeological resources. AHPA provides for preservation of historical and archaeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program. The ARPA prescribes steps to be taken by investigators to preserve data. If remedial activities would cause irreparable loss or destruction of significant scientific, prehistoric, historical, or archaeological data, mandatory data recovery and preservation activities would be necessary. The implementing regulations [40 CFR 6.301(c) and 43 CFR 7] would be potentially applicable if eligible structures were identified.

Endangered Species Act

The Endangered Species Act (ESA), 16 U.S.C. 1531, et seq., requires consultation with the resource agencies for remedial actions that may affect threatened or endangered species. Section 7 of the ESA requires that federal agencies consider whether their actions will jeopardize the existence of species that are listed as threatened or endangered by the United States Fish and Wildlife Service or the National Marine Fisheries Service. The ESA is potentially applicable, although threatened or endangered species are not known to be present at any of the potential work locations.

Executive Order on Floodplain Management

The Executive Order on Floodplain Management, Executive Order 11988, requires that federal agencies evaluate the potential effects of activities in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development. The EPA regulations to implement Executive Order 11988 are provided in 40 CFR 6.302(b). In addition, EPA has developed guidance, the *Policy on Floodplains and Wetlands Assessments for CERCLA Actions* (EPA, 1985). The requirements of this regulation are potentially applicable if any remedial activities affect the floodplain at the Site (for example, in the Cactus Flood Control Basin).

2.2.3 Potential Action-Specific ARARs

Action-specific ARARs are requirements that define acceptable containment, treatment, storage and disposal criteria and procedures. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities. The action-specific requirements do not in themselves determine the remedial alternative; rather, they indicate how, or to what level, a selected alternative must achieve the requirements.

The components of the remedial alternatives (described in Section 4) at the Site include groundwater extraction, conveyance, treatment, and delivery to a local purveyor or reinjection. Potential action-specific ARARs are summarized below.

Local Air Quality Management

Air stripping may be used to remove VOCs from contaminated groundwater. Air emissions from air strippers are regulated by the California Air Resources Board, which implements the federal Clean Air Act (CAA), as well as the air pollution control requirements of the California Health and Safety Code (H&SC), through local air quality management districts. Local districts may impose additional regulations to address local air emission concerns. The local air district for the B.F. Goodrich Site is the South Coast Air Quality Management District (SCAQMD). The SCAQMD has adopted several rules that are ARARs for air stripper emissions and construction activities.

SCAQMD Regulation XIII, comprising Rules 1301 through 1313, establishes new source review requirements. Rule 1303 requires that all new sources of air pollution in the district use best available control technology (BACT) and meet appropriate offset requirements. Emissions offsets are required for all new sources that emit in excess of 1 pound per day of VOCs.

SCAQMD Rule 1401 requires that best available control technology for toxics (T-BACT) be employed for new stationary operating equipment, if the cumulative carcinogenic impact from air toxics would exceed the maximum individual cancer risk limit of 1 in 1 million (1×10^{-6}) without T-BACT. Some of the contaminants (for example, TCE) found in B.F. Goodrich Site groundwater are air toxics subject to Rule 1401.

SCAQMD Rule 1401.1 applies to discharges that are within 500 feet of a school and requires that the discharges from a facility do not create a cancer risk in excess of 1 in 1 million (1×10^{-6}) at the school.

SCAQMD Rules 401 through 403 may also be ARARs. SCAQMD Rule 401 limits visible emissions from a point source. Rule 402 prohibits discharge of material that is odorous or causes injury, nuisance, or annoyance to the public. Rule 403 limits downwind particulate concentrations.

RCRA Subtitle C Hazardous Waste Identification and Generator Requirements and California Hazardous Waste Requirements

The RCRA requirements for identification and listing of hazardous waste can be found in 22 CCR, Division 4.5, Chapter 11. A solid waste is a RCRA hazardous waste if it exhibits any of the characteristics of ignitability, corrosivity, reactivity or toxicity identified in 22 CCR 66261.21, 66261.22(a)(1), 66261.22(a)(2), 66261.23, and 66261.24(a)(1), or if it is listed as a hazardous waste in Article 4 of Chapter 11. Under the California RCRA program, wastes can be classified as non-RCRA, state-only hazardous wastes if they exceed the soluble threshold limit concentration (STLC) or the total threshold limit concentration (TTLC) values listed in 22 CCR 66261.24(a)(2). It will be necessary to determine if any of the wastes generated at the Site during construction (for example, drill cuttings or soil from pipeline installation) or operation (for example, treatment residuals such as spent carbon) of the remedy are hazardous wastes under the federal or state RCRA programs.

Federal Underground Injection Control Regulations: 40 CFR 144.12-144.13

The federal SDWA, 42 U.S.C. §300f et seq., provides federal authority over injection wells. The Federal Underground Injection Control Plan, codified at 40 CFR Part 144, prohibits injection wells such as those that could be installed at the B.F. Goodrich Site from 1) causing a violation of primary MCLs in the receiving waters, and 2) adversely affecting the health of persons. 40 CFR §144.12, Section 144.13 of the Federal Underground Injection Control Plan provides that contaminated groundwater that has been treated may be reinjected into the formation from which it is withdrawn if such injection is conducted pursuant to a CERCLA cleanup and is approved by EPA. These regulations are applicable to any treated water that is reinjected into the aquifer.

Resource Conservation and Recovery Act §3020, 42 U.S.C. §6939b

Section 3020 of RCRA may also be applicable to the B.F. Goodrich Site interim action. This section of RCRA provides that the ban on the disposal of hazardous waste into a formation that contains an underground source of drinking water [set forth in Section 3020(a)] shall not apply to the injection of contaminated groundwater into the aquifer if: (i) such injection is part of a response action authorized by CERCLA; (ii) such contaminated groundwater is treated to substantially reduce hazardous constituents prior to such injection; and (iii) such response action will, upon completion, be sufficient to protect human health and the environment.

Federal Clean Water Act and California Porter-Cologne Water Quality Act The California Porter-Cologne Water Quality Act incorporates the requirements of the federal Clean Water Act (CWA) and implements additional standards and requirements for surface waters and groundwaters of the state.

The Regional Water Quality Control Board, Santa Ana Region (RWQCB) formulates and enforces water quality standards as defined in the Basin Plan. The Basin Plan identifies the beneficial uses of surface and ground waters and establishes water quality objectives necessary to protect beneficial uses. Water quality objectives impose limitations on receiving waters, rather than on discharges, and are applicable to any body of water that receives discharge from remedial activities associated with this OU.

The Basin Plan also incorporates State Water Resources Control Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California." Resolution No. 68-16 requires maintenance of existing state water quality unless it is demonstrated that a change will benefit the people of California, will not unreasonably affect present or potential uses, and will not result in water quality less than that prescribed by other state policies.

The substantive requirements of the Basin Plan may apply to the B.F. Goodrich Site interim action if treated water is reinjected into the aquifer or temporarily discharged to surface water during design, construction, or operation of the remedy.

Land Disposal Restrictions

CCR Title 22 defines hazardous wastes that cannot be disposed of to land without treatment. Land disposal requirements would apply to the disposal of spent carbon generated during the treatment of groundwater for VOCs and, potentially, to the disposal of treatment residuals associated with other technologies.

CERCLA Offsite Rule

Although they are not ARARs, CERCLA Section 121(d)(3) and EPA regulations establish independently applicable requirements regarding offsite disposal of hazardous substances. The CERCLA offsite rule would apply to all wastes generated during the remedy implementation (for example, drill cuttings, spent carbon from VOC treatment, spent resin from perchlorate treatment, soil generated during pipeline installation, etc.) that need to be shipped offsite for disposal.

2.3 Rialto Basin Judgment

On December 22, 1961, a decree was entered in San Bernardino County Superior Court regarding pumping of groundwater from the Rialto-Colton Basin ("The Lytle Creek Water & Improvement Company vs. Fontana Ranchos Water Company, et al.," Action 81264).

The parties to the decree were Lytle Creek Water and Improvement Company ("Lytle Creek"), Citizens Land and Water Company of Bloomington ("Citizens"), Fontana Union Water Company ("Fontana Union"), City of Colton ("Colton"), City of Rialto ("Rialto"), and Semi-Tropic County Water District ("Semi-Tropic").

The decree allows unlimited pumping from the basin if the average of the "spring-high water levels" at three wells specified in the decree (the "index wells") exceeds 1,002.3 feet. When the level is between 969.7 and 1,002.3 feet, a party's entitlement is the sum of the amounts specified in Section 5 of the decree (which lists amounts for each party to the decree) and Section 9 of the decree (which refers to amounts for particular wells). If the average “spring-high water level” drops below 969.7 feet, the entitlement is reduced by 1 percent for every foot the average is below 969.7 feet, but not by more than 50 percent.

The average of the “spring-high water level” elevations at the three index wells in the last 23 years is shown in Table 2-1 and Figure 2-1. The average has been below the 1,002.3-foot benchmark since 2003, and dropped below the 969.7 foot benchmark in 2008.

The four water purveyors currently pumping groundwater from the Rialto-Colton basin are Colton, Rialto, Fontana Water Company and West Valley Water District (WVWD). The entitlements for the four purveyors are those specified in Sections 5 and 9 of the 1961 decree (if any), and the amounts acquired from Lytle Creek, Citizens, Fontana Union, and Semi-Tropic.

- Colton reports that its entitlement is 3,900 acre-feet.
- Fontana Water Company reports that its entitlement is 920 acre-feet.
- Rialto reports that its entitlement is 4,366 acre-feet.
- WVWD reports that its entitlement is 6,104 acre-feet.

These amounts do not reflect leases or other temporary transfers between parties, such as the 1,600 acre-feet subject to a standby water lease between Fontana Water Company and the City of Rialto.

EPA intends to work with the parties to the decree to determine if groundwater extraction conducted as part of a remedial action is limited by the 1961 decree or other agreements, and should be allocated against the water rights of one of the parties.

2.4 Rialto-Colton Basin – Sustainable Yield

EPA is not aware of any detailed technical evaluations of the volume of groundwater that can, on average, be pumped from the Rialto-Colton Basin without causing a long-term decline in water levels.

The USGS completed a study of the Rialto-Colton Basin in 2001 (USGS, 2001) that included the development of a numerical computer model to simulate groundwater flow in the Basin. As part of their study, the USGS estimated the average annual recharge into the basin and average annual discharge from the basin between 1945 and 1996. The USGS estimated that the amount discharged from the Basin (35,220 acre-feet per year) was slightly more than the amount recharged (33,620 acre-feet per year) and that most of the discharge occurred as subsurface flow from the Rialto-Colton Basin into the Chino and North Riverside basins (23,700 acre-feet per year). With the discharge exceeding recharge, there was a decline in Basin water levels over this period. The USGS compiled pumping data over this period and estimated that the annual average pumping rate was 11,080 acre-feet per year. If average hydrologic conditions in the future are similar to (or drier than) conditions from 1945 to 1996, the sustainable pumping rate from the Basin may be less than 11,000 acre-ft.

Figure 2-1 is a graph of the average high (Spring) water levels for the index wells identified in the Basin Judgment. As the graph shows, these water levels were essentially the same at the beginning and end of 10-year period extending from 1992 through 2001. Figure 1-3 presents a graph of annual pumping from the portion of the Basin northwest of Colton

Avenue (located in the southeastern portion of the Basin near the Santa Ana River). Groundwater production in the portion of the Basin northwest of Colton Avenue is considered more likely to have an impact on water levels and flow directions in the portion of the Basin where the B.F. Goodrich Site contamination is located. The average annual pumping for the 1992-2001 period was just over 10,000 acre-feet per year. Although it doesn't account for variations in the other components of the water budget over this 10-year period, these data suggest that the sustainable pumping rate from this portion of the Basin may be in the general range of 10,000 acre-feet per year. As Figure 2-1 illustrates, water levels in the Basin have declined dramatically of late. This decline started around 2002, concurrent with a significant increase in groundwater production (Figure 1-3). For several years in a row, total annual pumping exceeded 15,000 acre-feet per year. This observation supports the conclusion that the sustainable pumping rate in the upper portion of the Basin is well below 15,000 acre-feet per year.

The influences of a remedial action on water levels in the Basin will need to be evaluated closely, particularly considering the significant increase in total pumping over the last several years. In addition, if the higher pumping rates are expected to continue into the future, particularly in the areas west of the 160-Acre Area, the resulting long-term changes in gradients and groundwater flow directions will need to be considered during design of the remedial action.

SECTION 3

Identification and Screening of Remedial Technologies

Section 3 identifies general response actions likely to satisfy the RAOs, identifies one or more remedial technologies for each general response action, and screens the technology options based on effectiveness, implementability, and cost.

Table 3-1 provides a complete list of general response actions and remedial technologies considered as part of this RI/FS. They include the following:

- No Action
- Hydraulic Control – Extracts contaminated groundwater from the aquifer using new or existing wells to limit the movement of contaminated groundwater past the extraction locations. Reduces mobility of the contaminated groundwater, impacts to downgradient areas, and the potential for future human exposure.
- Ex Situ Groundwater Treatment – Removes contamination from the extracted groundwater to reduce the volume of the contaminants.
- Treated Water End Use – Makes use of a valuable resource if the treated water is used as drinking water, and potentially reduces exposure by replacing water supplied by non-remedy wells affected or threatened by contamination. Treated water may also be injected back into the aquifer.
- In Situ Groundwater Treatment – Transforms contaminants in groundwater into less toxic or nontoxic compounds. Reduces toxicity, mobility, and/or volume of the contaminated groundwater.
- Groundwater Monitoring – Provides information regarding groundwater quality and the performance of the hydraulic control action.

The screening-level evaluation considers effectiveness, implementability, and cost.

- Effectiveness: The effectiveness of each technology was evaluated by considering the likelihood that it would satisfy the RAOs; the potential impacts to human health and the environment during the construction and implementation phases; and the reliability and success of the technology with respect to the types of contamination and other Site conditions.
- Implementability: Implementability was evaluated by considering factors such as the ability to obtain necessary permits (if needed for offsite activities); the availability and capacity of treatment, storage, and disposal services; and the availability of equipment and workers to implement the technology.

- Cost: In the screening of technologies, relative capital plus operations and maintenance (O&M) costs were used rather than detailed estimates. Engineering judgment was used to evaluate costs for each technology relative to the other options.

When multiple technologies were considered effective, implementable, and cost-effective, a representative technology was chosen and used in the development and analysis of remedial alternatives.

Table 3-1 also summarizes the results of the screening evaluation. Section 4 presents remedial alternatives assembled from four different technology combinations.

3.1 No Action

The No Action general response action is required by EPA guidance (EPA, 1988) as a baseline for comparison with other remedial alternatives. The No Action option does not include active remediation or monitoring.

3.2 Hydraulic Control Options and Targeted Areas and Depth of Contamination

3.2.1 Hydraulic Control Options

Extracting groundwater using new and/or existing production wells is the only remedial technology available to provide the hydraulic control needed to meet the RAOs. The following two options were considered for the hydraulic control of contaminated groundwater at the Site:

- Option 1: Extract contaminated groundwater from the Intermediate Aquifer at or downgradient of the 160-Acre Area to limit the movement of contaminated groundwater into downgradient portions of the Intermediate Aquifer and the Regional Aquifer.

- Option 2: Extract contaminated groundwater from the Regional Aquifer at or downgradient of the 160-Acre Area to limit the movement of contaminated groundwater into downgradient portions of the Regional Aquifer.

The two hydraulic control options were evaluated using a numerical groundwater flow model, as described in Section 3.3.1.

It is unlikely that hydraulic control Option 1 can be effective because of the nature of the Intermediate Aquifer. The Intermediate Aquifer is not fully saturated and can support only limited pumping during periods of low to intermediate water levels. This would make it expensive to construct and difficult to operate an effective groundwater containment system. During monitoring well installation, the Intermediate Aquifer was generally found to be low-yielding, variably saturated, and includes multiple zones of perched water above the laterally extensive BC Aquitard. The modeling results depicted in Figure 3-1 (and described further below) are consistent with these observations, suggesting a thin saturated interval or dry conditions in the Intermediate Aquifer during 2004 hydrologic conditions. An extraction system targeting contaminated groundwater in the Intermediate Aquifer would require a large number of low-capacity extraction wells and operation of those wells at highly variable rates. The field observations and the model suggest that continuous groundwater extraction from the Intermediate Aquifer even with a large number of extraction wells operating at relatively low rates would quickly dewater portions of the aquifer in hydraulic connection with the extraction wells. An extraction system drawing only from the Intermediate Aquifer might not reliably capture the entire area of contaminated groundwater, and it would be difficult to determine if capture had been achieved. Hydraulic control Option 1, extracting from the Intermediate Aquifer to provide hydraulic control, has been screened out and will not be considered further in this RI/FS.

The remedial alternatives presented in Section 4 make use of hydraulic control Option 2, in which contaminated groundwater is extracted solely from the Regional Aquifer. As discussed below, the remedial alternatives assume that extraction occurs in the area where the Intermediate and Regional aquifers merge.

3.2.2 Targeted Areas and Depth of Groundwater Contamination

The areas of contaminated groundwater targeted for hydraulic containment ("the target or targeted areas") are defined as the portion of the Intermediate Aquifer contaminated with perchlorate and TCE above MCLs, and the underlying portion of the Regional Aquifer contaminated with perchlorate and TCE above MCLs. The targeted areas are shown in Figures 1-5 and 1-6 in vertical cross section, and in Figure 3-2 in plan view. The California MCL for perchlorate is 6 μg/L, and the state and federal MCL for TCE is 5 μg/L.

The apparent upgradient boundary of the target area in the Intermediate Aquifer is near CMW-3, the northernmost groundwater monitoring well on the 160-Acre Area consistently above MCLs. The upgradient boundary of the target area in the Regional Aquifer is the location where contaminated groundwater begins to move from the Intermediate Aquifer to the Regional Aquifer, as shown in cross-section in Figures 1-5 and 1-6. The assumed location is at well WVWD-22, where perchlorate and TCE are present in the multi-port monitoring well PW-8, located adjacent to WVWD-22, at concentrations above the MCL in the uppermost of its four Regional Aquifer monitoring zones. Before it was converted into a monitoring well in 1999, WVWD-22 was a production well screened across both the Intermediate and Regional aquifers. The well was only operated sporadically and, given the strong vertically downward gradients observed in the area, may have acted as a conduit for downward migration of contamination into the Regional Aquifer before it was converted into a monitoring well.

It is also possible that contaminated groundwater has moved downward from the Intermediate to the Regional Aquifer via other wells screened in both aquifers (for example, old agricultural wells) or through the BC Aquitard. Given the extremely long vertical migration times through the aquitard predicted by EPA's modeling (hundreds of years), movement through the BC Aquitard is less likely to be a major contributor to vertical migration, except perhaps toward the downgradient portion of the Intermediate Aquifer, near where the two aquifers merge (Figures 1-5 and 1-6).

The downgradient boundary of the target area is where the Intermediate and Regional aquifers merge (Figures 1-5, 1-6, and 3-2). The aquifers appear to merge between WVWD-22 and Rialto-02. Based on information from GeoLogic's investigations (GeoLogic, 2007b) and

EPA's installation of new monitoring well EPA-MW4 in 2009, the location appears to be close to and possibly just upgradient of the Rialto-02 well.

It is expected that additional monitoring wells will be installed during remedial design to refine the upgradient and downgradient boundaries of the target areas. No monitoring wells are completed in the Regional Aquifer upgradient of well WVWD-22, although there are three regional aquifer piezometers at the 160-Acre Area (PW2a, PW3a, and PW4a).

Based on the interpreted depth of contamination in the vicinity of the Rialto-02 well (see Figures 1-5 and 1-6), the depth of the Regional Aquifer target area is approximately 650 to 700 feet bgs.

3.3 Groundwater Extraction

3.3.1 Groundwater Modeling

Model Development

This section briefly describes the development of a site-specific numerical groundwater flow model, and then presents the results of model simulations conducted to evaluate the extent to which the extraction of contaminated groundwater near the target area would satisfy the RAOs.

The model was developed for a portion of the Site (as shown in Figure 3-3) using the three-dimensional finite element model MicroFEM (Hemker and de Boer, 2010). The model simulates groundwater levels and groundwater flow from 1960 to 2020 based on user-specified groundwater pumping rates and locations, recharge rates and locations, upgradient and downgradient boundary conditions, and aquifer properties. The model is a transient model. Values for pumping rates and boundary heads vary over time (that is, values are specified for each of the 60 years in the simulation period). The majority of the model properties are the same as those in a finite difference groundwater flow model of the RCB developed by GeoLogic (2007a) under contract to San Bernardino County. Improvements made to the GeoLogic model include revised hydraulic conductivity near the Rialto-03 well (described further below), refinement of the location of Barrier H, alignment of the model boundaries with faults, and greater spatial resolution at flow barriers.

Figure 3-3 depicts the model boundaries or domain, and the location of key faults within the model domain. The boundaries of the model are Barrier J to the northwest; the San Jacinto Fault to the northeast; 2,200 feet past the Rialto-04 well to the southeast; and the Rialto-Colton Fault to the southwest. The model consists of three layers: layer 1 represents the Intermediate Aquifer; layer 2 represents the BC Aquitard separating the Intermediate and Regional aquifers, and layer 3 represents the Regional Aquifer. The model prescribes fixed heads at its upgradient and downgradient boundaries. Figures 3-4 and 3-5 depict the horizontal hydraulic conductivity distributions in the three model layers. Table A-1 in Appendix A provides values for the boundary heads and pumping rates from non-remedy wells. These values were based on data obtained from GeoLogic and, in the case of pumping rates, from the water purveyors.

Groundwater enters the model primarily through the northeast boundary and generally flows to the southeast, parallel to the San Jacinto and Rialto-Colton faults. Some groundwater may also flow to the west, as described below. Infiltration of precipitation and artificial recharge also contribute to groundwater recharge. Most of the groundwater leaves the modeled area through pumping of water supply wells, although some groundwater exits at the southeastern boundary of the model domain.

Evaluation of the Rialto-3 Aquifer Test

An aquifer test was performed by GeoLogic in 2006 (GeoLogic, 2007a) to estimate hydraulic conductivity in the Regional Aquifer in the vicinity of Rialto-03. Rialto-03 was pumped for 10 days at 1,240 gpm. During that time, drawdown was measured in four wells (two, two-well clusters) located 325 and 940 feet from Rialto-3. The data were evaluated using computer software known as MLU, which enables aquifer test analysis in a multilayer system. The MLU results indicated a horizontal hydraulic conductivity of the Regional Aquifer in the vicinity of Rialto-3 of 120 feet per day (ft/day). The test results also indicated a vertical hydraulic conductivity of 6 ft/day so the ratio of horizontal to vertical hydraulic conductivity is 20:1. As shown in Figure 3-4, the model was adjusted so that the hydraulic conductivity of the Regional Aquifer downgradient of where the Intermediate and Regional aquifers merge is 120 ft/day. The original value from the GeoLogic model was 80 ft/day. The results of the aquifer test analysis using MLU and the simulation of the same test using MicroFEM are presented in Figures A-1 through A-4 in Appendix A.

Model Calibration

Formal model calibration was not performed because of the model's similarity to the previously calibrated model developed by GeoLogic. However, model simulations were carried out to investigate whether the finite element version of the model achieved calibration targets.

A quantitative measure of calibration is presented in Figure A-5 showing a scattergram of measured and observed groundwater levels in the Intermediate Aquifer, the Regional Aquifer, and in the aquitard. The root-mean squared error for the simulation divided by the range of data (RMS/range) is 0.09. A typical criterion for acceptable model calibration is for the RMS/range to be less than 0.1.

Figure A-6 shows a comparison of observed and simulated groundwater level in Rialto-1, Rialto-3, and Rialto-4. The model does a reasonably good job of replicating the observed history of water levels, particularly in the late 1990s through 2004.

Model Simulations to Evaluate the Effectiveness of Additional Extraction – General Approach

After concluding that the transient model was adequately calibrated, model simulations were performed to evaluate the extent to which pumping contaminated groundwater near the target area would achieve the RAOs identified in Section 2.1.

All remedial simulations assume extraction at two “remedy wells”: one existing well (Rialto-02), and one new extraction well (designated EW-1). Figure 3-6 shows the location of Rialto-02 and the assumed location of the new well EW-1. The total extraction rate from these two wells varies from 1,125 to 5,000 gpm. The assumed location of the new well, EW-1, is along Easton Avenue approximately 600 feet east of Linden Avenue, and approximately 0.5-mile west of the Rialto-02 well. Well EW-1 is assumed to be 650 feet deep. The existing Rialto-02 well is 1,000 feet deep.

The extent to which pumping contaminated groundwater would achieve the RAOs is estimated by using the model to conduct forward "particle tracking." In each particle-tracking simulation, the model generates flow lines depicting the path that a particle of groundwater would follow moving through a selected steady-state flow field during the simulation period. See Figure A-9 for an example. The flow field is a snapshot of water levels selected from the output of the calibrated transient model. The selected flow field, well pumping rates, and other hydrologic input parameters are assumed to remain constant to generate the particle tracks. A simulation is run until all particles have reached a model boundary or have been removed from the model at a pumping well (typically tens or hundreds of years). Assuming steady state conditions is a reasonable, conservative approach for comparing remedial alternatives, but simulation results should be interpreted carefully because the actual flow field varies from year to year. Particular caution should be exercised in interpreting results when the selected flow field reflects extremely wet or dry years or other transient conditions.

Flow lines start at the boundaries of the target areas and at other designated locations inside the target areas. Separate particle tracking is performed for the Intermediate Aquifer target zone (particles starting in model layer 1) and for the Regional Aquifer target zone (particles starting in model layer 3).

Three flow fields were selected, representing historical conditions corresponding to three different years: 1998, 2001, and 2004. These three years represent different regional water levels (high, medium, and low) and different rates of pumping at non-remedial wells (that is, active water supply wells not associated with EPA's remedial activities). The conditions represented by the three years are described below.

Particle tracking simulations were completed for remedial pumping rates from zero (that is, no remedial pumping) to 5,000 gpm. The simulations that assume no remedial pumping are known as the "base case." For each remedial pumping rate, six figures are generated and are included in Appendix A. They show the effectiveness of the modeled pumping rate in capturing contaminated groundwater originating in the Intermediate and Regional Aquifer target areas during conditions similar to those that occurred in 1998, 2001, and 2004.

The results of the base case simulations for the Regional Aquifer are shown in Figures A-8, A-9, and A-10. Similarly, for the Intermediate Aquifer, the 2004, 2001, and 1998 base case particle-tracking results are shown in Figures A-35 through A-37, respectively.

The results of the remedial pumping particle tracking simulations are included as Figures A-11 through A-34 (for the Regional Aquifer) and Figures A-38 through A-61 (for the Intermediate Aquifer). Eleven pumping rates were evaluated. No figures are provided for flow rates between 3,645 gpm and 4,500 gpm because there was little difference in results in this range. Table 3-2 notes which figures correspond to which pumping rates. The phrase "excess pumping" noted in selected figures indicates that the assumed remedial pumping rate is in excess of that needed to provide hydraulic containment given the conditions in the particular simulation depicted in the figure.

Selected Flow Fields: 1998, 2001, and 2004 Conditions

The three historical conditions (1998, 2001, and 2004) used in the evaluations vary primarily in the elevation of regional water levels and in the pumping rates at nearby wells as follows:

- The 2001 conditions are the least challenging (that is, they require the least amount of remedial pumping to achieve capture). In 2001, regional water levels were neither extremely low nor high, and pumping at non-remedy wells capable of affecting hydraulic gradients in the target area was less than in subsequent years. Regional water levels are an important factor in determining the required amount of additional pumping because higher water levels create larger hydraulic gradients that require more pumping to overcome. Pumping at nearby wells can be important because it can create or change hydraulic gradients that also require more pumping to overcome. Of particular importance is the amount of pumping at several Fontana Water Company production well clusters located in the western part of the model domain (wells F10, F13, F49, pumped at a total of 4,900 acre-feet in 2000 and 7,800 acre-feet in 2001). Significant pumping at these wells, particularly well F49, which started pumping in early 2002, causes a westward hydraulic gradient, which may increase the amount of remedial pumping needed to maintain capture of the target area.
- The 2004 conditions are more challenging (that is, they require more pumping to achieve capture). In 2004, regional water levels were low as a result of below average precipitation in the previous several years, but pumping at the three Fontana Water Company production well clusters had increased to a total of 10,700 acre-feet. The low water levels result in relatively small hydraulic gradients in the primary direction of groundwater flow (northwest to southeast), increasing the impact of the westward, cross-gradient hydraulic gradients such as those caused by the Fontana Water Company pumping. Figure A-8 illustrates this effect, showing flow lines from the target area to the Fontana Water Company well clusters. Although these flow lines indicate the potential for westward flow during steady-state conditions, they do not necessarily mean that a significant volume of contaminated groundwater has flowed from the target area toward the west. Groundwater flow and associated contaminant transport rates are relatively slow and the transient conditions in the basin act to limit the influence of any one particular flow condition.
- The 1998 conditions are the most challenging. In 1998, regional water levels were high in response to a generally above-average precipitation cycle that started in 1990 and significantly increased hydraulic gradients.

Pumping Assumptions at Non-Remedy Wells

Table 3-3 presents the pumping rates specified in the groundwater model for existing production wells (that is, "non-remedy wells) in the base case and remedial particle-tracking simulations. As is discussed further below, the pumping rates presented in Table 3-3 differ, in some cases, from historical pumping rates.

In all base case and remedial simulations, the Rialto-03 well is assumed to pump at 1,500 gpm, consistent with the City's plans to operate the well (in combination with new supplemental extraction wells) as part of the remediation project installed by San Bernardino County downgradient of the former bunker area. To date, the Rialto-03 well has been pumping and treating at much lower rates than the 1,500 gpm anticipated as part of the fully operational remediation system. If the Rialto-03 well treatment plant starts producing closer to 1,500 gpm in the future, the City will likely only be pumping around 300 gpm of water from other wells in the RCB. For the particle-tracking simulations, this 300 gpm has been assigned to the Rialto-04 well, leaving the Rialto-05 well inactive. Assigning the pumping to the Rialto-04 well is a more conservative assumption than assigning it to the Rialto-05 well because the Rialto-04 well is closer to the target area (although it is still a mile downgradient). In recent years, the Rialto-04 well has been inactive because of perchlorate contamination and the Rialto-05 well has been pumped at an average of approximately 625 gpm on an annual basis.

The Rialto-06 well is also currently inactive because of contamination. Pumping at the Rialto-06 well would not affect simulation results because it is located outside the modeled area and its hydraulic effect is already represented by the downgradient specified-head boundary condition (based on measured water levels) in the model. However, increased production at the Rialto-06 well in the future could result in a slightly steeper gradient across the model domain, which could result in higher extraction rates being needed to achieve capture. The Rialto-07 well has been inactive since 1993 because of poor production and is assumed to be turned off in the particle-tracking simulations.

Other key wells that affect hydraulic gradients and groundwater flow directions in the general vicinity of the remedial alternatives being evaluated in this RI/FS include the Rialto-01 well, and Fontana Water Company wells F-10A, F-10B, F-13A, F-13B and F-49A (see Figure 3-2 for well locations). The flow rates assumed in the model for the Rialto-01 well are based on data provided by the City of Rialto (and match the values used in GeoLogic's model). The data for the five Fontana Water Company wells are based on the pumping rates included in the GeoLogic model for the three years of interest (1998, 2001, and 2004). Fontana Water Company has recently provided EPA with pumping values for these five wells that do not match the numbers in the GeoLogic model. The reason for these discrepancies is not clear; however, the differences do not appear to be large enough to result in substantive changes to the particle-tracking results.

Evaluations of Flow from the Regional Aquifer

Figures A-11 through A-34 show simulated flow lines originating in the Regional Aquifer. The figures show flow lines for each of the eight pumping rates evaluated during 1998, 2001, and 2004 conditions. Table 3-2 provides estimates, as a percentage, of the level of hydraulic containment provided by each of the eight groundwater extraction rates. The percentages are estimates of the number of flow lines that end at one of the two "remedy" extraction wells or remain in the target area, divided by the total number of flow lines.

As noted above, the 1998 conditions are the most challenging for hydraulic containment, and using these high water level conditions in the steady-state particle-tracking simulations is very conservative. Because the simulated particles take decades to move through the steady-state flow field, this approach is equivalent to assuming that the 1998 high water-level conditions persist for decades. However, high water levels in the Regional Aquifer, similar to those that occurred in 1998, historically have not persisted for such a long period. Water levels are typically cyclical, ranging from high to low water levels coincident with wet and dry climatic conditions. High water levels are expected to occur less frequently in the near future, given the recent over-pumping of the basin and the associated water level declines with little rebound observed during wet periods. Even after the heavy rainfall observed during the winter of 2004-2005, which resulted in Intermediate Aquifer water levels rising by more than 40 feet, Regional Aquifer water levels increased only slightly.

Evaluations of Flow from the Intermediate Aquifer

Figures A-38 through A-61 show flow lines originating in the Intermediate Aquifer for each of the eight pumping rates, assuming 1998, 2001, and 2004 conditions. Table 3-2 provides estimates, as a percentage, of the level of hydraulic containment provided by each of the eight groundwater extraction rates.

The estimates of the level of hydraulic containment in the Intermediate Aquifer make use of a Intermediate Aquifer Modeling Target (rather than the larger Intermediate Aquifer Target Zone) located at the downgradient end of the Intermediate Aquifer, as shown in Figures 1-5, 1-6, and 3-2. This modified target area is believed to provide more realistic results than the larger target area for two reasons: 1) little or no downward movement of contaminants from the Intermediate Aquifer through the BC Aquitard into the Regional Aquifer is expected (except where the Intermediate Aquifer thins and disappears); and 2) the limited saturated thickness, variable saturation, and perched conditions during periods of low to intermediate water levels in the Intermediate Aquifer make it difficult to realistically simulate downward movement through the Intermediate Aquifer. Simulations of downward movement through the Intermediate Aquifer with the larger target area provided results that may not be representative of actual conditions. The particles are shown either moving into the BC Aquitard, or they became stranded in the portions of the Intermediate Aquifer where the saturated thickness was limited during low to intermediate water level conditions. These simulations assume that the specified water levels continue unchanged for a period of tens or hundreds of years.

If the larger Intermediate Aquifer Target Zone were instead used in the simulations, the model would indicate that higher extraction rates would be needed to achieve the same level of hydraulic containment.

All of the Intermediate Aquifer particle-tracking results using the Intermediate Aquifer Modeling Target during periods of low to moderate regional water levels (2004 and 2001) show that the remedy wells successfully control migration, even at pumping rates as low as 1,125 gpm (Table 3-2 and Appendix A figures). These results reflect the limited flow expected to occur out of the Intermediate Aquifer during most conditions. As described above, Figure 3-1 illustrates this limited flow capacity during 2004 low water conditions (without any remedy well extraction), when portions of the Intermediate Aquifer are dry. Because of the limited saturated thickness and the variable saturation that results in perched conditions within the Intermediate Aquifer, groundwater flow is likely very slow except during high water conditions.

In the figures showing flow lines that originated in the Intermediate Aquifer during periods of high water levels (1998), little or no containment is shown except at the highest pumping rate evaluated (5,000 gpm). This result is due to the conservative, steady-state particle-tracking approach, which infers that the high water level conditions observed in 1998 would persist for decades, combined with the simulated location of the new extraction well being slightly upgradient of where the Intermediate and Regional aquifers are assumed to merge. Moving the extraction wells slightly farther downgradient might significantly improve containment of groundwater originating in the Intermediate Aquifer.

For these reasons, the failure to show full containment in the particle-tracking simulations of the Intermediate Aquifer might be of limited importance and, therefore, is given little weight in the discussion of groundwater extraction scenarios in Section 3.2.2 and in the evaluation of remedial alternatives described in Section 5.

Model Limitations

The model, like all computer models, has important limitations. The following limitations are in addition to those described above.

- The assumption of fixed head boundary conditions results in large and abrupt changes in water levels that probably overestimate actual variability in subsurface inflow and outflow. Figures A-7a and A-7b illustrate these problems. Figure A-7b shows that the head difference between the upgradient and downgradient boundaries in the model changes over 200 feet in a single year. Although the validity of this assumption has not been evaluated using actual water level data, the effect of such large and short-term changes is to generate anomalous water budget conditions near the model boundaries. An example of this effect is the simulated but unlikely reversal of flow across the northwest model boundary in the late 1980s and 1990s shown in Figure A-7a. To lessen the impact of the assumed boundary condition on transient fluxes, steady state simulations were completed using a range of historical water level and pumping conditions (that is, the 1998, 2001, and 2004 conditions).
- The decision to base the particle-tracking evaluation on steady-state simulations gives significant weight to the more extreme hydrologic conditions (particularly the 1998 conditions) by inferring that the specified condition would persist for decades. Historical precipitation and water level data indicate that conditions vary considerably, with alternating periods of wet and dry years.
- There is very little data available on hydrogeologic conditions in the Intermediate Aquifer. Based on observations during drilling through the Intermediate Aquifer, this zone is variably saturated with water occurring in relatively thin vertical horizons that are separated by dry sediments. The lateral connectivity of these isolated saturated zones is not known. Computer simulations of this type of aquifer on a regional scale are challenging and the oversimplified depiction of the Intermediate Aquifer in the model may not accurately reflect actual flow conditions.

Although the model has significant limitations, it is believed adequate for the purposes of the RI/FS to estimate the approximate remedial pumping rates required for hydraulic capture of the targeted areas of contamination during varying groundwater conditions. However, to refine the target extraction rates and locations during remedial design (unless the No Action alternative is selected) and to evaluate the future effects of alternative pumping rates from non-remedy and remedy wells and varying water level/basin inflow conditions over time, a more sophisticated groundwater flow model may be needed. The more refined model would attempt to reproduce past water level history based on actual water budgets, and make more limited use of (or not use) the fixed head boundaries assumed in the current model. The area included in a revised model would probably also need to extend beyond the boundaries of the current model.

3.3.2 Groundwater Extraction

This section describes three groundwater extraction scenarios (which are incorporated into the remedial alternatives described in Section 4), and uses the modeling results described above to estimate the amount of pumping required in each scenario. The three scenarios are full containment during low to intermediate groundwater levels, full containment during most groundwater conditions, and full containment during all groundwater conditions.

Full Containment during Low to Intermediate Groundwater Levels

Based on the modeling simulations described in Section 3.3.1, extraction of approximately 1,500 gpm (on average) would provide full containment of the Regional and Intermediate aquifers during low and intermediate water level conditions, similar to conditions that have been present for the last several years in the RCB. In this pumping scenario, the existing Rialto-02 well would pump an average of 600 gpm and the new extraction well EW-1 would pump an average of 900 gpm. To provide a small safety factor and some additional system flexibility, the peak rate assumed for this scenario is 1,650 gpm, which is 10 percent above the targeted average rate. For conceptual design and costing of remedial alternatives, the assumed peak extraction is distributed as 660 gpm from the Rialto-02 well and 990 gpm from the new extraction well EW-1.

During high water level conditions, however, the model indicates that remedial pumping at 1,500 gpm would only contain an estimated 59 percent of the Regional Aquifer target area and none of the Intermediate Aquifer target area. It should be noted that further refinement of the extraction well locations (in relation to the location of the Intermediate/Regional Aquifer merge area) would improve hydraulic containment in the Intermediate Aquifer. The significance of this modeling result also depends on how long the high water level conditions last. The steady-state particle-tracking simulations conducted to evaluate this extraction alternative infer that high water levels would persist for decades. If high water levels are of shorter duration (for example, 1 or 2 years), the distance that contaminated groundwater moves past the extraction wells would be limited. The level of containment during remedy operation would also depend on future pumping rates at nearby wells, and the actual size and configuration of the targeted area of contamination.

In this and the other two extraction alternatives, the new well is assumed to be located at the edge of existing public streets to limit problems with future access. Because of the expected variability in future hydrogeologic conditions in the basin, it is assumed that both extraction wells are equipped with variable frequency drives (VFDs) to allow for varying the pumping rates over a relatively large range.

The extraction rates may be refined during remedial design as additional data are obtained on the location of the area where the Intermediate and Regional aquifers merge, the lateral and vertical extents of contamination in excess of MCLs, and planned pumping rates at non-remedy production wells.

Full Containment during All Expected Groundwater Conditions

To improve containment during high water levels and to provide full containment during expected groundwater conditions, this scenario increases peak pumping capacity to 3,200 gpm. As shown in Table 3-2, a 3,200-gpm capacity provides for the flexibility to increase pumping during high water level conditions to a rate that would provide an estimated 94 percent containment of the Regional Aquifer target area. Because, high water level conditions are not expected to persist for the long periods of time inferred by the steady-state modeling, actual containment in the Regional Aquifer is expected to be at or near 100 percent. Although the simulations still indicate no containment of the Intermediate Aquifer, further refinement of the extraction well locations is expected to improve containment, and this result is given limited weight in the evaluation of remedial alternatives. This scenario would also provide greater flexibility to increase pumping if the extent of contamination is larger than anticipated.

Extraction of contaminated groundwater is assumed to occur from two extraction wells located along Easton Street (Rialto-02 and EW-1), in the same locations as described above. Although the system would be designed to handle 3,200 gpm, the long-term average extraction rate would be much lower. For remedial alternative evaluations, it is assumed that the average total pumping rate would be approximately 1,840 gpm. This value assumes that the remedy would operate at 1,500 gpm during periods of low to intermediate water levels and 3,200 gpm during high water levels, and that low to intermediate water levels occur 80 percent of the time. The assumption that higher than average water level conditions would occur 20 percent of the time is based on a review of graphs of historical water level data and annual precipitation information for the RCB presented in two USGS reports (USGS, 1997 and 2001). Over the last 50-plus years, high water conditions have been observed about 20 percent of the time (that is, approximately 1 out of 5 years on average). Assuming that high-water level conditions will continue at this frequency in the future is a conservative assumption, given the ongoing water level declines observed in the RCB that appear to be associated with increased groundwater production over the past 10 years.

In this pumping scenario, the Rialto-02 well would produce an average of 740 gpm and the new extraction well EW-1 would average 1,100 gpm. It is assumed that the two wells would each be equipped with VFDs to provide flexibility in responding to increasing water levels or other changes in groundwater conditions.

Full Containment during All Groundwater Conditions

To provide 100 percent containment during all modeled conditions, this scenario increases peak pumping capacity to 5,000 gpm. As described in Section 3.3.1, the steady-state particle-tracking approach infers that relatively extreme hydrologic conditions continue for many decades beyond what has occurred historically. Hydrologic conditions typically vary with alternating periods of wet and dry years.

The extraction rate required to show capture of 100 percent of the flow lines in the Intermediate Aquifer particle-tracking simulations under 1998 groundwater conditions is approximately 5,000 gpm (Table 3-2). The extraction rate required to show capture of 100 percent of the flow lines in the Regional Aquifer target area is 4,050 gpm.

As with the other scenarios, two extraction wells are assumed. These include the existing Rialto-02 well and the new extraction well EW-1 (Figure 3-6). During peak water level conditions, the two wells would need to produce 5,000 gpm: Rialto-02 at 2,250 gpm and EW-1 at 2,750 gpm. However, the long-term average total pumping rate is assumed to be 2,200 gpm (880 gpm from the Rialto-02 well and 1,320 gpm from well EW-1), which represents a 20 percent increase over the 1,840 gpm rate described above for the prior containment scenario. It is anticipated that most of the time, the extraction wells would be operated at the lower average rates needed to provide containment during low or intermediate water levels. It is assumed that both wells would be equipped with VFDs to provide operational flexibility; however, VFDs do not provide a wide enough range to allow the two wells to be pumped continuously over the full range of extraction rates desired (for example, from approximately 1,500 gpm up to a 5,000 gpm). During normal conditions, to achieve the target rates in the range of 1,500 to 2,000 gpm the wells would need to be operated on a part-time basis.

3.3.3 Estimated Treatment Plant Influent Concentrations

This section describes the methodology used to estimate contaminant concentrations in the extracted groundwater (that is, influent concentrations) that would enter the water treatment plant assumed in the remedial alternatives. The concentrations are used to select representative, cost-effective treatment technologies and estimate treatment plant sizes and costs.

Contaminant concentrations in groundwater at the Site have varied considerably with time, despite the relatively short monitoring record for most locations. It is expected that concentrations would continue to change throughout the life of the remedy. The influent concentrations are intended to be conservative estimates of the long-term average and peak concentrations that could be observed at a treatment plant.

Only perchlorate and TCE have consistently been detected at concentrations exceeding MCLs beneath the 160-Acre Area and in downgradient locations. Trace concentrations of other VOCs have been detected, but these detections have generally been isolated and sporadic. Based on currently available data, there are no other known contaminants (either VOCs or other constituents) that would be present at high enough concentrations to warrant treatment. Therefore, only perchlorate and TCE have been considered in the influent estimates.

The following discussion presents estimates of average and peak treatment plant influent concentrations for perchlorate and TCE. Estimated peak influent concentrations are used for treatment plant conceptual design and to estimate capital costs. Estimated average influent concentrations are used to estimate annual treatment plant O&M costs.

Treatment plant influent estimates were developed using the following steps.

1. It is assumed that 20% of the flow into a treatment plant would come from the Intermediate Aquifer and 80% would come from the Regional Aquifer. This assumption is conservative since the actual percentage of Intermediate Aquifer water is likely to be lower and contaminant concentrations are higher in the Intermediate Aquifer than in the Regional Aquifer

2. Water quality data from the Rialto-02 production well and the PW-5, PW-8 and WVWD-22 (Intermediate Aquifer) monitoring wells (Figure 1-5) are considered the most representative of potential future influent concentrations. The Rialto-02 well is included as one of the two extraction wells in all of the remedial alternatives and the three monitoring wells are located near the likely area of extraction. The Regional Aquifer is represented by the Rialto-02 well, the PW-5 well, and the deeper zones in the PW-8 well. The Intermediate Aquifer is represented by the WVWD-22 intermediate depth monitoring well and the shallowest zone in well PW-8.

3. The peak concentrations assumed for the Intermediate Aquifer are 600 μg/L for perchlorate and 100 μg/L for TCE. Both of these values are considerably higher than the recent results from wells WVWD-22 and PW-8 (Figure 1-5 and Table 1-2), but take into account potential future slugs of elevated concentrations migrating away from the source areas in the 160-Acre Area. Peak perchlorate concentrations at the WVWD-22 monitoring well were over 800 μg/L in 2000.

4. Peak concentrations for the Regional Aquifer are estimated at 300 μg/L for perchlorate and 35 μg/L for TCE. These peak concentrations are based on recent data from well PW-5 which has ranged from non-detect to 1,400 μg/L for perchlorate and 23 to 44 μg/L for TCE in individual monitoring zones.

5. Average Regional Aquifer influent concentrations are assumed to be 70 μg/L (perchlorate) and 5 μg/L (TCE). These estimates are based primarily on recent data from Rialto-02 (Table 1-2) and a review of the nearby monitoring well data. The average Intermediate Aquifer concentrations are estimated at 120 μg/L for perchlorate and 20 μg/L for TCE. These estimates are based on recent results from the WVWD-22 and PW-8 Intermediate Aquifer monitoring results (Figure 1-5 and Table 1-2).

6. Based on the 80/20 percentage ratio of Regional Aquifer influent groundwater to Intermediate Aquifer influent groundwater noted above, the estimated blended peak influent concentrations are 360 μg/L for perchlorate and 48 μg/L for TCE. The estimated long-term average influent concentrations are 80 μg/L for perchlorate and 8 μg/L for TCE.

As noted above, "peak" concentrations are used for system design and estimating capital costs. Peak concentrations are intended to represent a reasonable worst-case scenario that could be observed at the treatment plant. Average influent concentrations are only used to estimate annual treatment plant O&M costs.

3.4 Treatment Technologies for Extracted Groundwater

This section describes technology options to remove perchlorate and VOCs from contaminated groundwater extracted at rates and locations described in Section 3.3.2. These options passed an initial technical implementability screening in which technologies that were considered infeasible or not applicable to the Site were eliminated.

3.4.1 TCE Treatment

This section describes three treatment technologies capable of removing TCE from groundwater:

- Air Stripping
- Liquid Phase Granular Activated Carbon
- Advanced Oxidation

Air Stripping

Due to the high vapor pressure and low solubility of TCE in water, air-stripping technologies are able to remove TCE from groundwater to levels suitable for the expected end uses of the treated water (for example, as a potable drinking water supply or reinjection into a drinking water aquifer). Air stripping transfers contaminants from the groundwater to the air, and then the offgas is usually treated to remove or destroy the contaminants. Off-gas treatment is typically accomplished by passing the air stream through vapor-phase granular activated carbon (VGAC) or, less often, a thermal or catalytic oxidizer. If an oxidizer is used, it may need to be equipped with a scrubber to remove hydrochloric acid prior to discharge of the treated off-gas stream.

A possible disadvantage of air stripping is that it increases the pH of the treated water, which can cause scaling in the air stripper and downstream equipment.

Air stripping can be accomplished using different types of equipment, including:

- Packed tower aeration
- Low-profile aeration
- Bubble diffusion
- Aspiration or centrifugal stripping

Liquid-Phase Activated Granular Activated Carbon Adsorption

Because of its relatively high adsorptive capacity, TCE can also be removed by liquid-phase granular activated carbon (LGAC). Adsorption is a process in which constituents are attached to the internal surface of activated carbon.

In a typical system, water is pumped through a vessel filled with carbon. Over time, the carbon becomes saturated with contaminants until the contaminant “breaks through” the carbon bed.

A lead-lag configuration is often used to provide redundant treatment and increase the life of the carbon. The first bed is allowed to become saturated with a contaminant, while a second bed in series is allowed to capture any “leakage.” When the first LGAC bed is saturated, the lag bed is placed into the first position and a fresh bed of carbon is provided for the lag position.

Use of LGAC creates spent carbon that is typically regenerated offsite for reuse or disposed of offsite.

Advanced Oxidation Processes

TCE can also be removed from groundwater by using an advanced oxidation process (AOP). Advanced oxidation processes typically employ ultraviolet (UV) light and a chemical oxidant that react to form hydroxyl radicals that react with the contaminant.

In a UV/oxidant (Ox) treatment system, the oxidant is injected into the contaminated water, which then passes through a tank containing numerous UV lamps. An advantage of UV/Ox and other AOP technologies is that they are destructive technologies (that is, TCE is destroyed). Possible disadvantages are higher costs, incomplete destruction of the targeted contaminant, and excess hydrogen peroxide in the treated water.

3.4.2 Perchlorate Treatment

This section describes treatment technologies capable of removing perchlorate from groundwater. Four potential perchlorate removal technologies are described below:

- Ion exchange using a synthetic resin
- LGAC
- Biological treatment
- Membrane processes

Other technologies such as conventional filtration, sedimentation, and air stripping have not been shown to effectively remove perchlorate from water and are not discussed further.

Ion Exchange

Ion exchange technologies have been used to remove perchlorate from groundwater at numerous locations in California and nationally. At least 12 systems are in use at or near the Site, providing potable water to residents and businesses.

In a typical application, the water is filtered to remove any suspended solids and passed through a vessel containing a chloride-based anion exchange resin. The perchlorate ions replace the chloride ions in the resin, thereby removing the perchlorate from the water. The resin is replaced periodically when it has lost its contaminant-loading capacity. The spent resin is typically regenerated or disposed offsite. In recent years, vendors have developed "perchlorate-specific" resins, increasing resin life and lowering costs.

Alternatively, ion exchange systems can have regenerable resin beds in which the resin is regenerated onsite with a sodium chloride solution. A disadvantage of the regenerable ion exchange process is that a waste brine stream is produced during regeneration of the ion exchange resin. This perchlorate-rich brine must be disposed or further treated. The regeneration process also wastes a portion of the water passing through the treatment system.

LGAC

LGAC also has a limited capacity to adsorb perchlorate from water. Both coconut shell and coal-based LGAC have some capacity to remove perchlorate but are unlikely to be cost-effective technologies because of the low removal efficiency.

Biological Treatment

Biological treatment has been used to remove perchlorate from groundwater at the Aerojet Superfund site in northern California since the late 1990s, and has been tested extensively at the Site as part of a Department of Defense-funded treatment evaluation. Biological treatment for perchlorate consists of adding nutrients in a controlled environment to sustain microbes that are capable of anaerobic degradation of perchlorate to chloride and oxygen. Biologically active filters employing microbes have been used in drinking water treatment for decades to help remove particles and biodegradable organic matter.

The process option used in northern California and tested at the Site is a fluidized bed bioreactor (FBR) in which the contaminated groundwater is augmented with a carbon substrate [for example, ethanol, acetate, or acetic acid (vinegar)] and phosphoric acid to promote biological growth. After the carbon substrate and nutrients are added, the perchlorate-contaminated groundwater is introduced into a vessel containing LGAC or other media that serves as a substrate for microbial growth. The bioreactor operates in an anoxic mode, in which the microbes use nitrate and perchlorate for cellular respiration instead of oxygen. The bioreactor produces a waste biomass that typically requires offsite disposal. Additional treatment is needed after the bioreactor, with the type of treatment depending on the end use of the water. If the treated water is intended for potable use, aeration (to re-oxygenate the water), filtration (to remove residual biomass and any other solids), and disinfection would be required. A backwash storage tank and other equipment would be needed to allow backwashing of the filter.

The primary advantage of a biological treatment process is that perchlorate is destroyed. Also, nitrate concentrations are reduced, and the process does not significantly increase the treated water total dissolved solids (TDS) or anion concentrations. A disadvantage is that a biological treatment process has not been used in California to remove perchlorate and provide potable water. The system has been demonstrated capable of providing potable water in pilot-scale testing and the California Department of Public Health (CDPH) has accepted the technology for potable water use but has not issued a water supply permit for a public water system using the technology.

Membrane Technologies

Membrane processes including reverse osmosis (RO) and nanofiltration are effective in removing perchlorate. However, these processes are likely to be more expensive than other options, and will non-selectively remove other dissolved salts in addition to perchlorate. In addition, membrane processes create a concentrated waste stream requiring further treatment and/or disposal.

3.4.3 Disinfection

Disinfection will be required if the treated water is to be used as potable supply, and may be required for some non-potable end uses, such as recycling and reuse. Typical disinfection processes include the addition of various disinfecting chemicals such as chlorine, ozone, chlorine dioxide, chloramine, and peroxone (ozone/hydrogen peroxide) and/or UV irradiation.

3.5 Treated Water End Use

3.5.1 Potable Water End Use

It is anticipated that the treated water can be supplied into the potable water delivery system of one or more of the four major water purveyors in the RCB. The water purveyors with large, distribution facilities (for example, pipelines and tanks) located closest to the assumed treatment plant location are WVWD and Fontana Water Company. The City of Rialto also has some pipelines in the area but, based on preliminary discussions with City representatives, has a limited capacity to distribute additional water in the project area. The City of Colton does not have any existing facilities in the vicinity of the assumed locations for the extraction and treatment systems. The water purveyor with the largest unused water right in the RCB is WVWD (see Section 2.3 for a description of the Rialto-Colton Basin Judgment).

Providing treated water to purveyors can offer important remedial benefits if it replaces extraction at wells that may be contributing to the spread of contamination. Accepting treated water from a treatment plant operated as part of the remedy could also benefit water purveyors whose wells are either affected or threatened by contamination by providing them with a reliable alternative water supply.

Preliminary discussions have been held with the water purveyors regarding how much treated water they could potentially accept. Purveyors have not yet been asked to provide firm commitments to accept treated water.

It has been assumed that a treatment facility constructed as part of the remedy would supply water to purveyors at a constant flow rate year round. However, the actual demands that purveyors must satisfy vary daily and seasonally, with daily summer demand typically twice as high as daily winter demand. If a remedy is selected that involves providing treated water to purveyors, the validity of the constant flow assumption would be further evaluated cooperatively with the expected recipients of treated water. During remedial design, additional analyses may be conducted to compare the effectiveness, cost, and implementability of constant versus seasonally varied extraction rates. If a remedy is selected that involves providing treated water to purveyors, additional discussions among EPA, purveyors, and other affected parties would be necessary to determine the precise amount of water each purveyor would accept. Factors expected to affect the decision include:

- Purveyor’s interest in accepting treated water
- Cost of providing water to the purveyor, including the purveyor's contribution
- Purveyor’s water quality acceptance requirements
- Location of wells from which the purveyor would reduce extraction, if any
- Flow rate that the purveyor can accept on a constant and seasonally variable basis
- Institutional constraints associated with distribution to the purveyor

A number of institutional issues would need to be addressed before treated water can be supplied to purveyors. These include the following:

- Agreements would be needed with each purveyor that would receive treated water from the remedy. The agreements would need to specify the amount of treated water each purveyor would accept; the delivery location; and operational, liability, financial and water rights arrangements.

- Arrangements would be needed to account for the new extraction from the basin. It is assumed that the volume of treated water supplied to a purveyor would be allocated against the purveyor's water rights as if the purveyors had pumped the water themselves.

- Potable use of the treated water is likely to trigger CDPH Policy 97-005, which requires extensive sampling and analysis as part of a source water assessment, testing and approval of the treatment system, and a lengthy permitting process for offsite distribution.

3.5.2 Non-potable Water End Use

Non-potable use of the treated water has potential advantages over potable end use in that there may be fewer agreements needed with third parties. Options for non-potable use of the treated water include reinjection into the Regional Aquifer via new injection wells, discharge to the Cactus Basin via storm drains and subsequent infiltration within the Basin, discharge to the Santa Ana River, or discharge to end users that have beneficial uses for non-potable water, such as a recycled water system.

Discharge to storm drains that convey water to the Cactus Basin would require minimal conveyance piping of the treated water. However, the Cactus Basin is located above high levels of groundwater contamination in the Regional Aquifer at and downgradient of well PW-5 (Figure 1-7). The infiltrated water could adversely affect flow directions and contaminant migration in an area where the extent of contamination and groundwater flow directions have not yet been adequately defined. The capacity of Cactus Basin to accept the treated water is also uncertain and it is not known whether constant use of the Basin for recharge is compatible with the primary flood control use of the Basin. Because of the lack of information and potential negative impacts on migration, this discharge option is not further considered at this time. However, once the downgradient plume extent is further defined and if information can be developed on Basin recharge capacities, this option could be revisited in the future.

Discharge to the Santa Ana River would be very costly because of the great distance from the likely treatment plant locations. Because this discharge option appears to be cost-prohibitive, it is not considered further.

Because there is not a local recycled water system in place now or expected in the near future, this option was not considered further. Other non-potable end uses also appear to be limited. As part of their evaluation of a potential 1,000-gpm biological treatment system at well WVWD-22, Tetra Tech (Tetra Tech EC Inc., 2006) identified four significant industrial users and one park within two miles of well WVWD-22 that could potentially use non-potable water. However, the total annual water use for these five users is 490 acre-feet (or approximately 300 gpm if taken continuously, which the users would likely not accept).

Because these potential volumes are only a small portion of the likely discharge from this remedy, it is not considered further.

Treated water discharge into reinjection wells is a viable option. If placed properly, injection wells can help accelerate cleanup by flushing the aquifer and can help with migration control by reducing hydraulic gradients. Other potential advantages to reinjection are the minimization or avoidance of water rights issues and the lack of constraints on system operation associated with variable purveyor water demands. Due to the extent of downgradient contamination and incompletely defined flow directions, it would not be advisable to install the injection wells downgradient of the extraction wells for this remedy. The injection wells should be located upgradient of the 160-Acre Area to potentially help accelerate remediation. This necessitates installation of a considerable length of conveyance piping from the treatment system to the injection well location.

The injection wells could be constructed similarly to the extraction wells. Injection wells are prone to clogging and can potentially require considerable maintenance depending on the chemistry of the injected water compared to the local aquifer at the injection location. Additional treatment of the extracted water may be needed to limit potential encrustation (scaling) of the injection well screens and mineral precipitation in the aquifer.

3.6 In Situ Groundwater Treatment

The same principles described in Section 3.4.2 for biological treatment can be used to treat TCE-contaminated groundwater in situ. In a technology known as in situ biological treatment (ISB), chemicals (“electron donors”) are added to the aquifer to facilitate the microbial conversion of the targeted contaminant to innocuous end products. Perchlorate can also be treated using anaerobic ISB, although the conditions required for effective perchlorate removal differ from those required for TCE. Anaerobic ISB processes have been implemented in both proprietary and nonproprietary forms, using a variety of electron donors, various nutritional amendments, and a variety of approaches to deliver the materials to the targeted area. There is an economic limit to the size of the plume that can be treated with ISB, but ISB can be combined with monitoring or other remedial approaches.

Laboratory microcosm studies have shown that both TCE-reducing and perchlorate-reducing bacteria are indigenous to many soils, sediments, and groundwater. These organisms can often be stimulated to degrade TCE and perchlorate to below detection limits. Laboratory-scale test results, however, are limited in their predictive capacity for long-term, full-scale application of ISB. Bench-scale (column) and pilot-scale testing would be necessary to assess the capacity of the naturally occurring bacteria in the Regional Aquifer to degrade TCE and perchlorate.

The following limitations are common to the full-scale ISB processes, and must be considered in any subsequent technology evaluations:

- Intrusive methods are required to introduce the electron donor to the formation.
- Aquifer heterogeneity can adversely affect delivery of reagents or nutrients (because reagents follow preferential flow paths).

- Potential biofouling or scaling of the aquifer, remediation wells, or monitoring wells can occur with continued operation.
- The ISB process may mobilize metals (for example, iron, manganese, and arsenic), generate hydrogen sulfide [if oxidation reduction potential (ORP) is not adequately controlled], or degrade water quality in other ways.

ISB is considered below in combination with monitoring and/or additional plume containment, rather than as a stand-alone technology. Two ISB processes are evaluated in the following sections. The two processes differ primarily in the method used to deliver the electron donor to the aquifer.

3.6.1 Groundwater Injection/Recirculation Systems

This technology involves delivering the electron donor and other amendments directly to the groundwater to stimulate biodegradation. The electron donors are typically water-soluble with low viscosity, and are injected into the upgradient portion of the plume or source area. The amendments treat the groundwater as it moves downgradient.

This technology can be implemented by conventionally installed injection wells. Passive treatment consists of upgradient injection only. Active treatment includes a recirculation system in which the substrate and treated groundwater are extracted downgradient and reinjected at the upgradient injection points, or circulated cross-gradient. Both passive and active enhanced ISB systems can be configured as a large injection grid or in multiple staggered rows to create an anaerobic reaction zone across broad areas of a plume.

Substrate amendments applied in recirculation systems are more readily controlled and distributed throughout the treatment zone relative to passive systems. However, well spacing for recirculation systems is generally on the order of 30 to 100 feet, which would not be practical at the Site.

The ISB process has been proven effective in transforming TCE and perchlorate to harmless byproducts in full-scale applications in relatively small areas. Passive and active systems are both potentially effective. The long-term potential for biofouling of the treatment system or aquifer is not well known, but fouling has occurred in similar applications, particularly recirculation systems.

Active and passive ISB substrate injections would be moderately to poorly implementable. Implementing this technology at the Site would require hundreds or thousands of injection points, which would be difficult to install given the extent of residential and commercial development in the Rialto area, combined with the large depth to groundwater.

The installation of ISB is anticipated to have high capital costs due to the number and depth of extraction, injection, and monitoring wells and associated piping. The recirculation ISB system would have moderate O&M cost, even if the period of operation was relatively short (that is, 5 to 10 years).

Both passive and active ISB systems are screened out from further evaluation as a component of remedial alternatives due to high cost, uncertain effectiveness in a large area, and moderate to low implementability.

3.6.2 Fixed/Active Bio-Barriers

Fixed bio-barriers use solid or highly viscous amendments placed perpendicular to the groundwater flow direction. The contaminated groundwater flows through the reactive zone, resulting in decreased TCE and perchlorate concentrations on the downgradient side of the bio-barrier. The fixed bio-barrier typically consists of engineered trenches or injected barriers with slow-release substrates such as vegetable oil, chitin, or compost materials. However, in this area trenches would not be feasible. A bio-barrier must be constructed with a continuous reaction zone, sufficient residence time for the biological reaction, and a permeability that is equivalent to, or lower than, the surrounding subsurface.

The bio-barrier would require injection of a liquid substrate to multiple depths, or a vapor substrate such as ethanol sparged from the bottom of the barrier. The system would allow for the adjustment of the rate, lateral delivery profile, and type of substrate loading.

Bio-barrier systems have been proven effective in transforming TCE and perchlorate to harmless byproducts in small-scale applications. The long-term potential for biofouling of the aquifer in the treatment area is not well known, but biofouling has been observed in similar applications.

Because of the size of the area needing to be addressed in this application (and the large depth to water), it is not likely that a bio-barrier could be effective in this portion of the B.F. Goodrich Site.

Even if it was thought that the treatment could be comprehensive and uniform enough to meet the containment goals of the remedy, identifying an appropriate location for the barrier would be challenging. A vertically applied bio-barrier, injecting or sparging the amendment through permanent vertical wells, would be required. Assuming horizontal spacing of the wells between 30 and 100 feet, between 30 and 100 wells would be required.

The installation of an ISB bio-barrier is anticipated to have high capital and material costs (due to the well installation requirements) and significant uncertainty as to the likelihood of success. Accordingly, an active ISB bio-barrier system is screened out from further evaluation as a component of the remedial alternatives.

3.7 Raw and Treated Water Conveyance Considerations

In all of the remedial alternatives, untreated (raw) groundwater is conveyed to the treatment plant. Treated groundwater is conveyed and used for one or a combination of the following water use options:

- **Distribution to Local Water Purveyors.** Treated potable water may be distributed to local water purveyors for use as municipal supply (drinking water), industrial supply, or irrigation (reclaimed use). The most likely options are: 1) delivery to WVWD or (2) delivery to Fontana Water Company, both for potable use. It is also possible the City of Rialto could distribute some treated water for potable use.
- **Aquifer Recharge.** Treated water may be distributed to injection wells upgradient of the 160-Acre Area for recharge to the aquifer.

3.7.1 Pipeline Alignment Overview

The three groundwater extraction scenarios would involve various pipeline delivery systems from the groundwater extraction wells to the treatment facility, and then to either the local potable water system(s) as described above, or to aquifer injection wells. Estimated pipeline diameters are 8 inches to 18 inches. Pipelines would typically be constructed in trenches varying from 24 to 42 inches wide, with 3 feet of earth cover. There are a considerable number of alternative pipeline routes for the conveyance of water from wells to treatment and then from treatment to final delivery point. The attached figures show:

- Figure 3-6 – Potential Locations for the Wells and Treatment Facilities
- Figure 3-7 – Existing Water Distribution System Features
- Figure 3-8 – Possible Pipeline Routes for Raw Water and Treated Water Delivery to Injection Wells and WVWD Zone 4
- Figure 3-9 – Possible Pipeline Routes for Treated Water Delivery to WVWD Zone 3 and Fontana Water Company

In this evaluation, a number of assumptions were made, and representative pipeline routes to estimate costs were selected. Figures 3-8 and 3-9 highlight the pipeline routes assumed in the remedial alternative cost estimates, and also show several alternative routes. More detailed analysis would need to be completed during remedial design before final routes are selected. Considerations in the selection of pipeline routes include minimizing overall length, and avoidance of high-traffic or recently surfaced streets. Other considerations include locating and avoiding, if possible, routes near sensitive receptors or essential facilities such as hospitals, police and fire stations, or schools. Other factors include avoidance of conflicts with significant utilities, which could include large storm drains or sanitary sewers (relatively difficult to relocate), and the necessity to use alternative, more expensive pipeline installation techniques such as micro-tunneling or bore and jacked casings, versus open trench.

Pipelines must cross the I-210 freeway in some of the options (although a freeway crossing is assumed only in the Alternative 2b cost estimate). The bridge overpasses appear to be box girders, in which case there may be “blockouts” or “corridors” within the bridge cells where utilities have been, and can be, placed. If these are being fully used or otherwise unavailable, then horizontal directional drilling (HDD) beneath the freeway could be used.

3.7.2 Preliminary Utility Information

The presence or lack of utilities in the candidate routes would also have an effect on route selection and ease of construction. It appears that all of the pipeline routes are in the City of Rialto or adjacent unincorporated areas. The following companies were identified as having utilities in possible alignment corridors:

- AT&T Distribution
- San Gabriel Valley Municipal Water District
- Southern California Edison (SCE) Distribution
- Metropolitan Water District
- Kinder Morgan Energy Partners

- SCE Telecommunications
- Time Warner Cable
- Fontana Water Company
- City of Rialto Water Department
- West Valley Water District
- San Bernardino Valley Municipal Water District
- CE Transmission Eastern
- Southern California Gas Company
- Golden State for Time Warner Telecom

Minimum separation distances are required between untreated water mains and potable water mains, and between potable water mains and sanitary and storm sewers. Often, potholing of significant utilities is required during the design phase to confirm utility locations.

3.7.3 Permitting and Regulatory Needs

In addition to the minimum separation requirements noted in Section 3.7.2, pipeline construction typically involves additional permitting and regulatory requirements, potentially including Encroachment Permits from the City of Rialto or San Bernardino County to work in their streets and California Department of Transportation (Caltrans) construction permits to cross the I-210 freeway. In locations where permits are not needed (see Section 2.2), the substantive requirements of applicable permits must be complied with and the permitting process would provide a mechanism for coordinating remedy construction with local entities.

Most municipalities require Traffic Control Plans as part of the Encroachment Permit, at least for their arterial streets. Any work in the Caltrans right-of-way is also likely to entail the preparation of a Traffic Control Plan. Traffic Control Plans commonly require the work to be done in phases to minimize disruption to the traveling public and avoid construction during busy morning and evening commuter time periods.

3.7.4 Summary of Preliminary Hydraulic Criteria

Preliminary hydraulic criteria were identified to estimate conveyance system costs. A key criterion is maximum fluid velocity, which is important in determining pipeline size. Table 3-4 summarizes nominal pipe distances between facilities, selected pipe diameters, and notes whether the route must cross I-210, which would substantially increase pipeline installation cost. In addition, Figure 3-7 identifies the high water level (HWL) for most of the potable water storage reservoirs in the vicinity. All of the water service areas are gravity-fed by storage tanks. This means that to deliver water to storage, a pipeline can connect to a transmission main that feeds to and from the tank, and the static pumping head from treatment to storage can be determined. The static pumping head consists of the elevation difference between the treatment plant, or pump station, and the system storage tank. The friction loss in the pipelines is added to this value to arrive at the pumping head required and pump motor horsepower. Each scenario includes enough pumps so that the design flow rate can be delivered with the largest pump inoperable. This redundancy increases system reliability.

3.7.5 Preliminary Pipeline Design Criteria

Several pipeline materials are available in the expected diameter (8 to 18 inches) and pressure range [less than 150 pounds per square inch (psi)]. These include ductile iron pipe (DIP), polyvinyl chloride (PVC), and high-density polyethylene (HDPE). These three materials are routinely used for untreated or nonpotable water and for treated water in the size and pressure indicated. Pipe joints are normally unrestrained except where thrust is a consideration, in which case proprietary thrust restraint devices are often used instead of concrete thrust blocks, which can be compromised by construction of future utility trenches. Appurtenances such as air release valves at high points, blow-off valves at low points, and intermediate valves would also be needed. These appurtenances are accounted for in the remedial alternative cost estimates provided in Appendix B by including a contingency in the cost-per-foot estimates.

3.8 Groundwater Monitoring Program

Groundwater monitoring is a required component of all of the remedial alternatives. It is expected that new groundwater monitoring wells and piezometers would be installed to supplement the existing wells. The number and location of the new wells would depend on the selected remedy, the availability of existing monitoring wells, and the extent of contamination. However, at a minimum, piezometers are required in the vicinity of each extraction well to help with evaluation of well-specific capture zones and overall hydraulic containment.

The groundwater monitoring program would include the following types of data collection:

- Collecting groundwater samples and depth-to-water measurements from the Site monitoring wells, and laboratory analysis of the samples for perchlorate, VOCs, and other parameters to be determined
- Acquisition of third-party water quality and depth-to-water data from other wells within the RCB
- Acquisition of pumping records for all production wells within the RCB and stormwater flows into the Cactus Basin
- Acquisition of precipitation data for the RCB
- Acquisition of relevant data, including water levels, groundwater quality, and pumping records from adjacent basins, as appropriate

Additional monitoring program details are described in Section 4.2.5.

SECTION 4

Remedial Alternatives Development

This section describes several remedial alternatives developed from a combination of the remedial technologies identified and screened in Section 3. In Section 5, the remedial alternatives are compared and evaluated based on cost, implementability, and effectiveness. It is expected that EPA will select one of the remedial alternatives (or a modified version of one of the alternatives) as a proposed remedy. The costs for each alternative are detailed in Appendix B.

The alternatives include the No Action Alternative and four action alternatives. Each of the four action alternatives includes groundwater extraction to provide hydraulic control, treatment of the extracted groundwater, discharge of the treated water to an appropriate end use, and groundwater monitoring. The four alternatives vary primarily in the rate at which contaminated groundwater is extracted and treated, in the water treatment technology used to remove perchlorate, and in the end use of the treated water.

All alternatives assume that the targeted area of groundwater contamination is as described in Section 3. Alternative 1 is intended to hydraulically contain contaminated groundwater from the target area during low to moderate water levels and provide only partial containment during higher water levels. Alternative 2 is intended to fully contain contaminated groundwater during all expected groundwater conditions. In Alternative 2, two separate treatment and discharge options are evaluated. Alternative 3 is intended to hydraulically contain contaminated groundwater in the Regional and Intermediate Aquifer target areas during all modeled water level conditions, including relatively extreme hydrologic conditions that have not occurred historically. The average and peak flow rates for the two wells in each alternative were selected based on the model simulations presented in Section 3. VFD pumps capable of operating over a range of extraction rates are assumed in each alternative. The average flow rates are used to estimate annual O&M costs and mass recovery calculations. The peak rates are used for system design and estimating capital costs.

The remedial alternatives presented in this section are:

- No Action Alternative (Section 4.1)
- Alternative 1 – Pump and Treat 1,500 to 1,650 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply (Section 4.2)
- Alternative 2A – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply (Section 4.3)
- Alternative 2B – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater (Section 4.4)
- Alternative 3 – Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply (Section 4.5)

4.1 No Action Alternative

EPA guidance (EPA, 1988) requires that a No Action Alternative be considered and compared to the action alternatives. The No Action Alternative does not include active remediation or monitoring. No cost is associated with this alternative. If the No Action Alternative is selected, contaminated groundwater will continue to migrate unimpeded from the areas targeted by this OU, further degrading downgradient water resources and delaying ultimate remediation of the groundwater.

4.2 Alternative 1: Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply

Alternative 1 includes the installation of a groundwater pump-and-treat system intended to provide full hydraulic containment of contaminated groundwater in the target areas of the Regional Aquifer and Intermediate Aquifer during low to intermediate water level conditions. Alternative 1 would provide partial containment during high water level conditions. This alternative consists of five key components:

- Groundwater Extraction: One new extraction well (EW-1) and one existing extraction well (Rialto-02) are assumed (as described in Section 3.3.2).
- Groundwater Treatment: Ion exchange technology is assumed for perchlorate removal and LGAC treatment for VOC removal. The treatment plant design capacity is 1,650 gpm (10% above the assumed average rate) with an assumed average pumping rate of 1,500 gpm. Disinfection of treated water by chlorination is included to provide potable water that can be delivered directly into a purveyor's system.
- Treated Water End Use: The treated water would be provided to a local water purveyor for direct potable use. WVWD is the purveyor assumed for cost-estimating purposes because their facilities are the closest to the assumed treatment plant location and they are likely to have adequate demand and water rights to accept the water.
- Conveyance Systems: Pipelines are needed to convey the untreated or raw water from the extraction wells to the treatment plant. Pipelines and booster pumps are also needed to transport the treated water to WVWD. In this alternative, it is assumed that the treated water would be provided to WVWD's potable water distribution line in Cactus Avenue (as shown in Figure 3-8).
- Groundwater Monitoring: Monitoring is needed to measure system performance and provide early warning of upgradient changes in hydrogeologic or contaminant conditions that could affect remedy operation.

Each of these key system components is discussed in more detail below. These descriptions provide the basis for the estimation of costs in Appendix B. As described in Section 5.1.7, it is assumed that water purveyors that receive potable water from the project will provide reimbursement for the water at rates consistent with their avoided water production costs.

A constant O&M cost is assumed for treatment plant operations. This assumes that extraction rates and the contaminant concentrations in the extracted groundwater do not vary over time. However, there would likely be reductions in treatment costs (for example, resin and carbon replacement costs) over the years resulting from expected decreases in contaminant concentrations. In addition, the extraction rates needed for containment are expected to decline over the long-term as the size of the contaminated area shrinks.

4.2.1 Groundwater Extraction

Groundwater extraction is accomplished with two extraction wells: the existing Rialto-02 well, and new extraction well EW-1. The computer groundwater modeling simulations presented in Section 3 were used to select the new well location and extraction rates for the existing and new wells. The assumed average pumping rates are 600 gpm and 900 gpm, respectively. The estimated peak pumping rates are 660 gpm for the Rialto-02 well and 990 gpm for well EW-1. The Rialto-02 well is located east of Ayala Drive between Easton Street and the I-210 freeway (Figure 3-2) and is currently shut down due to perchlorate and TCE contamination.

Well	Screened Interval (bgs)	Average Flow Rate (gpm)	Maximum Flow Rate (gpm)
Rialto-02	588 – 1000	600	660
EW-1 (new)	450 – 650	900	990

The assumed location for well EW-1 is on Easton Street approximately 600 feet east of Linden Avenue and south of the I-210 freeway (Figure 3-2). A small plot (less than 0.25-acre) of land may be needed to support installation of the new extraction well EW-1. The exact location would depend on future land use in the area, and may be affected by the relocation of Easton Street to the south to allow for commercial real estate development along the south side of the I-210 freeway. The Rialto-02 well is currently on City of Rialto property, and thus no property purchase is assumed. The Rialto-02 well is fully operational.

The extraction well pumps would each be equipped with a VFD to allow for adjustment of the pumping rate in response to changes in groundwater elevations or changes in the extraction rate required to maintain hydraulic containment. The VFDs would also allow the pumping rate to be adjusted seasonally in response to the WVWD potable water demands. It is assumed the pump controls and VFD would be placed in a weatherproof, climate-controlled enclosure. The enclosure and well, including the extraction pump and motor, would be surrounded by a security fence. Electrical utilities would be needed for well EW-1 because none currently exist in the immediate vicinity.

4.2.2 Groundwater Treatment

For Alternative 1, the groundwater treatment system would be designed with a treatment capacity of 1,650 gpm and operated at an average flow of 1,500 gpm. The assumed location of the system is on the same City of Rialto-owned parcel where the Rialto-02 well is located. According to the City of Rialto, in the near future the parcel will be expanded to 0.75-acre, which should provide adequate space for the placement of the groundwater treatment system. If the City of Rialto does not expand the parcel size at the Rialto-02 well, acquisition of additional nearby land may be required. Electrical utilities are available at the site. During the design phase, the adequacy of these utilities should be evaluated.

The average influent TCE and perchlorate concentrations are estimated to be 8 µg/L and 80 µg/L, respectively (see Section 3.2.3), with a maximum design concentration of 360 µg/L for perchlorate and 48 µg/L for TCE. For distribution to local water purveyors as potable water supply, the extracted water will be treated to “nondetection” levels, which are assumed to be the CDPH Detection Limit Requirement (DLR) values of 1.0 µg/L for TCE and 4.0 µg/L for perchlorate.

It is assumed that the water would first be filtered to remove any suspended solids or particulates to minimize the potential for fouling of downstream treatment units. The filtered water would then be treated using ion exchange to remove perchlorate. It is assumed that the ion exchange resin would not be regenerated onsite but would be periodically replaced and disposed (that is, single-use disposable resin). For cost estimating, it is assumed that an ion exchange resin that is highly selective for perchlorate will be used, although a regenerable system could also be effective.

Following perchlorate removal, the VOCs, predominantly TCE, would be removed by LGAC. If this alternative is ultimately implemented, an economic evaluation should be conducted during the design phase to evaluate the long-term costs of LGAC versus air stripping with offgas treatment. Offgas treatment, if implemented, may be accomplished with VGAC or catalytic oxidation (which would require scrubbing of the hydrochloric acid from the treated air effluent).

It is assumed that change-out of all spent carbon (whether LGAC or VGAC) would occur onsite, then the spent carbon would be transported offsite for disposal or regeneration. The LGAC system would be equipped with backwash facilities to remove carbon fines after carbon change-outs.

After treatment of the groundwater to remove perchlorate and VOCs, the water would be disinfected to CDPH standards using a liquid chlorination system prior to discharge to the WVWD potable water distribution system. A thorough evaluation of disinfection system requirements would be needed during the preliminary design phase. Specifically, depending on the length of the delivery pipeline from the treatment plant to the existing supply system, a secondary storage tank may be necessary to meet the requirement for contact time (that is, concentration-time, or CT requirement).

Figure 4-1 presents a preliminary process flow diagram (PFD) for the assumed Alternative 1 treatment system.

4.2.3 Treated Water End Use

For Alternative 1, it is assumed that all of the treated and disinfected water would be transferred to the WVWD potable water distribution system. WVWD has indicated that it has sufficient demand to accept the 1,500-gpm average flow rate on a year-round, continuous basis. Operation of the treatment system would likely be integrated into the operation of the WVWD system by using the flow from the treatment system as a baseline supply for the overall system. An interface between the groundwater treatment system and the WVWD supervisory control and data acquisition (SCADA) (Testco) system would be required to provide necessary real-time information such as flow rate, system operational status, bulk volume, etc.

4.2.4 Conveyance Systems

It is assumed that the extracted groundwater from well EW-1 would be delivered to the treatment system via a subsurface, 10-inch-diameter pipeline installed in Easton Street. The pipeline would be about 3,000 feet long. The pipeline may be installed using traditional trenching methods or may be installed using the HDD method. The condition of Easton Street and future development plans in the vicinity of Easton Street may dictate the installation methods (that is, traditional method if Easton Street is to be relocated or repaved after the piping installation or HDD if Easton Street is in like-new condition and is in its permanent location).

Conveyance from the Rialto-02 well to the treatment system would only require a short run of piping. The ground elevation at the existing Rialto-02 well site is 1,450 feet.

It is assumed that the treated water would be transferred from the treatment system to the WVWD potable water system along Cactus Avenue through a subsurface, 12-inch pipeline installed in Easton Street, as shown in Figure 3-8. This section of the pipeline would connect the treatment system to the WVWD existing 30-inch potable water line located in Cactus Avenue. The 30-inch pipeline supplies water to Zone 4 of the WVWD distribution system. As such, the pressure of the treated water must be boosted to a level to overcome the static head of Zone 4. Given that the existing Zone 4 Reservoir has a HWL of 1,524 feet, the booster pump is sized to transfer 1,650 gpm at 74 feet of head plus friction pressure losses.

4.2.5 Groundwater Monitoring

Groundwater monitoring included as part of this alternative has two main purposes: 1) provide information to monitor the effectiveness of the containment system and optimize its operation, and 2) provide early warning of changes in upgradient contaminant conditions and groundwater elevations that could affect containment system operation. Upgradient conditions that could affect system operations include increases or decreases in the lateral or vertical extent of contamination, increases or decreases in contaminant concentrations, or detection of new contaminants that could necessitate extraction rate or treatment plant modifications. As noted previously, changes in groundwater elevations will affect the extraction rates needed to provide containment.

The existing and planned monitoring network would need to be augmented with two new, nested piezometer pairs located near each extraction well to supplement existing monitoring wells and piezometers. The piezometers would allow measurement of hydraulic head at multiple locations and multiple-depth intervals, which would help define the size of the extraction well capture zone and evaluate capture throughout the depths targeted for containment. The new, nested piezometers would be completed at depths of approximately 450 and 650 feet.

The wells in the monitoring network would generally be monitored at either a semiannual or annual monitoring frequency (Table 4-1). The monitoring frequencies shown in Table 4-1 are subject to revision prior to implementation of the remedy, depending on how much additional monitoring has been completed by that time.

4.3 Alternative 2a: Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply

Alternative 2a includes installation of a groundwater pump-and-treat system intended to hydraulically contain contaminated groundwater in the targeted areas during all expected groundwater conditions. This alternative consists of five key components:

- Groundwater Extraction: This alternative assumes the use of existing extraction well Rialto-02 and one new extraction well (EW-1) located along Easton Street (as described in Section 3.3.2).
- Groundwater Treatment: Ion exchange is assumed for perchlorate removal and LGAC for VOC removal, with a design capacity of 3,200 gpm (and an average operating rate of 1,840 gpm). Disinfection of treated water by chlorination is included to provide potable water that can be delivered directly into a purveyor's system.
- Treated Water End Use: Treated water would be provided to a local water purveyor (or purveyors) for direct potable use. WVWD is assumed for cost-estimating purposes because their facilities are the closest to the assumed treatment plant location and they are expected to have adequate demand and water rights to accept the average extraction rate of 1,840 gpm. It should be noted that it may be difficult for WVWD to accept the full 3,200 gpm of treated water that would be generated during high water level conditions.
- Conveyance Systems: Pipelines are needed to convey the untreated or raw water from the extraction wells to the treatment plant. Pipelines and booster pumps are also needed to transport the treated water to WVWD. For costing, it is assumed that all of the treated water would be provided to WVWD and delivered to their potable water distribution line in Cactus Avenue. However, other purveyors and delivery locations are also feasible.
- Groundwater Monitoring: Monitoring is needed to evaluate system performance and provide early warning of upgradient changes in hydrogeologic or contaminant conditions that could affect remedy operation.

Each of these key system components is discussed in more detail below. These descriptions provide the basis for the estimation of costs in Appendix B. As described above for Alternative 1, the cost estimates assume some level of purveyor reimbursement for the treated water they receive from the project. Also, as described for Alternative 1, the cost estimates assume constant O&M costs over time. However, contaminant concentrations and pumping rates will both likely decline over the long term, thereby reducing treatment plant O&M.

4.3.1 Groundwater Extraction

Groundwater extraction would be accomplished with two extraction wells: the existing Rialto-02 well, and new extraction well EW-1. The computer groundwater modeling simulations presented in Section 3 were used to select the new well location and approximate extraction rates for the existing and new well. The average pumping rates would be 740 gpm for the Rialto-02 well and 1,100 gpm for new extraction well EW-1. The estimated peak pumping rates for each well are listed below. See Section 4.2.1 for additional information on the locations of extraction well EW-1 and the Rialto-02 well. The land needed for the installation of well EW-1 is the same as in Alternative 1. Both well locations are shown in Figure 3-2.

Well	Screened Interval (bgs)	Average Flow Rate (gpm)	Maximum Flow Rate (gpm)
Rialto-02	588 – 1000	740	1,200
EW-1 (new)	450 – 650	1,100	2,000

As in Alternative 1, the extraction wells would each be equipped with a VFD to provide flexibility in extraction rates. It is assumed that the pump controls and VFD would be placed in a weatherproof, climate-controlled enclosure. The enclosure and well, including the extraction pump and motor, would be surrounded by a security fence. Electrical utilities must be provided for the EW-1 well location because none currently exist in the immediate vicinity.

It is assumed that a VFD and associated enclosure would be added to Rialto-02 well. The Rialto-02 well is currently on City of Rialto property, and thus no property purchase is assumed. No additional electrical utilities are expected to be required.

4.3.2 Groundwater Treatment

For Alternative 2a, the groundwater treatment system would be designed with a treatment capacity of 3,200 gpm. However, for estimating operational costs it is assumed that the system would operate at the average rate of 1,840 gpm. The system would be located on the same City of Rialto-owned parcel where the Rialto-02 well is located. As described above for Alternative 1, the Rialto-02 well parcel reportedly will be expanded to 0.75-acre, which should provide adequate space for the placement of the groundwater treatment system. Electrical utilities are available at the site. During the design phase, the adequacy of these utilities should be evaluated.

The treatment system to be implemented for Alternative 2a is the same as described above in Section 4.2.2 for Alternative 1, except that the design treatment capacity of 3,200 gpm is approximately twice the 1,650-gpm treatment capacity for Alternative 1. The system includes filtration to remove any solids, ion exchange for perchlorate treatment, LGAC for VOC removal, and disinfection. Additional details on these technologies are provided in Section 4.2.2. Figure 4-2 presents a preliminary PFD for the assumed Alternative 2a treatment system.

A thorough evaluation of disinfection system requirements should be conducted during the preliminary design phase. Specifically, depending on the length of the delivery pipeline from the treatment plant to the existing supply system, a secondary storage tank may be necessary to meet the requirement for contact time (that is, concentration-time, or CT requirement).

4.3.3 Treated Water End Use

For Alternative 2a, it is assumed that all of the treated and disinfected water would be transferred to the WVWD potable water distribution system. Based on discussions with WVWD, they should be able to accept the average rate of 1,840 gpm on a year-round, continuous basis. If the extraction rate were varied seasonally, WVWD could increase the average amount of water they could accept. If this alternative is selected, additional coordination with WVWD would be required during remedial design to ensure that the appropriate system capacity is incorporated into the design to provide the necessary seasonal flow flexibility. Also, it may be a challenge for WVWD to accept the peak design flow of 3,200 gpm if high water level conditions persist for an extended period. The need for additional purveyor discharge options would need to be assessed further during remedial design.

Operation of the treatment system would likely be integrated into the WVWD system operation by using the flow from the treatment plant as a seasonally adjusted baseline supply for the overall system. An interface between the groundwater treatment system and the WVWD SCADA (Testco) system would be required to provide necessary operational data.

4.3.4 Conveyance Systems

It is assumed that the extracted groundwater from well EW-1 would be transferred to the treatment system in a subsurface, 14-inch-diameter pipeline approximately 3,000 feet long installed in Easton Street. As described for Alternative 1, the piping may be installed using traditional trenching methods or may be installed using the HDD method, depending on the condition of Easton Street (see Section 4.2.4 for additional details). Conveyance from the Rialto-02 well to the treatment system would require only a short run of piping. The ground elevation at the existing Rialto-02 well site is 1,450 feet.

It is assumed that the treated water would be transferred from the treatment system to the WVWD potable water system through a subsurface, 18-inch pipeline approximately 3,520 feet long, installed in Easton Street, as shown in Figure 3-8. This section of pipe would connect the treatment system to WVWD's existing 30-inch potable water line in Cactus Avenue. The 30-inch pipeline supplies water to Zone 4 of the WVWD distribution system. As such, the pressure of the treated water must be boosted to a level to overcome the static head of Zone 4. Given that the Zone 4 Tank HWL is 1,524 feet, the booster pump would be sized to transfer 3,200 gpm (maximum), 1,840 gpm (average) at 74 feet of head plus expected friction losses.

Other discharge options include delivery to WVWD Zone 3 or to the City of Rialto, neither of which would require pumping. However, the distance to these facilities is much further away, requiring installation of significantly more piping.

4.3.5 Groundwater Monitoring

The monitoring program for Alternative 2a is the same as for Alternative 1, described in Section 4.2.5.

4.4 Alternative 2b: Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater

Alternative 2b includes installation of the same groundwater pump-and-treat system as described above for Alternative 2a. The difference is that Alternative 2b assumes non-potable end use (aquifer recharge using injection wells) and the biological treatment process for perchlorate removal. Assuming non-potable end use and the biological treatment process allows for comparison to the other remedial alternatives that assume potable end use and the ion exchange treatment system for perchlorate. The key components of this alternative include:

- Groundwater Extraction: Same as Alternative 2a.
- Groundwater Treatment: FBR biological treatment for perchlorate removal and LGAC treatment for VOC removal, with a design capacity of 3,200 gpm (1,840 gpm average).
- Treated Water End Use: Treated water would be recharged to the aquifer using two new injection wells located along the upgradient (northern) boundary of the 160-Acre Area.
- Conveyance Systems: Pipelines are needed to convey the raw water from the extraction wells to the treatment plant. Pipelines and booster pumps are also needed to transport the treated water to injection wells.
- Groundwater Monitoring: Same as Alternative 2a.

Each of these key system components is discussed in more detail below. These descriptions provide the basis for the estimation of costs in Appendix B.

4.4.1 Groundwater Extraction

The Alternative 2b extraction component is the same as described above in Section 4.3.1 for Alternative 2a.

4.4.2 Groundwater Treatment

For Alternative 2b, the groundwater treatment system would be designed with a capacity of 3,200 gpm. It is assumed that the system would be operated at an average flow of 1,840 gpm. The system would be located on the same City of Rialto-owned parcel where the Rialto-02 well is located, as described in Section 4.3.2. The average influent TCE and perchlorate concentrations are estimated to be 8 μg/L and 80 μg/L, respectively (see Section 3.3.3), with a maximum design concentration of 48 μg/L for TCE and 360 μg/L for perchlorate. For injection back into the aquifer, the extracted water would need to be treated to below the drinking water MCLs. As a conservative assumption, it is assumed the water would be treated to the same concentrations as assumed for the potable end use. Similar to the potable water, the "non-detect" levels are assumed to be 1.0 μg/L for TCE and 4.0 μg/L for perchlorate.

It is assumed that the groundwater would first be treated to remove perchlorate using a biological FBR process.

The FBR process would generate a biomass solids sludge that would need to be removed. Solids collection tanks and filter presses would be provided to collect and dewater the sludge for offsite disposal.

Following perchlorate removal, the VOCs, predominantly TCE, would be removed by LGAC. Additional detail on VOC treatment is provided in Section 4.2.2.

It is assumed that LGAC change-out would be conducted onsite and the spent carbon would be transported offsite for regeneration or disposal. The LGAC system would share the collection tanks and sludge dewatering filters provided for the FBR process to remove carbon fines after carbon change-outs.

After treatment of the groundwater to remove perchlorate and VOCs, a pH control system would adjust the pH of the water prior to injection, if necessary. The treated water would also be filtered through bag or cartridge filters before injection to remove any remaining solids.

Figure 4-3 presents a preliminary PFD for the assumed Alternative 2b treatment system.

4.4.3 Treated Water End Use

The treated water would be transferred to two new injection wells on the northern boundary of the 160-Acre Area. It is assumed that injection wells would be installed in Casa Grande Drive between North Alder Avenue and North Locust Avenue. The two new injection wells would be completed to approximately 700 feet bgs. The screened interval would be completed from approximately 450 to 700 feet bgs. The injection wells would be equipped with isolation valves at the wellheads, in-well water level monitoring, internal treated water drop-tube, flowmeter, and water chemistry controller.

On average, each injection well would be handling 1,000 gpm. Although it is anticipated that this rate should be readily achievable at each location, field tests should be conducted during remedial design to confirm injection capacity.

4.4.4 Conveyance Systems

The raw water conveyance system for Alternative 2b is the same as described above in Section 4.3.4 for Alternative 2a.

It is assumed that the treated water would be transferred from the treatment system to the two new injection wells in Casa Grande Drive through a subsurface, 18-inch-diameter pipeline, as shown in Figure 3-8. The pipeline would be routed from the treatment system to Cactus Avenue, where it would be routed north on Cactus Avenue and cross the I-210 freeway. Reportedly, a spare empty corridor exists in the Cactus Avenue overpass that would allow for the routing of the pipeline across the I-210 freeway. If a spare corridor does not exist or if WVWD or the City of Rialto has future plans for the corridor, other options to route the piping across the I-210 freeway should be investigated during the preliminary design phase, including use of spare empty corridors in the freeway overpasses at West Ayala Drive or Linden Avenue (if any exist), or installing a horizontal boring beneath the freeway.

The estimated costs associated with this alternative assume a spare corridor is available either in Cactus Avenue or in the other freeway overpasses. Once on the north side of the I-210 freeway, it is assumed that the pipeline would be routed west in West Casmalia Street and then north in Maple Avenue to Casa Grande Drive, a total distance of about 17,600 feet. Other candidate north-south streets include Locust, Linden, and Cedar avenues. The pressure of the treated water must be boosted to a level to overcome the static head associated with the elevation increase from the treatment system to the injection wells. The booster pump would need to be sized to transfer 3,200 gpm at approximately 200 feet of head plus frictional head losses.

4.4.5 Groundwater Monitoring

The monitoring program for Alternative 2b is the same as for Alternative 1, described in Section 4.2.5, except that additional monitoring may be required near the injection wells.

4.5 Alternative 3: Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply

Alternative 3 includes the installation of a groundwater pump-and-treat system intended to hydraulically contain contaminated groundwater in the target area during all modeled groundwater conditions, including extended periods of relatively extreme hydrologic conditions. This alternative consists of five key components:

- <u>Groundwater Extraction</u>: One existing and one new well, as described for Alternative 1. The combined flow rate during high water level conditions is 5,000 gpm, although the long-term average rate is expected to be much lower (the assumed average flow rate for costing purposes is 2,200 gpm).
- <u>Groundwater Treatment</u>: The assumed treatment technologies are ion exchange for perchlorate removal and LGAC for VOC removal, with a design capacity of 5,000 gpm (the assumed average flow rate for costing is 2,200 gpm). Disinfection of treated water by chlorination is included to provide potable water.
- <u>Treated Water End Use</u>: Treated water would be provided to local water purveyors for direct potable use. Distribution to both WVWD and Fontana Water Company is assumed for costing. Because of the periodic high flow rates, no single purveyor can accept all of the treated water.
- <u>Conveyance Systems</u>: Raw water would be piped from the extraction wells to the treatment plant. Pipelines and booster pumps are needed to transport the treated water to local water purveyors. For costing purposes, it is assumed that the treated water would be provided to WVWD at its potable water distribution line in Cactus Avenue and to Fontana Water Company at its storage tanks located near Easton and Alder Avenues (Fontana's 13A/13B well cluster). Other delivery options are also feasible.

- Groundwater Monitoring: Monitoring is needed to evaluate system performance and provide early warning of upgradient changes in hydrogeologic or contaminant conditions that could affect remedy operation.

Each of these key system components is discussed in more detail below. These descriptions provide the basis for estimating the costs in Appendix B. As described for the other alternatives, purveyor reimbursement is incorporated into the cost estimates and the O&M costs are assumed to remain constant throughout the life of the project.

4.5.1 Groundwater Extraction

Groundwater extraction would be accomplished with two extraction wells: the existing Rialto-02 well, and one new well, EW-1 (Figure 3-2). The new well, EW-1, is described in Section 4.2.1.

During peak water level conditions, the two wells need to produce 5,000 gpm: Rialto-02 at 2,250 gpm and EW-1 at 2,750 gpm. However, because peak water levels are not expected to last for an extended period, the average flow rate assumed for this alternative is 2,200 gpm, 20 percent higher than the rate assumed in Alternatives 2a and 2b. The estimated average pumping distribution is the Rialto-02 well at 880 gpm, and well EW-1 at 1,320 gpm.

Well	Screened Interval (bgs)	Average Flow Rate (gpm)	Maximum Flow Rate (gpm)
Rialto-02	588 – 1,000	880	2,250
EW-1 (new)	450 – 650	1,320	2,750

If this alternative is selected, it is expected that extraction rates would be re-evaluated during remedial design as additional data are obtained regarding the location of the downgradient end of the BC Aquitard and the lateral and vertical extent of groundwater contamination.

The amount of land needed for the installation of well EW-1 is the same as in Alternative 1. As in Alternatives 1 and 2, both extraction wells would be equipped with VFDs to provide operational flexibility; the pump controls and VFDs would be placed in weatherproof, climate-controlled enclosures; and the enclosures and wells, including the extraction pump and motor, would be surrounded by a security fence. Electrical utilities must be provided at the EW-1 well location because none currently exist in the immediate vicinity.

4.5.2 Groundwater Treatment

For Alternative 3, the groundwater system would be designed with a treatment capacity of 5,000 gpm; however, for estimating operational costs it is assumed that the system would operate at the average rate of 2,200 gpm. The system would be located on the same City of Rialto-owned parcel where the Rialto-02 well is located. As noted above, the City's expanded parcel size should provide adequate space for the placement of the groundwater treatment system. Electrical utilities are available at the site. During the design phase, the adequacy of these utilities should be evaluated.

The treatment system to be implemented for Alternative 3 is the same as described above in Section 4.2.2 for Alternative 1, except that the design treatment capacity of 5,000 gpm is approximately triple the 1,650-gpm treatment capacity for Alternative 1. The technologies include filtration to remove any solids from the extracted groundwater, ion exchange for perchlorate treatment, LGAC for VOC removal, and disinfection to meet potable water requirements. Additional details on these technologies are provided in Section 4.2.2. Figure 4-4 presents a preliminary PFD for the assumed Alternative 3 treatment system.

A thorough evaluation of disinfection system requirements should be conducted during the preliminary design phase. Specifically, depending on the length of the delivery pipeline from the treatment plant to the existing supply system, secondary storage may be necessary to meet the requirement for contact time (that is, concentration-time, or CT requirement).

4.5.3 Treated Water End Use

For Alternative 3, it is assumed that the treated and disinfected water would be delivered to WVWD and Fontana Water Company. Based on discussions with WVWD representatives, WVWD would be able to accept at least 2,000 gpm year-round on a continuous basis. Additional treated water would be delivered to Fontana Water Company at its large storage reservoirs, located near Easton and Alder avenues. The rate at which water would be delivered to each water purveyor during high water level conditions (up to 5,000 gpm) has not been determined; however, the distribution pipelines have been sized to provide up to 3,000 gpm to WVWD and 2,500 gpm to Fontana Water Company. If this alternative is selected, additional coordination with WVWD and Fontana Water Company would be required during remedial design to ensure that the appropriate system capacity is incorporated into the design to provide the necessary seasonal flow flexibility for both purveyors.

For costing purposes, it is assumed that WVWD would receive 2,000 gpm continuously and Fontana Water Company would receive 200 gpm continuously. Operation of the treatment system would need to be integrated into the WVWD and the Fontana Water Company systems. Details would need to be worked out during remedial design, including how to distribute the treated water to each purveyor as treatment rates increase from the average rate of 2,200 gpm to the peak rate of 5,000 gpm. An interface between the groundwater treatment system and the WVWD SCADA (Testco) system would likely be required to provide necessary operational data. There would also need to be some real-time sharing of operational data between WVWD and Fontana Water Company to ensure smooth system operation.

4.5.4 Conveyance Systems

The raw water conveyance system for Alternative 3 conveys water from well EW-1 and the Rialto-02 well to the treatment plant and is the same as described in Section 4.3.4 for Alternative 2a.

It is assumed that the treated water would be transferred from the treatment system to the WVWD potable water system through a subsurface, 16-inch pipeline installed in Easton Street, as shown in Figure 3-8. This section of pipe would connect the treatment system to the existing 30-inch potable water line in Cactus Avenue, a distance of about 3,520 feet. The

30-inch pipeline supplies water to Zone 4 of the WVWD distribution system. As such, the pressure of the treated water must be boosted to a level to overcome the static head of Zone 4. Given that the Zone 4 Tank HWL is 1,524 feet, it is assumed that the booster pump would be sized to transfer 3,000 gpm at 74 feet of head plus friction pressure losses.

It is assumed that treated water that WVWD cannot accept would be directed to Fontana Water Company through a subsurface, 16-inch pipeline installed in Easton Street, a total distance of about 9,600 feet. As described previously (Section 4.2.4), the piping may be installed using traditional trenching methods or may be installed using the HDD method, depending on the condition of Easton Street. A second booster pump station would be required to provide the necessary head to deliver water to the Fontana Water Company reservoirs to the west.

4.5.5 Groundwater Monitoring

The monitoring program for Alternative 3 is the same as for Alternative 1, described in Section 4.2.5.

SECTION 5

Detailed Analysis of Remedial Alternatives

This section provides a detailed analysis of remedial alternatives developed to achieve the RAOs for the B.F. Goodrich Site Interim Source Area OU. The four remedial alternatives described in Section 4 (Alternatives 1, 2a, 2b, and 3) are evaluated against the criteria specified in EPA regulations and guidance (EPA, 1988). The alternatives are evaluated individually against each criterion, and then are compared to determine their relative strengths and weaknesses.

The nine CERCLA evaluation criteria are:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State acceptance
9. Community acceptance

The NCP (40 CFR 300.430(e)(9)(iii)) categorizes these nine criteria into three groups: 1) threshold criteria, 2) primary criteria, and 3) modifying criteria.

Threshold criteria are requirements that an alternative must meet to be eligible for selection as the preferred alternative, and include overall protection of human health and the environment and compliance with ARARs (unless an ARAR is waived).

The primary criteria (also known as the balancing criteria) are long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The comparison of remedial alternatives is based primarily on these criteria.

Modifying criteria include state acceptance and community acceptance and may be used to modify aspects of the preferred alternative when preparing the ROD. Modifying criteria are generally evaluated after public comment on the RI/FS and the proposed plan. Accordingly, only the two threshold and five primary balancing criteria are considered in the detailed analysis described in this document. The following sections contain descriptions of the threshold and primary criteria, individual evaluations of each alternative (without regard to the other alternatives), and a comparative evaluation of the alternatives. Descriptions of the remedial alternatives are provided in Section 4.

5.1 Description of Evaluation Criteria

5.1.1 Overall Protection of Human Health and the Environment

This evaluation criterion assesses whether each alternative adequately protects human health and the environment from unacceptable risks posed by contaminants at the Site.

The overall assessment of protection draws on the assessments conducted as part of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. It considers how risks would be eliminated, reduced, or controlled through remedial action, as summarized in Table 5-1.

5.1.2 Compliance with ARARs

This evaluation criterion is used to determine if each alternative would comply with federal and state ARARs, or whether invoking waivers to specific ARARs is justified. Factors considered during the ARARs evaluation are presented in Table 5-2. Potential ARARs are identified in Section 2.

5.1.3 Long-Term Effectiveness and Permanence

This evaluation criterion examines the risk remaining at the site after a remedial alternative has been implemented and the RAOs have been met. The primary focus is the adequacy and reliability of the remedial alternative and the controls that may be required to manage the risk posed by treatment residuals and untreated wastes. The factors considered during the analysis are presented in Table 5-3.

5.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

This evaluation criterion addresses the extent to which an alternative employs treatment technologies that permanently and significantly reduce the toxicity, mobility, and volume of hazardous materials at the Site. CERCLA and the NCP prefer remedial actions that use treatment to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of the total volume of contaminated media. Factors considered during the analysis are presented in Table 5-4.

5.1.5 Short-Term Effectiveness

This evaluation criterion considers the effects of each alternative on workers, the community, and the environment during the construction and implementation process. The short-term effectiveness evaluation addresses potential impacts prior to meeting the RAOs. Factors considered in the analysis are presented in Table 5-5.

5.1.6 Implementability

This criterion is used to evaluate the technical feasibility and administrative feasibility (that is, the ease or difficulty) of implementing each alternative and the availability of required services and materials during implementation. Factors considered in the analysis are presented in Table 5-6.

5.1.7 Cost

This criterion estimates the cost of implementing each alternative, including engineering, construction, and O&M costs incurred over the life of the project. A 25 percent contingency is included for capital costs; a 10 percent contingency is included for O&M costs. According to CERCLA guidance, cost estimates for remedial alternatives are to be developed with an expected accuracy range of –30 to +50 percent.

The costs of the remedial alternatives are compared using the estimated net present value (NPV) of the alternative. The NPV allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. Although it is not yet known how long the remedy will operate, the high contaminant concentrations measured in groundwater upgradient of the extraction locations suggest that active remediation could be required for decades. For estimating NPV, both 15-year and 30-year periods of operation have been assumed. O&M for the remedial alternatives may extend beyond 30 years.

For all alternatives, the NPV was calculated using the discount rate of 7 percent described in EPA policy directive *Revisions to OMB Circular A-94 on Guidelines and Discount Rates for Benefit-Cost Analysis* (EPA, 1993).

The capital costs, annual O&M costs, and 30-year NPV for each of the alternatives are summarized in Table 5-7. Detailed cost estimates and cost estimate assumptions are provided in Appendix B.

5.2 Individual Analysis of Remedial Alternatives

In this section, each alternative is evaluated with respect to the seven threshold and primary criteria. Further evaluation is provided in Section 5.3, the comparison of remedial alternatives.

5.2.1 No Action Alternative

Overall protection of human health and the environment – The No Action Alternative would not provide any additional protection of human health and the environment. Contaminated groundwater would continue to spread into portions of the Regional Aquifer that are currently clean or contain only low concentrations of contaminants. Unaffected drinking water production wells could be contaminated, and wells that are already contaminated may see contaminant levels rise. Affected wells would remain shut down or require treatment to prevent the contamination from entering the drinking water supply.

Compliance with ARARs – Because no actions would be taken as part of this alternative, no ARARs apply to the No Action Alternative.

Long-term effectiveness and permanence – The No Action Alternative would allow uninhibited migration of the contaminants in groundwater to continue, with long-term impacts to the Regional Aquifer and downgradient production wells in the RCB and possibly adjacent groundwater basins. The continued spread of contamination in the Regional Aquifer would further degrade a critical drinking water resource and represent an ongoing, long-term threat to human health and the environment.

Reduction of toxicity, mobility, or volume through treatment – Because the No Action Alternative does not include treatment, it would not achieve any reduction of toxicity, mobility, or volume of the contaminated groundwater.

Short-term effectiveness – The No Action Alternative does not include any construction; therefore, there would be no short-term impacts to human health or the environment. RAOs would not be achieved as part this alternative.

Implementability – The No Action Alternative is implementable by definition.

Cost – There are no direct costs associated with the No Action Alternative, although there could be significant costs imposed on water purveyors whose water supply wells have been or are in the future affected by contamination at the Site. Potential costs include the cost of water treatment, the incremental cost of alternative water supplies, and costs associated with the loss of operational flexibility caused by closure of a water supply well.

5.2.2 Alternative 1 – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply

Overall protection of human health and the environment – By limiting the spread of contaminated groundwater from the targeted areas, Alternative 1 would significantly reduce the long-term threats to human health and the environment. The water treatment technologies included in Alternative 1 would permanently remove contamination from the extracted groundwater. Alternative 1 would achieve capture of both the Intermediate and Regional Aquifer target zones during periods of low and moderate water levels. Capture would be incomplete during high water level conditions. If high water levels lasted for several years, contaminants would likely migrate into downgradient areas.

Compliance with ARARs – Alternative 1 would be configured to meet all chemical-specific, location-specific, and action-specific ARARs. Most ARARs are associated with performance of the treatment plant and management of any wastes generated at the plant

Long-term effectiveness and permanence – Alternative 1 would be designed to achieve complete capture of the Intermediate Aquifer and Regional Aquifer target zones during low and intermediate water level conditions. Only partial capture of the Intermediate and Regional aquifers would be achieved during high water level conditions. Model simulations estimate that up to 62 percent capture (at peak rates of 1,650 gpm) would be attained in the Regional Aquifer. The amount of Intermediate Aquifer capture would depend on final placement of the extraction wells compared to the location where the Intermediate and Regional Aquifer merge, and other factors.

The extraction and treatment systems should operate reliably. Groundwater extraction is a proven technology for providing hydraulic containment.

Reduction of toxicity, mobility, or volume through treatment – Alternative 1 satisfies the statutory preference for treatment. Ion exchange treatment for perchlorate removal and either air stripping or LGAC for VOC removal are proven technologies that have a demonstrated ability to remove the contaminants from the extracted groundwater, significantly reducing the mobility and toxicity of the contaminants. If the treatment residuals (for example, used carbon and resin) are destroyed or reactivated, the remedy would permanently reduce the mass and volume of contaminants. Contaminant concentrations in treated water discharged from the plant would be below MCLs and at or close to non-detect levels.

The mass of TCE and perchlorate removed, as estimated from the assumed average extraction rate, assumed average influent concentrations, and 30 years of remedy operation, would be 1,600 pounds (lbs) and 15,800 lbs, respectively.

The anticipated treatment residuals (for example, spent carbon and spent resin) are commonly generated by water treatment systems, are readily manageable, and should not pose long-term risks to human health or the environment.

Short-term effectiveness – Alternative 1 assumes the installation of one extraction well, construction of a treatment plant, construction of a 4,000-foot pipeline from the new well to the treatment plant, construction of a 3,500-foot pipeline from the new treatment plant to the Cactus Avenue trunk line, and construction of a short pipeline from the Rialto-2 well. All construction activities would take place in developed areas (primarily industrial) with minimal impacts to the community or the environment expected. Noise, dust abatement, and traffic controls would be required during remedy construction to protect the community. Any contaminated drill cuttings or purge water encountered would be treated onsite or transported offsite for disposal. Remedial construction would employ routine construction techniques, and standard Occupational Safety and Health Administration (OSHA) requirements would be protective of workers during construction. It is expected that the remedy would be constructed in approximately 1 year and that RAOs would be achieved shortly after startup (except during high water level conditions).

Implementability – Alternative 1 is based on widely used, proven technologies for both construction and operation. No significant difficulties are expected because of the type of technologies employed, and the system would be designed to handle some increase in flow or influent concentrations (to be determined during remedial design). The extraction, treatment, and conveyance technologies are known to be proven and reliable, and Alternative 1 would not interfere with the implementation of future response actions in the area.

The effectiveness of treatment would be monitored by sampling and analysis of the treated groundwater. The effectiveness of the capture would be monitored indirectly using data collected from existing and new groundwater monitoring wells and piezometers, and groundwater flow modeling.

Implementation of Alternative 1 would require property or long-term access agreements for the construction of extraction wells, treatment facilities, and conveyance facilities. In addition, implementing Alternative 1 would require addressing administrative issues associated with groundwater extraction and delivery of water to local water purveyors, including:

- Agreements would be needed with water purveyors that receive treated water specifying the amount of water the purveyor would accept, the location of water delivery, costs of the water and other operational arrangements.

- Arrangements may be needed to address limitations on groundwater pumping resulting from the 1961 Rialto-Colton decree or overpumping in the RCB. This would likely include accounting for any water supplied to a local purveyor against the purveyor's water rights allocation.
- Water purveyors that served the treated groundwater would need to obtain approval from the CDPH for modifications to their water supply permits.

Required services and materials for implementation of Alternative 1 should be readily available locally, including qualified contractors for construction and operation of the remedy.

Cost – The estimated capital and annual O&M costs for Alternative 1 are $9.7 million and $1.18 million, respectively. The corresponding NPV is $20.5 million (15 years) to $24.4 million (30 years).

5.2.3 Alternative 2a Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply

Overall protection of human health and the environment – Alternative 2a provides significant reduction in the long-term threat to human health and the environment posed by the groundwater contamination in the targeted areas. Groundwater treatment would permanently remove contamination from the extracted groundwater. Alternative 2a is expected, with improved placement of the extraction wells, to achieve capture of target zones in the Intermediate Aquifer and Regional Aquifer during all expected groundwater conditions.

Compliance with ARARs – Alternative 2a would be configured to meet all chemical-specific, location-specific, and action-specific ARARs. Most ARARs are associated with performance of the treatment plant and management of any wastes generated at the treatment plant.

Long-term effectiveness and permanence – Alternative 2a would be designed to achieve complete capture of the target zones in the Intermediate Aquifer and Regional Aquifer during all expected groundwater conditions. The modeling results estimate 94 percent capture of the Regional Aquifer target zone during high water-level conditions but, because high water-level conditions are not expected to persist for the long periods inferred by the particle tracking approach, actual containment in the Regional Aquifer is expected to be at or near 100 percent. The modeling simulations of the Intermediate Aquifer are given limited weight due to limitations in the modeling described in Section 3.3. This alternative is expected to provide an effective, long-term reduction in risk to the downgradient aquifer and associated production wells.

The extraction and treatment systems should operate reliably. Groundwater extraction is a proven technology for providing the desired containment, and the assumed treatment technologies are effective on the known contaminants.

Reduction of toxicity, mobility, or volume through treatment – Alternative 2a satisfies the statutory preference for treatment. The ion exchange treatment for perchlorate and either air stripping or LGAC for VOCs are capable of fully removing the contaminants from the extracted groundwater, significantly reducing the mobility and toxicity of the contaminants.

If the treatment residuals (for example, used carbon and resin) are destroyed or reactivated, the remedy would provide a permanent reduction in the mass and volume of contaminants. Contaminant concentrations in treated water discharged from the plant would be below MCLs, at or close to non-detect levels.

The mass of TCE and perchlorate removed, as estimated from the assumed average extraction rate, assumed average influent concentrations, and 30 years of remedy operation, would be 1,900 lbs and 19,300 lbs, respectively.

The anticipated treatment residuals (for example, spent carbon and spent resin) are commonly generated by water treatment systems, are readily manageable, and should not pose long-term risks to human health or the environment.

Short-term effectiveness – Alternative 2a assumes the installation of one extraction well (EW-1), construction of a treatment plant, construction of a 4,000-foot-long pipeline from the new well to the treatment plant, construction of a 3,500-foot-long pipeline from the new treatment plant to the Cactus Avenue trunk line, and construction of a short pipeline from the Rialto-2 well. All construction activities would take place in developed areas (primarily industrial) with limited impacts expected to the environment. Noise, dust abatement, and traffic controls would be required during construction to protect the community, but the potential impacts are not greater than in other similar-sized municipal construction projects. Any contaminated drill cuttings or purge water encountered would be treated onsite or transported offsite for disposal. Standard OSHA requirements would be protective of workers during the remedial actions. Following completion of remedial design, it is expected that the remedy would take approximately 1 to 1.5 years to complete construction and startup. RAOs would be achieved shortly after startup.

Implementability – Alternative 2a would employ widely used, proven technologies for both construction and operation. No significant difficulties are expected with the type of technologies planned, and the system would be designed to be flexible enough to handle increased flows or higher influent concentrations. The extraction, treatment, and conveyance technologies are known to be proven and reliable, and Alternative 2a would not interfere with the implementation of future response actions in the area.

The effectiveness of treatment would be monitored by sampling and analysis of the treated groundwater. The effectiveness of the capture would be monitored indirectly using data from existing and new groundwater monitoring wells and piezometers, and groundwater flow modeling.

Implementation of Alternative 2a would require property or long-term access agreements for the installation of extraction wells, treatment facilities, and conveyance facilities. In addition, implementing Alternative 2a would require addressing administrative issues associated with groundwater extraction and delivery of water to local water purveyors, including:

- Agreements would be needed with water purveyors that receive treated water specifying the amount of water the purveyor would accept, the location and timing of water delivery, costs of the water and other operational arrangements.

- Arrangements may be needed to address limitations on groundwater pumping resulting from the 1961 Rialto-Colton decree or overpumping in the RCB. This would likely include accounting for any water supplied to a local purveyor against the purveyor's water rights or allocation.
- Water purveyors that served the treated groundwater would need to obtain approval from the CDPH for modifications to their water supply permits.

Required services and materials for implementation of Alternative 2a should be readily available locally, including qualified contractors for construction and operation of the remedy.

Cost – The estimated capital and O&M costs for Alternative 2a are $13.5 million and $1.35 million, respectively. The corresponding NPV is $25.8 million (15 years) to $30.3 million (30 years).

5.2.4 Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater

Overall protection of human health and the environment – The overall protection of human health and the environment provided by Alternative 2b is essentially the same as Alternative 2a. Alternative 2b could provide slightly better protection if the treated water is reinjected or recharged in a location that accelerates groundwater cleanup without increasing potential contaminant migration into new areas beyond the capture zone of the groundwater extraction wells.

Compliance with ARARs – Same as Alternative 2a. Alternative 2b would be designed to meet all chemical-specific, location-specific, and action-specific ARARs.

Long-term effectiveness and permanence – Generally the same as Alternative 2a.

Reduction of toxicity, mobility, or volume through treatment – Similar to Alternative 2a, except that the biological treatment process assumed for perchlorate removal is a destructive technology ensuring permanent reduction in the mass and volume of perchlorate.

Short-term effectiveness – In addition to the construction activities described above for Alternative 2a, this alternative assumes the installation of two groundwater injection wells at the northern boundary of the 160-Acre Area and construction of a 17,600-foot-long pipeline from the treatment plant to the injection wells. Although the risks to the community and environment associated with this additional construction remain relatively low, there would be some increased impacts from the larger construction project. The additional construction could increase the time required for the implementation effort.

Implementability – The implementability of Alternative 2b is similar to that described above for Alternative 2a. Alternative 2b would not require agreements with water purveyors for receipt of treated water and use of pumping rights, but the need to construct the additional 3 miles of pipeline to carry the treated water to the injection area adds to the administrative requirements of this alternative.

Cost – The estimated capital and O&M costs for Alternative 2b are $22.3 million and $1.45 million, respectively. The corresponding NPV ranges from $35.5 million (15 years) to 40.3 million (30 years).

5.2.5 Alternative 3 Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply

Overall protection of human health and the environment – Alternative 3 would significantly reduce the long-term threat that groundwater contamination migrating away from the targeted areas represents to human health and the environment. The extracted groundwater would be treated so that the threat posed by the contamination is eliminated. Alternative 3 is intended to provide full capture of the target zones in the Intermediate Aquifer and Regional Aquifer during all expected groundwater conditions (similar to Alternative 2), with an extra margin of safety.

Compliance with ARARs – Alternative 3 would be configured to meet all chemical-specific, location-specific, and action-specific ARARs. Most ARARs are associated with performance of the treatment plant and management of any wastes generated at the treatment plant.

Long-term effectiveness and permanence – Alternative 3 would be designed to achieve complete capture of the Intermediate Aquifer and Regional Aquifer target zones during all modeled groundwater conditions. As described in Section 3.3.2, the modeling approach infers that relatively extreme hydrologic conditions continue for many decades, beyond what has occurred historically. This alternative would provide an effective, long-term reduction in risk to the downgradient aquifer and associated production wells.

The extraction and treatment systems should operate reliably. Groundwater extraction is a proven technology for providing the desired containment, and the assumed treatment technologies are effective on the known contaminants.

Reduction of toxicity, mobility, or volume through treatment – Alternative 3 satisfies the statutory preference for treatment. The ion exchange treatment for perchlorate and either air stripping or LGAC for VOCs are capable of fully removing the contaminants from the extracted groundwater, significantly reducing the mobility and toxicity of the contaminants. If the treatment residuals (for example, used carbon and resin) are destroyed or reactivated, the remedy would permanently reduce the mass and volume of contaminants. Treated water discharged from the plant would be below MCLs, probably at or close to non-detect levels.

The mass of TCE and perchlorate removed would be 2,300 lbs and 23,100 lbs, respectively, as estimated from the assumed average extraction rate, assumed average influent concentrations, and 30 years of remedy operation.

The anticipated treatment residuals (for example, spent carbon and spent resin) are commonly generated by water treatment systems, are readily manageable, and should not pose long-term risks to human health or the environment.

Short-term effectiveness – Alternative 3 assumes the installation of one extraction well, construction of a treatment plant, construction of a 4,000-foot-long pipeline from the new well to the treatment plant, construction of a 3,500-foot-long pipeline from the new treatment plant to the Cactus Avenue trunk line, construction of a 9,600-foot-long pipeline to tie into the Fontana Water Company delivery system, and construction of a short pipeline from the Rialto-2 well. All construction activities would take place in developed areas (primarily commercial/industrial) with limited impacts expected to the local community and the environment. Noise, dust abatement, and traffic controls would be required during the construction to protect the community, but the potential impacts are not greater than in other similar-sized municipal construction projects. Any contaminated drill cuttings or purge water encountered would be treated onsite or transported offsite for disposal. Standard OSHA requirements would be protective of workers during the remedial actions. Following completion of remedial design, it is expected that the remedy would take approximately 1.5 years to complete construction and startup. RAOs would be achieved shortly after startup.

Implementability – Alternative 3 would employ widely used, proven technologies for both construction and operation. No significant difficulties are expected with the type of technologies planned, and the system would be designed to handle some increase in flow or influent concentrations. The extraction, treatment, and conveyance technologies are proven and reliable and Alternative 3 would not interfere with the implementation of future response actions in the area.

The effectiveness of treatment would be monitored by sampling and analysis of the treated groundwater. The effectiveness of the capture would be monitored indirectly using data from existing and new groundwater monitoring wells and piezometers, and groundwater flow modeling.

Implementation of Alternative 3 would require property or long-term access agreements for the installation of extraction wells, treatment facilities, and conveyance facilities. Implementation of Alternative 3 would also require addressing administrative issues associated with groundwater extraction and delivery of water to local water purveyors, including:

- Agreements would be needed with the multiple water purveyors that would receive treated water specifying the amount of water the purveyor would accept, the location and timing of water delivery, costs of the water and other operational arrangements.
- Arrangements may be needed to address limitations on groundwater pumping resulting from the 1961 Rialto-Colton decree or overpumping in the RCB. This would likely include accounting for any water supplied to a local purveyor against the purveyor’s water rights or allocation.
- Water purveyors that served the treated groundwater would need to obtain approval from the CDPH for modifications to their water supply permits.

Required services and materials for implementation of Alternative 3 should be readily available locally, including qualified contractors for construction and operation of the remedy.

Cost – The estimated capital and O&M costs for Alternative 3 are $19.1 million and $1.44 million, respectively. The corresponding NPV is $32.2 million (15 years) to $37.0 million (30 years).

5.3 Comparative Analysis of Remedial Alternatives

In this section, the relative performance of each alternative is evaluated in relation to the seven threshold and primary criteria. The comparative analysis identifies the advantages and disadvantages of each alternative to assist EPA in choosing a preferred remedial alternative. Table 5-8 presents the detailed comparison of the alternatives.

5.3.1 Overall Protection of Human Health and the Environment

Alternatives 1 through 3 protect human health and the environment without substantial negative impacts. None of the remedial actions would exacerbate site conditions.

The No Action Alternative provides the least overall protection of human health and the environment. Limitations of the No Action Alternative include increased potential for human exposure; leaving the burden of constructing and operating treatment facilities to water purveyors; the increased cost and difficulty of operating existing treatment facilities if more highly contaminated groundwater reaches existing facilities; the increased likelihood of future increases in contaminant concentrations at active water supply wells; and the increased eventual cost, difficulty, and time required for containment or restoration of the aquifer. The only advantage of the No Action Alternative is that there is no risk associated with treatment residuals because none are created.

Alternatives 1 through 3 would reduce short- and long-term risks to human health and the environment by limiting the spread of contaminated groundwater from the highly contaminated source areas at the 160-Acre Area into less-contaminated areas or depths to reduce the impact of continued contaminant migration on downgradient water supply wells and to protect future uses of less-contaminated and uncontaminated areas. Alternatives 1, 2, and 3, in this order, would provide increasing levels of control of further migration of contaminated groundwater, although there is likely to be minimal difference in the level of control between Alternatives 2 and 3.

Alternatives 1 through 3 would also reduce the toxicity, mobility, and volume of the contaminants and remove significant contaminant mass from the aquifer. The VOC and perchlorate treatment technologies would be effective in meeting federal and state drinking water standards.

Alternatives 1, 2a, and 3 also offer the benefit of providing treated water to purveyors whose wells are currently affected by contamination and are further threatened by continued contaminant migration, providing the affected purveyors with a clean water supply source.

The negative impacts associated with these alternatives include the disruption that would result from installation of pipelines and other components of the remedy, and the impacts of handling, treating, and disposing of treatment residuals (for example, air emissions or spent carbon and spent resin).

Alternative 2 would include additional extraction and more robust containment than Alternative 1, and Alternative 3 would include additional extraction and slightly more robust containment compared to Alternatives 2a and 2b. The additional extraction would provide some additional protection for downgradient areas and would remove additional contaminant mass, but it may take longer to reach agreements to distribute the treated water.

5.3.2 Compliance with ARARs

Alternatives 1 through 3 would be configured to comply with all chemical-specific, location-specific, and action-specific ARARs. Section 2 describes the potential ARARs and TBCs that may apply to the remedial alternatives. Most of the ARARs are associated with discharges of treated groundwater from the treatment plant or management and disposal of treatment residuals. No ARARs waivers should be needed.

No ARARs are associated with the No Action Alternative.

5.3.3 Long-Term Effectiveness and Permanence

This evaluation criterion assesses the extent to which each remedial alternative reduces risk after the RAOs are met. Residual risk can result from exposure to untreated waste or treatment residuals. The magnitude of the risk depends on the magnitude of the wastes and the adequacy and reliability of controls, if any, that are used to manage untreated waste and treatment residuals. For this interim remedy, untreated waste refers to contaminated groundwater not removed from the aquifer. Treatment residuals may include spent carbon and spent resin.

The performance of the alternatives in relation to this criterion has been evaluated primarily by estimating the extent to which each alternative prevents the migration of contamination into less-contaminated areas. Preventing or reducing contaminant migration reduces contaminant concentrations in downgradient areas, reducing risk by reducing the likelihood of exposure.

Also considered in evaluating the performance of each alternative is the relative magnitude of the treatment residuals. The actual types and magnitude of the treatment residuals would depend on the type of treatment technology used.

The No Action Alternative achieves no additional migration control and produces no treatment residuals. In contrast to the No Action Alternative, all of the remedial alternatives would be relatively effective in meeting the RAOs of this interim remedy. All alternatives are expected to provide complete hydraulic containment during low and intermediate water level conditions. During high water level conditions, the model indicates that the remedial pumping rates assumed in Alternative 1 would not hydraulically contain the Intermediate Aquifer and would not provide complete containment of the Regional Aquifer. Alternatives 2a, 2b, and 3 are expected to provide complete containment during all expected groundwater conditions.

The remedial alternatives would be effective in reducing the short- and long-term risks to human health and the environment by inhibiting downgradient migration of contamination and removing substantial contaminant mass. The remedial alternatives would:

- Minimize increases in the extent of contamination, decreasing the potential for human exposure

- Potentially reduce the need for water purveyors with active downgradient water supply wells to install new wellhead treatment units
- Reduce the cost and difficulty of operating existing treatment facilities by preventing highly contaminated groundwater from reaching active water supply wells
- Reduce the eventual cost, difficulty, and time required for containment or restoration of the aquifer. (If no action is taken, continued contaminant migration will result in the need to treat larger volumes of contaminated water.)

Also considered in this evaluation criterion is the risk resulting from treatment residuals. In Alternatives 1 through 3, if LGAC is used for VOC treatment, the spent carbon would need to be handled and transported offsite for regeneration or disposal. If air stripping with VGAC off-gas controls is used, residual risk would result from air emissions in addition to the handling and disposal of spent carbon. Off-gas treatment would be designed to meet air emissions requirements and limit the incremental risk from air emissions to acceptable levels. Compliance with RCRA and Department of Transportation regulations would result in minimal risks being associated with spent carbon and spent resin treatment residuals. The magnitude of the residual risks from treatment residuals for Alternatives 2 and 3 would be slightly higher than for Alternative 1 because of the higher average extraction rates.

5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 1 through 3 all satisfy the statutory preference for treatment. All alternatives would employ treatment technologies that would significantly reduce the volume of contaminants by inhibiting contaminant migration, and reduce the toxicity and volume of contaminants by reducing contaminant concentrations to low or non-detectable levels.

The ion exchange treatment or FBR biological treatment technologies for perchlorate removal, and either air stripping or LGAC for VOC removal, would permanently remove the contaminants from the extracted groundwater, greatly reducing mobility. The adsorptive VGAC or LGAC technologies for VOCs would be destructive if the carbon reactivation process is considered. The biological process considered for perchlorate in Alternative 2b is also a destructive technology. The use of disposable resin for perchlorate treatment may also result in permanent destruction of the perchlorate if the resin is regenerated. Note that the treatment technologies used in the development of the alternatives are not tied to a specific alternative; for example, a modified Alternative 2b could be selected that uses ion exchange instead of FBR, or modified Alternatives 1, 2a, and 3 could use FBR instead of ion exchange.

Alternative 1 treatment would remove an estimated 1,600 lbs and 15,800 lbs of TCE and perchlorate, respectively, over 30 years. Alternatives 2a and 2b would remove approximately 1,900 lbs and 19,300 lbs of TCE and perchlorate, respectively, and Alternative 3 would remove approximately 2,300 lbs and 23,100 lbs of TCE and perchlorate, respectively.

5.3.5 Short-Term Effectiveness

None of the alternatives pose unmitigable risks to the community during construction and implementation, nor do any of the alternatives pose unmitigable risks to workers beyond general construction hazards associated with large construction projects. No unmitigable negative environmental impacts are anticipated in the areas in which facilities would be constructed.

The RAOs would be met shortly after the selected alternative begins extracting and treating groundwater. The construction and implementation phase ends when the entire alternative is operational. The time until RAOs would be achieved is difficult to predict because there are a number of participating parties and institutional issues that must be resolved prior to implementation of any of the remedial alternatives. The actual construction processes required for Alternatives 1, 2a, and 3 are similar, so implementation times should be similar. However, there are additional administrative issues associated with the higher peak flow rates in Alternative 3 that may slow down implementation of that alternative. Alternative 2b includes installation of a long pipeline to the reinjection area. This additional construction effort may take longer than the other alternatives. Conversely, there are fewer institutional obstacles associated with implementing Alternative 2b, which may offset the longer construction time frame.

It is expected that Alternatives 1 through 3 would be constructed within 1 to 2 years. All construction activities would take place in developed areas with minimal expected impacts to the environment. Noise and dust abatement during construction, and onsite treatment or offsite disposal of the contaminated drill cuttings and purge water, would be required to protect the community during the remedy implementation. Standard OSHA requirements would be protective of workers during the remedial actions.

All alternatives are assigned a high ranking because there are no unmitigable risks to the community, workers, or the environment during construction and implementation. There are no significant differences expected among the remedial alternatives in short-term effectiveness, except for differences that may result from delays in implementation resulting from institutional obstacles. Institutional obstacles are described in more detail in the following section.

5.3.6 Implementability

The extraction, treatment, and conveyance technologies included in Alternatives 1 through 3 are widely used and are generally known to be proven and reliable. The biological treatment process for perchlorate removal assumed in Alternative 2b is not as widely used as ion exchange, although it has been demonstrated to be effective. No significant difficulties are expected because of the type of technologies employed.

None of the remedial alternatives would interfere with the implementation of future response actions in the area and all could be modified, if necessary, to accommodate higher flow rates, additional extraction wells, or different treatment methods.

All of the alternatives include an extensive monitoring program to evaluate remedy performance and to provide early warning of changes in contaminant concentrations or groundwater flow that may require modifications in extraction rates, well locations, or treatment methods to ensure attainment of RAOs.

Implementation of any of the remedial alternatives would require acquisition of property and/or access arrangements for the construction of extraction wells, treatment facilities, and conveyance facilities. Alternatives 2b and 3 include much larger conveyance systems and treatment facilities than Alternatives 1 and 2a, increasing the likelihood that difficulties would be encountered in acquiring property or arranging access, resulting in potential schedule delays.

Implementing Alternatives 1 through 3 would require resolution of the following administrative issues associated with the extraction, injection, or delivery of treated groundwater to local water purveyors:

- Agreements would need to be reached with purveyors that would receive the treated groundwater generated by the remedy, specifying the amount of water each purveyor would accept; the treated water delivery location; responsibility for any necessary capital improvements to purveyor systems; and to determine operational, liability, financial, and other arrangements.
- Arrangements may be needed to address limitations on groundwater pumping resulting from the 1961 Rialto-Colton decree or overpumping in the RCB. This would likely include accounting for any water supplied to a local purveyor against the purveyor's water rights or allocation.
- Arrangements would need to be made to account for any water reinjected or otherwise recharged.
- Water purveyors serving the treated groundwater would need to obtain approval from the CDPH for modifications to their water supply permits.

Alternatives 2a (up to 3,200 gpm) and 3 (up to 5,000 gpm) involve periodic distribution of much larger volumes of water than Alternative 1. Distributing this additional treated water would probably require arrangements with additional parties (particularly in Alternative 3), possibly delaying implementation of the project. Alternative 2b does not require any arrangements with water purveyors to receive the treated water, thus reducing the administrative requirements associated with water purveyor agreements.

Implementation of each alternative would require the fabrication of treatment plant equipment, pumps, and conveyance pipe. However, none of the required equipment or materials are out of the ordinary and all required services and materials are believed to be available, including qualified contractors for construction and operation of technologies under consideration.

None of the alternatives are assigned a high ranking for the implementability criterion (see Table 5-8), reflecting the significant administrative arrangements that are needed to implement any of the alternatives, the need to acquire land or arrange access, and other difficulties associated with a construction project in a developed area. Alternative 1 is assigned a moderate to high ranking, reflecting the fact that it is the least complex alternative, probably requiring the fewest participating parties and fewest agreements.

5.3.7 Cost

No direct costs are associated with the No Action Alternative. The estimated capital and O&M costs for Alternatives 1 through 3 are shown on Table 5-7. The capital and annual O&M costs for Alternative 1 are estimated to be $9.7 million and $1.18 million, respectively, with a corresponding NPV of $24.4 million, assuming 30 years of O&M. The estimated capital and annual O&M costs for Alternative 2a are $13.5 million and $1.35 million, respectively, with a corresponding NPV of $30.3 million assuming 30 years of O&M. The estimated capital and annual O&M costs for Alternative 2b are $22.3 million and $1.45 million, respectively, with a corresponding NPV of $40.3 million, assuming 30 years of O&M. The estimated capital and annual O&M costs for Alternative 3 are $19.1 million and $1.44 million, respectively, with a corresponding NPV of $37.0 million.

As indicated above, Alternative 1 has the lowest estimated NPV at $24.4 million. Alternative 2a has the next lowest NPV cost at $30.3 million. Alternative 2b has a significantly higher NPV cost of $40.3 million, which is the highest of the remedial alternatives. This is primarily due to the high capital costs associated with the fluidized bed biological treatment process and the long pipeline from the treatment plant to the injection well location. The NPV of Alternative 3 is $37.0 million, $3.3 less than Alternative 2b. The estimated cost for Alternative 2b could be lowered by using ion exchange treatment technology instead of FBR. Alternative 2b would still have the highest capital cost of the remedial alternatives because of the additional long pipeline.

Numerous assumptions are made in estimating these costs. For the most part, deviations from assumptions would not affect the relative costs of the remedial alternatives. Major assumptions, and order-of-magnitude estimates of their possible impact on the cost estimates, are described below. The majority of the estimated capital costs of the remedial alternatives are associated with the treatment and conveyance components. The majority of the estimated operating costs of the remedial alternatives are for the purchase of electricity, resin, and carbon.

Aquifer Specific Capacity: It is assumed that a single extraction well can extract up to approximately 3,000 gpm from the upper few hundred feet of the Regional Aquifer. Existing wells in the area have historically extracted 1,000 to 2,000 gpm, but not typically as high as 3,000 gpm from these depths. If multiple wells are required to achieve the necessary extraction rates (rather than a single well), capital costs will increase.

Availability of Existing Wells: It is assumed that an inactive existing water supply well (Rialto-2) owned by a local purveyor (City of Rialto) can be used as part of the remedy. If, instead, a new well must be constructed, capital costs will increase.

Estimated Contaminant Concentrations: If actual contaminant concentrations differ from the estimated concentrations, or if new contaminants are detected, operating costs may change. If the deviations are large, capital modifications may be necessary. If new VOCs are detected that require treatment, this may affect the performance of either air stripping (with VGAC off-gas treatment) or LGAC as the selected VOC treatment technology, potentially resulting in the need for supplemental treatment technologies. Also, if the contaminant loading is greater or less than estimated, carbon and resin usage may increase or decrease.

If air stripping with carbon off-gas control is used and the air-to-water ratio has to be modified in response to higher VOC concentrations, VGAC carbon usage will change. If increasing the air-to-water ratio results in airflow in excess of the hydraulic capabilities of the VGAC adsorbers, additional off-gas treatment units may be needed to treat the additional air volume from the air strippers.

If air stripping is used and contaminant concentrations are much higher than estimated, more strippers may need to be added, or LGAC polishing units could be added. Each of these responses would likely result in increased capital and O&M costs.

If supplemental treatment technologies or the expansion of existing processes become necessary, additional land may be required for construction.

Number of Treatment Facilities: If multiple treatment facilities are constructed rather than one centralized facility, costs are likely to increase.

Pipeline Alignments: The pipeline alignments shown in the drawings are intended for cost estimating purposes only. Actual alignments are expected to differ, depending on final treatment plant location, treated water recipients and distribution locations, construction constraints and other factors. Modifying the pipeline alignments will affect the cost of implementation.

Distributing Treated Water to Purveyors at Constant Flow: If treated water is distributed to local water purveyors at varying, rather than constant, flow rates, conveyance costs would change.

Property Acquisition: The cost of purchasing land (if required) is not included in the cost estimates.

SECTION 6

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Tables

Table 1-1
Soil, Soil Gas, and Groundwater Testing at and Downgradient of the 160-Acre Area
B.F. Goodrich Site RI/FS, Rialto, California

Sample Collection Date(s)	Report Date	Consultant	Testing
March 2003	4/11/2003	PES Environmental, Inc.	Analysis of approximately 30 soil samples to a maximum depth of 8' bgs in areas used by American Promotional Events - West, Inc. (APE). All samples analyzed for perchlorate; two samples analyzed for volatile organic compounds (VOCs).
November 2003	12/15/2003	Kleinfelder, Inc.	Analysis of approximately nine soil samples from three trenches to a maximum depth of 10' bgs, and approximately six soil samples from a boring to a maximum depth of 50' bgs, in areas used by Pyro Spectaculars. All samples analyzed for perchlorate and VOCs.
December 2003	1/6/2004	PES Environmental, Inc.	Analysis of approximately eight soil samples to a maximum depth of 8' bgs in an area used by APE, to further evaluate contaminated soil detected in Mar 2003 investigation.
March 2004	4/20/2004	Locus Technologies	Analysis of approximately 46 soil samples from 11 locations, to a maximum depth of 15' bgs, in areas owned by Wong Chung Ming. All samples analyzed for perchlorate; approximately 22 samples analyzed for VOCs.
May - August 2004	3/24/2005	Geosyntec Consultants	Analysis of approximately 12 soil samples at 8 locations, and 101 soil gas samples at 61 locations, to a maximum depth of 12' bgs in areas associated with former B.F. Goodrich operations. All soil and groundwater samples analyzed for perchlorate, VOCs, metals, NDMA, 1,4-dioxane, RDX, and selected anions. Installation and sampling of 18 temporary wells, installation and initial sampling of 4 permanent groundwater monitoring wells (PW1-PW4), and installation of 3 piezometers (PW2A - PW4A).
September 2004	2/10/2005	Environ International Corp.	Analysis of approximately 23 soil samples from 12 locations, and 96 soil gas samples from 47 locations, to a maximum depth of 12' bgs in areas associated with West Coast Loading Corp. Soil samples analyzed for perchlorate, VOCs, metals, NDMA, 1,4-dioxane, RDX, and other anions.
Dec 2004 - January 2005	4/15/2005	Kleinfelder, Inc.	Analysis of approximately 11 soil samples. Five samples from trenches to a maximum depth of 5' bgs. Six samples from two borings through the bottom of the former "McLaughlin Pit" to a maximum depth of 20' bgs. All soil samples analyzed for perchlorate. One composited sample analyzed for VOCs.
May-05	Jan-06	Blasland, Bouck & Lee, Inc	Analysis of approximately 51 soil samples from 22 locations at depths of 5 or 10 feet bgs for perchlorate in the area where a buried pyrotechnic round was discovered in September 2003. Most samples also analyzed for VOCs, SVOCs, metals, PCBs, and explosives. Analysis of approximately 40 soil gas samples

Table 1-1
Soil, Soil Gas, and Groundwater Testing at and Downgradient of the 160-Acre Area
B.F. Goodrich Site RI/FS, Rialto, California

Sample Collection Date(s)	Report Date	Consultant	Testing
March 2006 - February 2007	3/30/2007	Environ International Corp. and Adverus	Analysis of approximately 355 soil samples and 124 soil gas samples, in 28 study areas that may have been associated with West Coast Loading Corp activities, and additional areas associated with other operations on the 160-Acre Area. Soil samples to a maximum depth of 25' bgs, except in Study Areas 18, 28, 41, and 46, where deeper sampling occurred. Installation and initial sampling of five, multi-depth groundwater monitoring wells- three by Pyro Spectaculars (CMW-01, CMW-02, CMW-03) and two by Emhart Industries (CMW-04 and CMW-05).
Apr-06	6/23/2006	Kleinfelder, Inc.	Analysis of approximately 23 soil samples from a trench or potholes in the area where a buried pyrotechnic round was discovered to a maximum depth of 8' bgs, and approximately 8 samples of stockpiled or excavated soils. Some samples also analyzed for metals.
April - July 2006	10/21/2006	Geosyntec Consultants	Installation and initial sampling of five multiport groundwater monitoring wells downgradient of the 160-Acre Area (PW5 through PW9).
April 2007 - June 2007	7/27/2007	Kleinfelder, Inc.	Analysis of approximately 41 soil samples from approximately 14 locations at depths of up to 52' bgs for perchlorate in the area where a buried pyrotechnic round was discovered. Some samples also analyzed for metals.
January 2008	3/5/08 (Sum. Table)	CH2M HILL	EPA sampling of 14 groundwater monitoring wells (39 total monitoring zones) and 3 water supply wells.
February 2008 – March 2008	4/22/2008	DPRA	Installation and initial sampling of two multiport groundwater monitoring wells by the City of Colton wells (CPW-16 and CPW-17).
May 2008 (also summarizes previous results)	9/4/2008	Kleinfelder, Inc.	Analysis of approximately nine soil samples from three borings at depths of up to 16.5 feet bgs for perchlorate, and approximately 20 soil samples from one deep boring at depths of up to 200 feet bgs for perchlorate.
March 2009	5/20/09 (Sum. Table)	CH2M HILL	EPA sampling of 20 groundwater monitoring wells (55 total monitoring zones) and 1 water supply well.
April - May 2009	Not Yet Available	Environ International Corp.	Installation and sampling of soil borings to depths of up to 400 feet bgs in the vicinity of historical West Coast Loading Corp activities that potentially involved handling of perchlorate. Soil samples were analyzed for perchlorate.
April 2009	Not Yet Available	CH2M HILL	Installation and sampling of 3 soil borings and 12 soil vapor probes to a depth of 100 feet bgs. The soil samples were analyzed for perchlorate and the soil vapor samples for VOCs. Two of the borings were installed within the inferred footprint of the historic Goodrich burn pits and the third was located approximately 50 feet to the southeast.
April 2009 - December 2009	Not Yet Available	CH2M HILL	Installation of six deep, multiport monitoring wells downgradient of the 160-Acre Area down to depths of approximately 850 to 900 feet bgs (EPA-MP1 through EPA-MP6). Five of the wells are completed with 5 monitoring zones and one has 6.

Table 1-2
Data Summary - VOCs and Perchlorate in EPA's 2008-2009 Groundwater Sampling
B.F. Goodrich Site RI/FS, Rialto, California

Chemical		Cal-EPA MCL	EPA MCL	Tap Water RSL		Regional Aquifer Monitoring Points												
Well ID =>	Unit			Cancer	Noncancer	PW-5 (Avg)	PW-9 (Avg)	PW-8(Avg)	PW-7 (Avg)	PW-6 (Avg)	1S/5W-11F (Avg)	CPW-17(Avg)	CPW-16(Avg)	RIALTO-5	1S/5W-3A (Avg)	WVWD-24	RIALTO-1	RIALTO-2
Sample Date =>						3/18/2009	3/19/2009	3/20/2009	3/24/2009	3/25/2009	3/30/2009	3/31/2009	4/1/2009	4/1/2009	4/2/2009	1/30/2008	1/30/2008	1/30/2008
Benzene	µg/L	1	5	4.1E-01	4.4E+01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	µg/L	0.5	5	2.0E-01	2.4E+01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	µg/L	80	80	1.9E-01	1.3E+02	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**3.5**	<0.5	<0.5
Methylene chloride	µg/L	5	5	4.8E+00	1.1E+03	<0.5	**0.26**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethene	µg/L	5	5	1.7E+00	NA	**5.8**	**1.74**	**0.74**	**0.25**	**0.26**	<0.5	<0.5	**0.48**	<0.5	**0.31**	<0.5	**0.83**	**4.2**
Perchlorate	µg/L	6		NA	2.6E+01	**288.1**	**119.5**	**5.9**	**4.5**	**14.1**	<1	**1.1**	**17.4**	<1	**13.6**	<1.0	**1.2**	**61**

Analyte		Cal-EPA MCL	EPA MCL	Tap Water RSL		Intermediate Aquifer Monitoring Points							
Well ID =>	Unit			Cancer	Noncancer	PW-8A	PW-3	PW-2	PW-4	PW-1	CMW-2 (Avg)	CMW-5 (Avg)	WVWD-22 Intermediate
Sample Date =>						3/20/2009	3/26/2009	3/27/2009	3/30/2009	1/23/2008	1/25/2008	1/29/2008	1/30/2008
Benzene	µg/L	1	5	4.1E-01	4.4E+01	**0.11**	<0.5	<0.5	<0.5	<0.5	**0.19**	**0.24**	<0.5
Carbon Tetrachloride	µg/L	0.5	5	2.0E-01	2.4E+01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**0.58**
Chloroform	µg/L	80	80	1.9E-01	1.3E+02	**0.31**	**0.22**	<0.5	<0.5	<0.48	<0.46	<0.5	<0.64
Methylene chloride	µg/L	5	5	4.8E+00	1.1E+03	<0.5	<0.5	<0.5	<0.5	<0.14	<0.42	<0.5	<0.5
Trichloroethene	µg/L	5	5	1.7E+00	NA	**46**	**19**	**19**	**3**	<0.5	**7.4**	**93**	**19**
Perchlorate	µg/L	6		NA	2.6E+01	**120**	**46**	**18**	**26**	<1	**8.9**	**105**	**73**

Notes
< = less than Reporting Limit
NA - Not available
Detected concentrations are bolded
Concentrations that exceed EPA RSL, but not an MCL are shaded in yellow.
Concentrations that exceed CalEPA/EPA MCLs are shaded in grey.
RSLs - EPA Regional Screening Levels, April 2009
The chloroform MCL is for total trihalomethanes, not just chloroform
Avg - Average. Non-detect results have been used at 1/2 of the reporting limit in calculating well-specific averages.

Table 1-3
Risk Evaluation for VOCs and Perchlorate in EPA's 2008-2009 Groundwater Sampling
B.F. Goodrich Site RI/FS, Rialto, California

Chemical		**Cal-EPA MCL**	**EPA MCL**	**Tap Water RSL**		**Regional Aquifer Monitoring Points**													Maximum Concentration	MCL Exceedance	Estimated Lifetime Cancer Risk	Estimated Hazard Index
Well ID =>	**Unit**			**Cancer**	**Noncancer**	PW-5 (Avg)	PW-9 (Avg)	PW-8(Avg)	PW-7 (Avg)	PW-6 (Avg)	1S/5W-11F (Avg)	CPW-17(Avg)	CPW-16(Avg)	RIALTO-5	1S/5W-3A (Avg)	WVWD-24	RIALTO-1	RIALTO-2				
Sample Date =>						3/18/2009	3/19/2009	3/20/2009	3/24/2009	3/25/2009	3/30/2009	3/31/2009	4/1/2009	4/1/2009	4/2/2009	1/30/2008	1/30/2008	1/30/2008				
Carbon Tetrachloride	µg/L	0.5	5	2.0E-01	2.4E+01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
Chloroform	µg/L	80	80	1.9E-01	1.3E+02	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**3.5**	<0.5	<0.5	3.5	0.04	1.8E-05	0.027
Trichloroethene	µg/L	5	5	1.7E+00	NA	**5.8**	**1.74**	**0.74**	**0.25**	**0.26**	<0.5	<0.5	**0.48**	<0.5	**0.31**	<0.5	**0.83**	**4.2**	5.8	1.16	3.4E-06	NA
Perchlorate	µg/L	6		NA	2.6E+01	**288.1**	**119.5**	**5.9**	**4.5**	**14.1**	<1	**1.1**	**17.4**	<1	**13.6**	<1.0	**1.2**	**61**	288.1	48.02	NA	11
																			Total Cancer Risk/Hazard		**2E-05**	**11**

Analyte		**Cal-EPA MCL**	**EPA MCL**	**Tap Water RSL**		**Intermediate Aquifer Monitoring Points**								Maximum Concentration	MCL Exceedance	Estimated Lifetime Cancer Risk	Estimated Hazard Index
Well ID =>	**Unit**			**Cancer**	**Noncancer**	PW-8A	PW-3	PW-2	PW-4	PW-1	CMW-2 (Avg)	CMW-5 (Avg)	WVWD-22 Intermediate				
Sample Date =>						3/20/2009	3/26/2009	3/27/2009	3/30/2009	1/23/2008	1/25/2008	1/29/2008	1/30/2008				
Carbon Tetrachloride	µg/L	0.5	5	2.0E-01	2.4E+01	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	**0.58**	0.58	1.16	2.9E-06	0.024
Chloroform	µg/L	80	80	1.9E-01	1.3E+02	**0.31**	**0.22**	<0.5	<0.5	<0.48	<0.46	<0.5	<0.64	0.31	0.004	1.6E-06	0.002
Trichloroethene	µg/L	5	5	1.7E+00	NA	**46**	**19**	**19**	**3**	<0.5	**7.4**	**93**	**19**	93	18.60	5.5E-05	NA
Perchlorate	µg/L	6		NA	2.6E+01	**120**	**46**	**18**	**26**	<1	**8.9**	**105**	**73**	120	20.00	NA	5
														Total Cancer Risk/Hazard		**6E-05**	**5**

Notes
< = less than Reporting Limit
NA - Not available
Detected concentrations are bolded
Concentrations that exceed EPA RSL, but not an MCL are shaded in yellow.
Concentrations that exceed CalEPA/EPA MCLs are shaded in grey.
RSLs - EPA Regional Screening Levels, April 2009
The chloroform MCL is for total trihalomethanes, not just chloroform
Avg - Average. Non-detect results have been used at 1/2 of the reporting limit in calculating well-specific averages.
MCL Exceedance = Maximum Concentration ÷Lower of Cal-EPA/EPA MCL
Estimated Lifetime Cancer Risk = (Maximum Concentration ÷ Tap Water Cancer RSL)*1E-06
Estimated Hazard Index = Maximum Concentration ÷ Tap Water Noncancer RSL

Table 2-1
Average Spring High Water Level Elevations for the Three Wells Included in the 1961 Rialto-Colton Basin Decree
B.F. Goodrich Site RI/FS, Rialto, California

Year	Average Spring High Water Elevation (feet above mean sea level)
1986	1034.99
1987	1039.99
1988	1031.99
1989	1027.99
1990	1022.99
1991	1014.99
1992	1002.99
1993	1003.33
1994	1002.99
1995	1002.66
1996	999.66
1997	1004.33
1998	1003.99
1999	1007.33
2000	1009.99
2001	1010.66
2002	1003.66
2003	985.99
2004	983.33
2005	977.66
2006	976.33
2007	968.33
2008	969.99
2009	964.66

Table 3-1
Summary of General Response Actions, Remedial Technologies and End Use Options
B.F. Goodrich Site RI/FS, Rialto, California

General Response Action	Remedial Technology or End Use	Description	Effectiveness	Implementability	Relative Cost	Screening Comments	Retained Y/N
No Action	None	The no-action general response action is required by EPA guidance (EPA, 1988) as a baseline for comparison with other remedial alternatives.	Low	High	Low	Does not include active remediation or monitoring.	Y
Hydraulic Control	Groundwater Extraction/Dewatering	Extract groundwater from the Intermediate Aquifer at or downgradient of the 160-Acre Area.	Moderate	Low	High	Would require large number of wells and risk dewatering the Intermediate Aquifer	N
		Extract groundwater from the Regional Aquifer at or downgradient of the 160-Acre Area	High	High	Moderate	Proven process for containment of groundwater contamination if wells properly sized and located	Y
Ex Situ Groundwater Treatment	Air Stripping	Transfer TCE and other volatile contaminants from the groundwater to the air	High	High	Moderate to High	Commonly used for TCE treatment; may require off-gas treatment to remove or destroy the contaminants	Y
	Liquid-Phase Granular Activated Carbon (LGAC) Adsorption	Transfer TCE and other volatile contaminants from the groundwater to activated carbon.	High	High	Moderate	Commonly used for TCE treatment	Y
	Advanced Oxidation Process	Use ultraviolet (UV) light and a chemical oxidant to form hydroxyl radicals which destroy TCE and other contaminants	High	High	High	Effective for TCE, but generally more expensive; may require additional treatment to remove oxidation by-products	Y
	Ion Exchange	Transfer perchlorate and other constituents from groundwater to a synthetic chloride-based anion exchange resin.	High	High	Moderate to High	Effective technology; cost can be driven by presence of other constituents that may bind to the resin.	Y
	Adsorption	Transfer perchlorate and other constituents from the groundwater to activated carbon.	Low	High	High	Not commonly used for perchlorate treatment due to poor adsorption	N
	Biological Treatment	Add nutrients to extracted groundwater water to sustain microbes capable of anaerobic degradation of perchlorate to chloride and oxygen	High	High	Moderate to High	Used for perchlorate treatment since the late 1990s	Y
	Membrane Technologies	Use reverse Osmosis (RO), nanofiltration, or similar technologies to remove perchlorate and other groundwater constituents	High	High	High	Produces e a concentrated waste stream requiring further treatment and/or disposal	N
	Disinfection of Treated Water	Add chlorine, ozone, chlorine dioxide, chloramine, peroxone (ozone/hydrogen peroxide) or other chemicals to disinfect the water. Alternatively, use UV irradiation.	High	High	Low	Required for potable use of treated water.	Y
End Use of Treated Water	Potable Water End Use	Deliver Treated Water to Existing Water Purveyors	High	High	Low	Remedial alternatives require relatively constant extraction rate; purveyor demand varies daily and seasonally	Y
	Nonpotable Water End Use	Reinjection into the regional aquifer via new wells	High	High	High	Reinjection would need to occur upgradient of groundwater contamination	Y
		Discharge to the Cactus Basin via storm drains	Low	High	Low	Could adversely affect groundwater flow and negatively impact hydraulic containment.	N
		Discharge to the Santa Ana River via storm drains	High	Low	High	Cost-prohibitive due to distance to the river	N
In Situ Groundwater Treatment	In Situ Bioremediation (ISB): Groundwater Injection/Recirculation Systems	Deliver amendments directly to the groundwater to stimulate biodegradation. The amendments move downgradient and treat the groundwater as it moves.	High	Low to Moderate	High	Would require very large number of injection points resulting in very high cost.	N
	In Situ Bioremediation (ISB): Fixed/Active Bio-Barriers	Place amendments perpendicular to the groundwater flow direction. The contaminated groundwater flows through the reactive zone decreasing TCE and/or perchlorate concentrations on the downgradient side of the bio-barrier.	High	Low to Moderate	High		N

Table 3-2
Summary of Hydraulic Containment Effectiveness for the Regional and Intermediate Aquifers
B.F. Goodrich Site RI/FS, Rialto, California

Flow Rate	Low Water Levels (2004)		Intermediate Water Levels (2001)		High Water Levels (1998)	
	Regional	Intermediate	Regional	Intermediate	Regional	Intermediate
(gpm)	Approximate % of Target Area Captured (App. A Figure showing results)					
1,125	95% (A-11)	100% (A-38)	100% (A-12)	100% (A-39)	46% (A-13)	0% (A-40)
1,500	100% (A-14)	100% (A-41)	100% (A-15)	100% (A-42)	59% (A-16)	0% (A-43)
1,650	100% (A-17)	100% (A-44)	100% (A-18)	100% (A-41)	62% (A-19)	0% (A-46)
1,825	100% (A-20)	100% (A-47)	100% (A-21)	100% (A-48)	67% (A-22)	0% (A-49)
2,175	100% (A-23)	100% (A-50)	100% (A-24)	100% (A-51)	76% (A-25)	0% (A-52)
2,500	100% (A-26)	100% (A-53)	100% (A-27)	100% (A-54)	83% (A-28)	0% (A-55)
3,200	100% (A-29)	100% (A-56)	100% (A-30)	100% (A-57)	94% (A-31)	0% (A-58)
3,645	100%	100%	100%	100%	97%	0%
4,050	100%	100%	100%	100%	100%	0%
4,500	100%	100%	100%	100%	100%	0%
5,000	100% (A-32)	100% (A-59)	100% (A-33)	100% (A-60)	100% (A-34)	100% (A-61)

TABLE 3-3
Pumping Rates for Existing Production Wells Assumed in Particle-Tracking Simulations
B.F. Goodrich Site RI/FS, Rialto, California

Well Name	Well Owner	Top Screen	Bottom Screen	1998 Groundwater Conditions (gpm)	2001 Groundwater Conditions (gpm)	2004 Groundwater Conditions (gpm)	Notes
Production Wells							
Rialto-01	Rialto	650	958	1,335	1,029	490	Production data from City of Rialto
Rialto-02	Rialto	588	1000	NA	NA	NA	Included separately as one of the extraction wells in the remedial alternatives
Rialto-03	Rialto	525	860	1,500	1,500	1,500	Assumed future pumping rate for landfill remedial action
Rialto-04	Rialto	355	878	300	300	300	Remainder of Rialto water rights if landfill remedy operating at 1,500 gpm.
Rialto-05	Rialto	360	840	-	-	-	Located right at model boundary
Rialto-07	Rialto	300	540	-	-	-	Well is inactive
Fontana-10B	FWC	500	1030	-	1,590	1,117	Production rates from GeoLogic. The rates are less than those provided by FWC.
Fontana-10C	FWC	440	990	-	-	1,045	Production rates from GeoLogic. The rate is similar to that provided by FWC.
Fontana-13A	FWC	520	990	1,226	1,282	866	Production rates from GeoLogic. The rates are less than those provided by FWC, particularly the 2004 rate.
Fontana-13B	FWC	600	1120	-	1,977	1,117	Production rates from GeoLogic. The 2001 rate is much lower than FWC reports and the 2004 rate is lower than the FWC rate.
Fontana-49A	FWC			-	-	1,556	Production rate from GeoLogic. The total is less than that provided by FWC.
Sierra Lakes	Sierra Lakes			-	-	310	Production rate from GeoLogic
WVWD-22[a]	WVWD	440	773	1,039	-	-	1998 rate taken from GeoLogic modeling

[a]Well completion information is from before the well was converted to a monitoring well cluster.

FWC = Fontana Water Company

WVWD = West Valley Water District

NA = Not Applicable

TABLE 3-4
Preliminary Pipeline Sizing Detail
B.F. Goodrich Site RI/FS, Rialto, California

	Description	Begin	End	Distance (feet)	Avg. Flow (gpm)	Design Flow (gpm)	Size (inches)	Freeway Crossing
Alt. 1	Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply	Rialto-2	TP	100	600	660	8	No
		EW-1	TP	3,000	900	990	10	No
	WVWD Zone 4	TP	Cactus Ave.	3,520	1,500	1,650	12	No
	WVWD Zone 3 (Route not used in remedial alts.)	TP	Cactus & Baseline	8,000	1,500	1,650	12	No
	City of Rialto Zone 4 (Route not used in remedial alts.)	TP	Cactus & Baseline	7,400	1,500	1,650	12	No
Alt. 2a	Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply	Rialto-2	TP	100	740	1,200	10	No
		EW-1	TP	3,000	1,100	2,000	14	No
	WVWD Zone 4	TP	Cactus Ave.	3,520	1,840	3,200	18	No
	WVWD Zone 3 (Route not used in remedial alts.)	TP	Cactus & Baseline	8,000	1,840	3,200	18	No
	City of Rialto Zone 4 (Route not used in remedial alts.)	TP	Cactus & Baseline	7,400	1,840	3,200	18	No
Alt. 2b	Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Re-inject the Treated Groundwater	Rialto-2	TP	100	740	1,200	10	No
		EW-1	TP	3,000	1,100	2,000	14	No
		TP	Injection Wells	17,600	1,840	3,200	18	Yes[(1)]
Alt. 3	Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply	Rialto-2	TP	100	880	2,250	14	No
		EW-1	TP	3,000	1,320	2,750	16	No
	WVWD Zone 4	TP	Cactus Ave.	3,520	--	3,000	16	No
	WVWD Zone 3 (Route not used in remedial alts.)	TP	Cactus & Baseline	8,000	--	3,000	16	No
	Fontana Water Co. Reservoir	TP	Alder & W. Highland	9,600	--	2,500	16	No
	City of Rialto Zone 4 (Route not used in remedial alts.)	TP	Cactus & Baseline	7,400	--	2,500	16	No

Note: TP = Treatment Plant; WVWD = West Valley Water District
(1) Remedial alternatives assume that the freeway crossing is via placement of 300 feet of pipe through an existing conduit in a bridge girder. If this conduit is not available to the project, a 500-foot-long pipe installed with HDD would be needed.

TABLE 4-1
Groundwater Monitoring Program - Existing Wells
B.F. Goodrich Site RI/FS, Rialto, California

Well Name	Well Owner	Top Screen	Bottom Screen	Total Depth	Wellhead Elevation	Sampling Frequency	Water Level Frequency
Monitoring Wells							
CMW1A	Pyro Spectaculars	428	448		1654.34	Annual	Quarterly
CMW1B	"	470	490		1654.3	Annual	Quarterly
CMW1C	"	513	533		1654.31	Annual	Quarterly
CMW2A	Pyro Spectaculars	432	452		1655.68	Annual	Quarterly
CMW2B	"	471	491		1655.68	Annual	Quarterly
CMW2C	"	511	531		1655.66	Annual	Quarterly
CMW3A	Pyro Spectaculars	419	439		1665.2	Annual	Quarterly
CMW3B	"	459	479		1665.19	Annual	Quarterly
CMW3C	"	504	524		1665.19	Annual	Quarterly
CMW4A	Emhart	400	420		1657.9	Annual	Quarterly
CMW4B	"	455	475		1658.02	Annual	Quarterly
CMW4C	"	490	510		1657.96	Annual	Quarterly
CMW5A	Emhart	400	420		1647.9	Annual	Quarterly
CMW5B	"	460	480		1648.07	Annual	Quarterly
CMW5C	"	500	520		1648.08	Annual	Quarterly
EPAMW-4A	EPA	411	421	782		Semiannual	Quarterly
EPAMW-4B	"	505	515	782		Semiannual	Semiannual
EPAMW-4C	"	585	595	782		Semiannual	Semiannual
EPAMW-4D	"	639	649	782		Semiannual	Semiannual
EPAMW-4E	"	752	762	782		Semiannual	Semiannual
PW-1	Goodrich	440	480	480	1704.48	Annual	Quarterly
PW-2	Goodrich	455	495	500	1639.36	Semiannual	Quarterly
PW-2A	Goodrich	622	642	642	1639.58	N/A	Semiannual
PW-3	Goodrich	456	496	501	1611.81	Semiannual	Quarterly
PW-3A	Goodrich	606	626	626	1611.81	N/A	Semiannual
PW-4	Goodrich	470	510	515	1626.56	Semiannual	Quarterly
PW-4A	Goodrich	638	648	648	1626.56	N/A	Semiannual
PW-5a	Goodrich	465	475	720	1423.64	Semiannual	Semiannual
PW-5b	"	510	520			Semiannual	Semiannual
PW-5c	"	555	565			Semiannual	Semiannual
PW-5d	"	615	625			Semiannual	Semiannual
PW-5e	"	670	680			Annual	Semiannual
PW-6a	Goodrich	440	450	720	1409.16	Semiannual	Semiannual
PW-6b	"	475	485			Semiannual	Semiannual
PW-6c	"	520	530			Semiannual	Semiannual
PW-6d	"	600	610			Annual	Semiannual
PW-6e	"	655	665			Annual	Semiannual
PW-7a	Goodrich	430	440	850	1401.14	Semiannual	Semiannual
PW-7b	"	495	505			Semiannual	Semiannual
PW-7c	"	565	575			Semiannual	Semiannual
PW-7d	"	635	645			Semiannual	Semiannual
PW-7e	"	685	695			Semiannual	Semiannual
PW-7f	"	750	760			Annual	Semiannual
PW-7g	"	815	825			Annual	Semiannual
PW-8a	Goodrich	440	450	808	1515.42	Semiannual	Quarterly
PW-8b	"	545	555			Semiannual	Semiannual
PW-8c	"	645	655			Semiannual	Semiannual
PW-8d	"	720	730			Annual	Semiannual
PW-8e	"	770	780			Annual	Semiannual
TW-1	Target	444	474		1644.13	Annual	Quarterly
WVWD-22 (current)	WVWD	470	480	492		Semiannual	Quarterly
		610	620	640		Semiannual	Semiannual

TABLE 5-1

Overall Protection of Human Health and the Environment

B.F. Goodrich Site RI/FS, Rialto, California

Analysis Factors	Considerations
Human Health Protection	Likelihood that the alternative reduces risk to human health from potential exposure to contaminants in groundwater.
Environmental Protection	Level of protection provided to downgradient aquifers through hydraulic containment of future releases from the source area.

Table 5-2
Compliance with ARARs
B.F. Goodrich Site RI/FS, Rialto, California

Analysis Factors	Considerations
Chemical-Specific ARARs	Likelihood that the alternative will achieve compliance with chemical-specific ARARs within a reasonable period of time.
	If it appears that compliance with chemical-specific ARARs will not be achieved, evaluation of whether a waiver is appropriate.
Location-Specific ARARs	Likelihood that the alternative will achieve compliance with the location-specific ARARs (if any apply).
	Evaluation of whether a waiver is appropriate if location-specific ARARs cannot be met.
Action-Specific ARARs	Likelihood that the alternative will achieve compliance with action-specific ARARs.
	Evaluation of whether a waiver is appropriate if action-specific ARARs cannot be met.

TABLE 5-3
Long-term Effectiveness and Permanence
B.F. Goodrich Site RI/FS, Rialto, California

Analysis Factors	Considerations
Magnitude of Residual Risks	Identity of remaining risks (risks from treatment residuals) and risks from untreated residual contamination.
	Magnitude of the remaining risks.
Adequacy and Reliability of Controls	Likelihood that the technologies will meet required process efficiencies or performance specifications.
	Type and degree of long-term management required.
	Long-term monitoring requirements.
	Operation and maintenance functions that must be performed.
	Difficulties and uncertainties associated with long-term operation and maintenance functions.
	Potential need for technical components replacement.
	Magnitude of threats or risks should the RA need replacement.
	Degree of confidence that controls can adequately handle potential problems.
	Uncertainties associated with land disposal of residuals and untreated wastes.

TABLE 5-4
Reduction of Toxicity, Mobility, or Volume through Treatment
B.F. Goodrich Site RI/FS, Rialto, California

Analysis Factors	Considerations
Treatment process and remedy	Likelihood that the treatment process addresses the principal threat.
	Special requirements for the treatment process.
Amount of hazardous material destroyed or treated	Portion (mass) of contaminant that is destroyed.
	Portion (mass) of contaminant that is treated.
Reduction in toxicity, mobility, or volume	Extent that the mass of contaminants is reduced.
	Extent that the mobility of contaminants is reduced.
	Extent that the volume of contaminants is reduced.
Irreversibility of treatment	Extent that the effects of the treatment are irreversible.
Type and quantity of treatment residual	Residuals that will remain.
	Quantities and characteristics of the residuals.
	Risk posed by the treatment residuals.
Statutory preference for treatment as a principal element	Extent to which the scope of the action covers the principal threats.
	Extent to which the scope of the action reduces the inherent hazards posed by the principal threats at the Site.

TABLE 5-5
Short-term Effectiveness
B.F. Goodrich Site RI/FS, Rialto, California

Analysis Factors	Considerations
Protection of the community during the RA	Risks to the community that must be addressed.
	How the risks will be addressed and mitigated.
	Remaining risks that cannot be readily controlled.
Protection of workers during RAs	Risks to the workers that must be addressed.
	How the risks will be addressed and mitigated.
	Remaining risks that cannot be readily controlled.
Environmental impacts	Environmental impacts that are expected with the construction and implementation of the alternative.
	Mitigation measures that are available and their reliability to minimize potential impacts.
	Impacts that cannot be avoided, should the alternative be implemented.
Time until RA objectives are achieved	Time to achieve protection against the threats being addressed.
	Time until any remaining threats are addressed.
	Time until RAOs are achieved.

Table 5-6
Implementability
B.F. Goodrich Site RI/FS, Rialto, California

Analysis Factors	Considerations
Technical Feasibility	
Ability to construct and operate the technology	Difficulties associated with the construction.
	Uncertainties associated with the construction.
Reliability of the technology	Likelihood that technical problems will lead to schedule delays.
Ease of undertaking additional RA	Likely future RAs that may be anticipated.
	Difficulty implementing additional RAs.
Monitoring considerations	Migration or exposure pathways that cannot be monitored adequately.
	Risk of exposure should the monitoring be insufficient to detect failure.
Administrative Feasibility	
Coordination with other agencies	Steps required to coordinate with regulatory agencies.
	Steps required to establish long-term or future coordination among agencies.
	Ease of obtaining permits for offsite activities, if required.
Availability of Services and Materials	
Availability of treatment, storage capacity, and disposal services	Availability of adequate treatment, storage capacity, and disposal services.
	Additional capacity that is necessary.
	Whether lack of capacity prevents implementation.
	Additional provisions required to ensure that additional capacity is available.
Availability of necessary equipment and specialists	Availability of adequate equipment and specialists.
	Additional equipment or specialists that are required.
	Whether there is a lack of equipment or specialists.
	Additional provisions required to ensure that equipment and specialists are available.
Availability of prospective technologies	Whether technologies under consideration are generally available and sufficiently demonstrated.
	Further field applications needed to demonstrate that the technologies could be used full-scale to treat the waste at the Site.
	When technology should be available for full-scale use.
	Whether more than one vendor will be available to provide a competitive bid.

Table 5-7
Remedial Alternative Cost Estimates
B.F. Goodrich Site RI/FS, Rialto, California

Alternative	Capital Cost	Annual O&M Cost[1]	NPV[3] of 15 year O&M cost	NPV[3] of 30 year O&M cost	Total NPV[2] - 15 years O&M	Total NPV[2] - 30 years O&M
1	$ 9,576,000	$ 1,179,000	$10,738,000	$14,630,000	$20,314,000	$24,206,000
2a	$ 13,138,000	$ 1,301,000	$11,849,000	$16,144,000	$24,987,000	$29,282,000
2b	$ 21,849,000	$ 1,505,000	$13,707,000	$18,676,000	$35,556,000	$40,525,000
3	$ 18,349,000	$ 1,487,000	$13,543,000	$18,452,000	$31,892,000	$36,801,000

[1]Annual O&M cost estimates (except Alt. 2b) assume a purveyor reimbursement rate of $75/acre-foot to offset the purveyor's avoided costs of producing the water. The actual rate may be different.
[2]Sum of Capital Cost and NPV of O&M
[3]NPV Calculations based on 7% discount rate

Table 5-8
Results of Qualitative Evaluation and Comparison of Remedial Alternatives
B.F. Goodrich Site RI/FS, Rialto, California

Alternative	Description	Protection of Human Health and Environment	Compliance with ARARs	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume (TMV) Through Treatment	Short-term Effectiveness	Implementability	Cost (millions)
No Action	No Action Alternative	**LOW** - Provides no protection to human health or the environment	**Not Applicable**	**LOW -** Achieves no additional containment.	**Not Applicable**	**Not Applicable**	**Not Applicable**	**$0**
1	Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply	**MODERATE** - Reduces short-term and long-term risks to human health and the environment by greatly reducing migration of contaminated groundwater in the regional aquifer. Overall protection is somewhat lower than other alternatives because of incomplete hydraulic containment during high water conditions allows some continued contaminant migration. Providing the treated water to a local purveyor helps offset the impacts of the contamination on existing water supply wells	**HIGH** - Would meet all ARARs.	**MODERATE** - Full containment during low and intermediate water level conditions, but partial containment during high water conditions. Minimal risk from treatment residuals.	**HIGH** - Meets preference for treatment and provides significant reduction of TMV	**HIGH** -There are no unmitigable risks to the community, workers, or the environment during construction and implementation.	**MODERATE to HIGH**- This alternative (and all of the others) is based on proven technologies. There are a number of administrative issues to be resolved, primarily associated with potable use of the treated water. This may slow remedy implementation.	Capital **$9.6** O&M **$1.2** NPV **$24.2**
2a	Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply	**HIGH** - Compared to Alternative 1, the complete hydraulic containment achieved during all expected groundwater conditions provides better overall protection of human health and the environment.	**HIGH** - Would meet all ARARs.	**HIGH** - Full containment during all expected groundwater conditions. Treatment residuals do not pose a significant risk.	**HIGH** - Meets preference for treatment and provides significant reduction of TMV	**HIGH** - Same as Alternative No. 1.	**MODERATE** - Similar to Alternative No. 1. However, the higher peak and average flow rates may pose greater administrative challenges.	Capital **$13.1** O&M **$1.3** NPV **$29.3**
2b	Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Re-inject the Treated Groundwater	**HIGH** - Similar to Alternative 2a. The non-potable end use may improve implementability of the alternative, but eliminate the benefit the treated water provides to local water purveyor(s).	**HIGH** - Would meet all ARARs.	**HIGH** - Same containment as Alternative 2a. Treatment residuals differ from Alternative 2a, but are not expected to result in significant risk.	**HIGH** - Meets preference for treatment and provides significant reduction of TMV	**HIGH** - Similar to Alternative No. 1, although increased pipeline construction slightly increases risks to the community during implementation.	**MODERATE** - Easier to implement than Alternative 2a because there is no potable end use. The significantly greater pipeline construction raises additional implementation challenges.	Capital **$21.8** O&M **$1.5** NPV **$40.5**
3	Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply	**HIGH** - Similar to Alternative 2a. The complete containment achieved during relatively extreme groundwater conditions, if they occur, provides an incremental benefit to overall protectiveness, but the higher cost and potential difficulties distributing the treated water during high water level conditions offset the increased protectiveness.	**HIGH** - Would meet all ARARs.	**HIGH** - Full containment during all modeled groundwater conditions, including extended periods of relatively extreme hydrologic conditions. Treatment residuals do not pose a significant risk.	**HIGH** - Meets preference for treatment and provides significant reduction of TMV	**HIGH** - Similar to Alternative 2b, although less pipeline needed and the treatment plant is considerably larger.	**MODERATE** - The higher peak and average flow rates and associated administrative issues make this alternative somewhat harder to implement than the others.	Capital **$18.3** O&M **$1.5** NPV **$36.8**

Cost is in millions of dollars
NPV = Net Present Value (based on 30 years of O&M and a 7% discount rate)

Figures

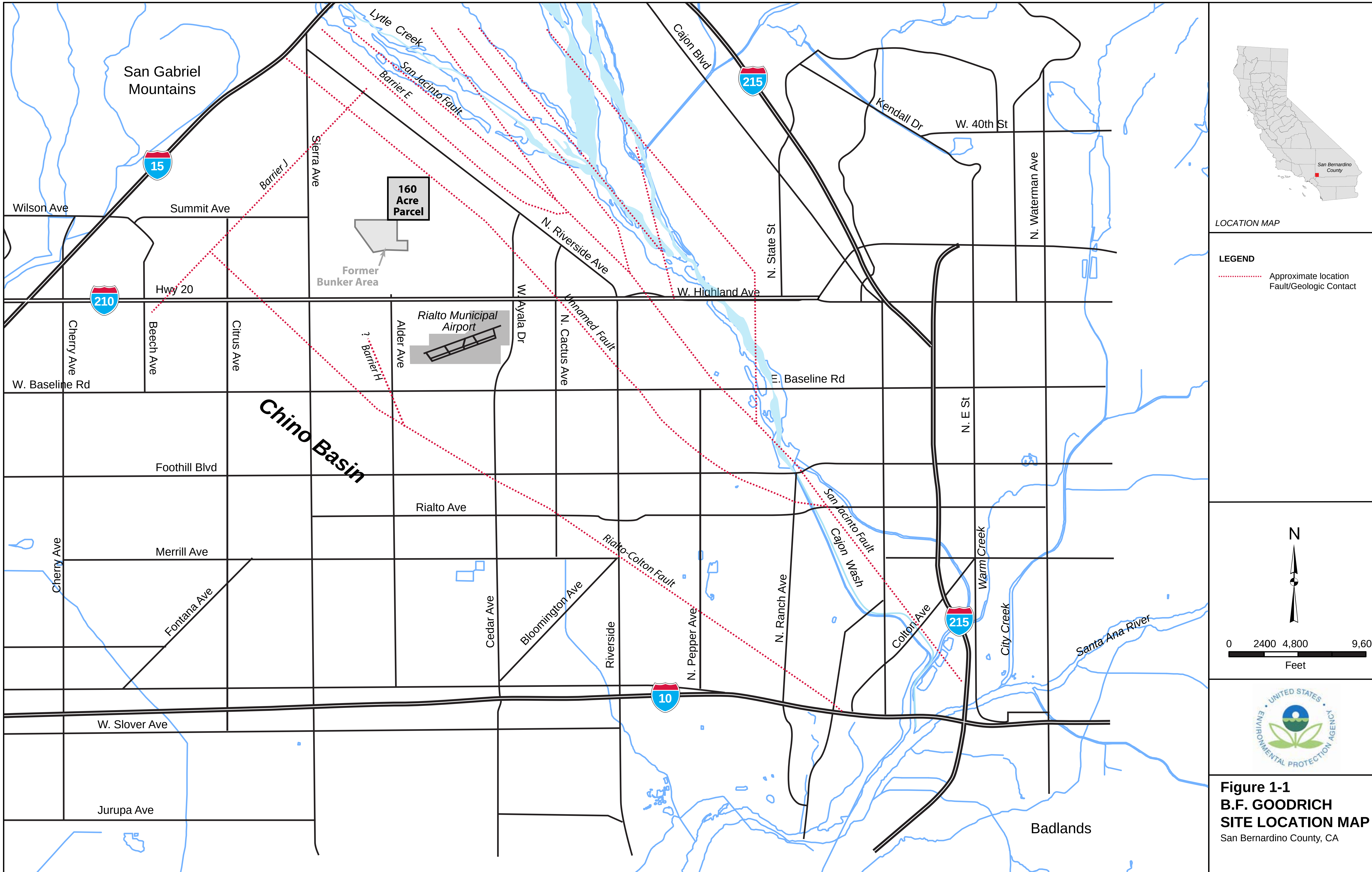


Figure 1-1
B.F. GOODRICH SITE LOCATION MAP
San Bernardino County, CA

ES062007006PHX_Rialto-Colton/Figure1-1_Site Map Location Map_rev6.ai (10/090)

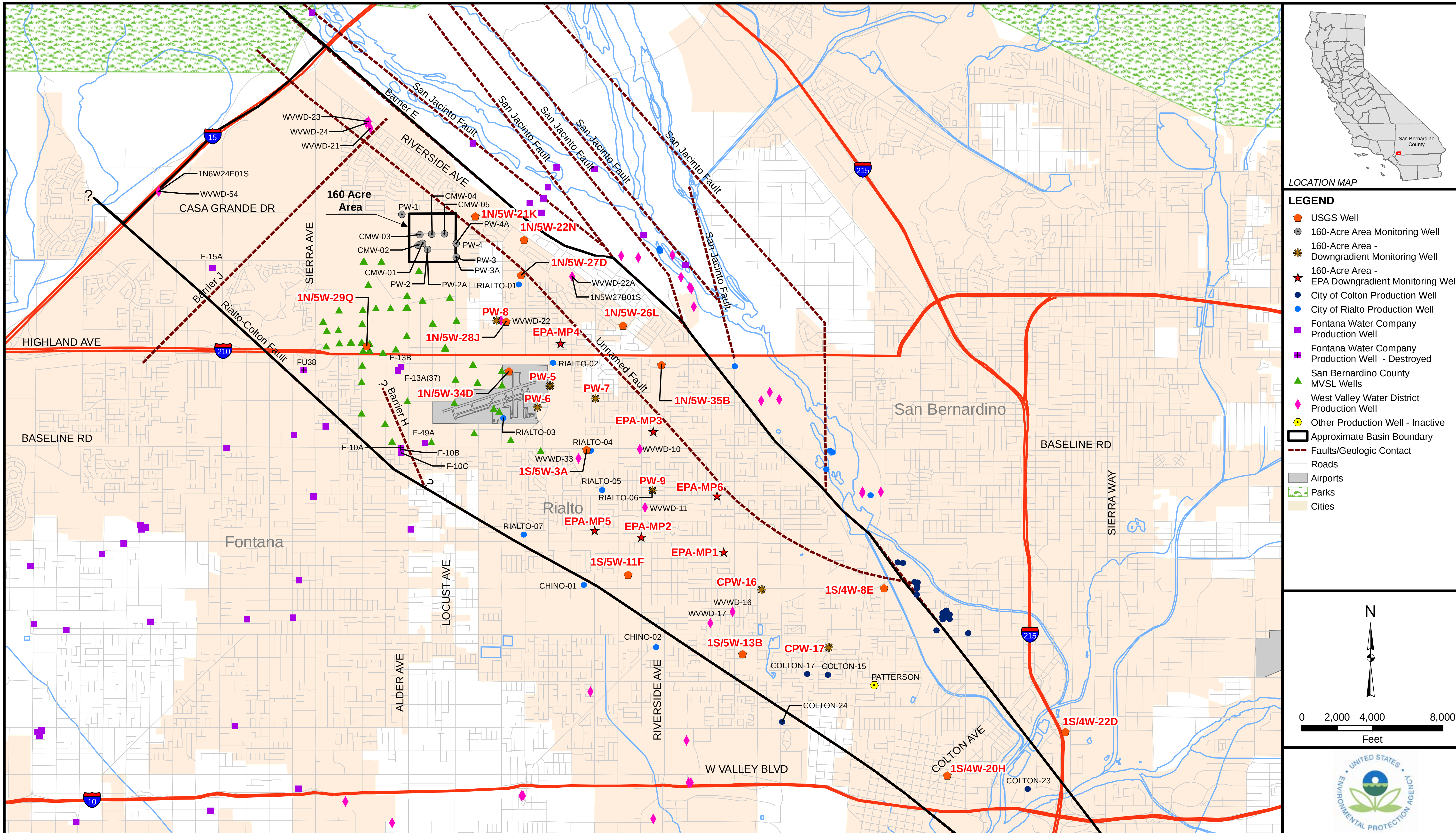


FIGURE 1-2
WELL LOCATION MAP
Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\CROSS_SECTION\FIGURE1-2_WELLSLOCATIONS_11X17.MXD CVONFREE 10/14/2009 15:59:53

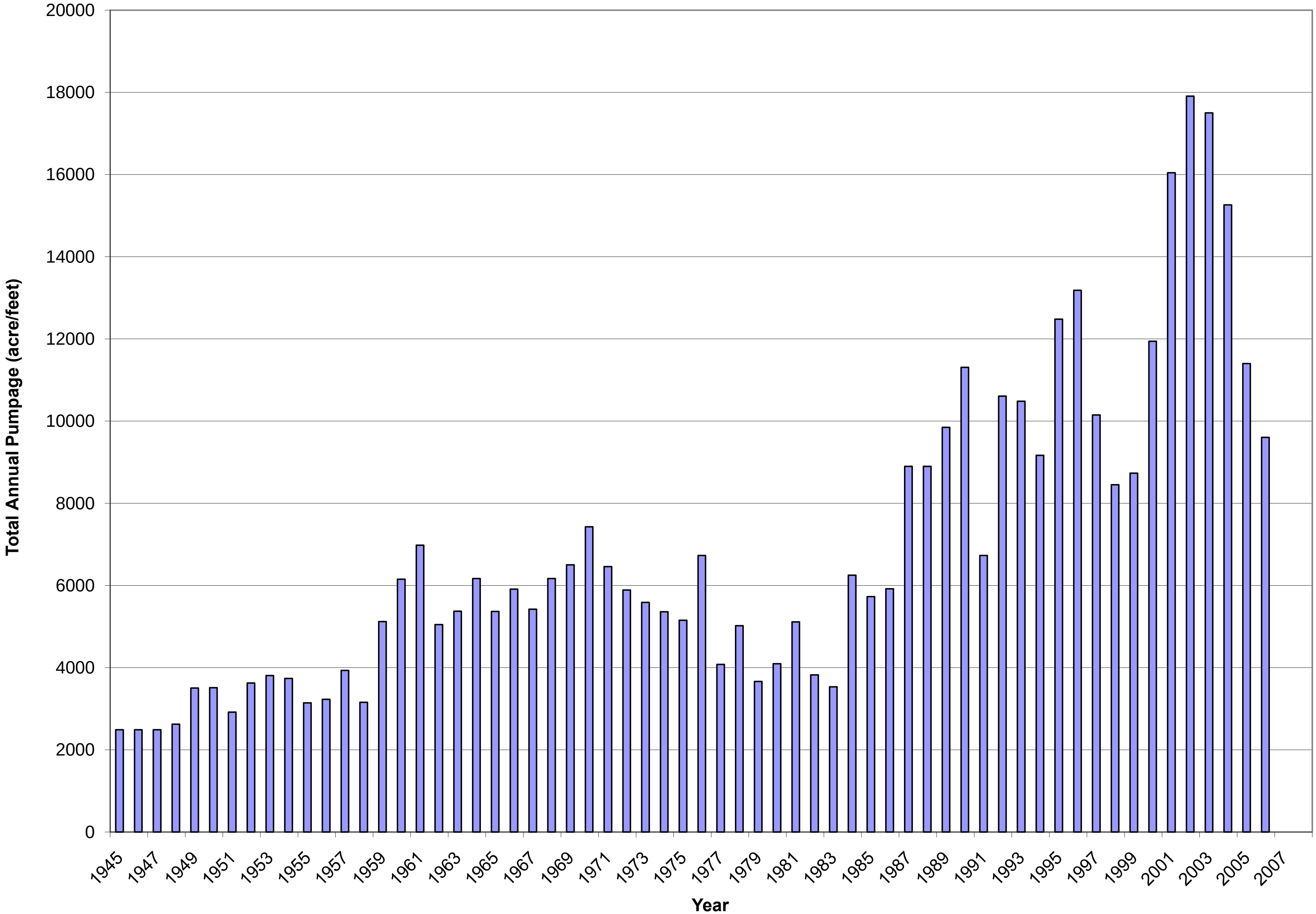


Figure 1-3
ANNUAL PUMPAGE
Rialto-Colton Basin - Portion Northwest of Colton Avenue

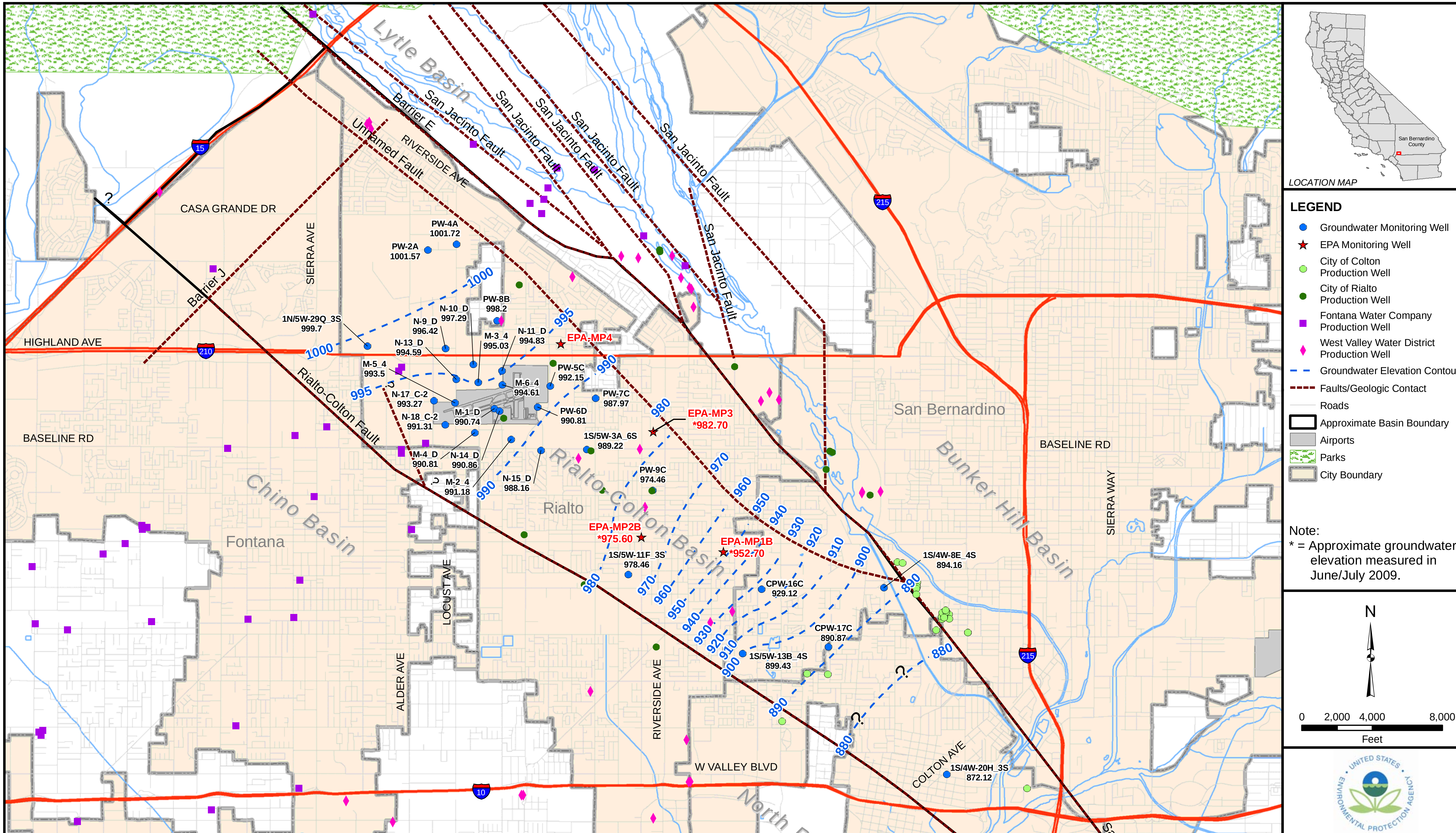
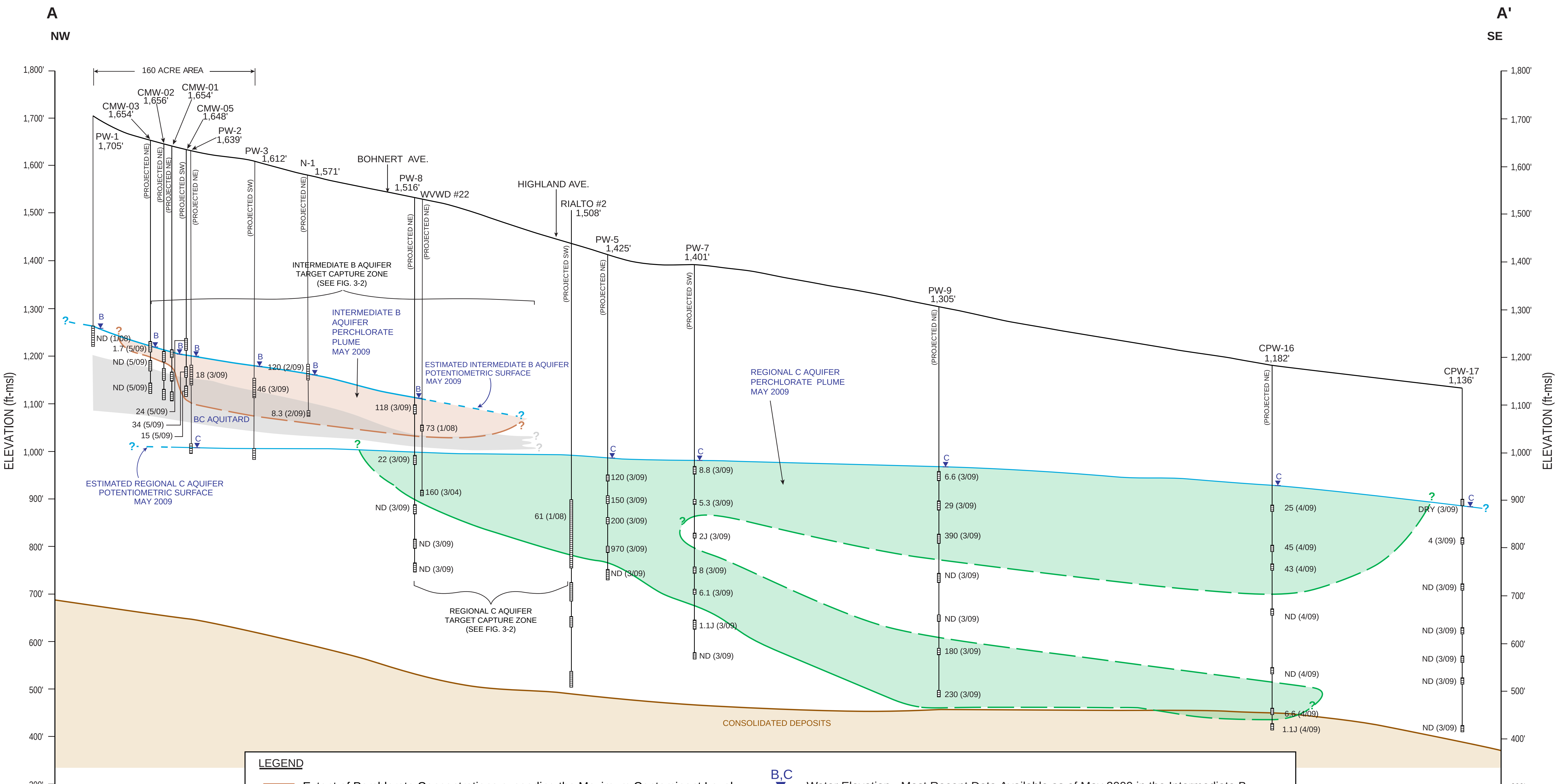


FIGURE 1-4
FEBRUARY-APRIL 2009 GROUNDWATER ELEVATION CONTOURS - REGIONAL AQUIFER

Rialto-Colton Basin
San Bernardino County, CA

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\GROUNDWATER_ELEVATION\FIGURE1-4_2009_GWE.MXD CVONFREE 8/4/2009 17:05:05



LEGEND

- Extent of Perchlorate Concentrations exceeding the Maximum Contaminant Level (6 ug/L) in the Intermediate B Aquifer; dashed and queried where not certain
- Extent of Perchlorate Concentrations exceeding the Maximum Contaminant Level (6 ug/L) in the Regional C Aquifer; dashed and queried where not certain
- ND Not Detected
- B,C Water Elevation - Most Recent Data Available as of May 2009 in the Intermediate B or Regional C Aquifer as noted; dashed and queried where not certain
- 29 (3/09) Perchlorate Concentration in ug/L and (month/year sampled) - Most Recent Data Available as of May 2009
- Approximate Extent of BC Aquitard
- Consolidated Deposits

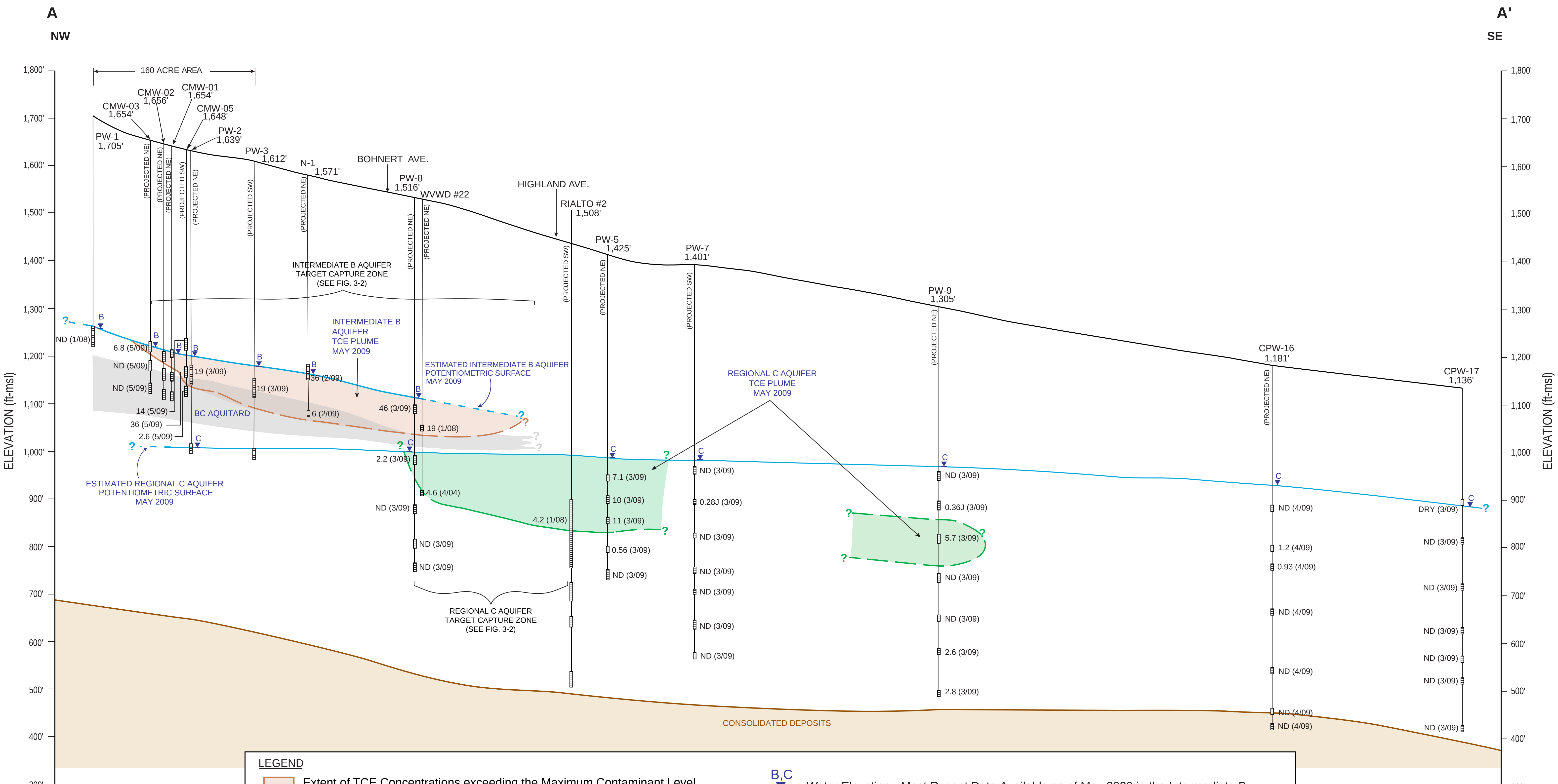
Notes: Consolidated Deposits based on interpretation by the USGS (2001) and referenced by DPRA (2008).
ft-msl = feet above mean sea level
J = estimated concentrations
ug/L = micrograms per liter

SCALE:
1" = 2,400' Horizontal
1" = 200' Vertical
12:1 Vertical Exaggeration

0 2,400
Approximate scale in feet

FIGURE 1-5
160 - ACRE AREA PERCHLORATE PLUME CROSS-SECTION RIALTO-COLTON BASIN

CH2MHILL



LEGEND

- Extent of TCE Concentrations exceeding the Maximum Contaminant Level (5 ug/L) in the Intermediate B Aquifer; dashed and queried where not certain
- Extent of TCE Concentrations exceeding the Maximum Contaminant Level (5 ug/L) in the Regional C Aquifer; dashed and queried where not certain
- ND Not Detected
- B,C Water Elevation - Most Recent Data Available as of May 2009 in the Intermediate B or Regional C Aquifer as noted; dashed and queried where not certain
- 19 (3/09) TCE Concentration in ug/L and (month/year sampled) - Most Recent Data Available as of May 2009
- Approximate Extent of BC Aquitard
- Consolidated Deposits

Notes: Consolidated Deposits based on interpretation by the USGS (2001) and referenced by DPRA (2008).
ft-msl = feet above mean sea level
J = estimated concentrations
ug/L = micrograms per liter
TCE = trichloroethene

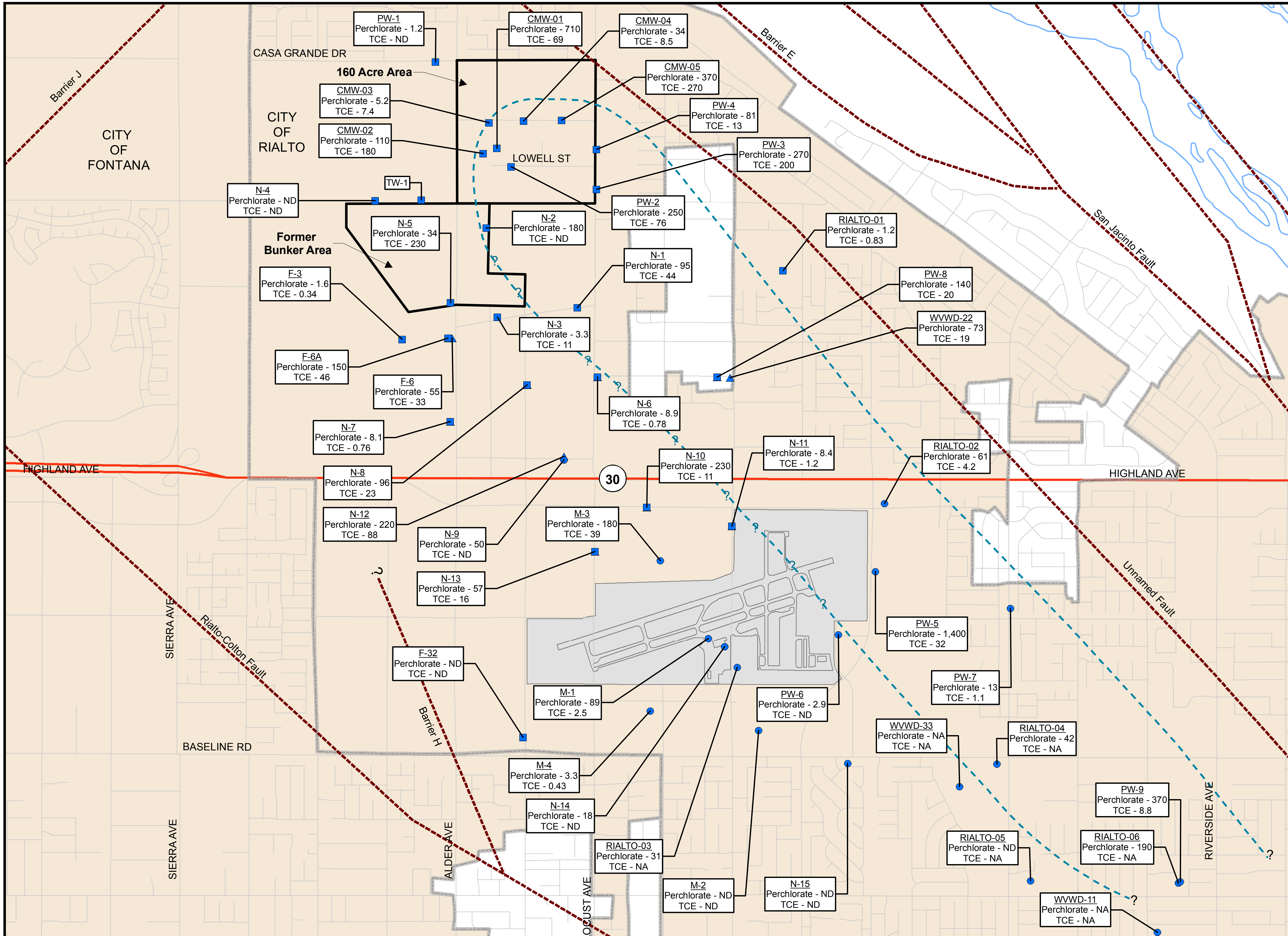
SCALE:
1“ = 2,400’ Horizontal
1” = 200’ Vertical
12:1 Vertical Exaggeration

0 2,400
Approximate scale in feet

FIGURE 1-6
160 - ACRE AREA
TCE PLUME
CROSS-SECTION
RIALTO-COLTON BASIN

CH2MHILL

SCO385219.FS.01 rialto_colton_cross_section_tce_v4.ai 1/10



LEGEND

- Regional Aquifer Wells
- Intermediate Aquifer Wells
- Intermediate/Regional Aquifer Wells
- Approximate Extent of B.F. Goodrich Site TCE/Perchlorate Contamination Above MCLs (Dashed Where Uncertain)
- Fault/Geologic Contact
- 160 Acre Area
- Former Bunker Area
- Freeways
- Water
- Airports
- Cities

Notes:
1. The Perchlorate and TCE values shown represent the maximum concentrations detected at that location during 2007/2008.
2. Perchlorate MCL = 6 µg/L
3. TCE MCL = 5 µg/L
4. NA = Not Available
5. ND = Non-detect

N

0 1,000 2,000

Feet

FIGURE 1-7
B.F. GOODRICH SITE APPROXIMATE EXTENT OF TCE AND PERCHLORATE CONTAMINATION

Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE1-7_160ACRE_PARCEL_TCE_PERCHLORATE.MXD CVONFREE 1/20/2010 15:50:54

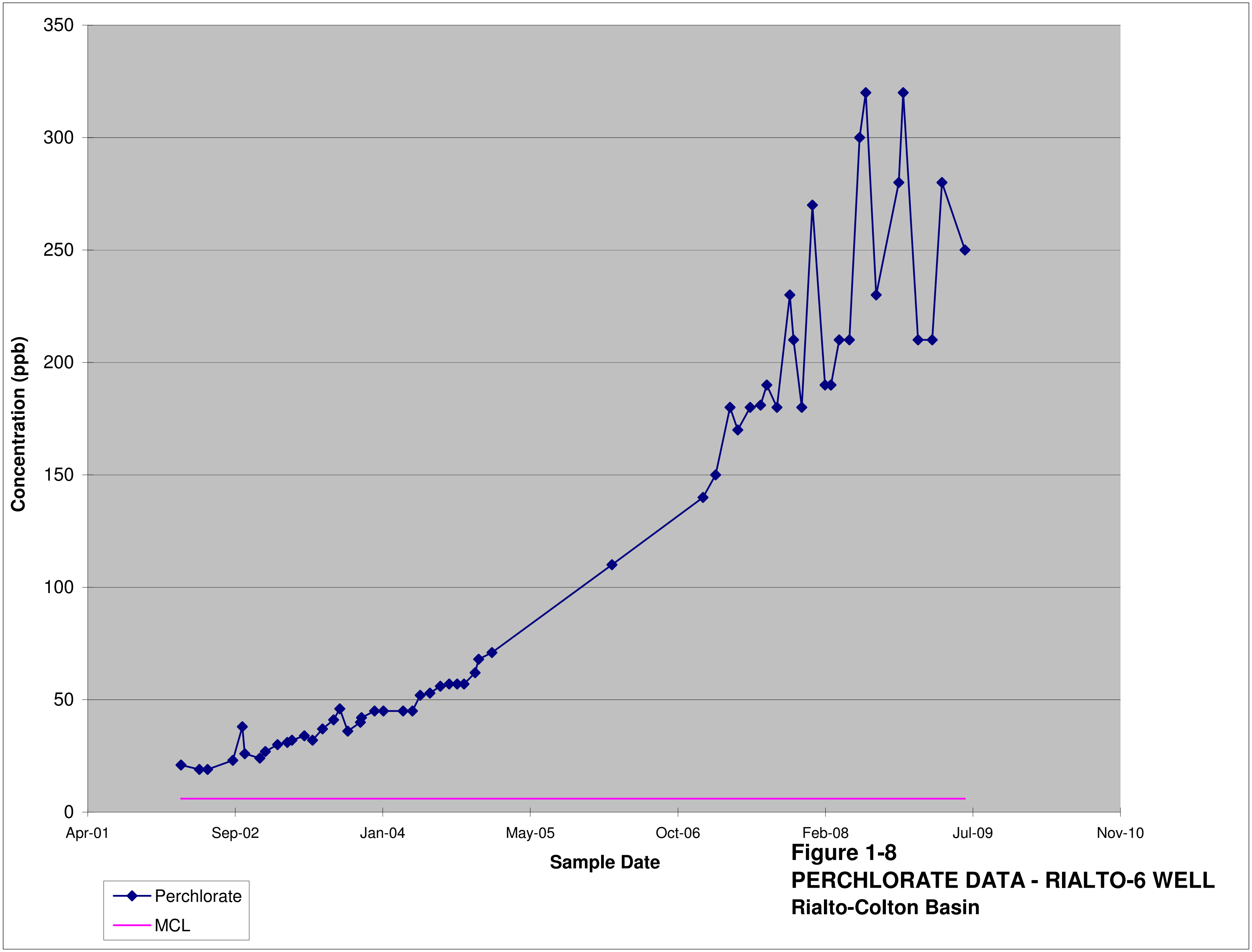
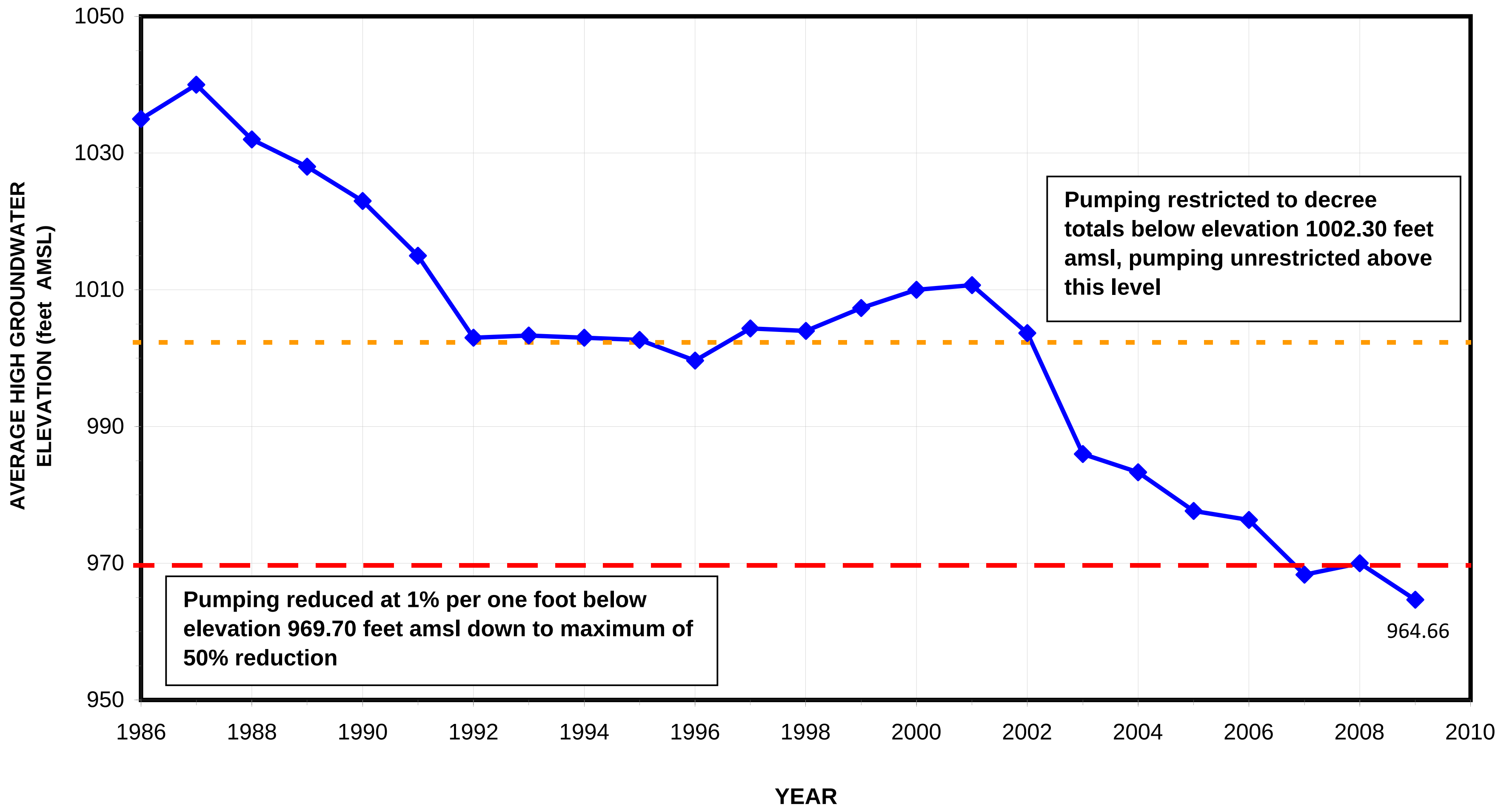


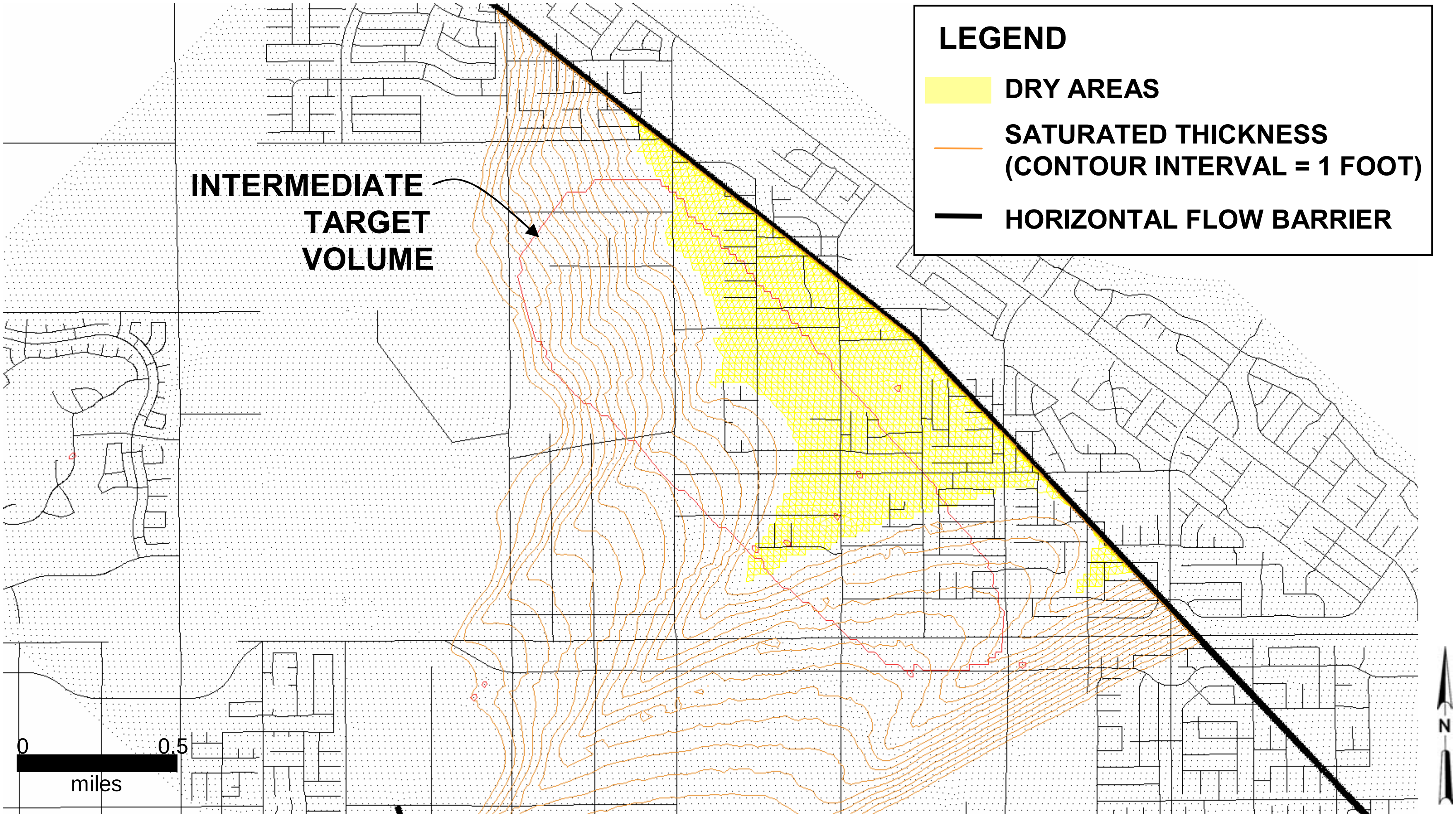
Figure 1-8
PERCHLORATE DATA - RIALTO-6 WELL
Rialto-Colton Basin



SOURCE: AQUI-VER, INC. Hydrogeology, Water Resources and Data Services, 2009
All data from San Bernardino Valley Municipal Water District. 2009 data not final, value plotted is draft from SBVMWD.

Figure 2-1
AVERAGE OF SPRING - HIGH GROUNDWATER ELEVATION IN RIALTO-COLTON BASIN INDEX WELLS

FIGURE 3-1
SATURATED THICKNESS OF INTERMEDIATE AQUIFER – 2004 CONDITIONS
RIALTO-COLTON BASIN



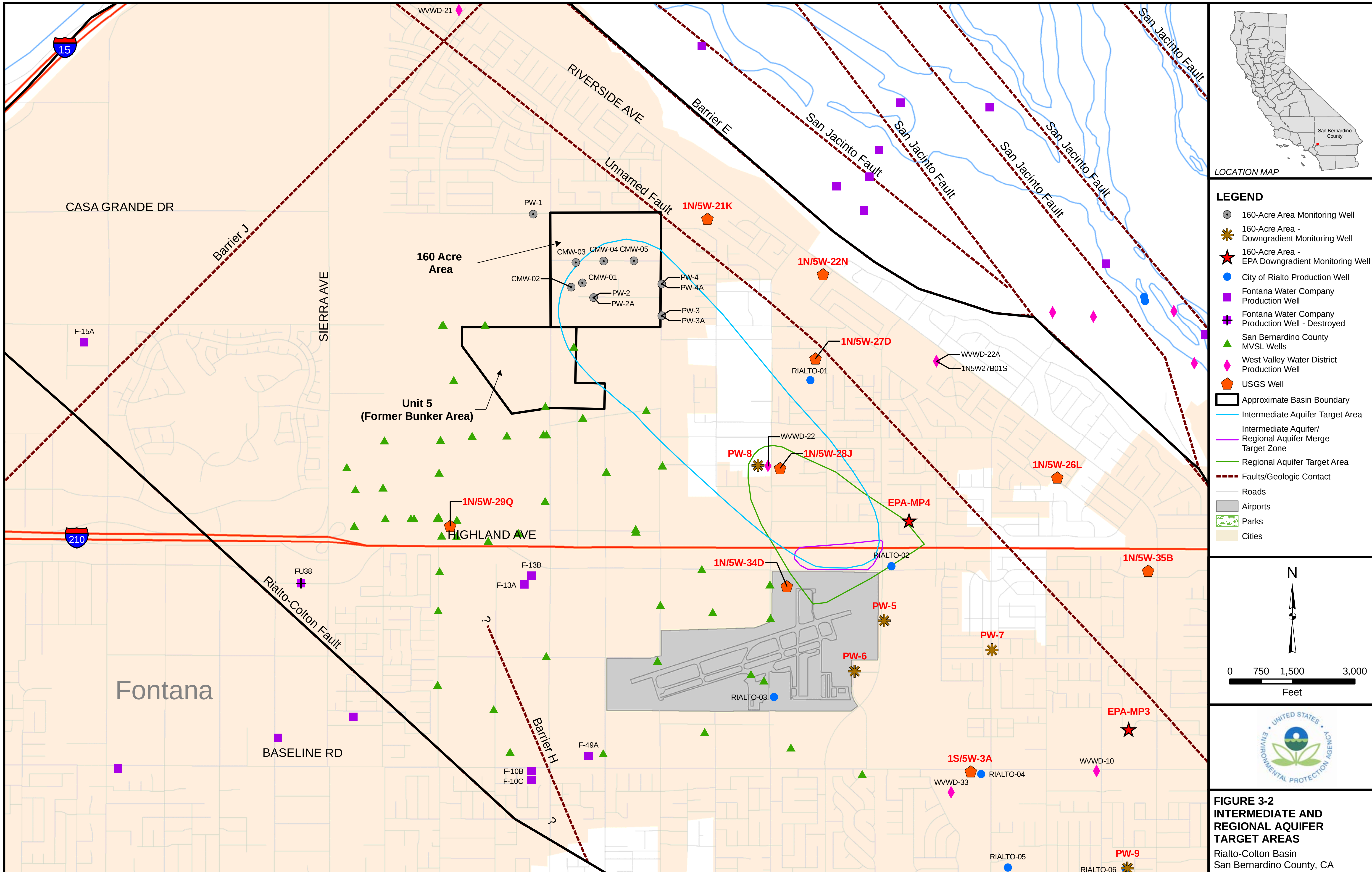


FIGURE 3-2
INTERMEDIATE AND REGIONAL AQUIFER TARGET AREAS
Rialto-Colton Basin
San Bernardino County, CA

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\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE3-2_TARGETAREAS.MXD CVONFREE 8/4/2009 17:11:33

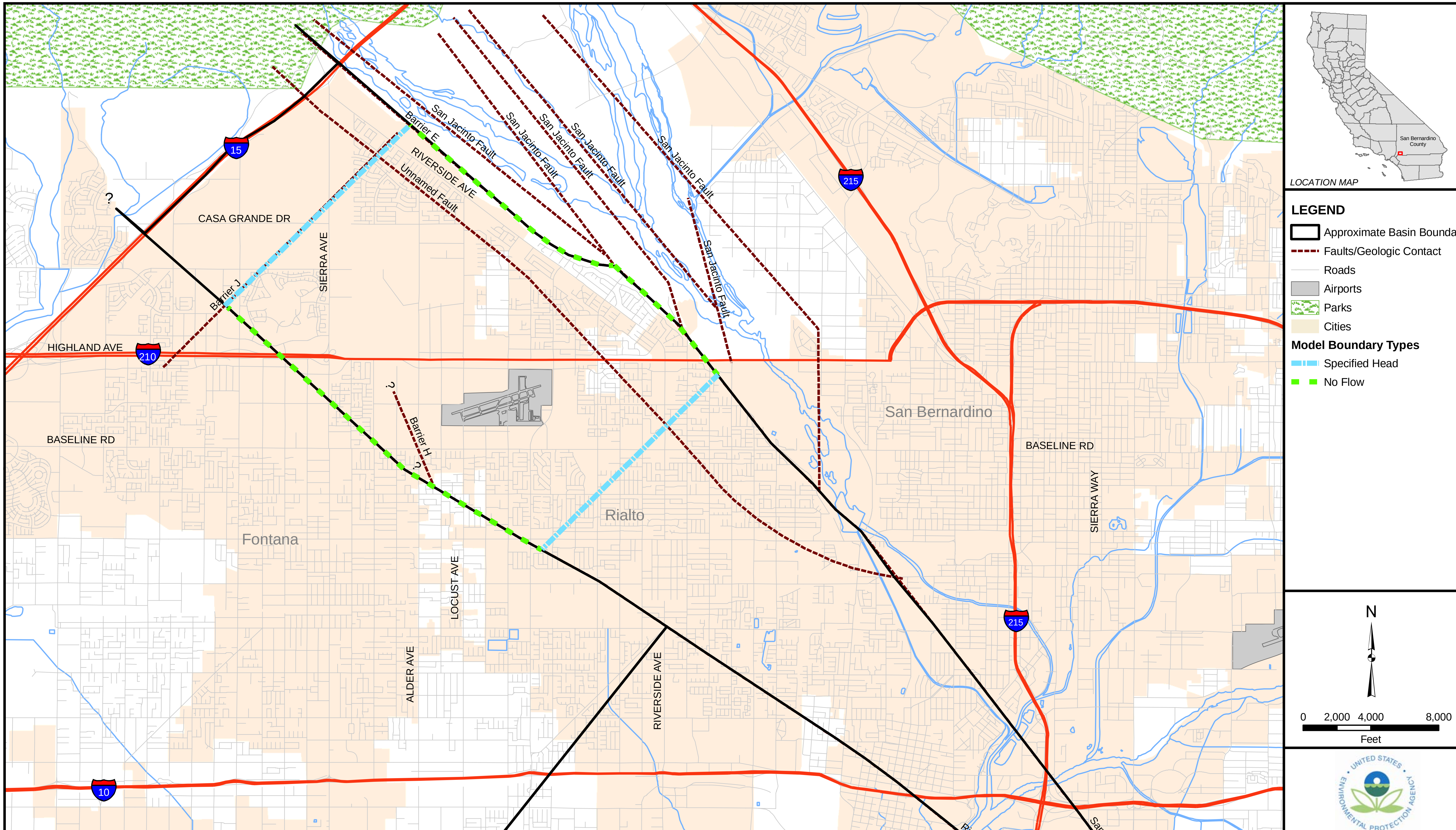


FIGURE 3-3
GROUNDWATER FLOW MODEL BOUNDARIES

Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE3-3_MODELBOUNDARIES.MXD TWONG2 7/28/2009 16:37:13

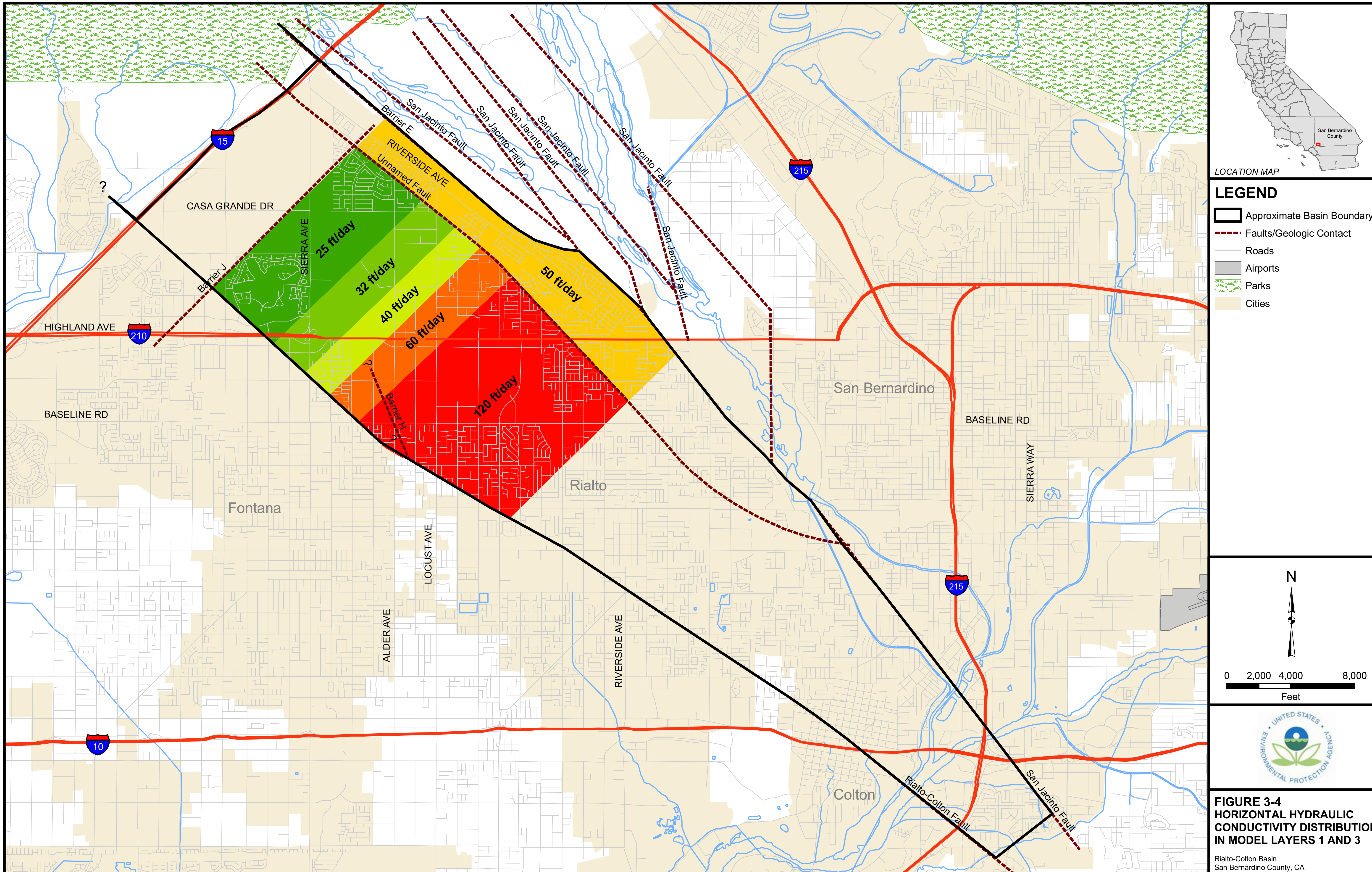


FIGURE 3-4
HORIZONTAL HYDRAULIC CONDUCTIVITY DISTRIBUTION IN MODEL LAYERS 1 AND 3

Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\120308\FIGURE1.X1_MODELBOUNDARIES1&3.MXD CVF 12/4/2008 09:27:43

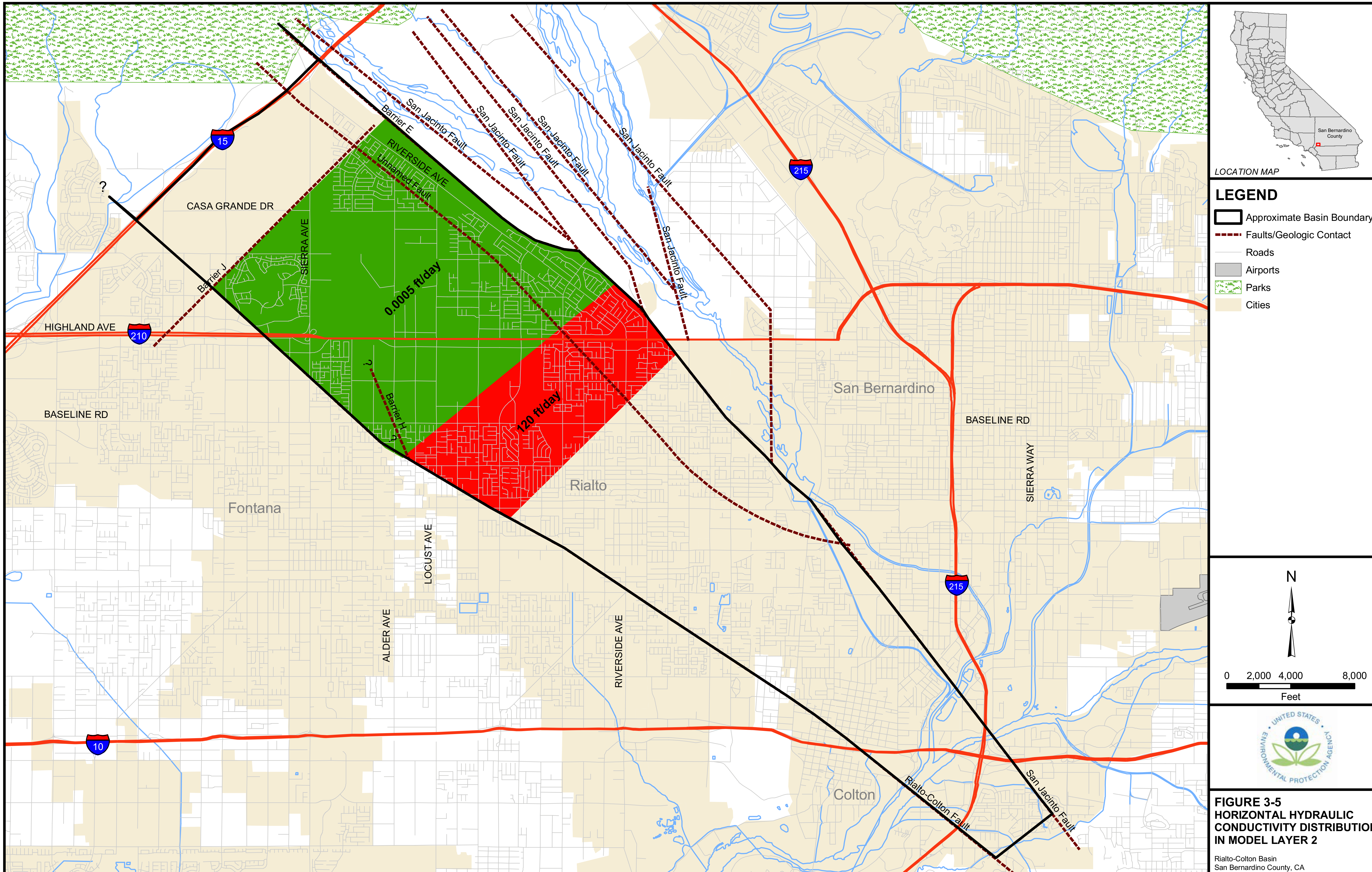


FIGURE 3-5
HORIZONTAL HYDRAULIC CONDUCTIVITY DISTRIBUTION IN MODEL LAYER 2

Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\120308\FIGURE1.X2_MODELBOUNDARY2.MXD CVF 12/4/2008 09:31:56

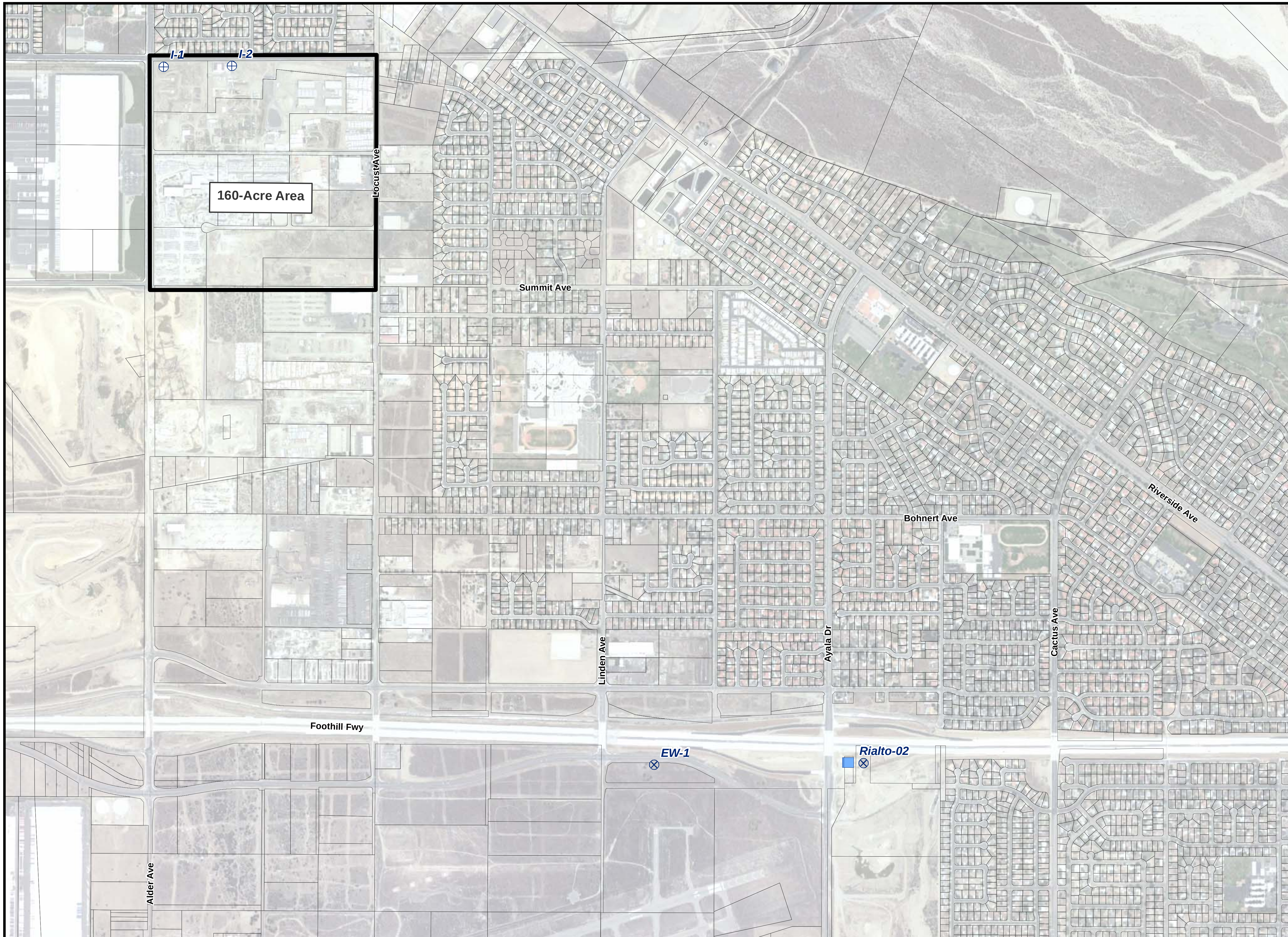
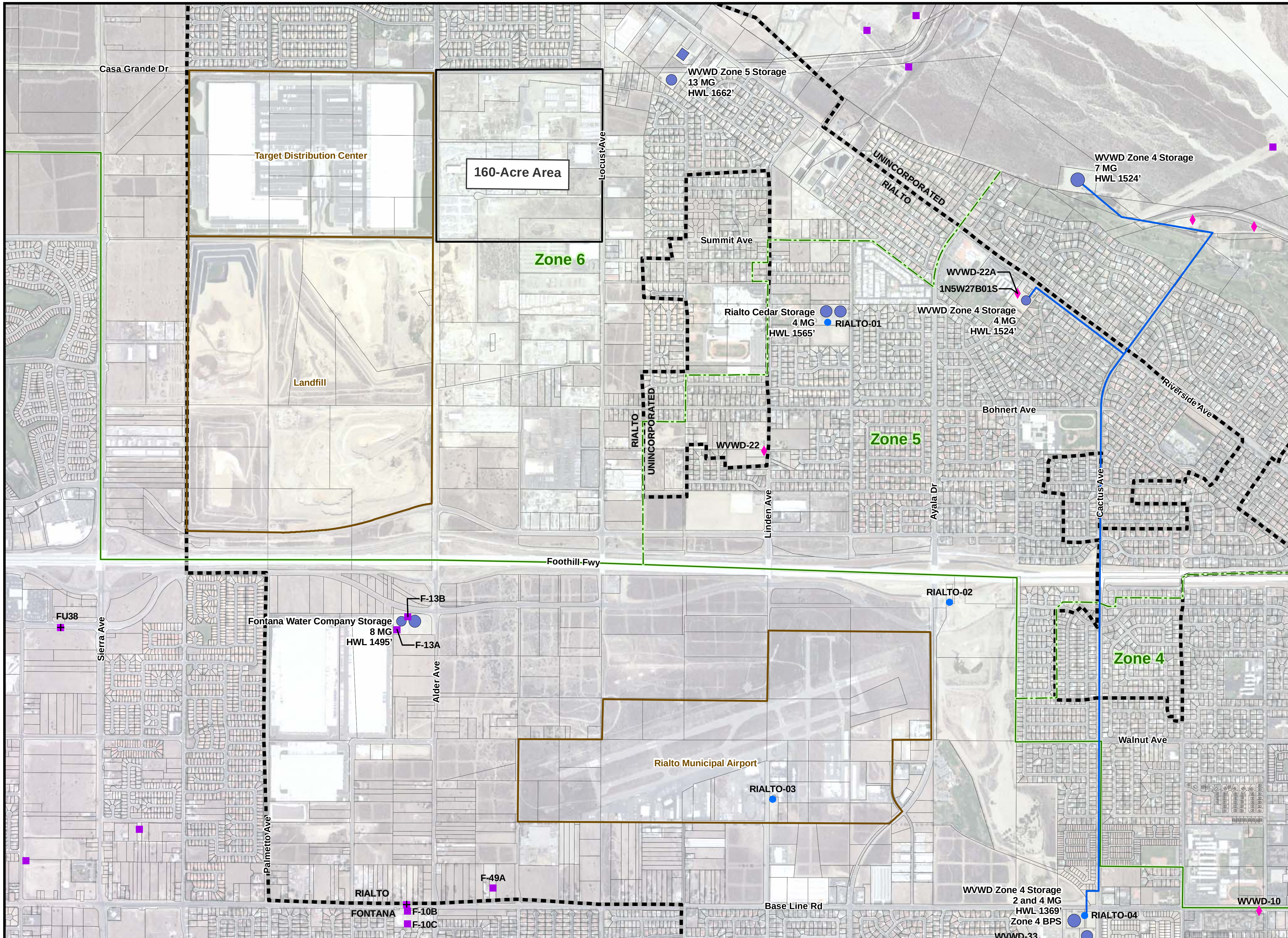


FIGURE 3-6
POTENTIAL LOCATIONS FOR INJECTION AND EXTRACTION WELLS AND TREATMENT FACILITIES
Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE3-6_WELLSANDTREATLOCS.MXD CVONFREE 10/14/2009 14:38:44

Image Source: Google Earth, 2008



LEGEND

- City of Rialto Production Well
- Fontana Water Company Production Well
- Fontana Water Company Production Well - Destroyed
- West Valley Water District Production Well
- Existing Zone 4 Pipeline Varies 16-24 Inch
- City Boundary
- Storage Tank
- Assessor's Parcel
- 160 Acre Area

West Valley Water District

- Pressure Zone (Labeled)
- Service Boundary

Notes:
1. HWL – high water level
2. MG – million gallons

N

0 500 1,000 2,000
Feet

FIGURE 3-7
EXISTING WATER DISTRIBUTION SYSTEM FEATURES

Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE3-7_PROJLOCMAP.MXD CVONFREE 8/4/2009 17:19:40

Image Source: Google Earth, 2008

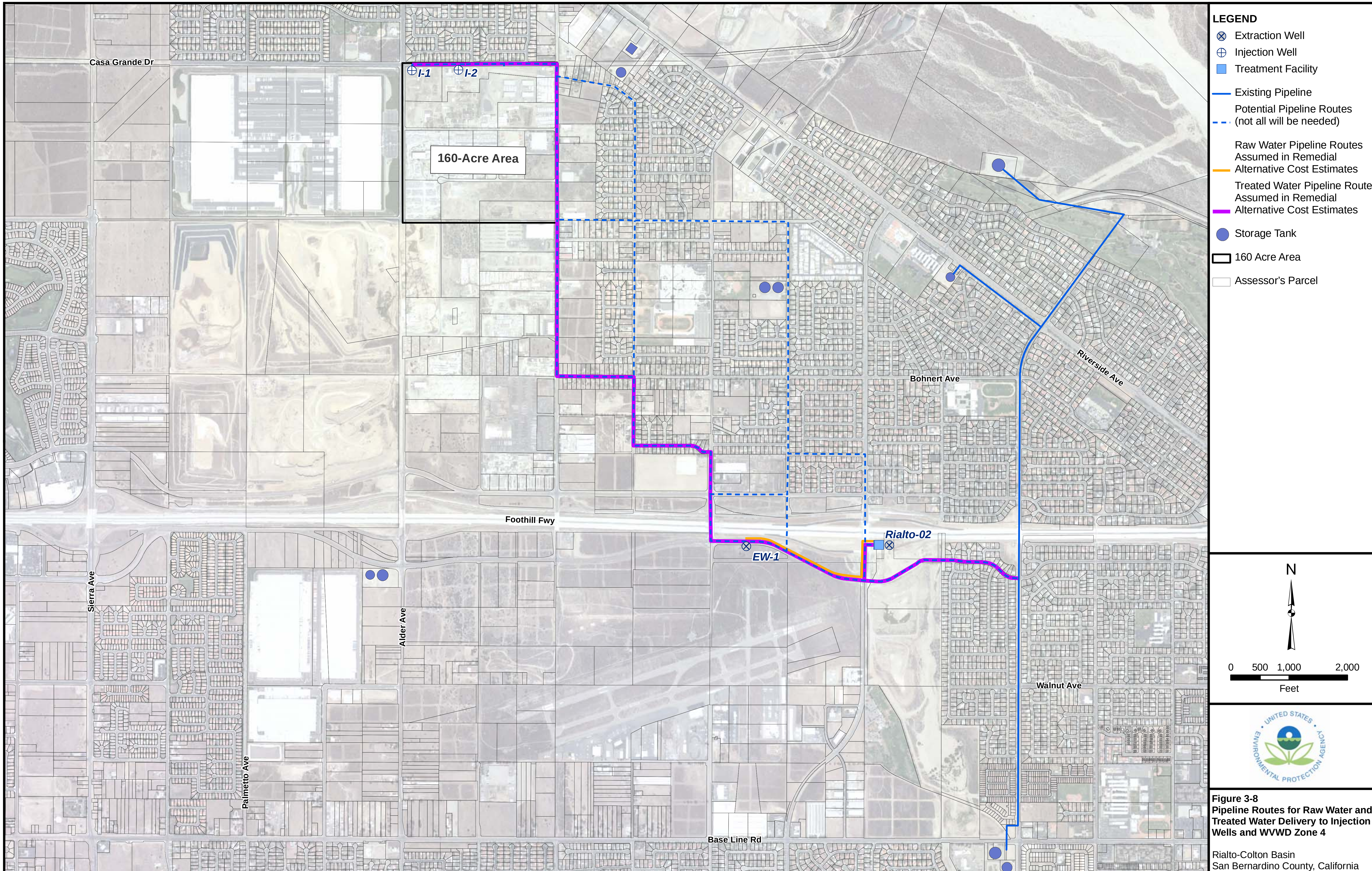


Figure 3-8
Pipeline Routes for Raw Water and Treated Water Delivery to Injection Wells and WVWD Zone 4

Rialto-Colton Basin
San Bernardino County, California

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\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE3-8_CANDPIPEROUTES.MXD CVONFREE 10/14/2009 14:39:40

Image Source: Google Earth, 2008

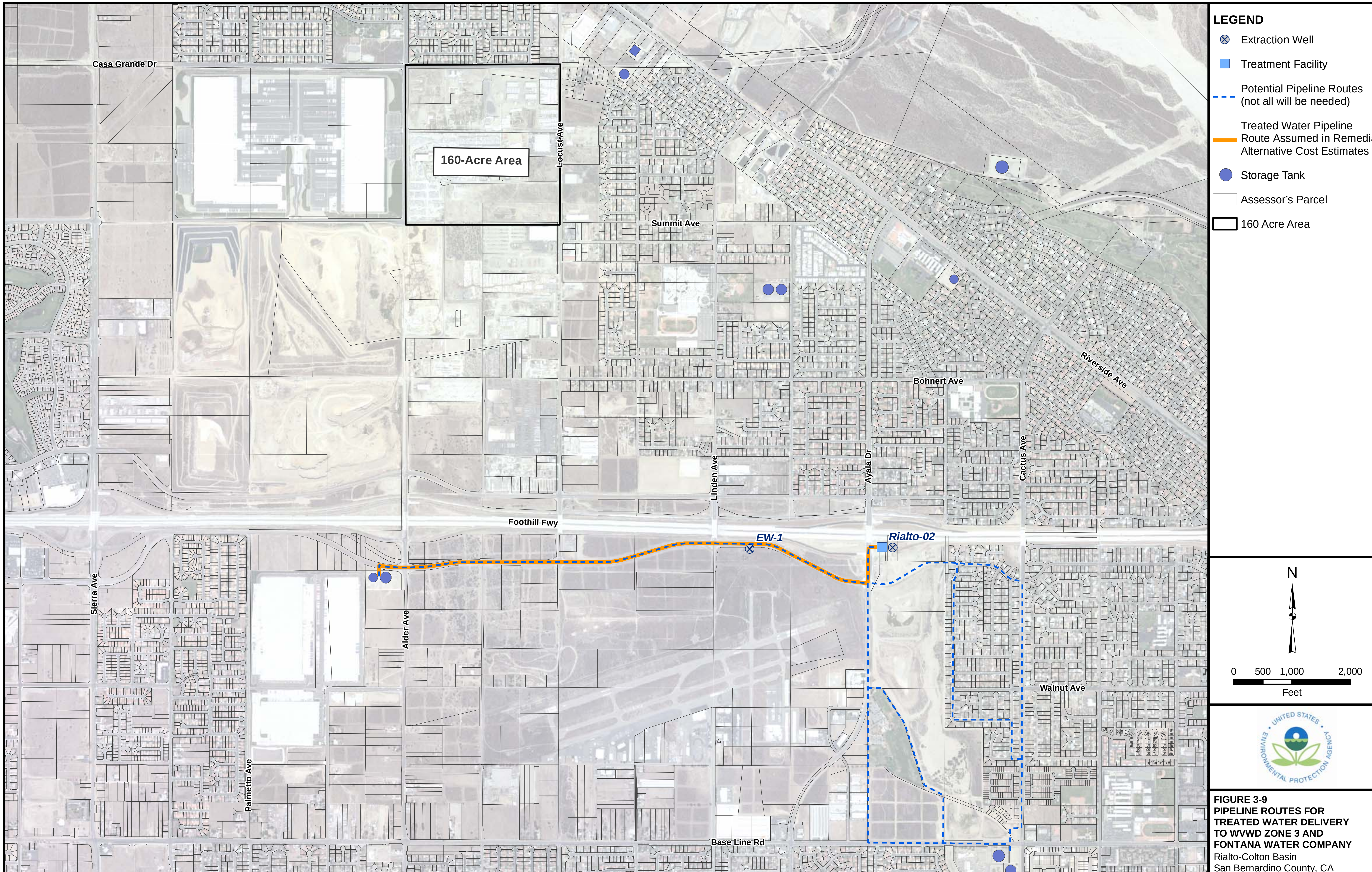
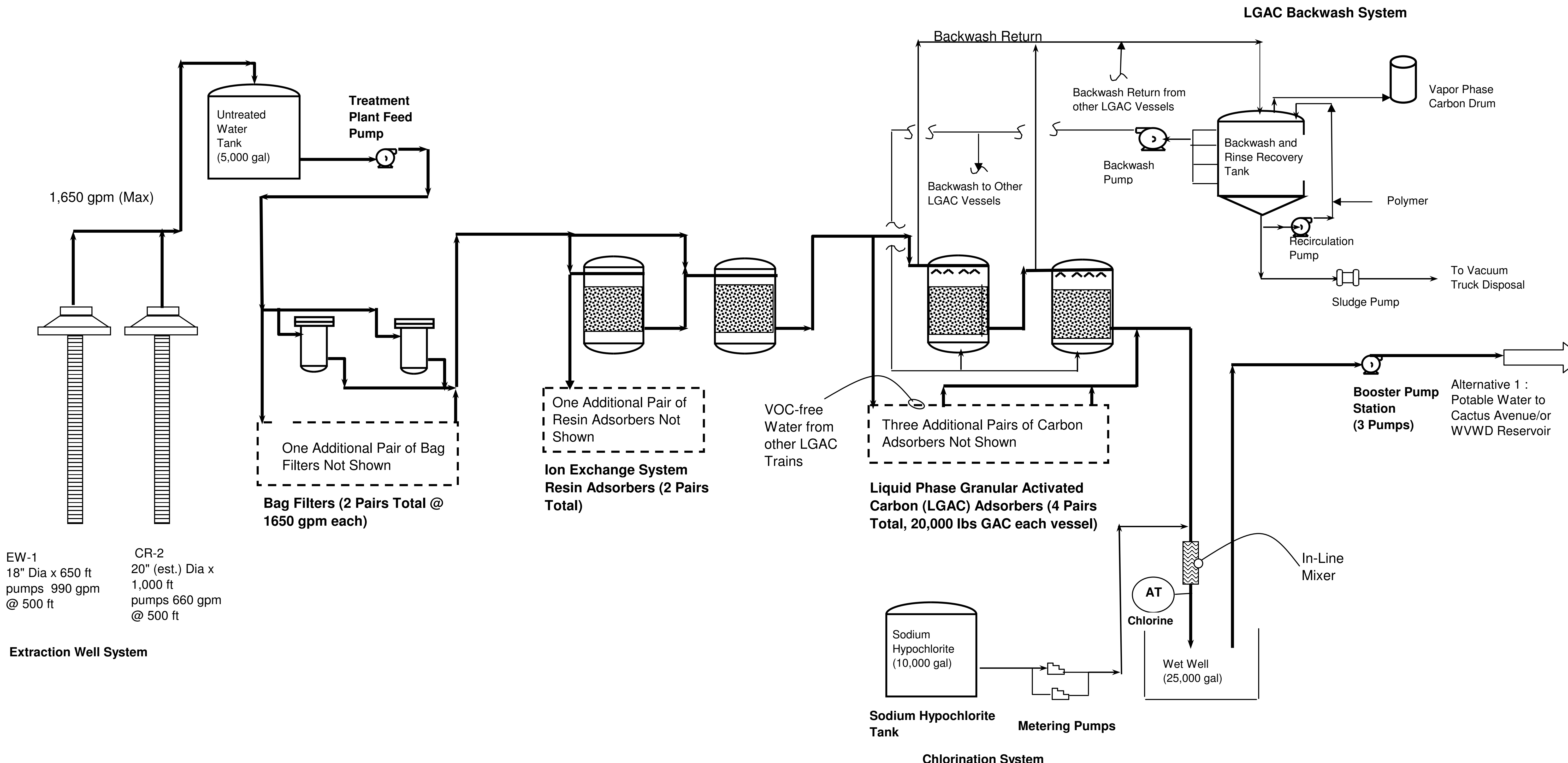


FIGURE 3-9
PIPELINE ROUTES FOR TREATED WATER DELIVERY TO WVWD ZONE 3 AND FONTANA WATER COMPANY
Rialto-Colton Basin
San Bernardino County, CA

CH2MHILL

\\MADISON\GROUPS\EMS\GIS_LIBRARY\RIALTO-COLTON\MAPFILES\REPORT_MAPFILES\072709\FIGURE3-9_ALTERDELIV.MXD TWONG2 7/27/2009 17:06:04

Image Source: Google Earth, 2008



Contaminant	Design	Average
Perchlorate (ug/l)	360	80
TCE (ug/l)	48	8
Flow Rate (gpm)	1,650	1500

Notes:
1. All treatment process equipment to be contained in lined secondary containment.
2. Most instrumentation, valves, and ancillary process piping not shown for clarity.
3. AT = analyzer/transmitter

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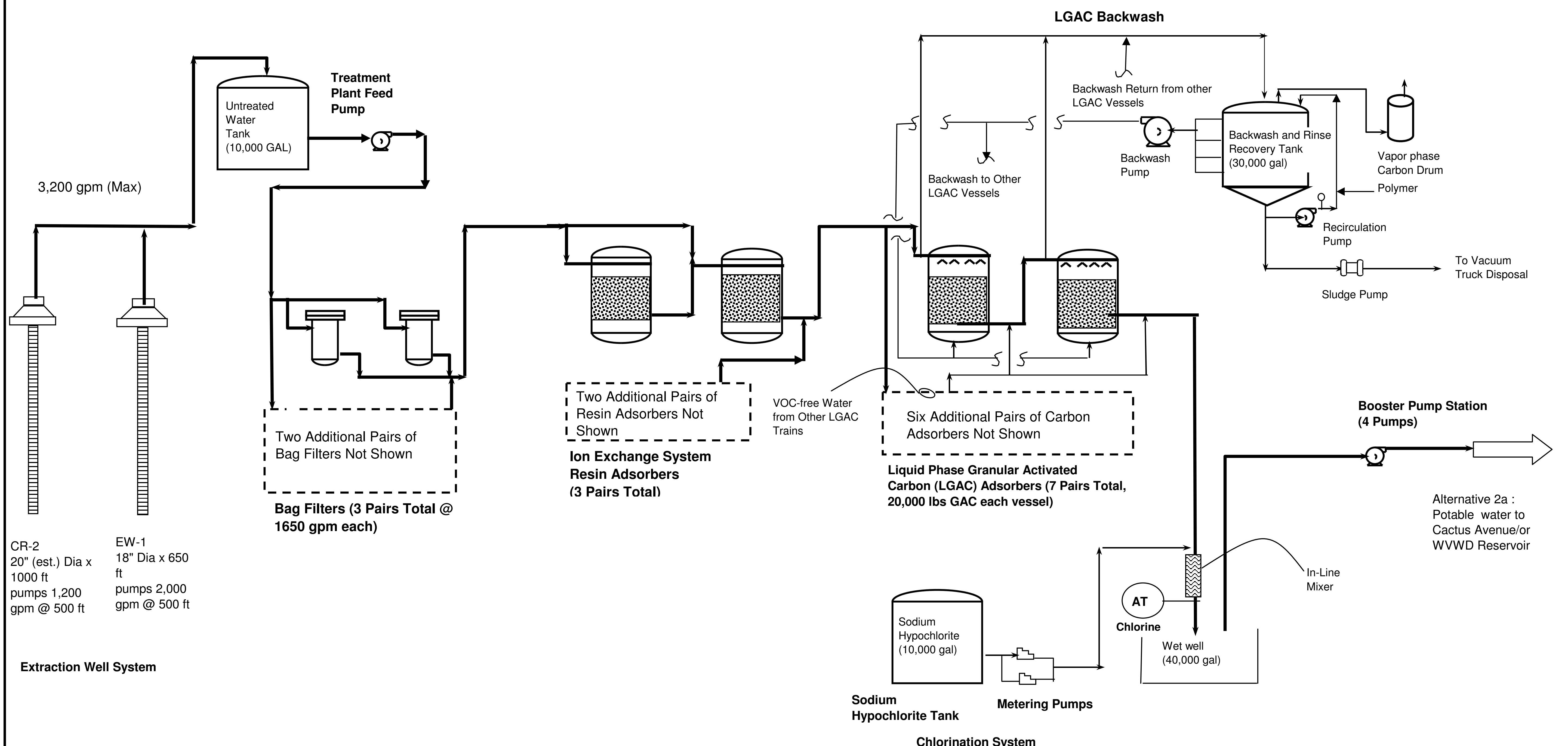
Figure 4-1
Alternative 1
Preliminary Process Flow Diagram
Ion Exchange and Liquid Phase GAC
B.F. Goodrich Site RI/FS Report



Contaminant	Design	Average
Perchlorate (ug/l)	360	80
TCE (ug/l)	48	8
Flow Rate (gpm)	3,200	1840

Notes:
1. All treatment process equipment to be contained in lined secondary containment.
2. Most instrumentation, valves, and ancillary process piping not shown for clarity.
3. AT = analyzer/transmitter

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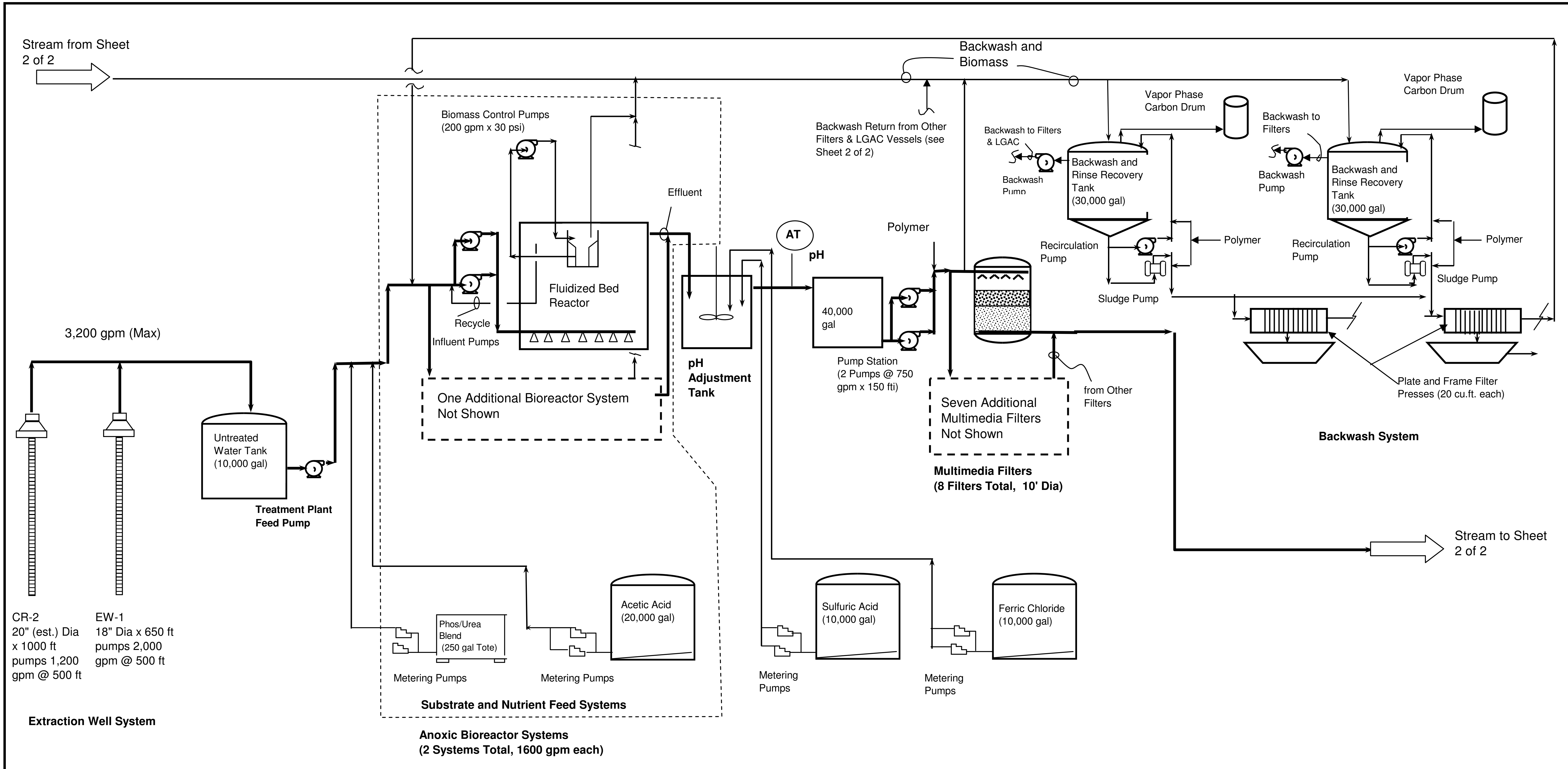
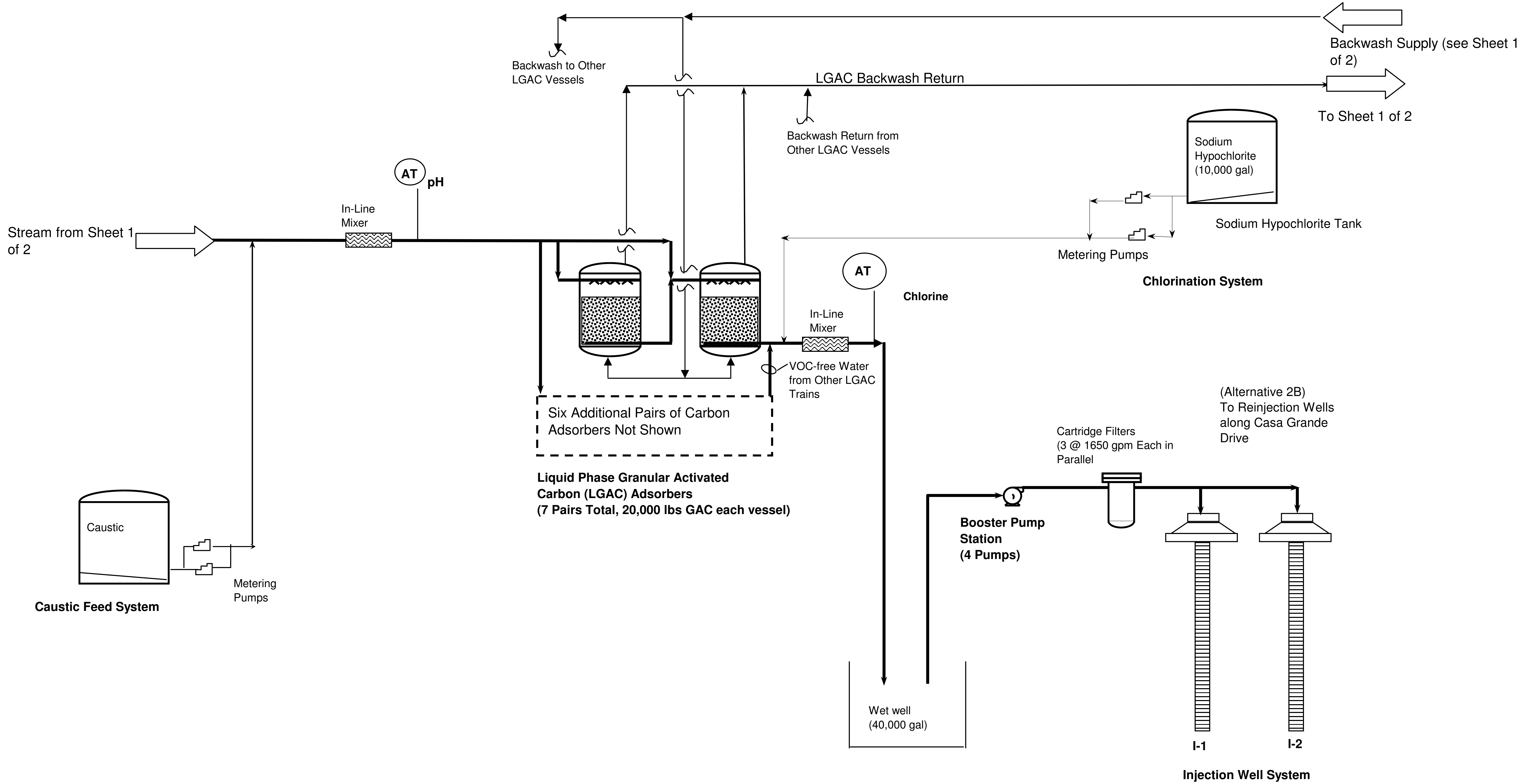
Figure 4-2
Alternative 2a
Preliminary Process Flow Diagram
Ion Exchange and Liquid Phase GAC

B.F. Goodrich Site RI/FS Report



Contaminant	Design	Average
Perchlorate (ug/l)	360	80
TCE (ug/l)	48	8
Flow Rate (gpm)	3,200	1,840

Figure 4-3 (sheet 1 of 2)
Alternative 2b
Preliminary Process Flow Diagram
Anoxic Bioreactor and Liquid Phase GAC
B.F. Goodrich Site RI/FS Report



Contaminant	Design	Average
Perchlorate (ug/l)	360	80
TCE (ug/l)	48	8
Flow Rate (gpm)	3,200	1840

Notes:
1. All treatment process equipment to be contained in lined secondary containment.
2. Most instrumentation, valves, and ancillary process piping not shown for clarity.
3. AT = analvzer/transmitter

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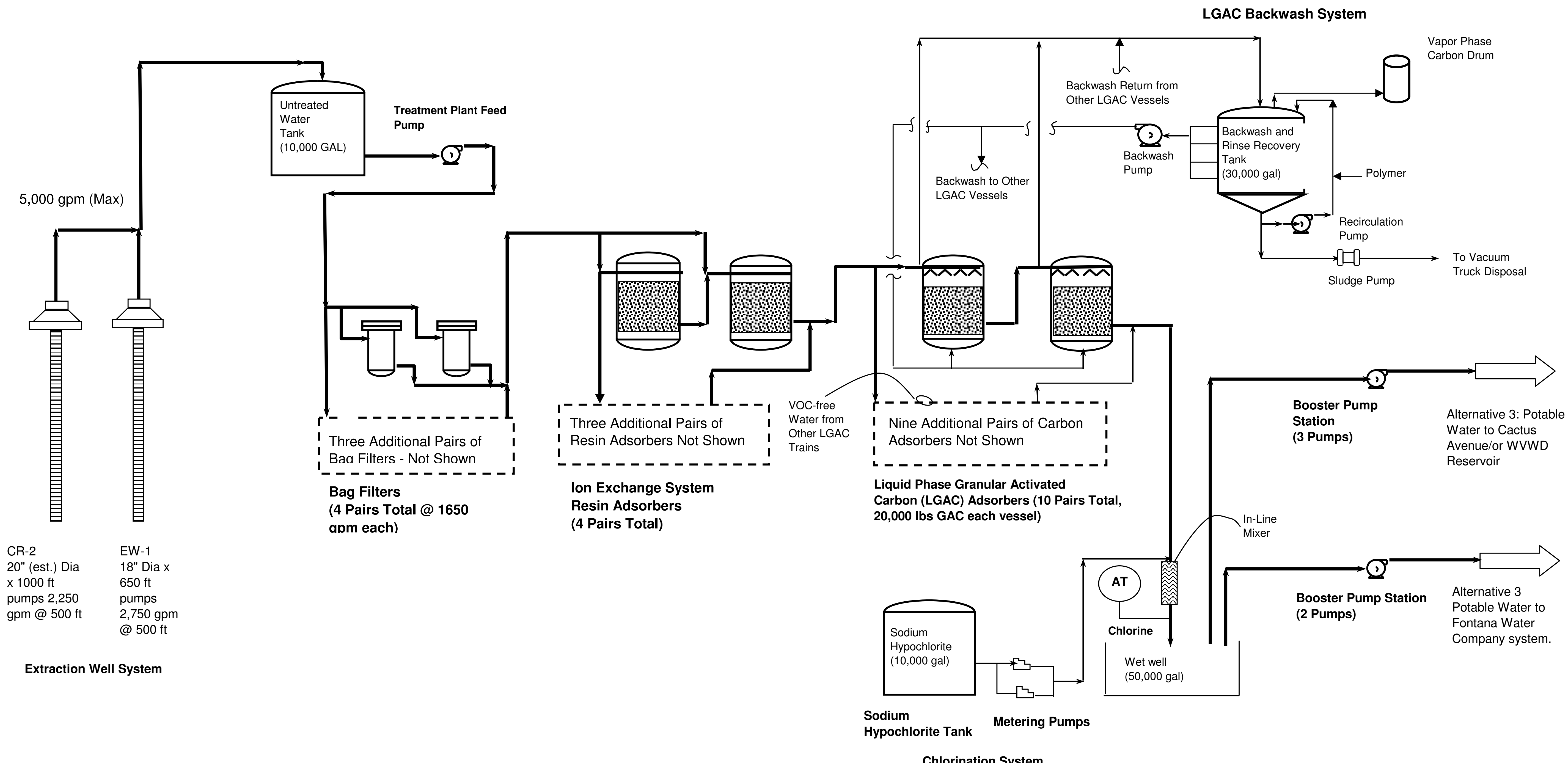
Figure 4-3 (sheet 2 of 2)
Alternative 2b
Preliminary Process Flow Diagram
Anoxic Bioreactor and Liquid Phase GAC
B.F. Goodrich Site RI/FS Report



Contaminant	Design	Average
Perchlorate (ug/l)	360	80
TCE (ug/l)	48	8
Flow Rate (gpm)	5,000	2,200

Notes:
1. All treatment process equipment to be contained in lined secondary containment.
2. Most instrumentation, valves, and ancillary process piping not shown for clarity.
3. AT = analyzer/transmitter

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Figure 4-4
Alternative 3
Preliminary Process Flow Diagram
Ion Exchange, and Liquid Phase GAC
B.F. Goodrich Site RI/FS Report

Appendix A
Groundwater Modeling Results

Table A-1
Boundary Heads and Pumping Rates
B.F. Goodrich Site RI/FS, Rialto,California

BOUNDARY HEADS (ft - MSL)												WELL FLOW (af/yr)												
decimal_year	duration	year	elapsed_time	nw_h1	ne_h1	se_h1	sw_h1	nw_h3	ne_h3	se_h3	sw_h3	WV#22	CR-1	CR-2	CR-3	CR-4	FU10A	FU10B	FU10C	F13A	F13B	FU35	Sierra Lakes Well	FU49
1960.5	365.25	1960	0	1400	1480	1015	1000	1271	1369	1015	1000	0	0	0	0	807.32	921.72	0	0	0	0	428	0	0
1961.5	365.25	1961	365	1400	1480	1015	1000	1271	1369	1015	1000	0	0	0	0	1371.74	921.72	0	0	0	0	428	0	0
1962.5	365.25	1962	730	1400	1480	1015	1000	1271	1369	1015	1000	0	0	723.14	0	753.32	921.72	0	0	0	0	428	0	0
1963.5	365.25	1963	1095	1400	1480	1015	1000	1271	1369	1015	1000	0	0	600.14	0	993.26	921.72	0	0	0	0	428	0	0
1964.5	365.25	1964	1460	1400	1480	1015	1000	1271	1369	1015	1000	0	0	790.64	0	1120.87	921.72	0	0	0	0	428	0	0
1965.5	365.25	1965	1825	1400	1480	1015	1000	1271	1369	1015	1000	0	95.94	697.38	0	884.52	921.72	0	0	0	0	428	0	0
1966.5	365.25	1966	2190	1400	1480	1015	1000	1271	1369	1015	1000	0	647.28	500.13	0	700.86	921.72	0	0	0	0	428	0	0
1967.5	365.25	1967	2555	1330	1390	993	1000	1060	1158	993	1000	0	558.45	338.56	0	488.03	921.72	0	0	0	0	428	0	0
1968.5	365.25	1968	2920	1330	1390	993	1000	1060	1158	993	1000	0	391.97	444.12	0	846.55	921.72	0	0	0	0	428	0	0
1969.5	365.25	1969	3285	1330	1390	993	1000	1060	1158	993	1000	0	797.62	104.21	0	1308.73	921.72	0	0	0	0	428	0	0
1970.5	365.25	1970	3650	1330	1390	993	1000	1060	1158	993	1000	0	993.39	84.01	0	1045.76	921.72	0	0	0	0	428	0	0
1971.5	365.25	1971	4015	1330	1390	993	1000	1060	1158	993	1000	0	1105.25	166.58	0	1092.42	921.72	0	0	0	0	428	0	0
1972.5	365.25	1972	4380	1330	1390	993	1000	1060	1158	993	1000	0	1507.67	332.43	0	816.17	921.72	0	0	0	0	428	0	0
1973.5	365.25	1973	4745	1330	1390	993	1000	1060	1158	993	1000	0	878.33	805.16	440.35	691.34	921.72	0	0	0	0	428	0	0
1974.5	365.25	1974	5110	1330	1390	993	1000	1060	1158	993	1000	0	1222.58	378	493.75	695.24	921.72	0	0	0	0	428	0	0
1975.5	365.25	1975	5475	1330	1390	993	1000	1060	1158	993	1000	0	1279.32	326.39	550.2	774.96	921.72	0	0	0	0	428	0	0
1976.5	365.25	1976	5840	1330	1390	993	1000	1060	1158	993	1000	0	1179.25	572.87	440.49	739.14	921.72	0	0	0	0	428	0	0
1977.5	365.25	1977	6205	1330	1390	993	1000	1060	1158	993	1000	0	766.55	105.14	330.22	434.29	921.72	0	0	0	0	428	0	0
1978.5	365.25	1978	6570	1330	1390	993	1000	1060	1158	993	1000	0	1118.91	283.07	253.52	588.8	921.72	0	0	0	0	428	0	0
1979.5	365.25	1979	6935	1330	1390	993	1000	1060	1158	993	1000	0	208	248.7	41.34	540.85	921.72	0	0	0	0	428	0	0
1980.5	365.25	1980	7300	1330	1390	993	1000	1060	1158	993	1000	0	700.93	280.72	0	503.49	921.72	0	0	988	0	428	0	0
1981.5	365.25	1981	7665	1380	1500	1035	1020	1291	1369	1035	1020	0	168.06	729.24	98.03	901.93	921.72	0	0	988	0	428	0	0
1982.5	365.25	1982	8030	1380	1500	1035	1020	1291	1369	1035	1020	0	74.15	348.24	2.37	571.38	921.72	0	0	988	0	428	0	0
1983.5	365.25	1983	8395	1380	1500	1035	1020	1291	1369	1035	1020	0	337.66	380.37	23.62	534.76	921.72	0	0	988	0	428	0	0
1984.5	365.25	1984	8760	1380	1500	1035	1020	1291	1369	1035	1020	0	494.07	1253.39	107.66	318.97	921.72	0	0	988	0	428	0	0
1985.5	365.25	1985	9125	1380	1500	993	1020	1291	1369	1035	1020	0	489.28	1130.01	13.31	226.05	921.72	0	0	988	0	428	0	0
1986.5	365.25	1986	9490	1380	1500	993	1020	1291	1369	1035	1020	0	799.74	712.81	40.17	658.64	921.72	0	0	1976	0	214	0	0
1987.5	365.25	1987	9855	1520	1390	993	978	1291	1369	1035	978	0	924.92	1626.38	147.71	1185.6	921.72	0	0	1976	0	214	0	0
1988.5	365.25	1988	10220	1520	1390	993	978	1291	1369	1035	978	0	1313.6	995.52	94.05	1080.21	921.72	0	0	1976	0	214	0	0
1989.5	365.25	1989	10585	1280	1390	1035	978	1291	1369	1035	978	0	1648.03	1476.8	97.95	1500.12	921.72	0	0	1976	0	214	0	0
1990.5	365.25	1990	10950	1280	1390	1035	978	1291	1369	1035	978	1675.85	1197.6	1655.51	1145.61	1119.53	921.72	0	0	988	0	428	0	0
1991.5	365.25	1991	11315	1280	1390	1035	978	1060	1158	993	978	1675.85	220.2	414.01	101.13	399.33	921.72	0	0	988	0	428	0	0
1991.9	135	1991	11450	1280	1390	1035	978	1060	1158	993	978	1675.85	220.2	414.01	101.13	399.33	921.72	0	0	988	0	428	0	0
1992.5	230.25	1992	11680	1360	1390	1035	1020	1290	1369	1035	1020	1675.85	1328.43	1538.58	478.84	69.66	921.72	0	0	988	0	428	0	0
1993.5	365.25	1993	12045	1360	1390	1035	1020	1290	1369	1035	1020	1675.85	676.38	1152.99	462.69	424.4	921.72	0	0	988	0	428	0	0
1994.5	365.25	1994	12410	1360	1390	1035	1028	1290	1369	1035	1028	1675.85	425.48	840.23	674.39	278.58	921.72	1813	0	1976	0	428	0	0
1995.5	365.25	1995	12775	1475	1390	1035	1020	1263	1369	1035	1020	1675.85	701.26	961.62	1418.72	316.95	921.72	1813	0	1976	0	428	0	0
1996.5	365.25	1996	13140	1475	1390	1035	1028	1263	1369	1035	1028	1675.85	704.29	1131.63	1270.22	80.34	921.72	1813	0	1976	0	428	0	0
1997.5	365.25	1997	13505	1475	1390	993	1028	1263	1158	993	1028	1675.85	1259.82	1156.53	943.71	141.55	0	1813	0	1976	0	0	0	0
1998.5	365.25	1998	13870	1475	1390	993	1029	1263	1158	993	1029	1675.85	2152.24	0	1571.52	178.87	0	0	0	1976	0	0	0	0
1998.9	130	1998	14000	1350	1390	993	1029	1140	1158	993	1029	1675.85	2152.24	0	1571.52	178.87	0	0	0	1976	0	0	0	0
1999.5	235.25	1999	14235	1260	1390	993	1031	1140	1158	993	1031	1675.85	1472.71	0	1534.89	480.79	0	0	0	1976	0	0	0	0
2000.5	365.25	2000	14600	1260	1390	993	1030	1140	1158	993	1030	0	1882.76	0	920.76	804.62	0	0	0	2054	2372	0	0	0
2001.5	365.25	2001	14965	1290	1390	993	1024	1140	1158	993	1024	0	1658.22	0	1185.62	1262.59	0	2564	0	2067	3188	0	0	0
2002.5	365.25	2002	15330	1290	1390	993	1012	1040	1158	993	1012	0	2415.72	0	1025.02	994.01	0	2140	458	2039	3188	0	500	2207
2003.5	365.25	2003	15695	1290	1390	993	1000	1040	1158	993	1000	0	1698.67	0	1306.73	137.34	0	1469	1735	1318	2098	0	500	2480
2004.5	365.25	2004	16060	1290	1390	993	996	1070	1158	993	996	0	789.61	0	830.23	0.59	0	1801	1685	1397	1801	0	500	2509
2005.5	365.25	2005	16425	1290	1390	993	992	1070	1158	993	992	0	0	0	2000	994	0	1654	1335	707	1543	0	500	2816
2006.5	365.25	2006	16790	1290	1390	993	991	1110	1158	993	991	0	0	0	2000	994	0	1557	1555	1397	974	0	500	2866
2007.5	365.25	2007	17155	1290	1390	993	1000	1110	1158	993	1000	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2008.5	365.25	2008	17520	1290	1390	993	1000	1110	1158	993	1000	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2009.5	365.25	2009	17885	1290	1500	1035	1000	1110	1369	1035	1000	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2010.5	365.25	2010	18250	1290	1500	1035	1005	1110	1369	1035	1005	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2011.5	365.25	2011	18615	1290	1500	1035	1005	1290	1369	1035	1005	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866

Table A-1
Boundary Heads and Pumping Rates
B.F. Goodrich Site RI/FS, Rialto,California

BOUNDARY HEADS (ft - MSL)												WELL FLOW (af/yr)													
decimal_year	duration	year	elapsed_time	nw_h1	ne_h1	se_h1	sw_h1	nw_h3	ne_h3	se_h3	sw_h3	WV#22	CR-1	CR-2	CR-3	CR-4	FU10A	FU10B	FU10C	F13A	F13B	FU35	Sierra Lakes Well	FU49
2012.5	365.25	2012	18980	1290	1390	993	1005	1290	1158	993	1005	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2013.5	365.25	2013	19345	1290	1390	993	1005	1290	1158	993	1005	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2014.5	365.25	2014	19710	1290	1390	993	1005	1290	1158	993	1005	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2015.5	365.25	2015	20075	1290	1390	993	1030	1290	1158	993	1030	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2016.5	365.25	2016	20440	1290	1390	993	1030	1290	1158	993	1030	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2017.5	365.25	2017	20805	1290	1390	993	1030	1290	1158	993	1030	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2018.5	365.25	2018	21170	1290	1390	993	1030	1290	1158	993	1030	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2019.5	365.25	2019	21535	1290	1390	993	1030	1290	1158	993	1030	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866
2020.5	366.25	2020	21901	1290	1390	993	1030	1290	1158	993	1030	0	0	0	2258	994	0	1557	1555	1397	974	0	500	2866

Figure A-1: Rialto-3 Aquifer Test Analysis – Monitoring Well N-14S

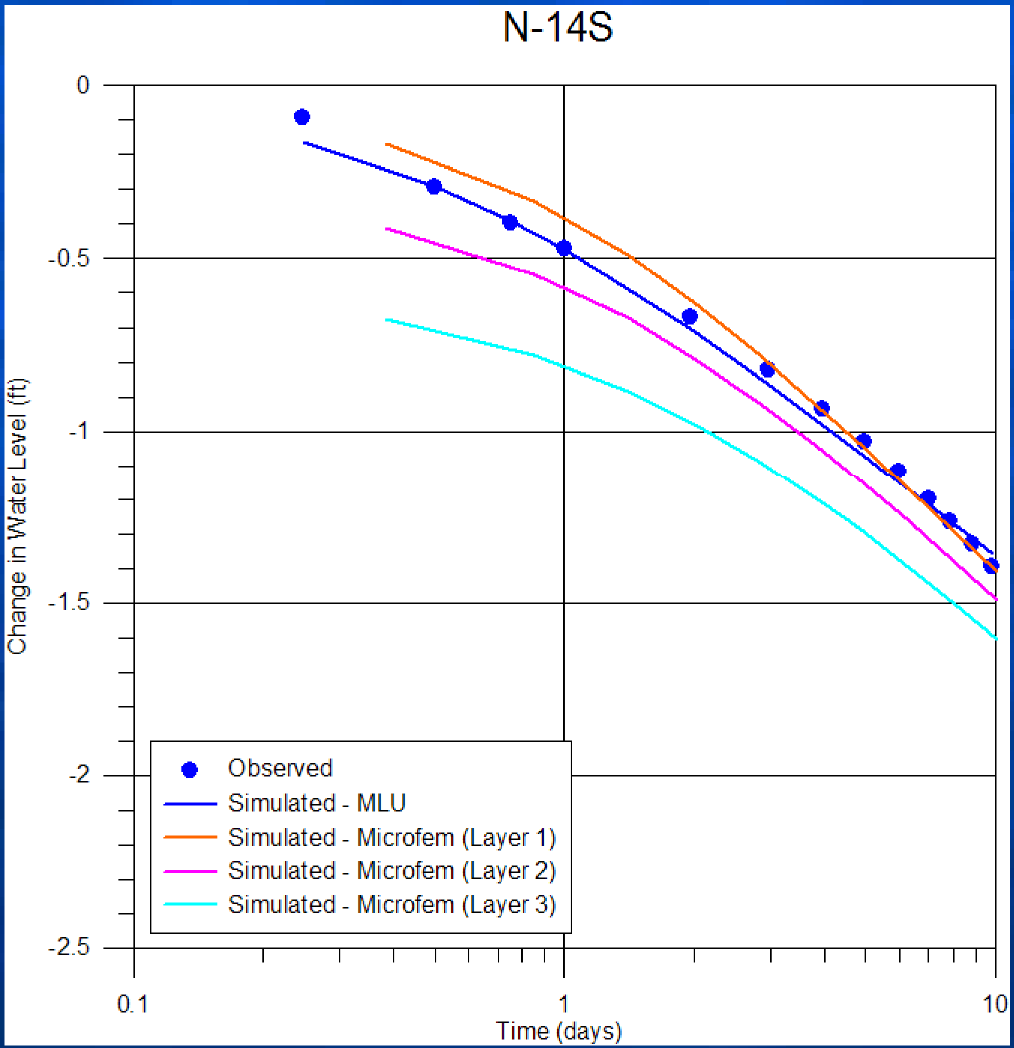


Figure A-2: Rialto-3 Aquifer Test Analysis – Monitoring Well N-14D

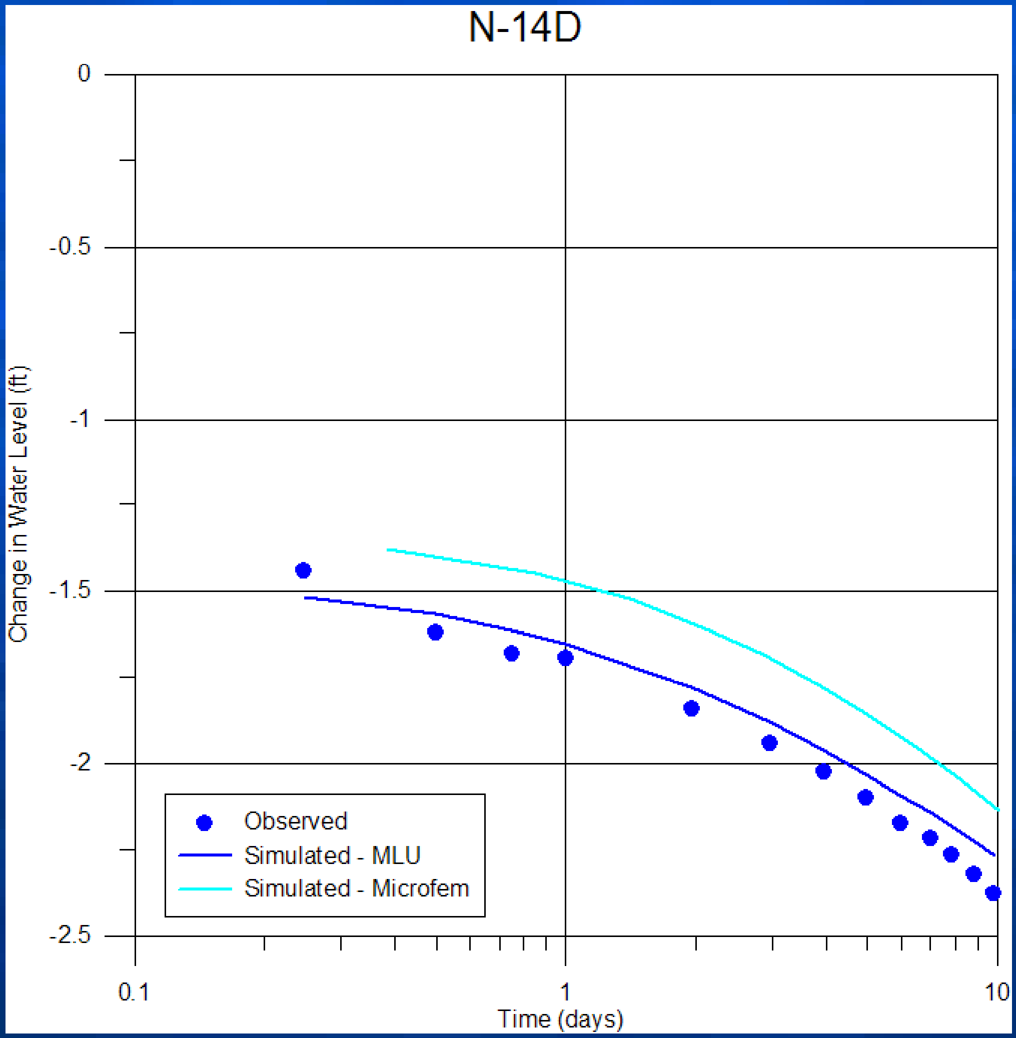


Figure A-3: Rialto-3 Aquifer Test Analysis – Monitoring Well M-1S

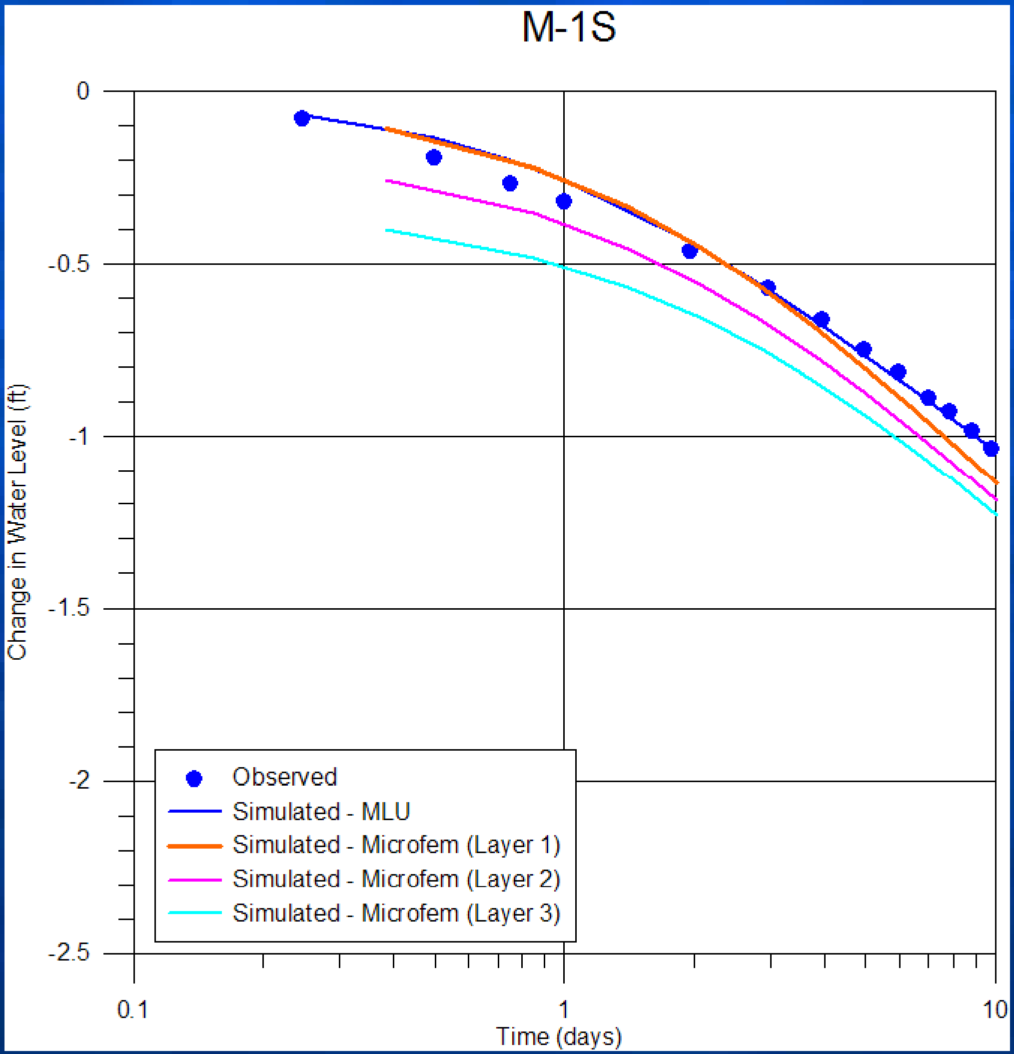


Figure A-4: Rialto-3 Aquifer Test Analysis – Monitoring Well M-1D

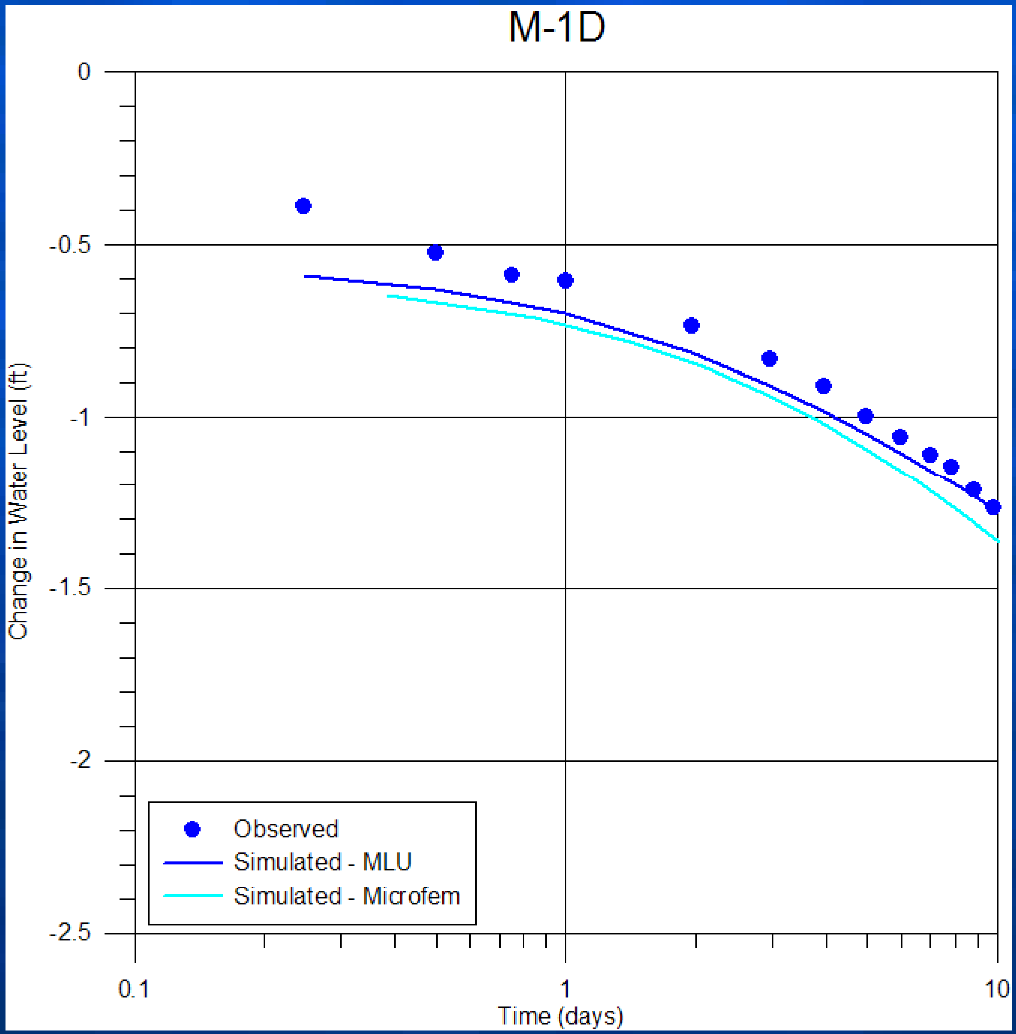


Figure A-5: Calibration Scattergram for 2004

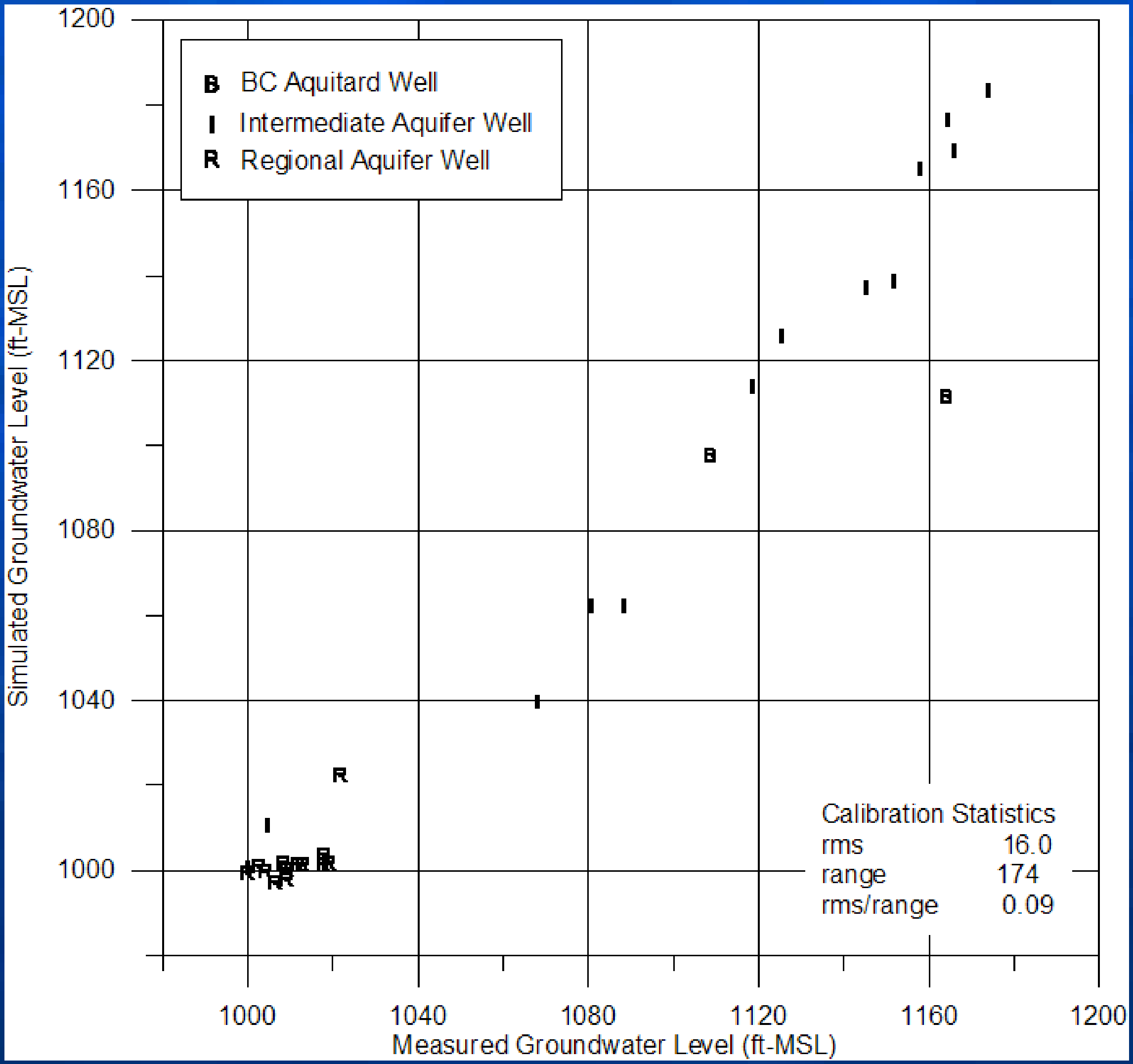


Figure A-6: Comparison of Observed and Simulated Groundwater Levels City of Rialto Wells CR-1, CR-2, and CR-3

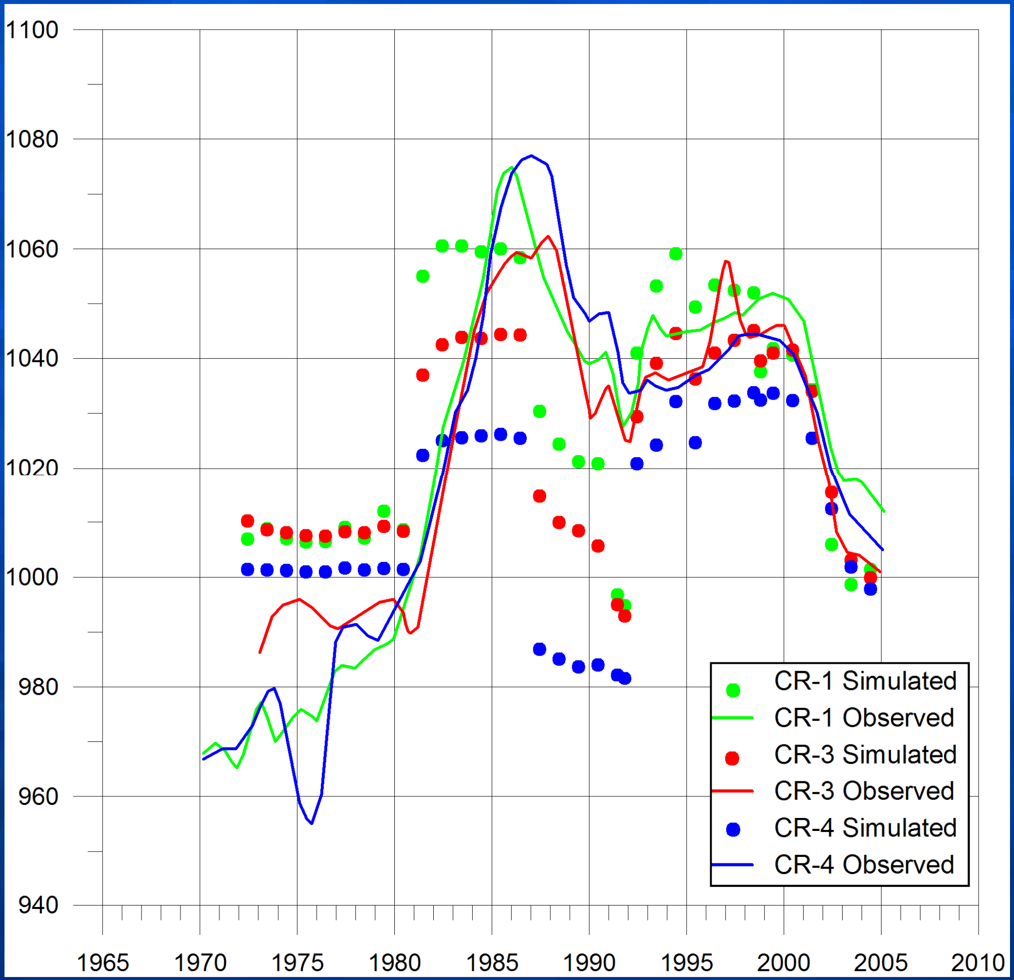
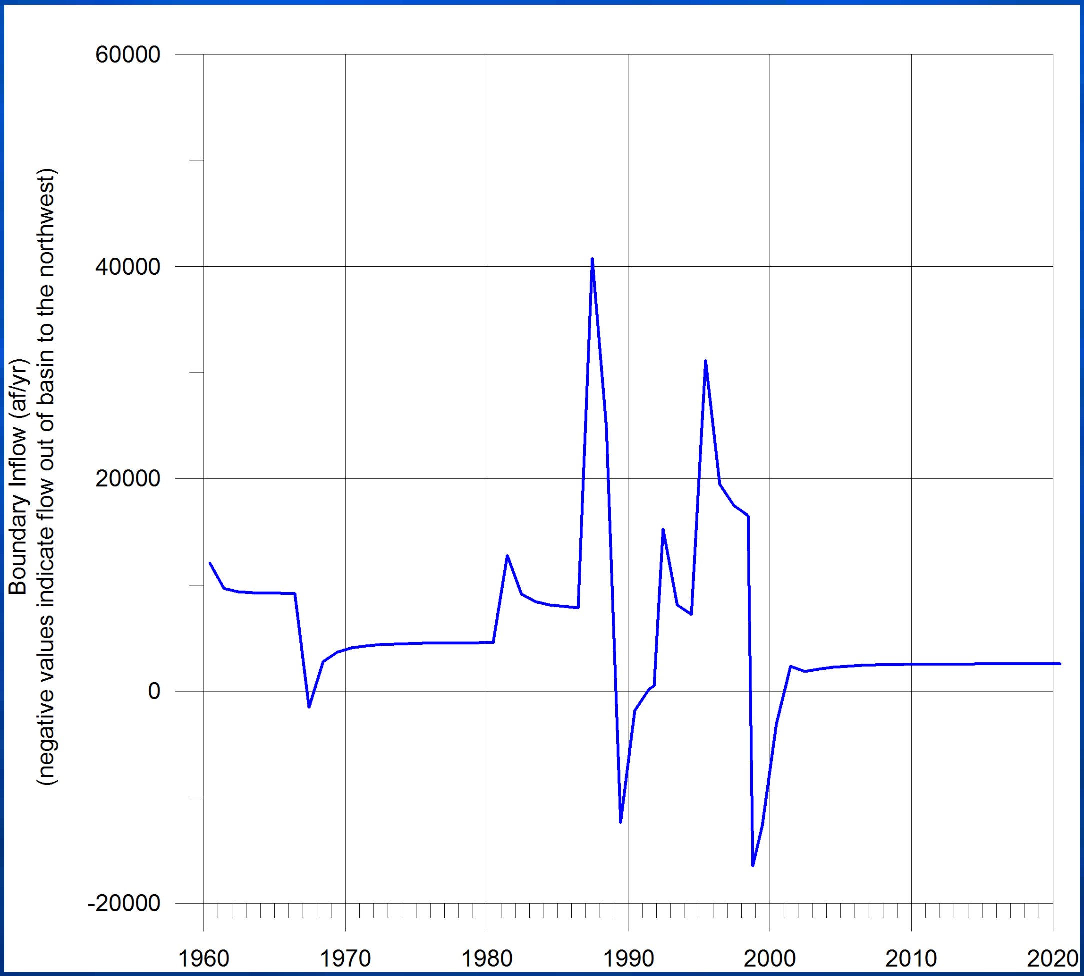
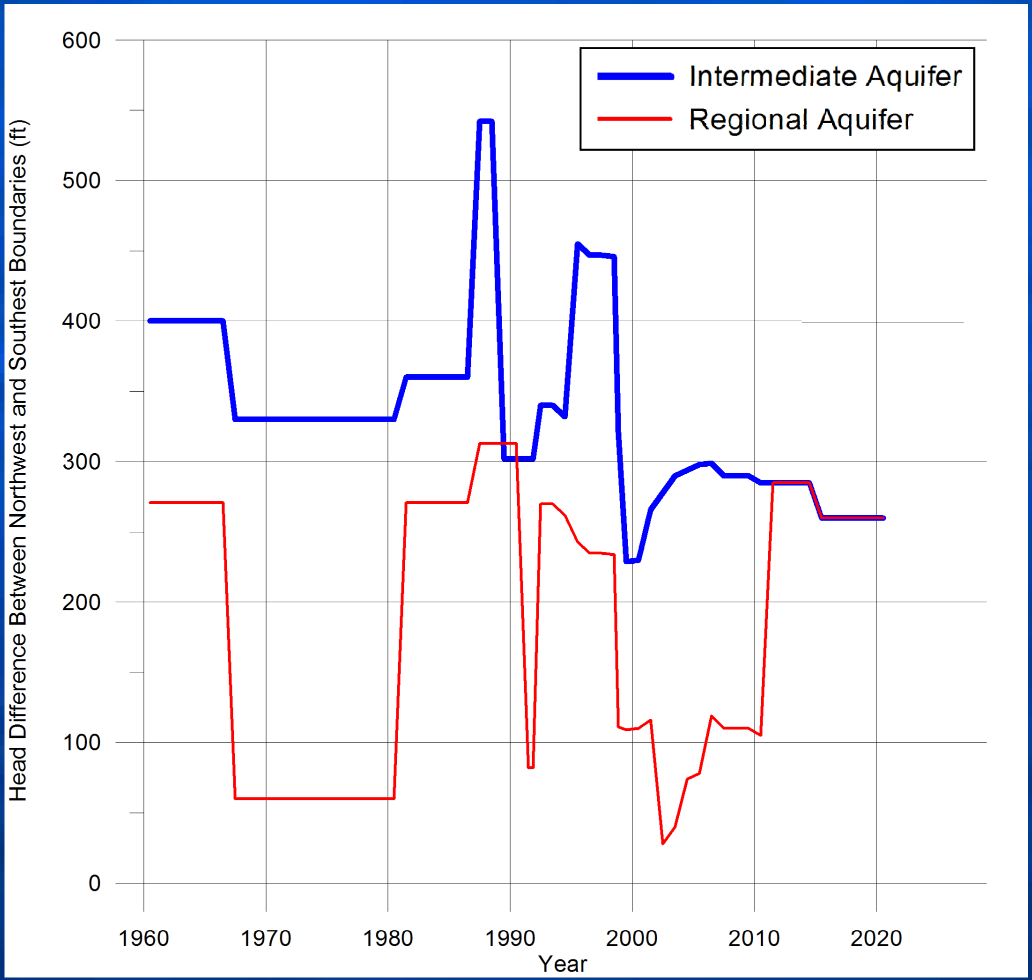


Figure A-7a: Anomalous Boundary Inflow



Boundary Inflow becomes negative in the late 1980s and 1990s. This implies an unlikely northwesterly flow direction near the upstream part of the model. This means that caution is needed when examining flow near this boundary

Figure A-7b: Large and Rapid Changes in Boundary Head



There is a large variation in the head difference between the upstream and downstream boundaries. This implies a large change in underflow in both the regional and intermediate aquifers. Underflow in the regional aquifer changed approximately by 500 percent between 1980 and 1990.

Figure A-8: Baseline Pumping 2004 Conditions – Regional Aquifer

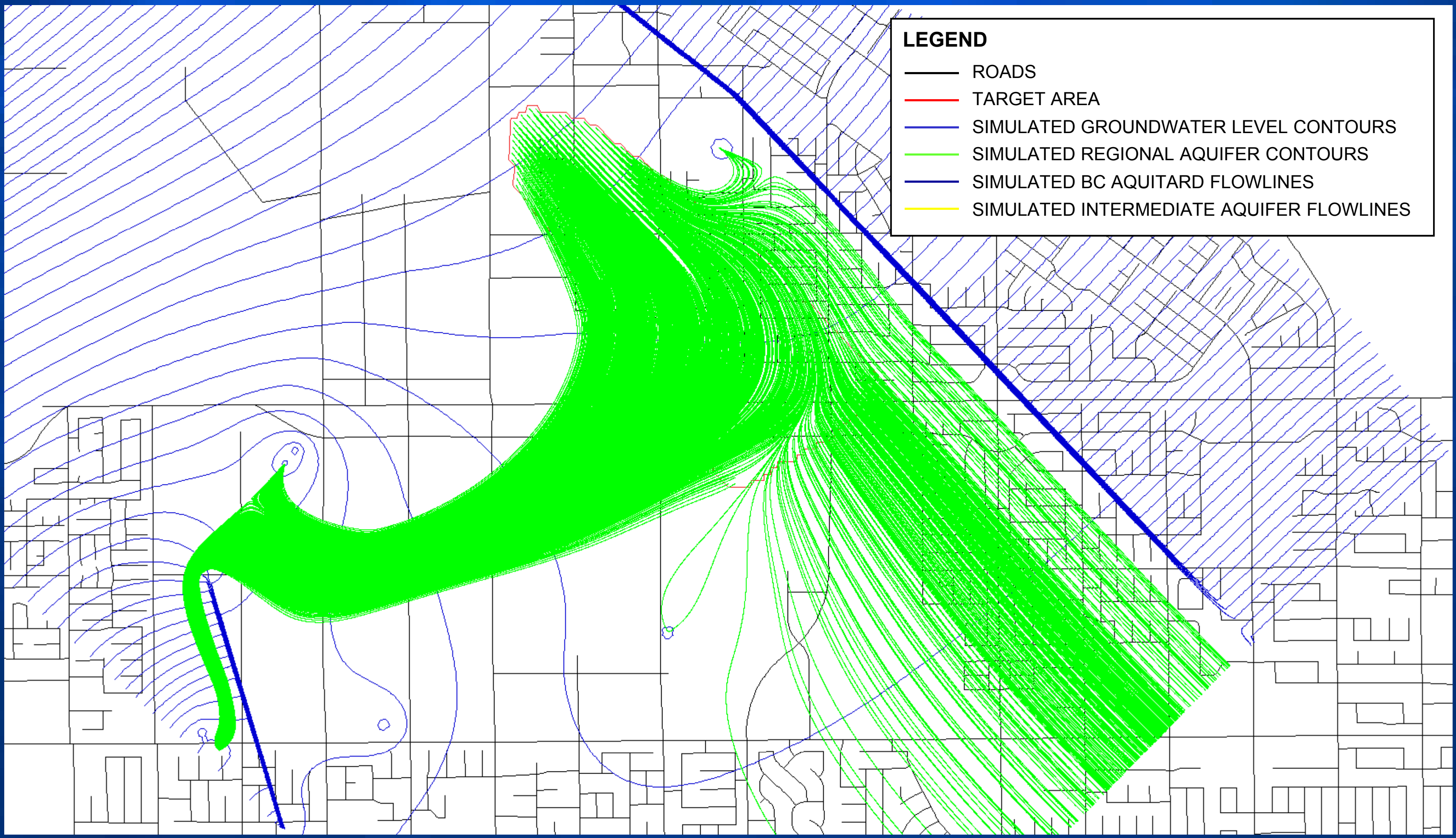


Figure A-9: Baseline Pumping 2001 Conditions – Regional Aquifer

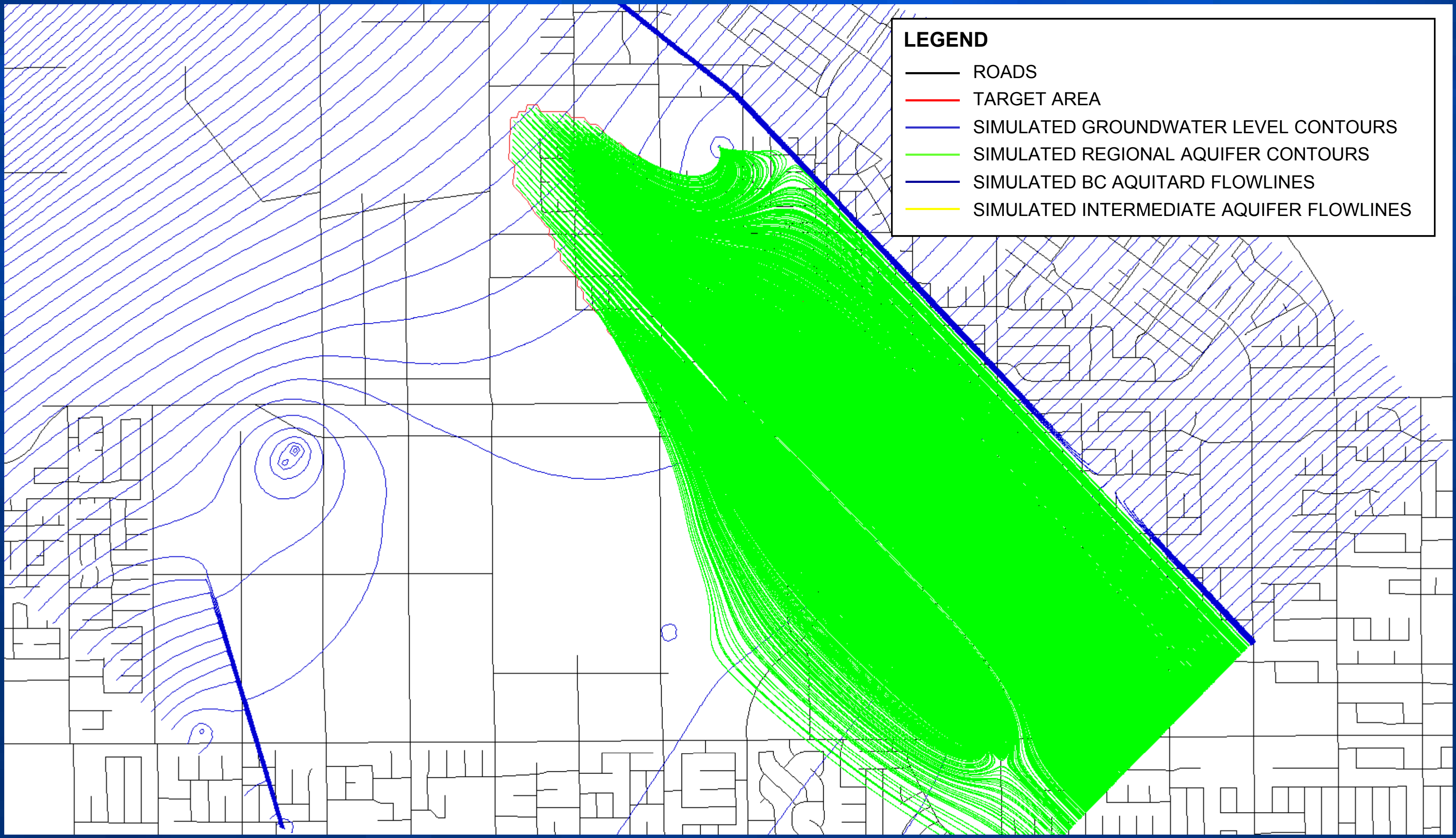


Figure A-10: Baseline Pumping 1998 Conditions – Regional Aquifer

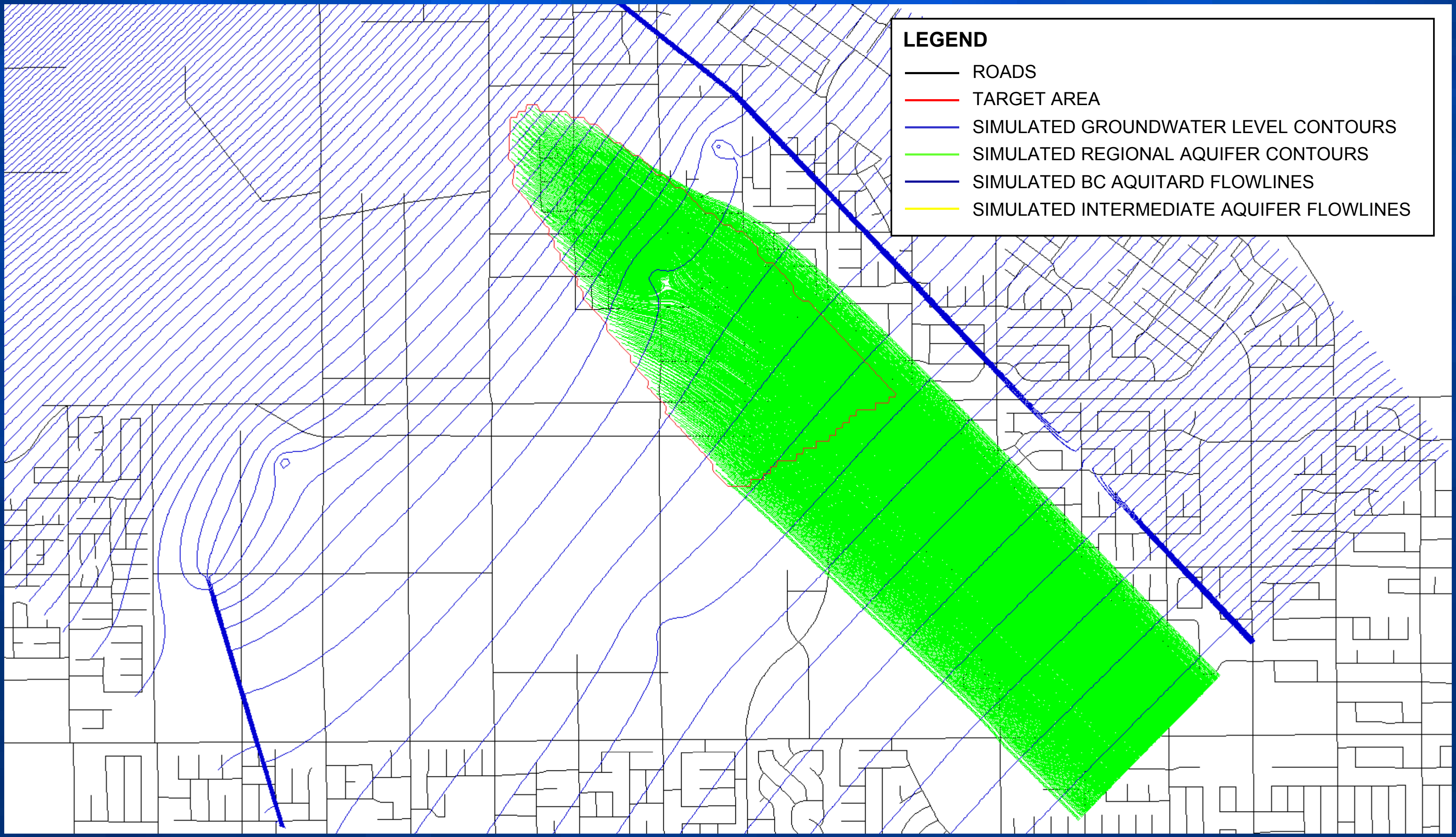
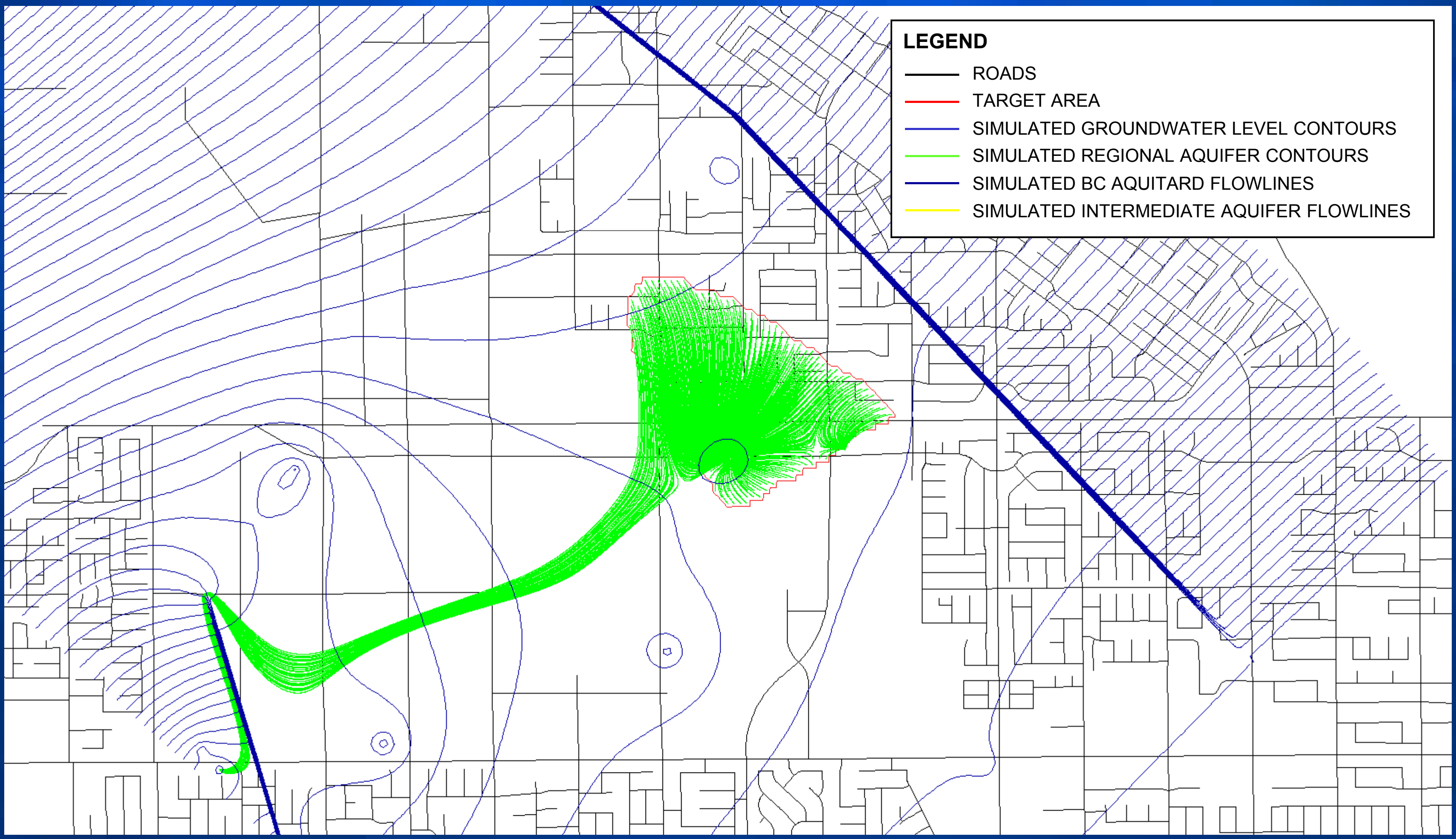
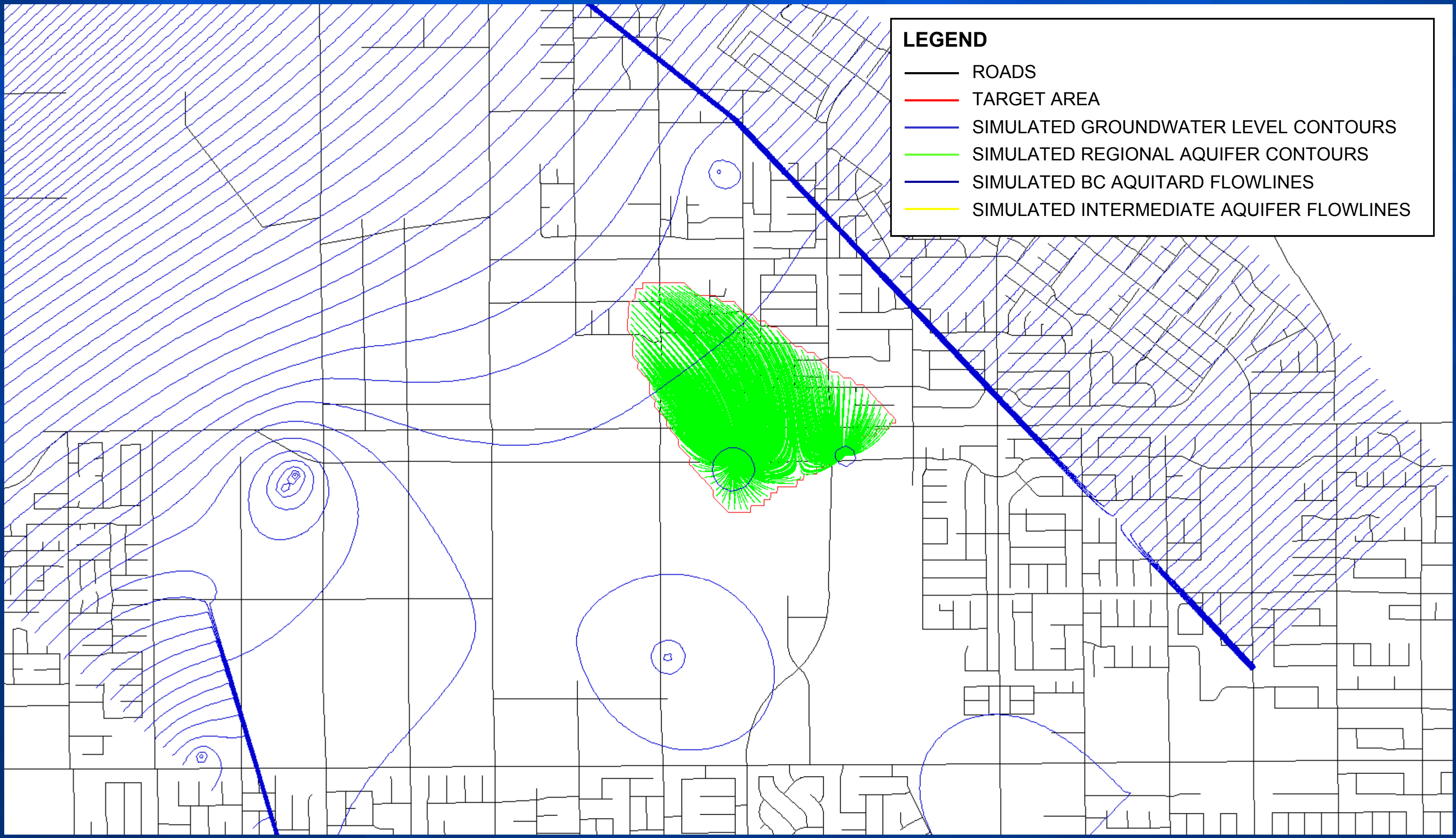


Figure A-11: 1,125 gpm Pumping 2004 Conditions – Regional Aquifer



95 percent capture in regional aquifer.

Figure A-12: 1,125 gpm Pumping 2001 Conditions – Regional Aquifer

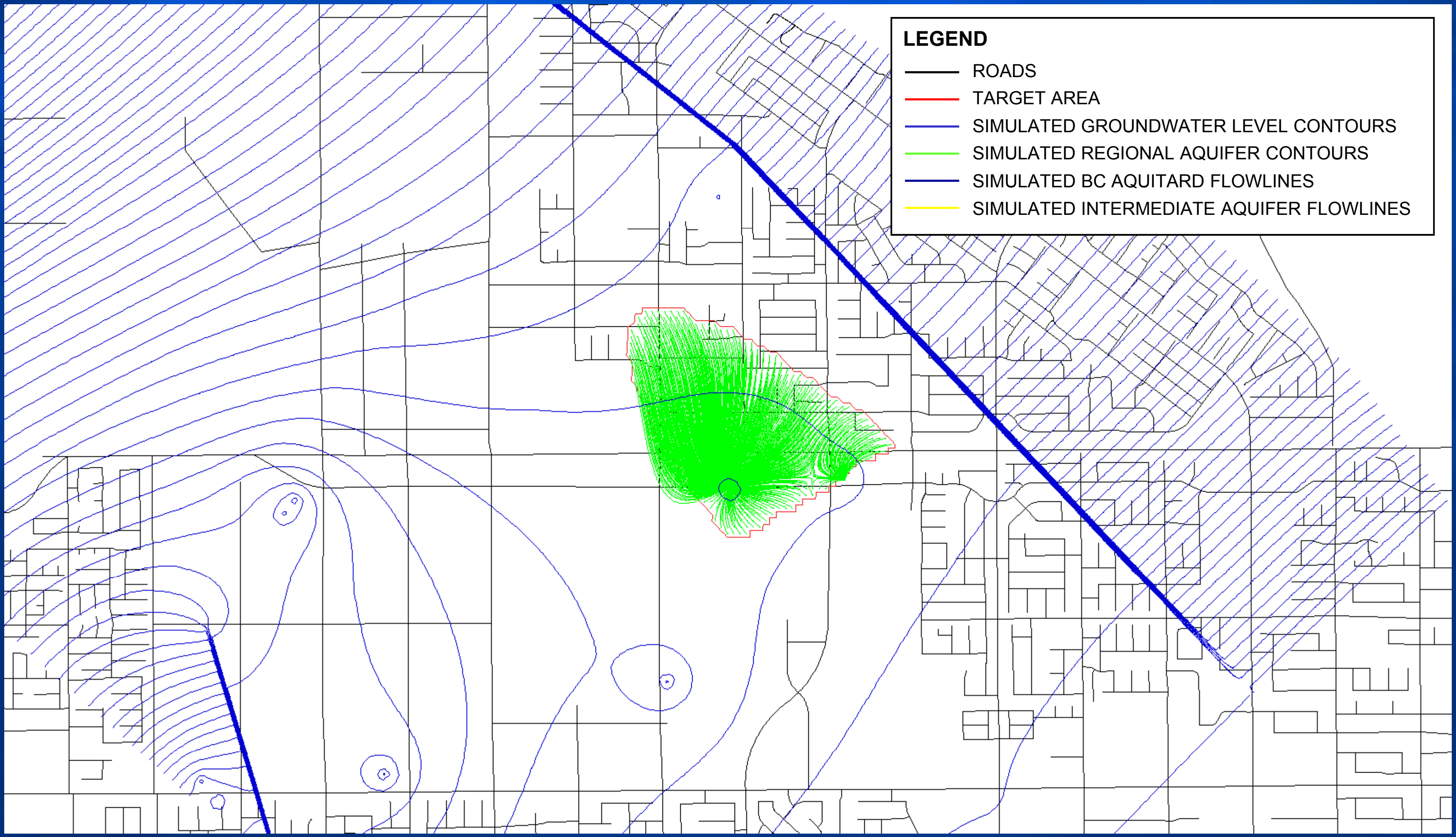


100 percent capture in regional aquifer.

Figure A-13: 1,125 gpm Pumping 1998 Conditions – Regional Aquifer

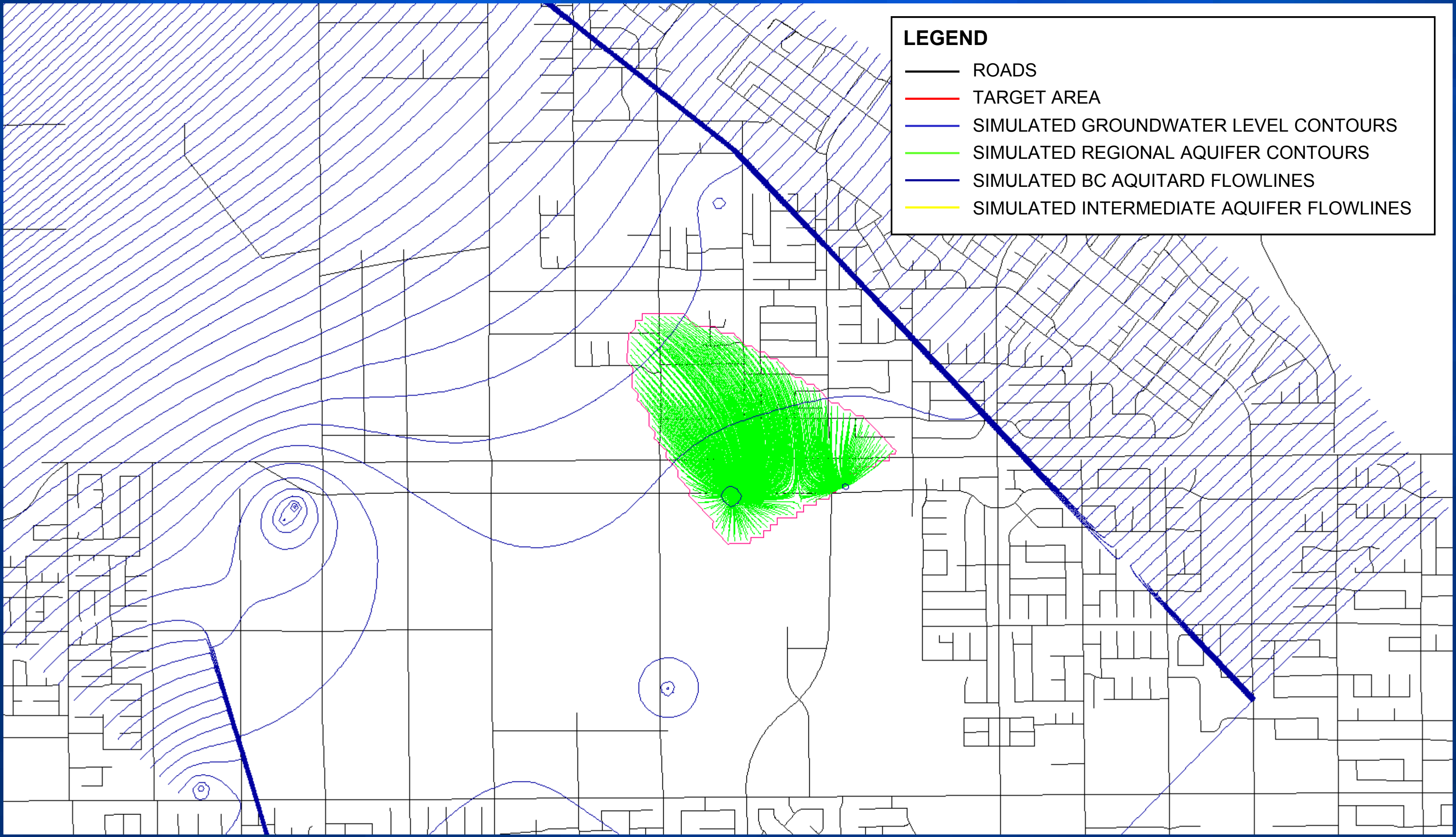
46 percent capture in regional aquifer.

Figure A-14: 1,500 gpm Pumping 2004 Conditions – Regional Aquifer



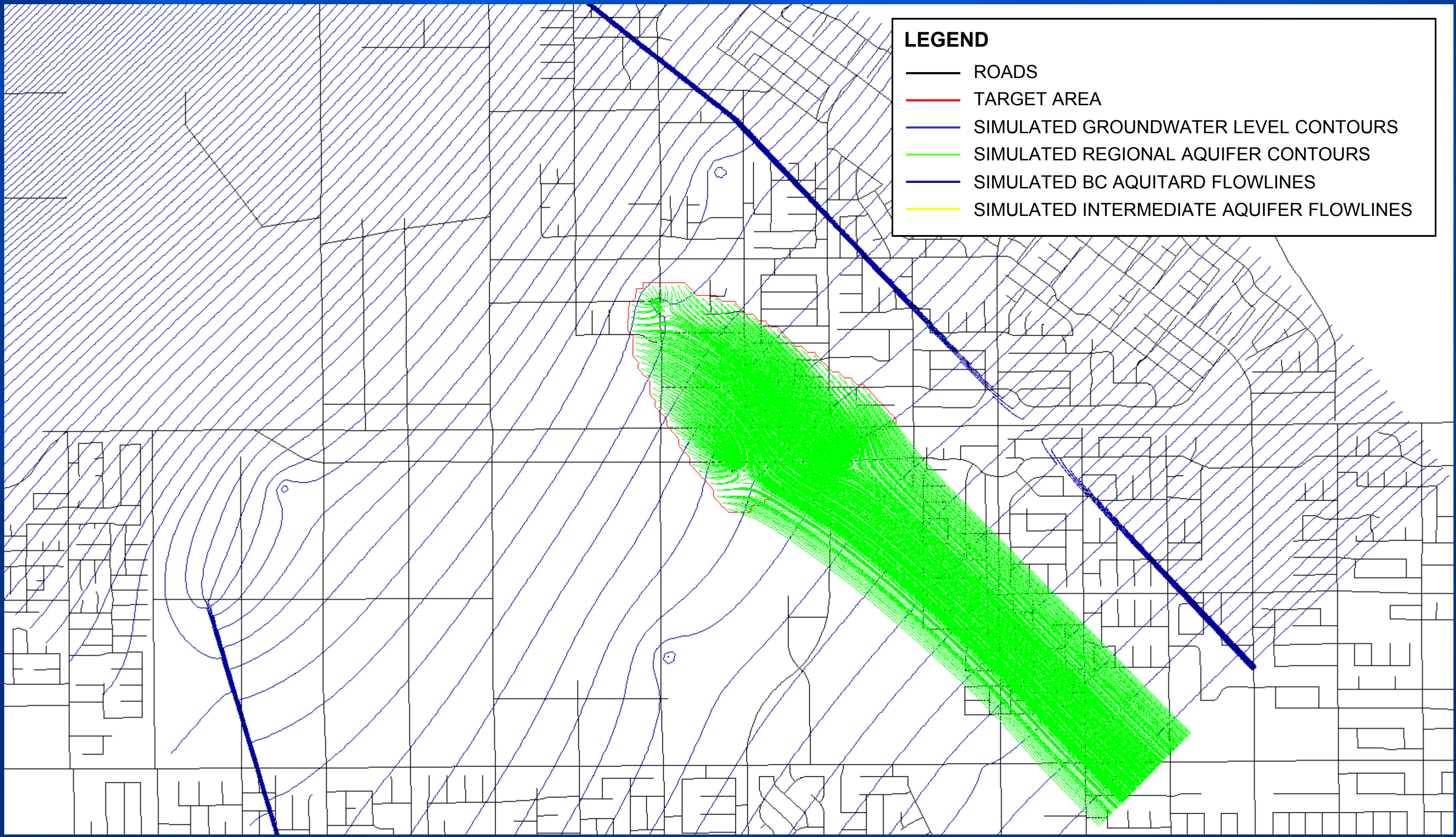
100 percent capture in regional aquifer.

Figure A-15: 1,500 gpm Pumping 2001 Conditions – Regional Aquifer



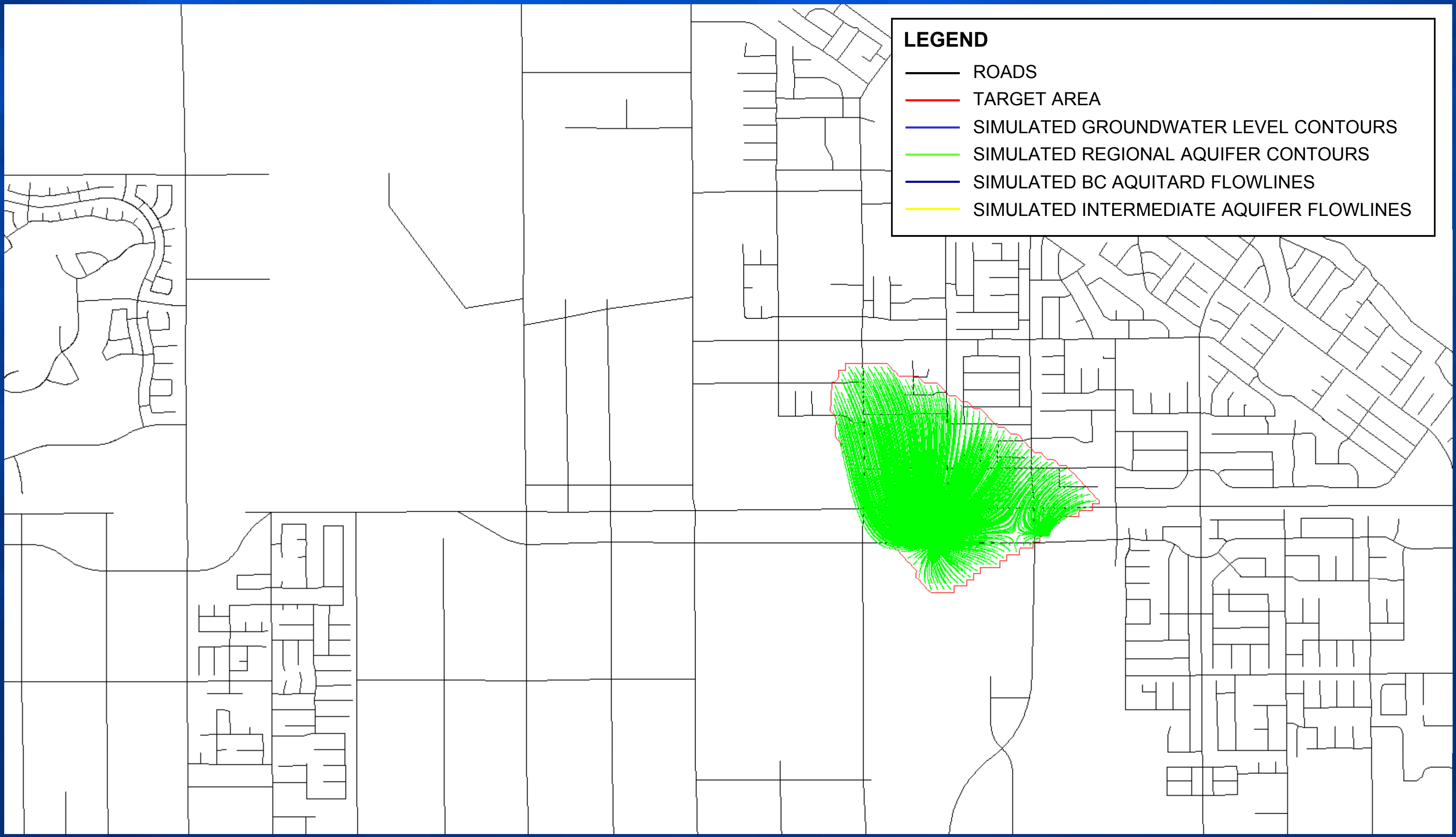
100 percent capture in regional aquifer (excess pumping).

Figure A-16: 1,500 gpm Pumping 1998 Conditions – Regional Aquifer



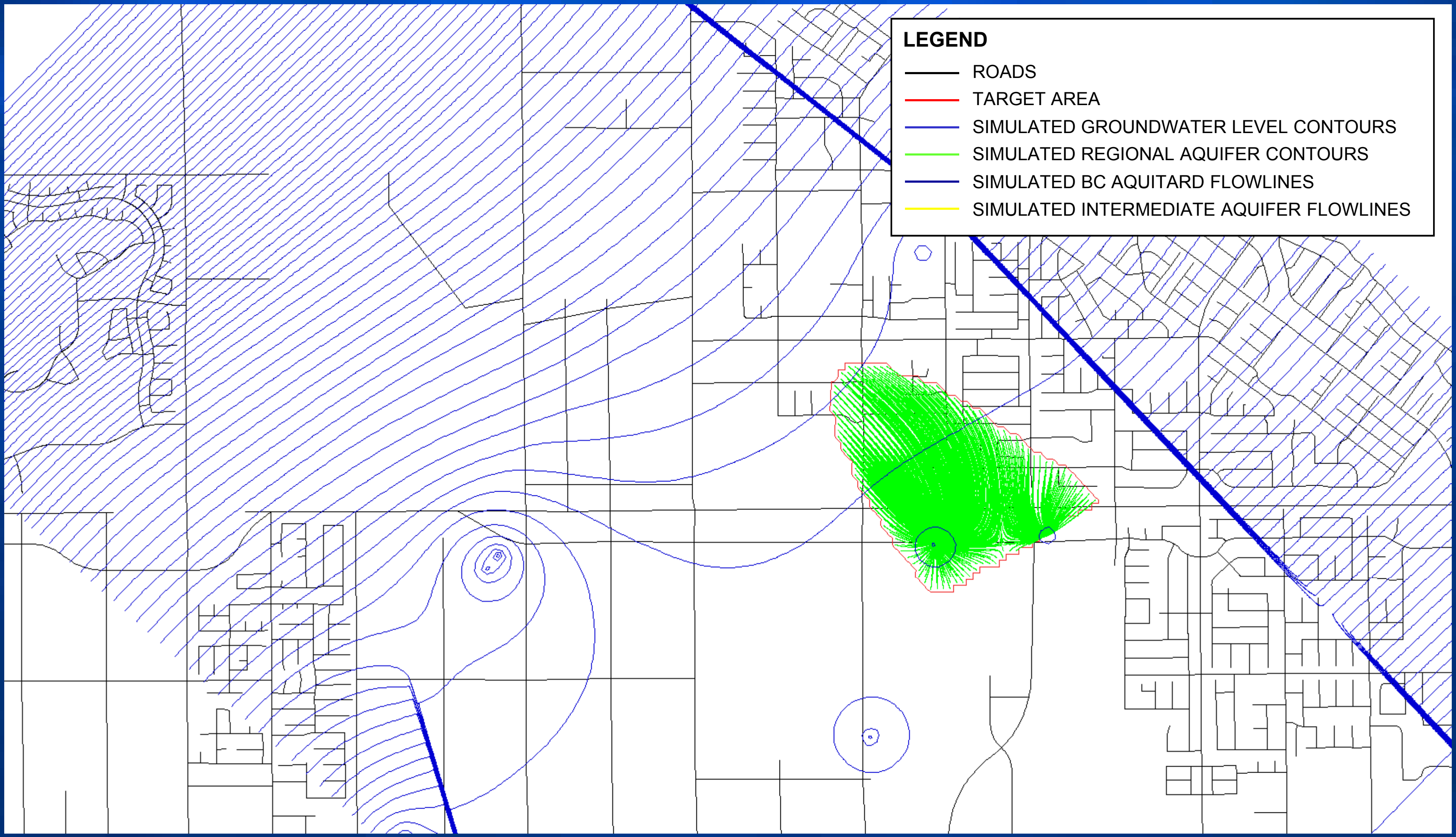
59 percent capture in regional aquifer.

Figure A-17: 1,650 gpm Pumping 2004 Conditions – Regional Aquifer



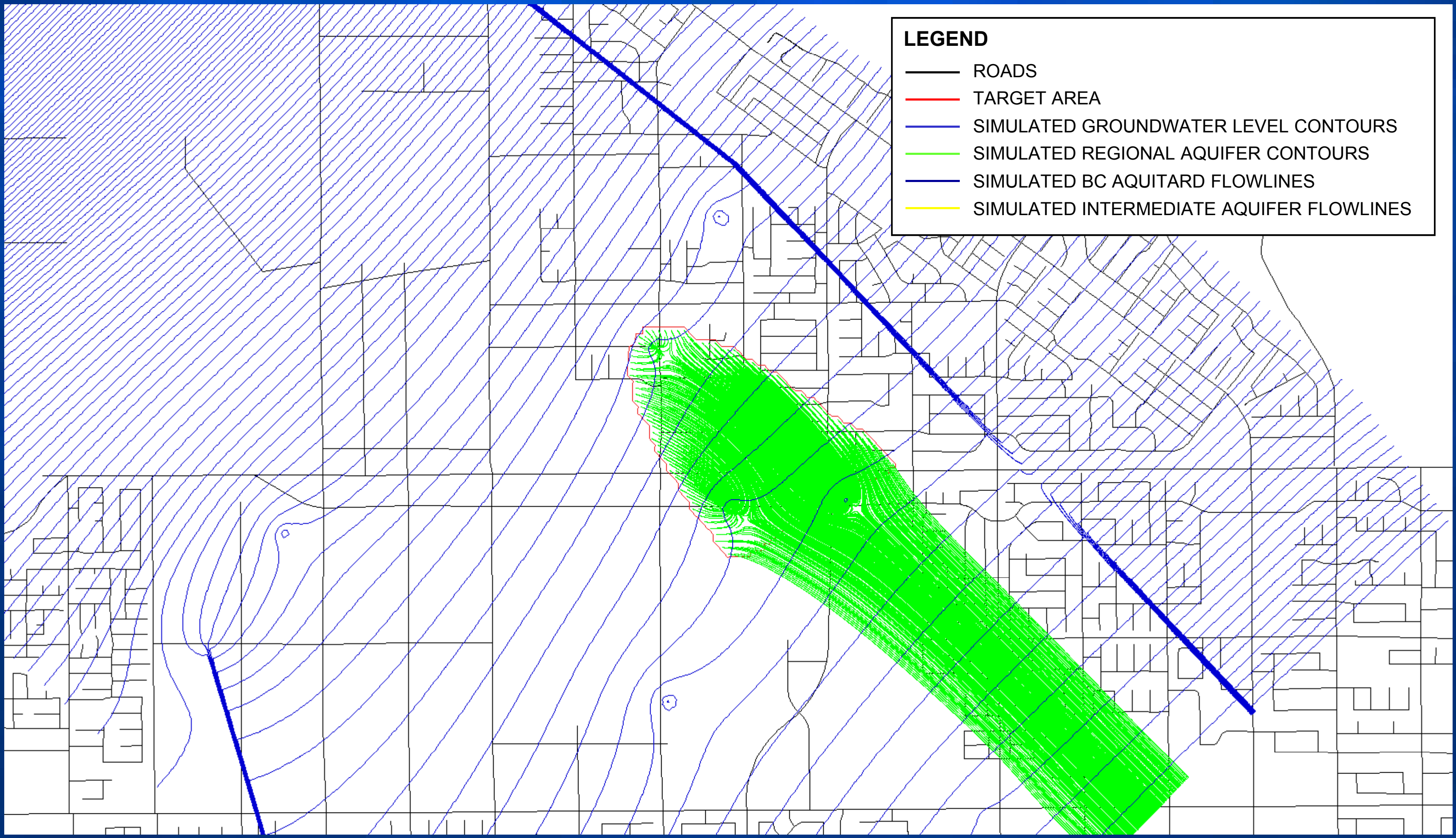
100 percent capture in regional aquifer (excess pumping).

Figure A-18: 1,650 gpm Pumping 2001 Conditions – Regional Aquifer



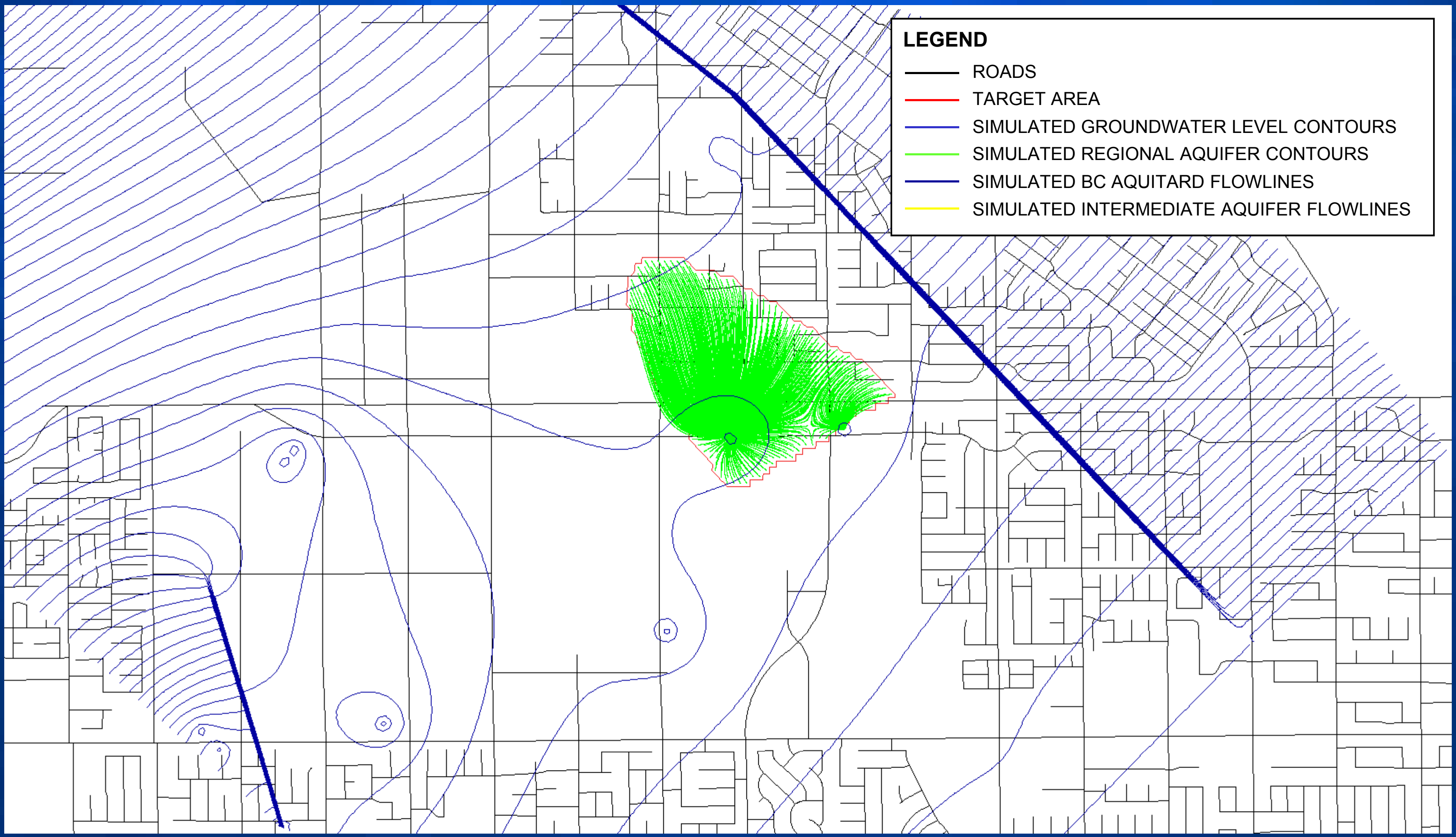
100 percent capture in regional aquifer (excess pumping).

Figure A-19: 1,650 gpm Pumping 1998 Conditions – Regional Aquifer



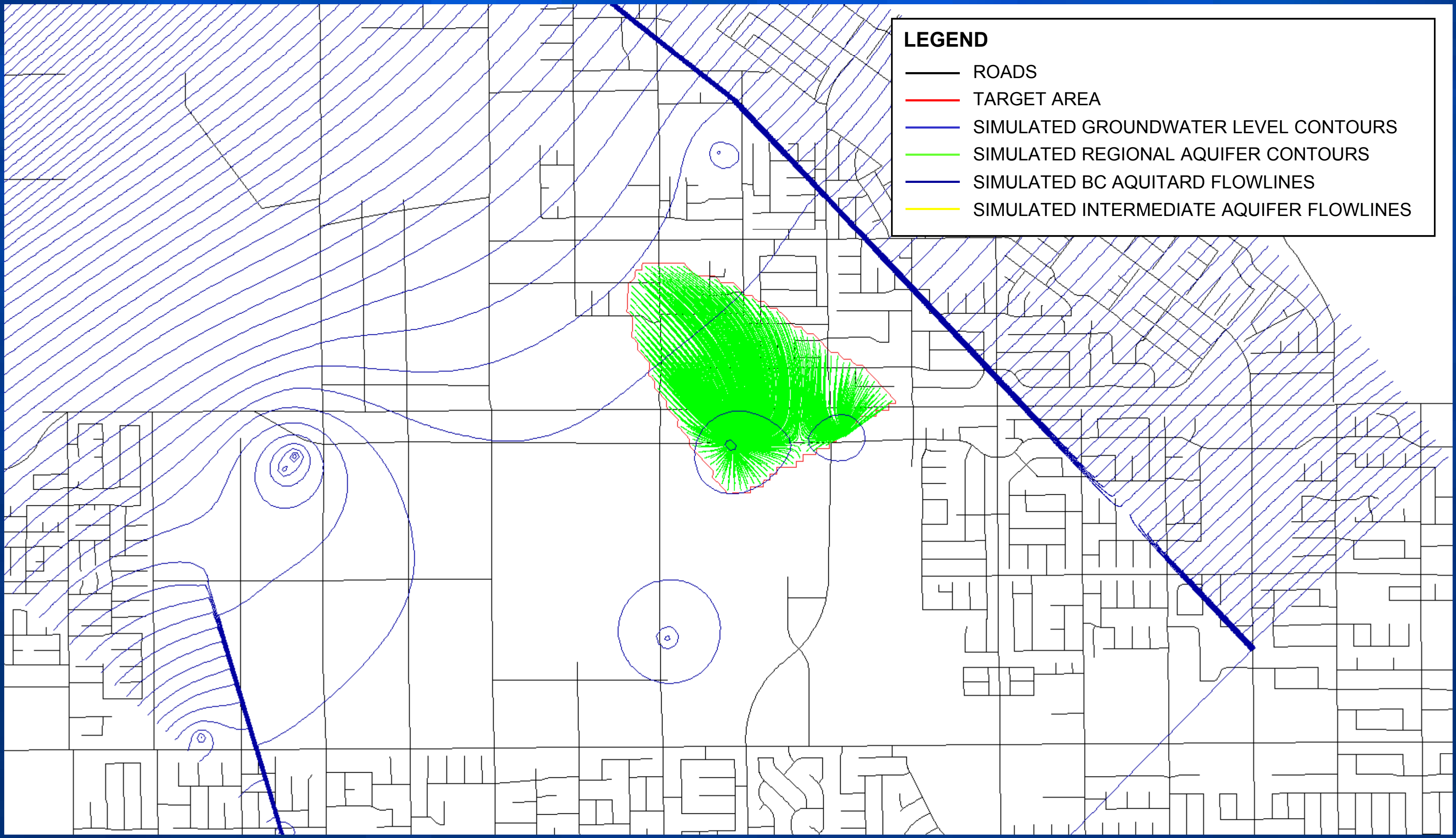
62 percent capture in regional aquifer.

Figure A-20: 1,825 gpm Pumping 2004 Conditions – Regional Aquifer



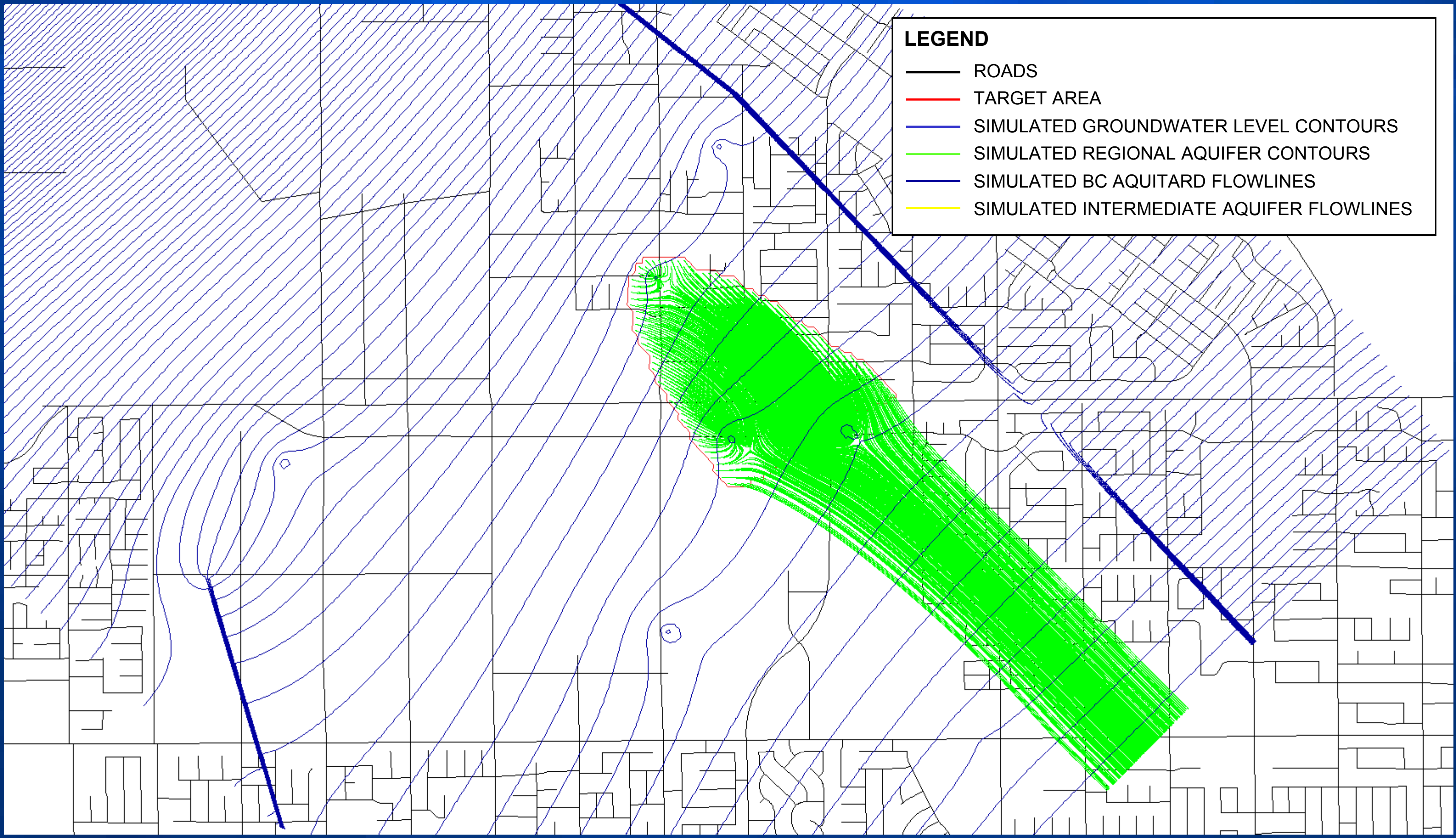
100 percent capture in regional aquifer (excess pumping).

Figure A-21: 1,825 gpm Pumping 2001 Conditions – Regional Aquifer



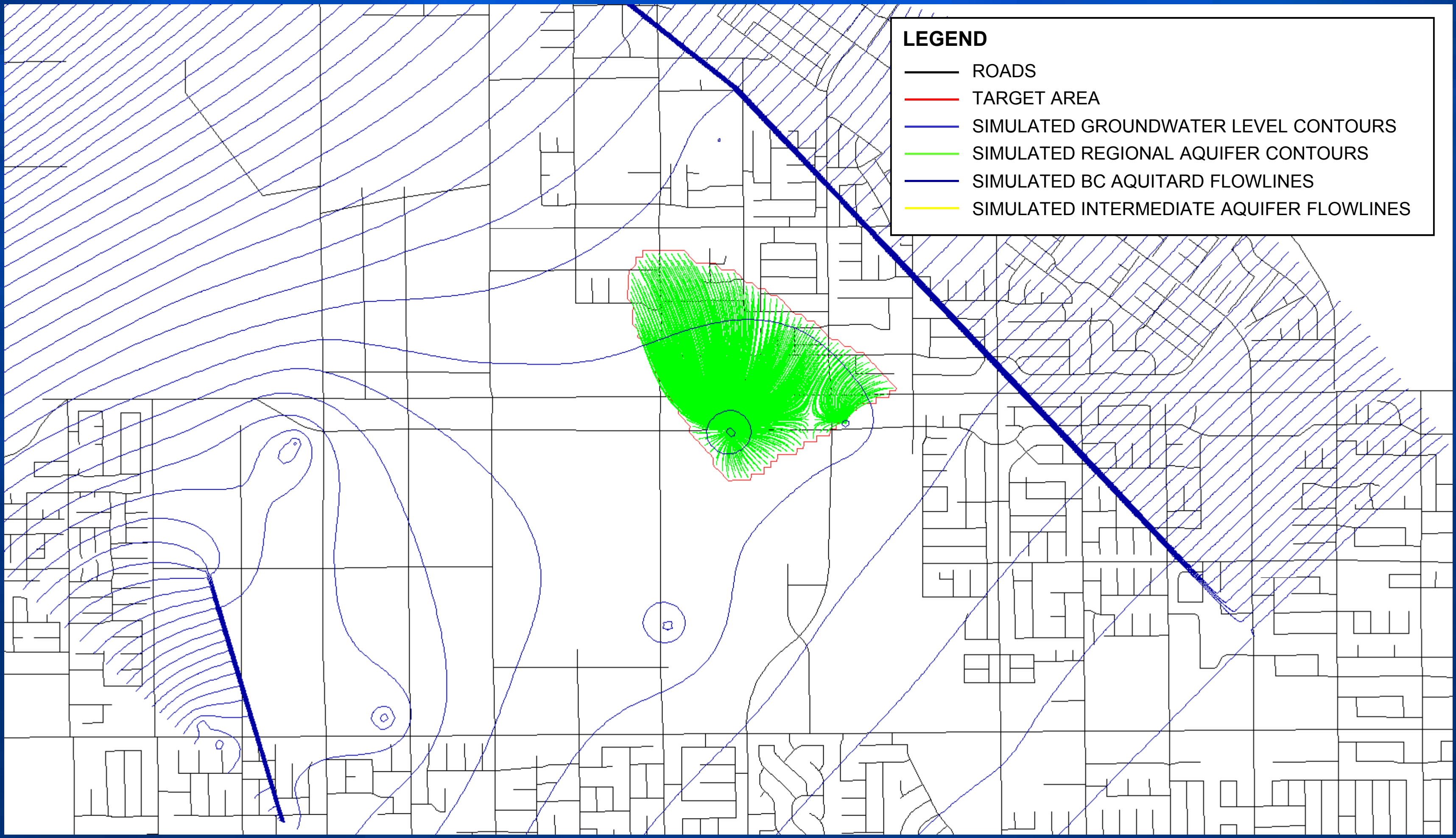
100 percent capture in regional aquifer (excess pumping).

Figure A-22: 1,825 gpm Pumping 1998 Conditions – Regional Aquifer



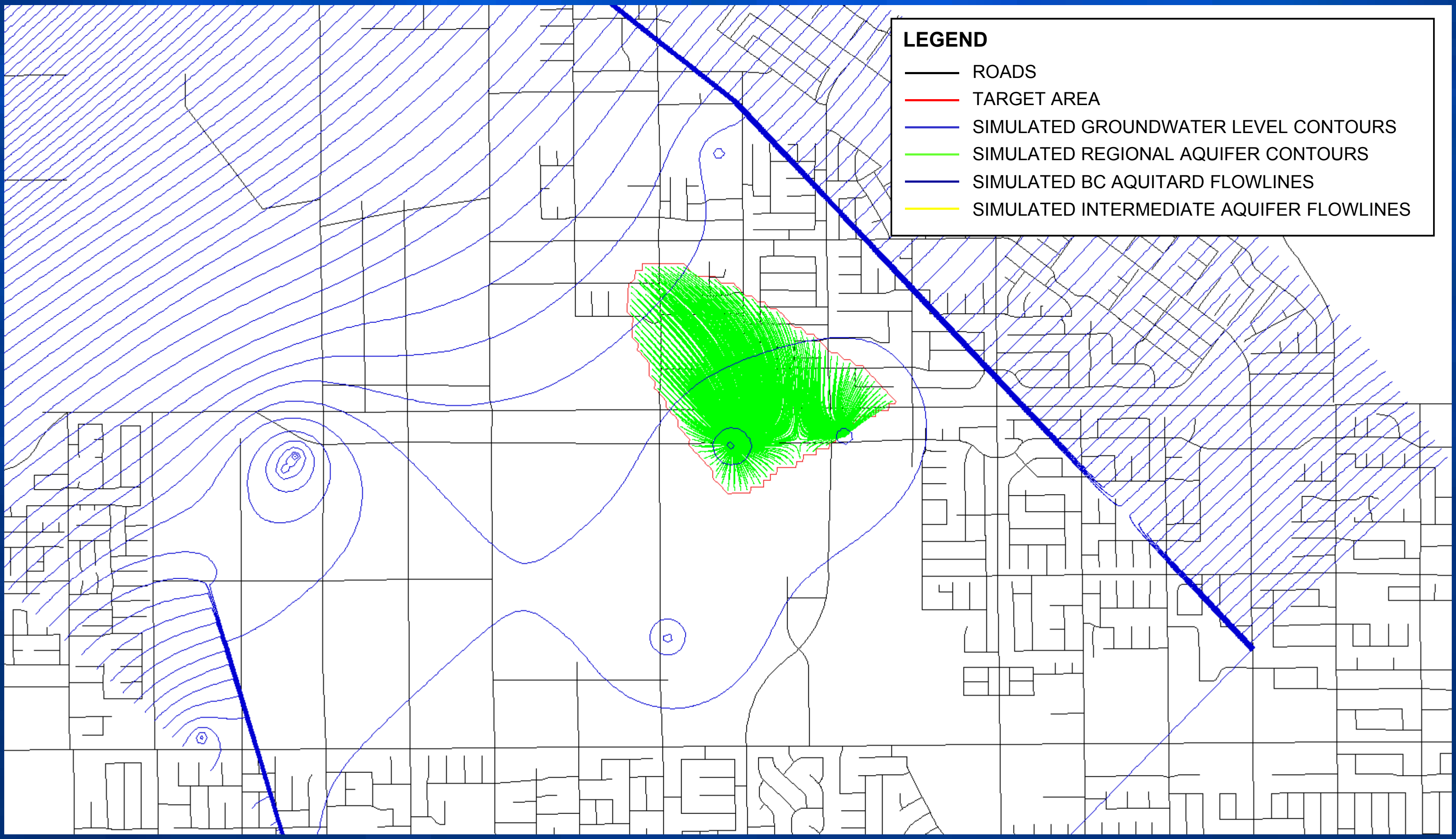
67 percent capture in regional aquifer.

Figure A-23: 2,175 gpm Pumping 2004 Conditions – Regional Aquifer



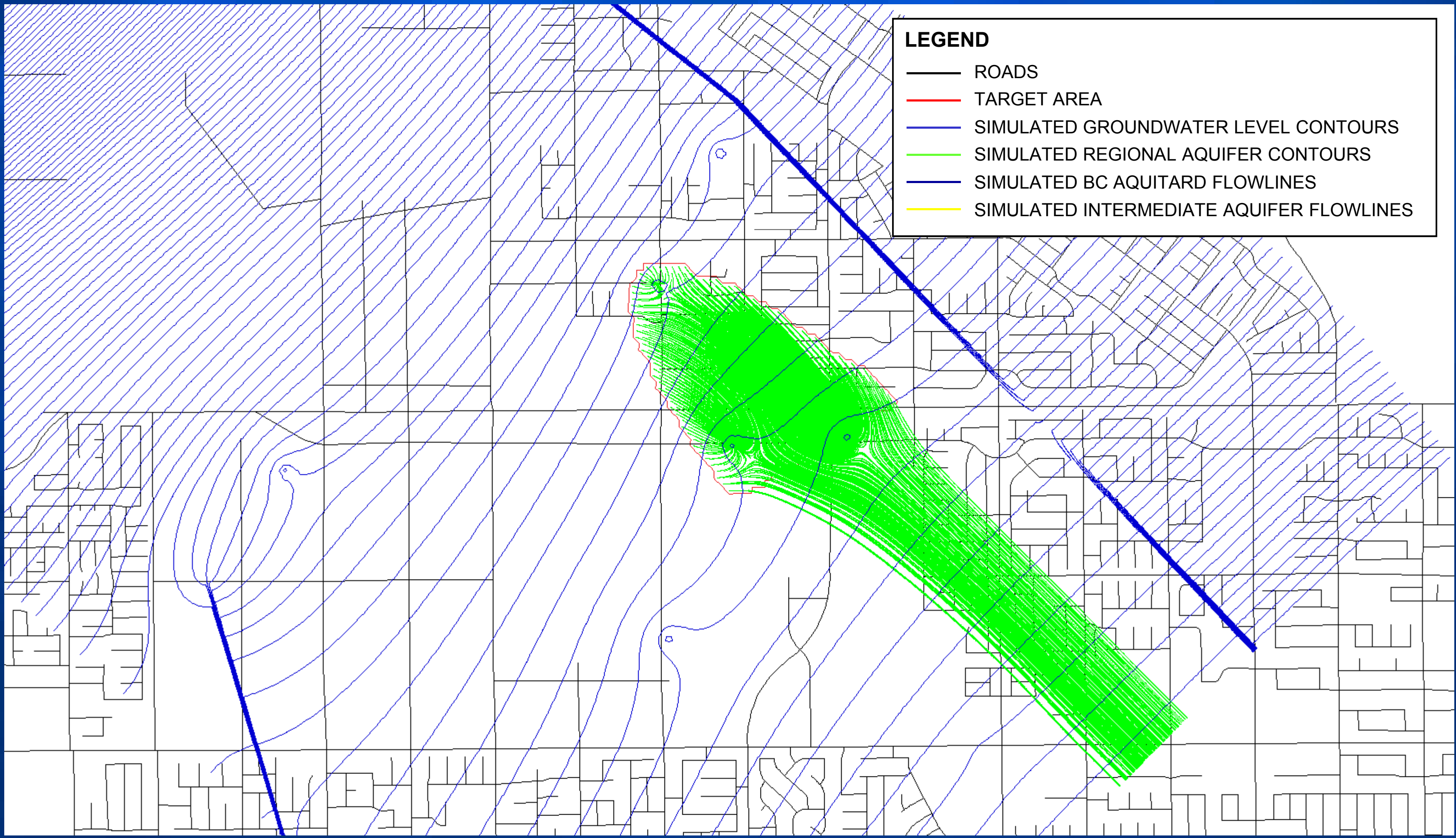
100 percent capture in regional aquifer (excess pumping).

Figure A-24: 2,175 gpm Pumping 2001 Conditions – Regional Aquifer



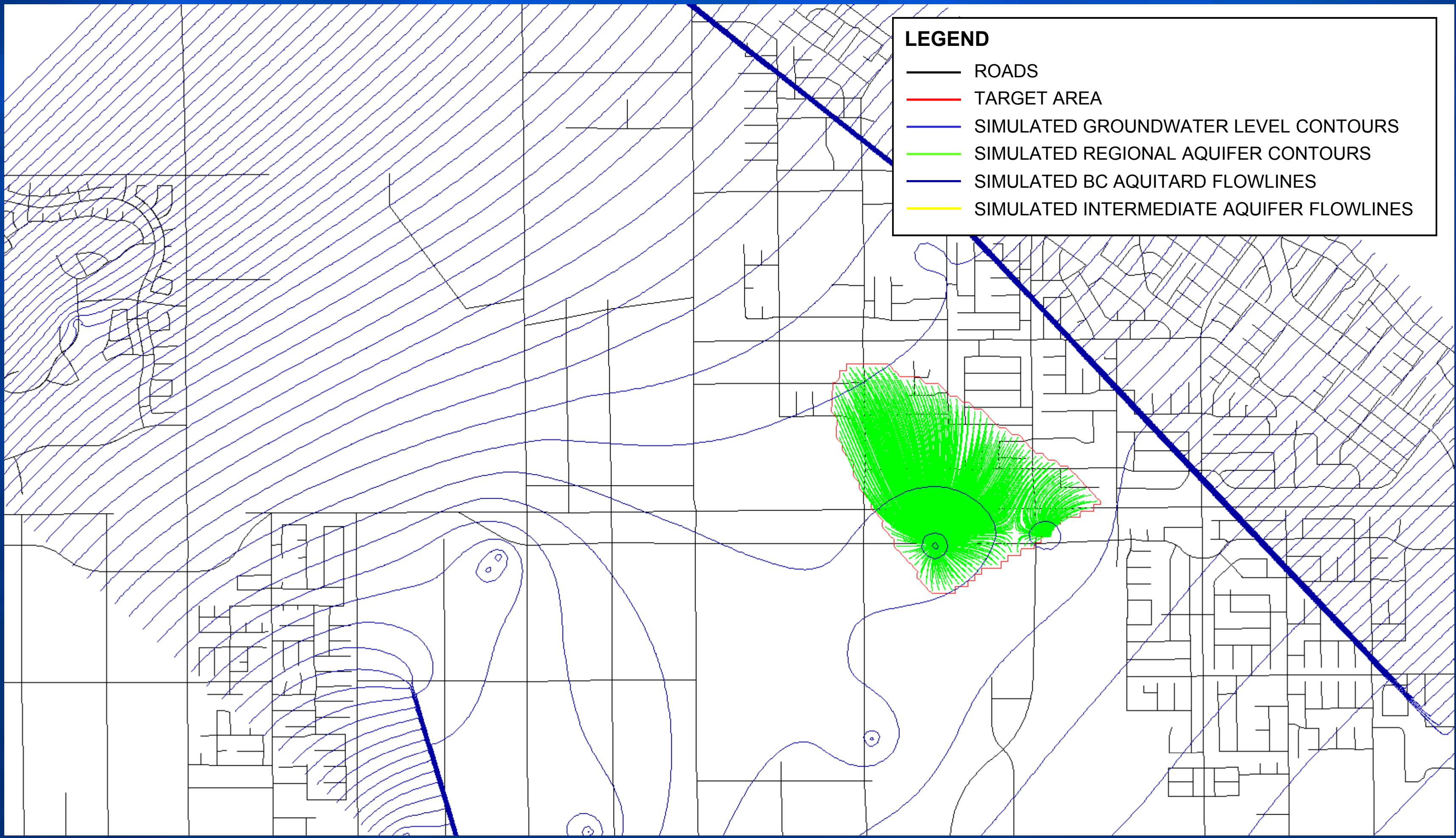
100 percent capture in regional aquifer (excess pumping).

Figure A-25: 2,175 gpm Pumping 1998 Conditions – Regional Aquifer



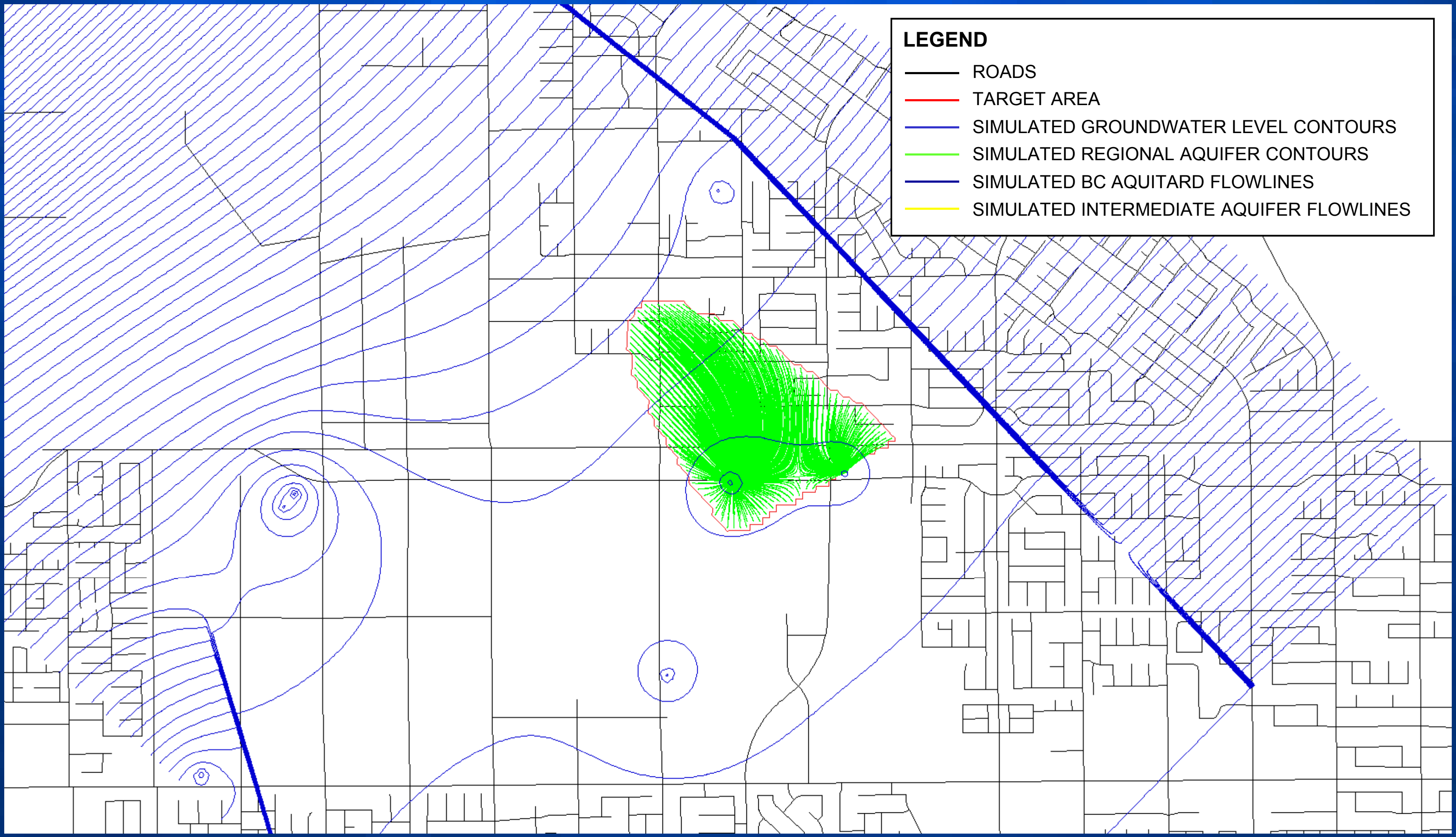
76 percent capture in regional aquifer.

Figure A-26: 2,500 gpm Pumping 2004 Conditions – Regional Aquifer



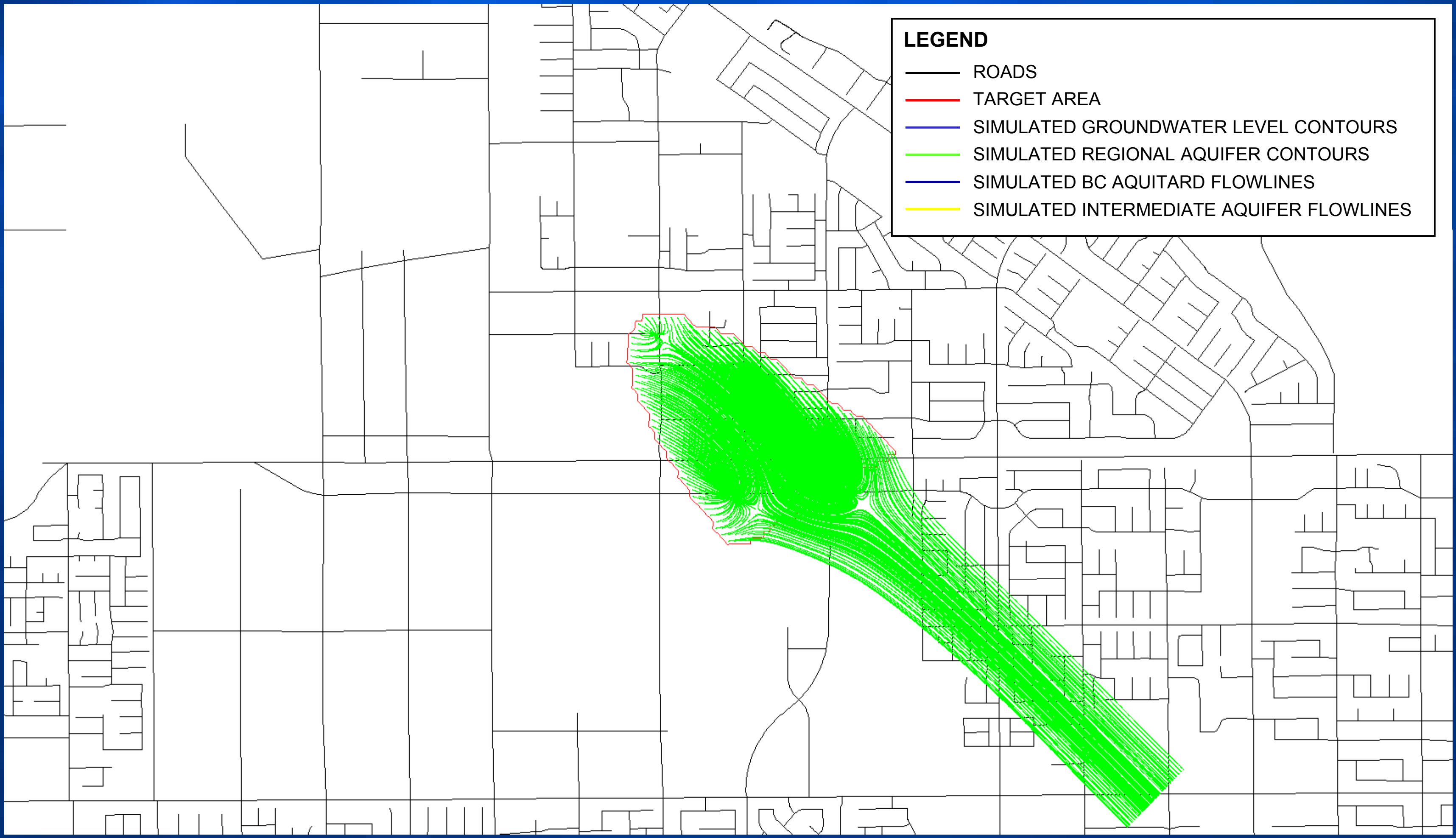
100 percent capture in regional aquifer (excess pumping).

Figure A-27: 2,500 gpm Pumping 2001 Conditions – Regional Aquifer



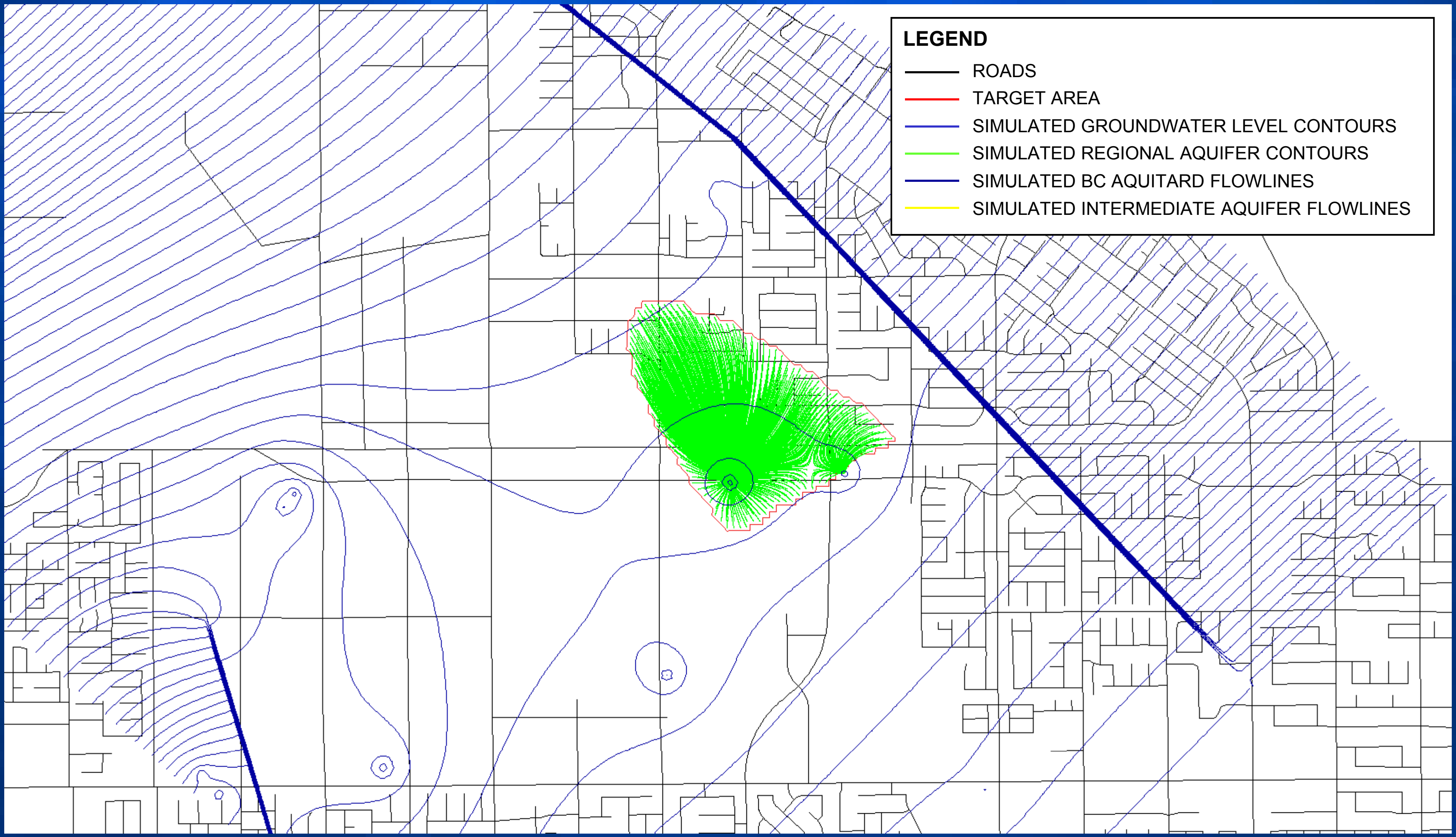
100 percent capture in regional aquifer (excess pumping).

Figure A-28: 2,500 gpm Pumping 1998 Conditions – Regional Aquifer



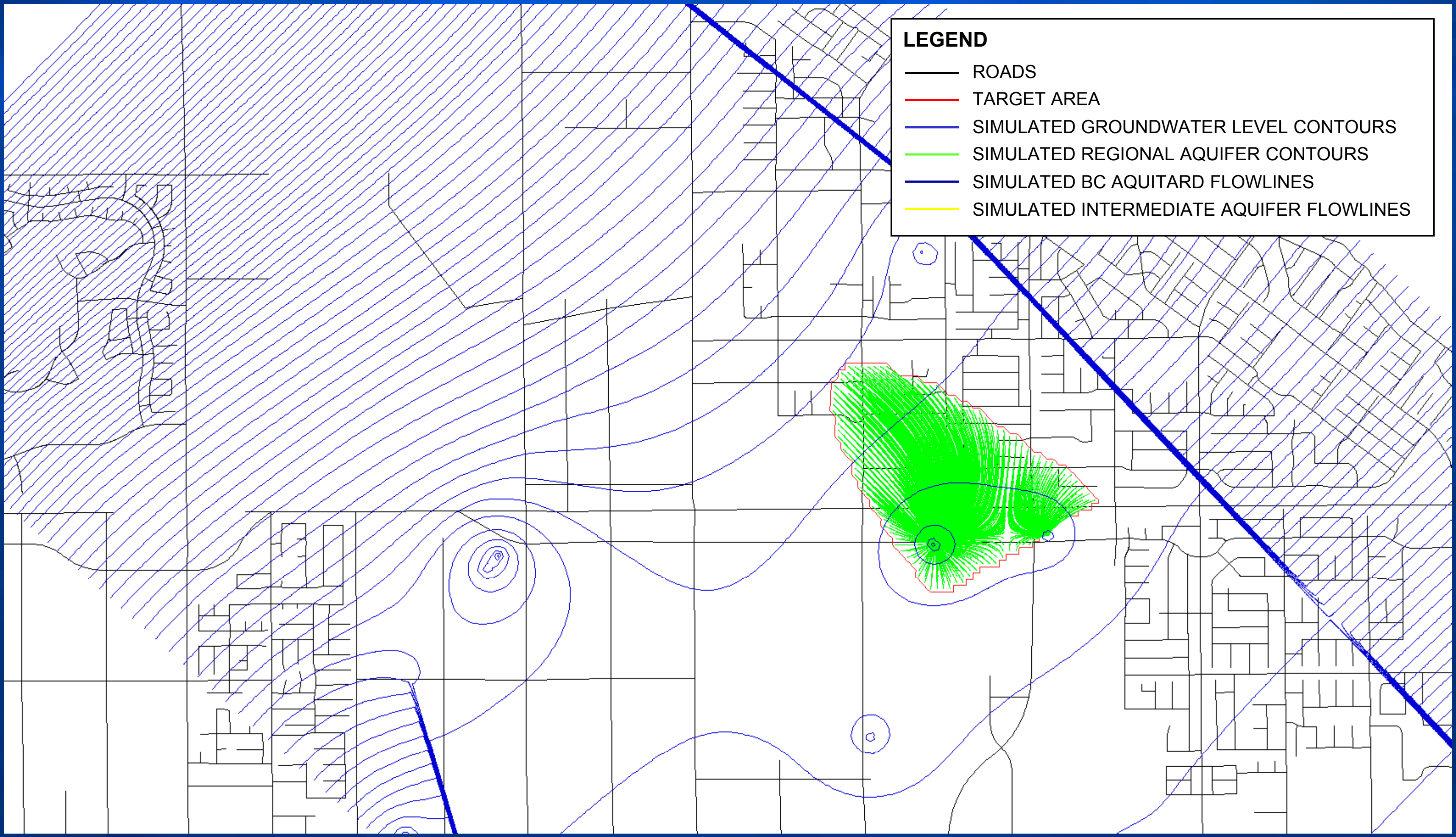
83 percent capture in regional aquifer.

Figure A-29: 3,200 gpm Pumping 2004 Conditions – Regional Aquifer



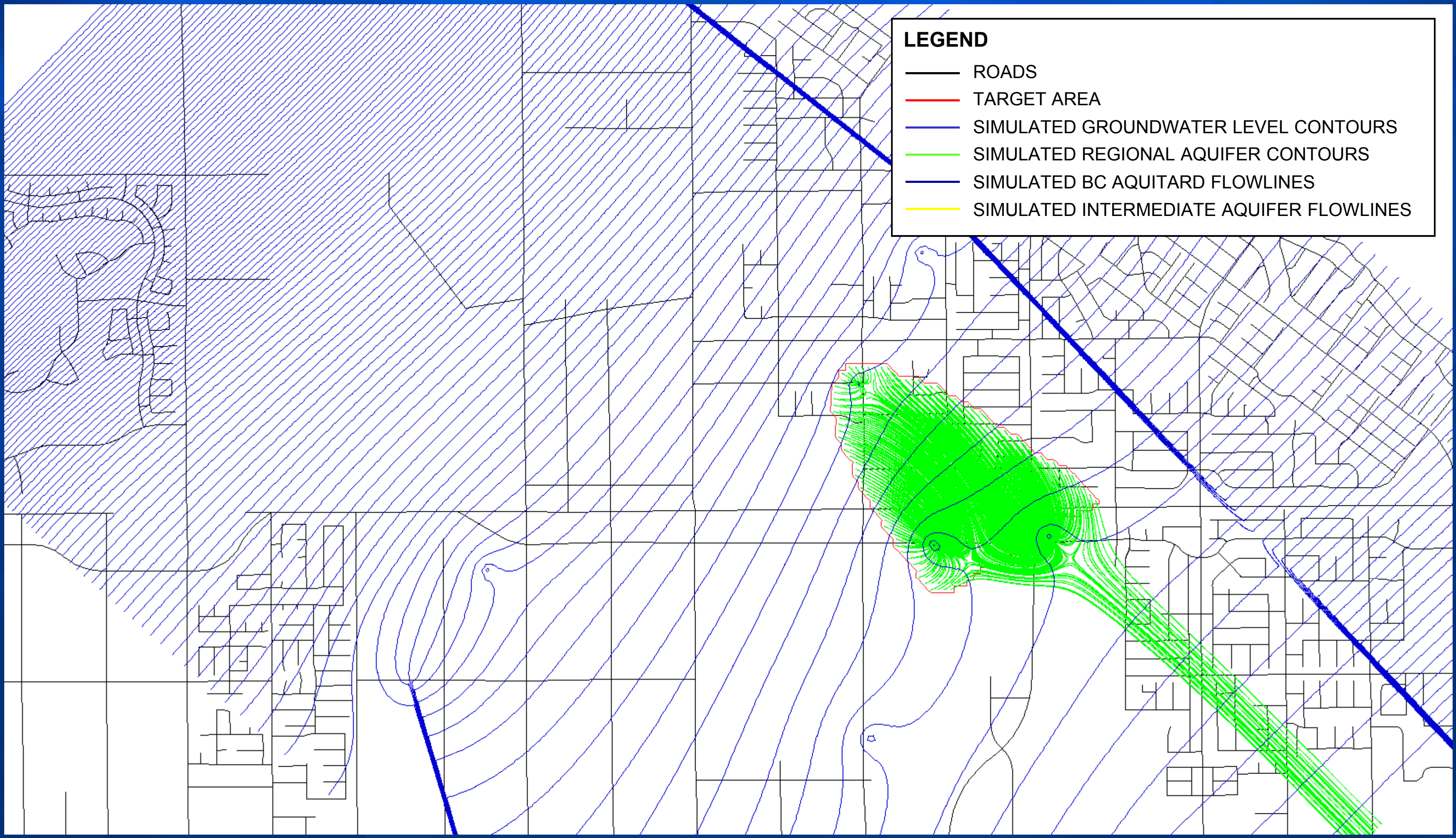
100 percent capture in regional aquifer (excess pumping).

Figure A-30: 3,200 gpm Pumping 2001 Conditions – Regional Aquifer



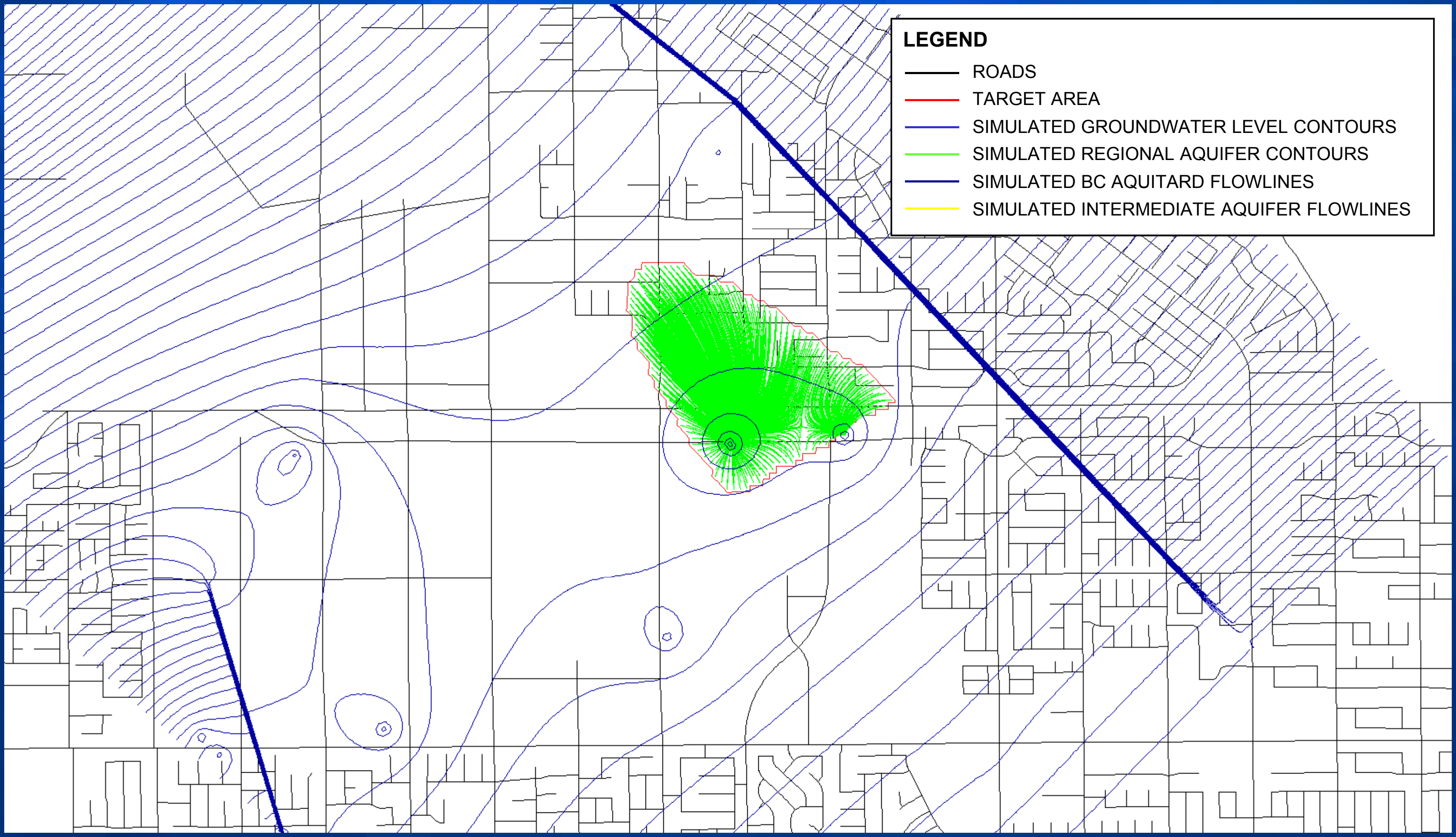
100 percent capture in regional aquifer (excess pumping).

Figure A-31: 3,200 gpm Pumping 1998 Conditions – Regional Aquifer



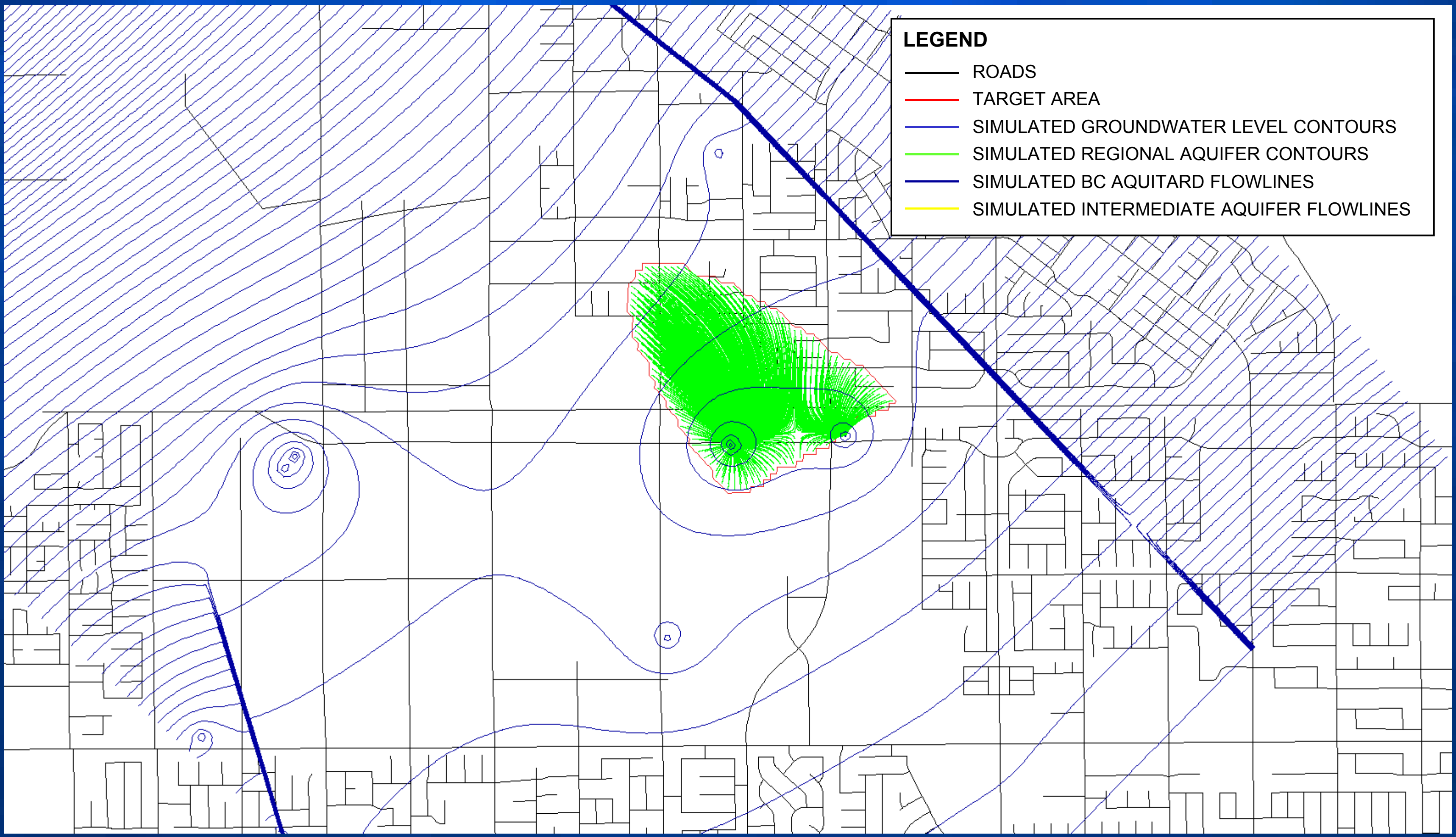
94 percent capture in regional aquifer.

Figure A-32: 5,000 gpm Pumping 2004 Conditions – Regional Aquifer



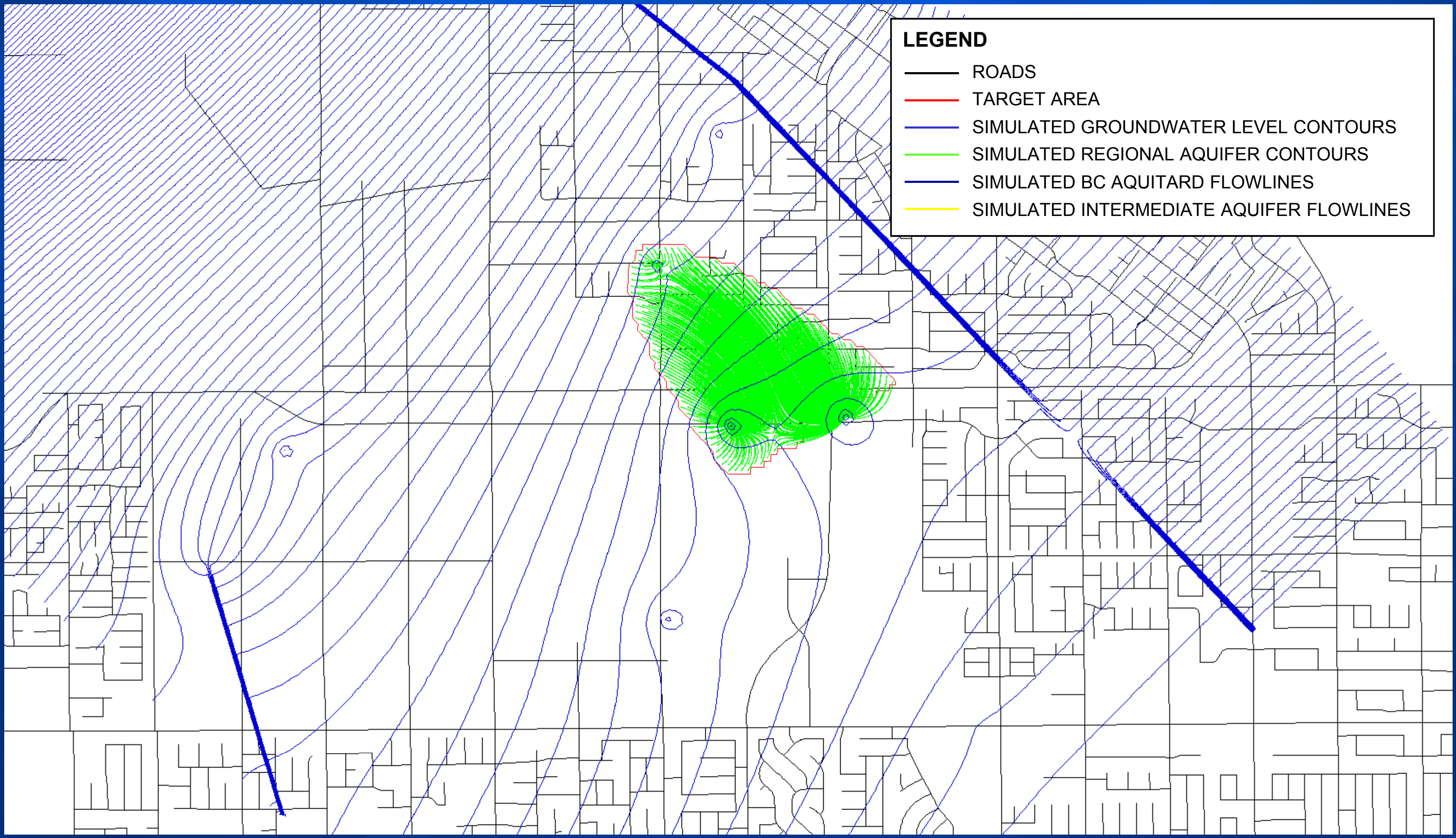
100 percent capture in regional aquifer (excess pumping).

Figure A-33: 5,000 gpm Pumping 2001 Conditions – Regional Aquifer



100 percent capture in regional aquifer (excess pumping).

Figure A-34: 5,000 gpm Pumping 1998 Conditions – Regional Aquifer



100 percent capture in regional aquifer (excess pumping).

Figure A-35: Baseline Pumping 2004 Conditions – Intermediate Aquifer

Figure A-36: Baseline Pumping 2001 Conditions – Intermediate Aquifer

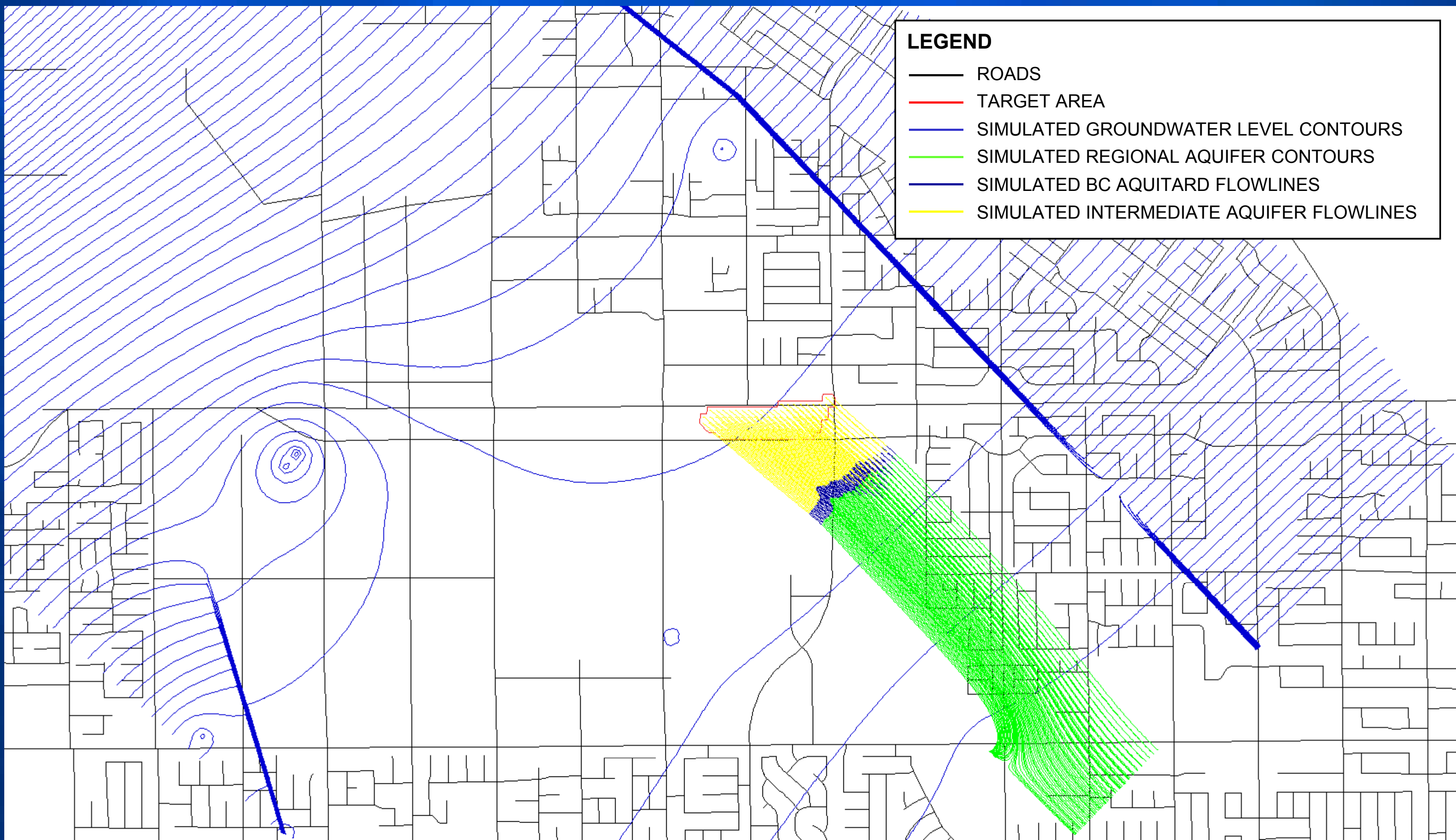


Figure A-37: Baseline Pumping 1998 Conditions – Intermediate Aquifer

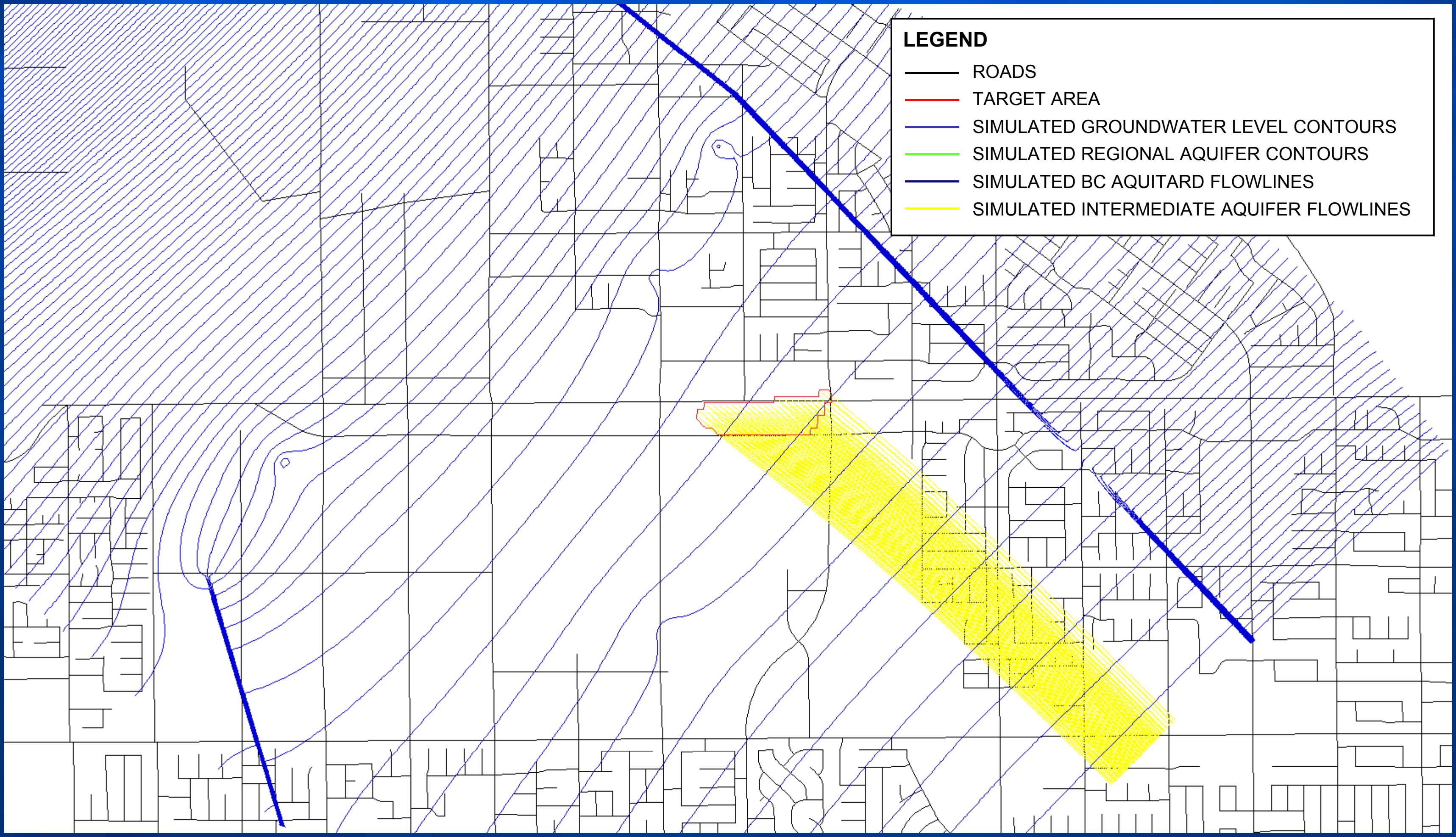
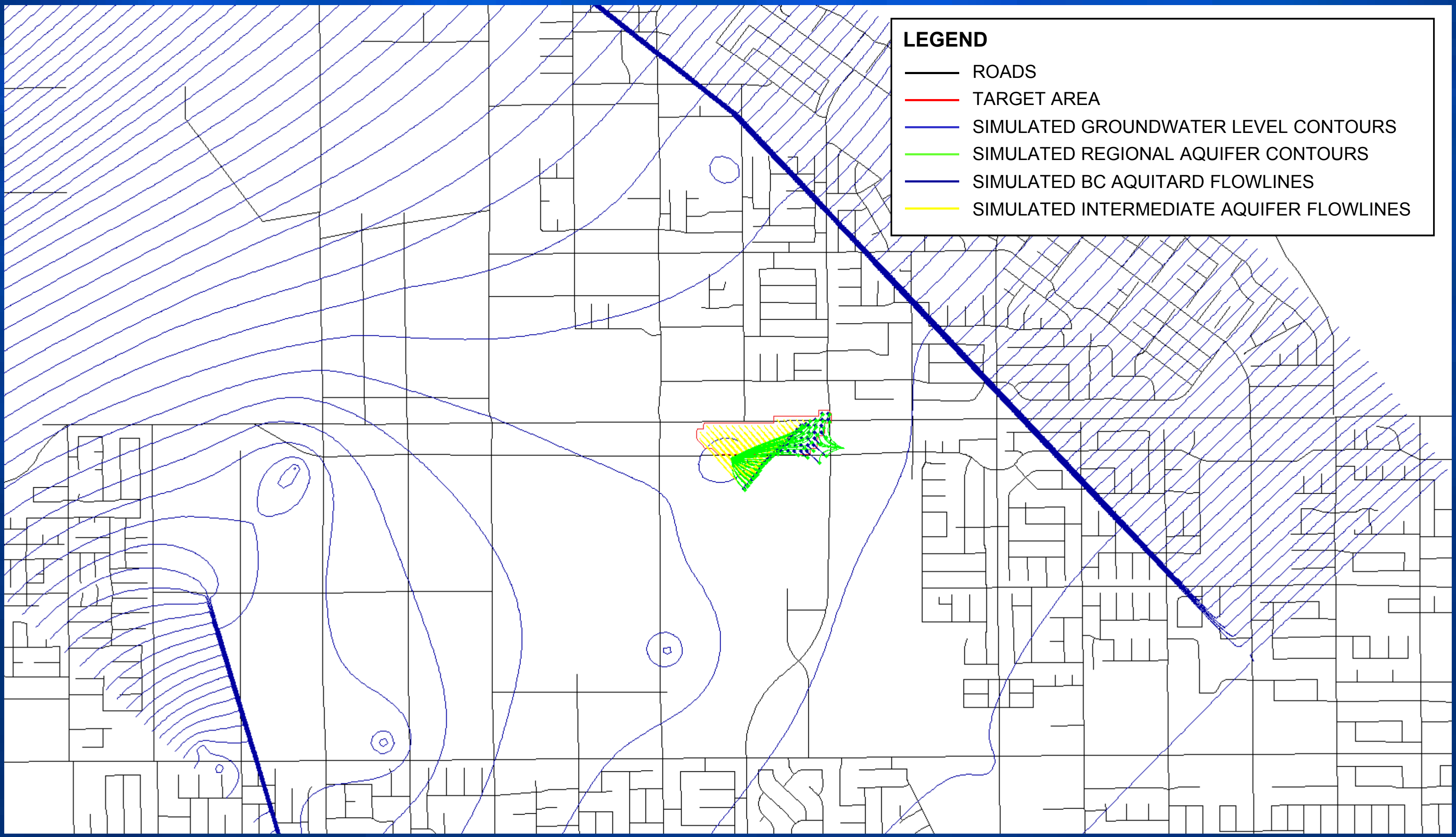
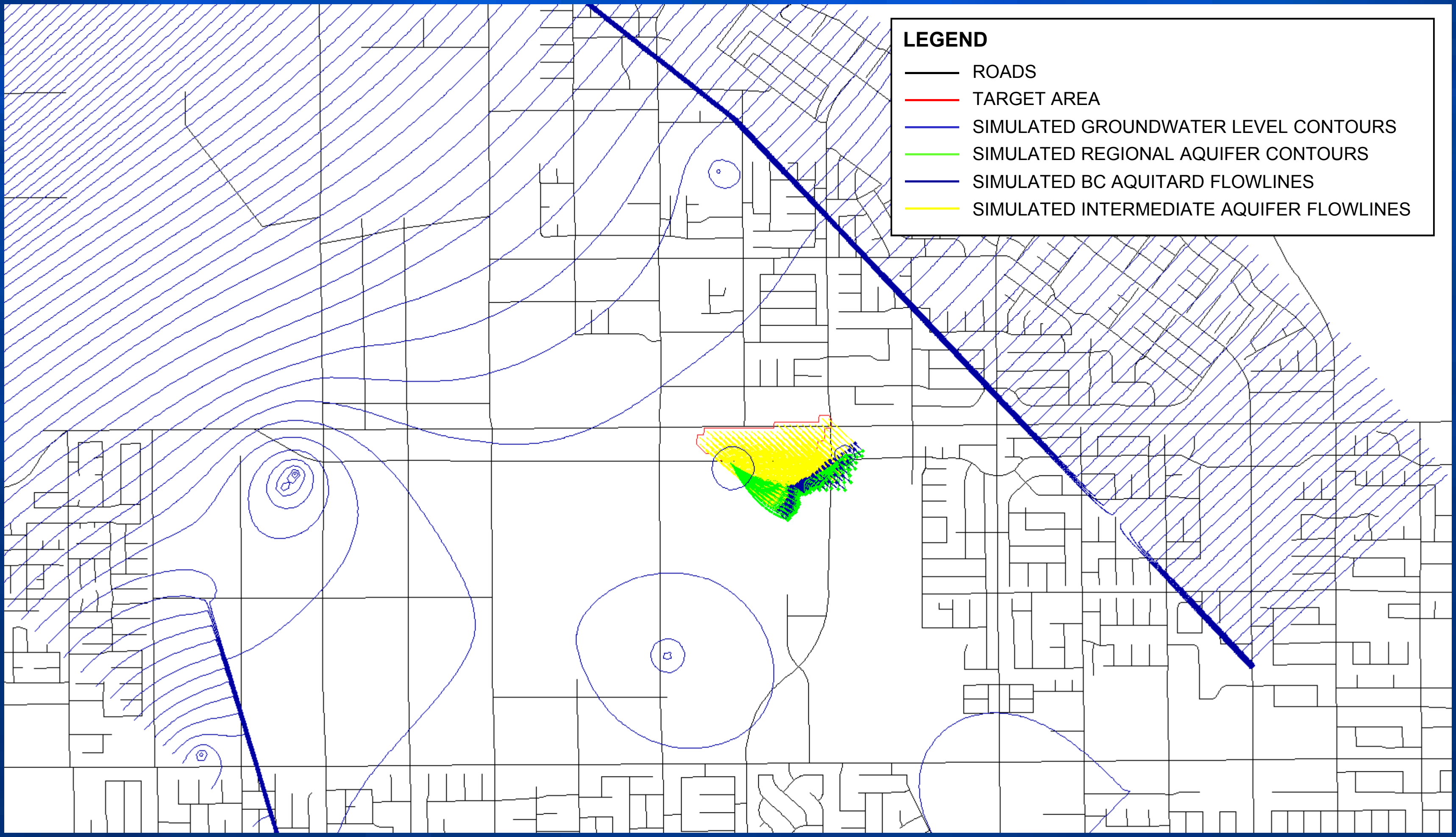


Figure A-38: 1,125 gpm Pumping 2004 Conditions – Intermediate aquifer



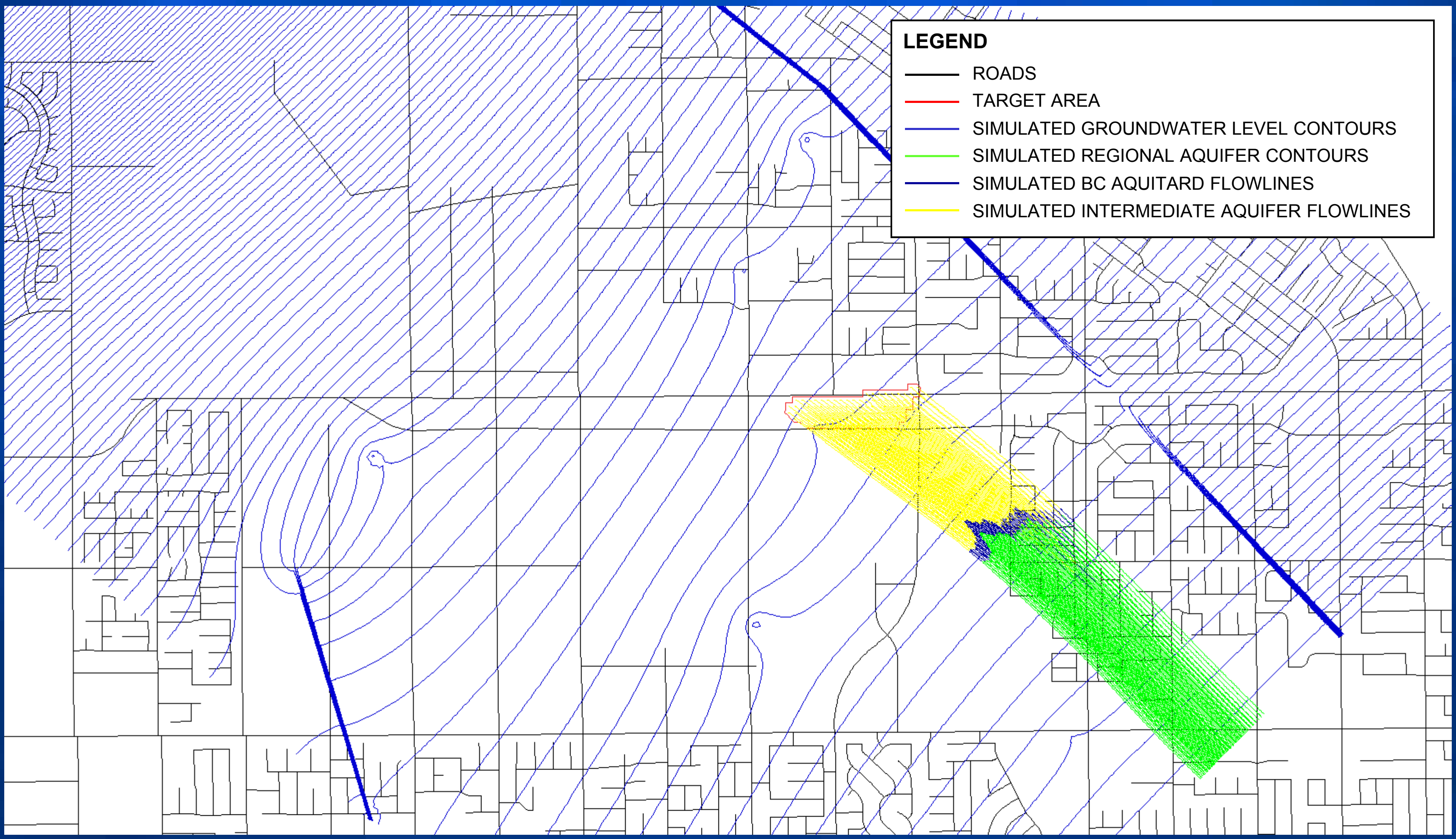
100 percent capture for intermediate aquifer.

Figure A-39: 1,125 gpm Pumping 2001 Conditions – Intermediate aquifer



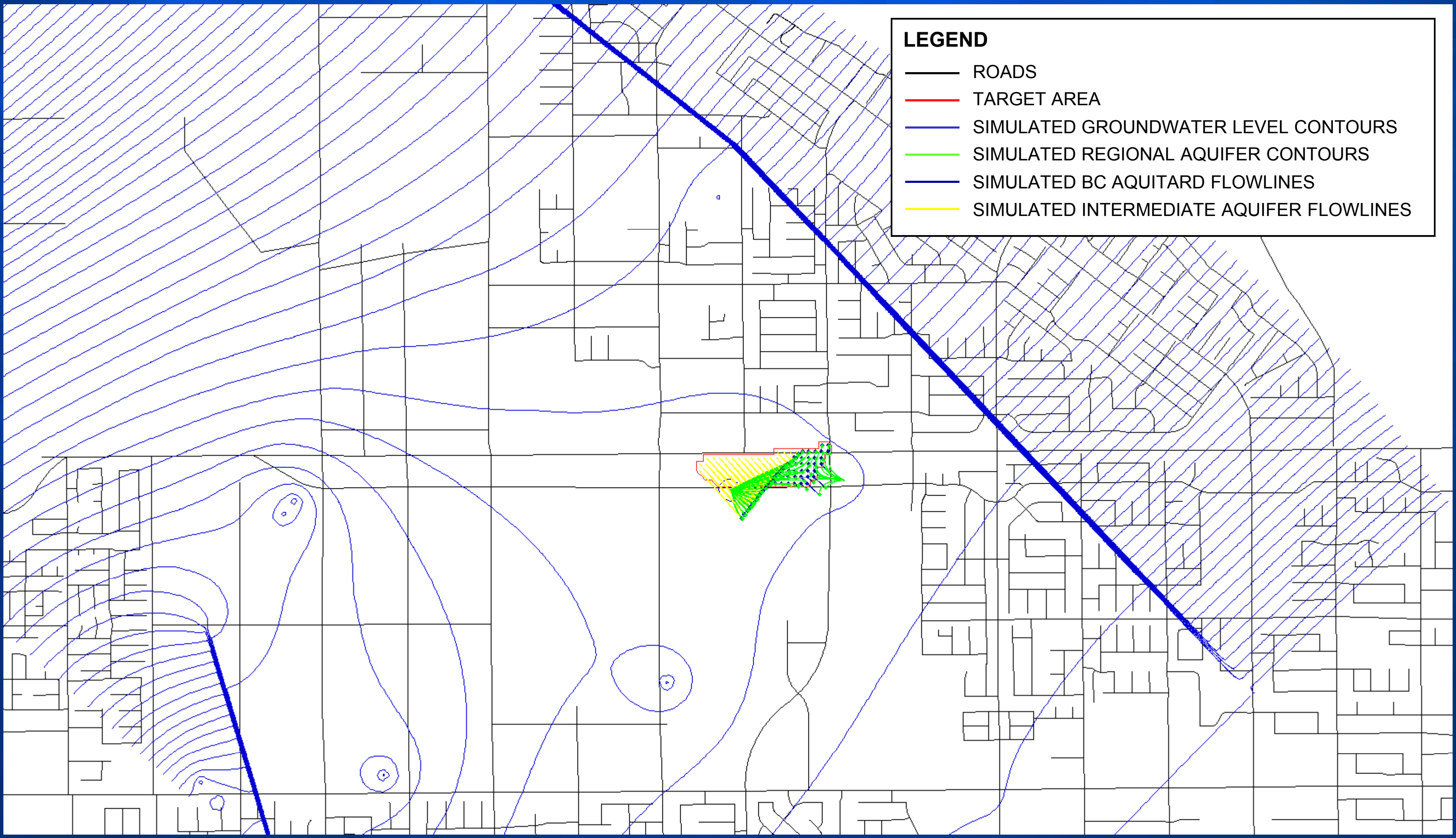
100 percent capture for intermediate aquifer.

Figure A-40: 1,125 gpm Pumping 1998 Conditions – Intermediate Aquifer



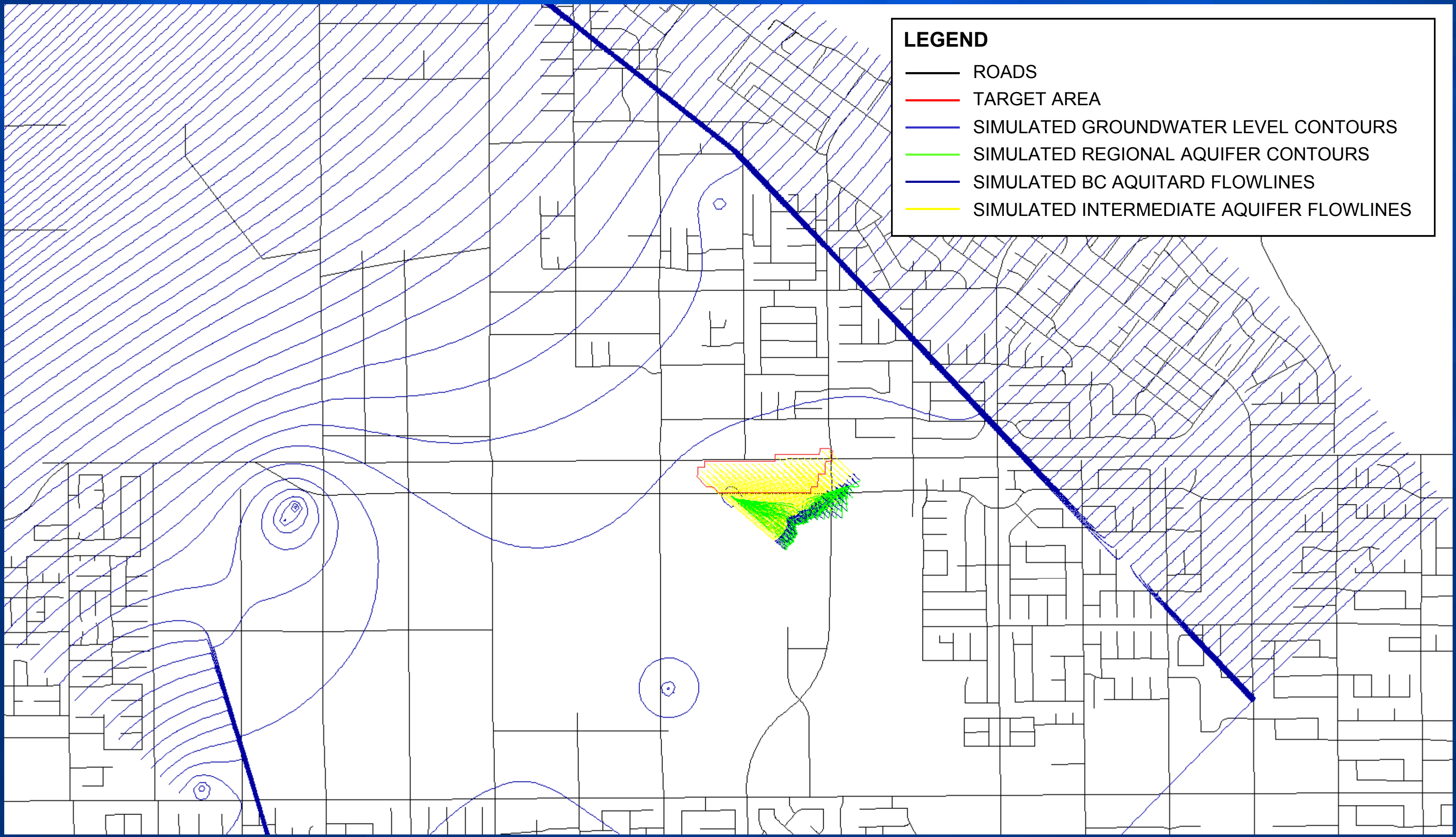
0 percent capture for intermediate aquifer.

Figure A-41: 1,500 gpm Pumping 2004 Conditions – Intermediate Aquifer



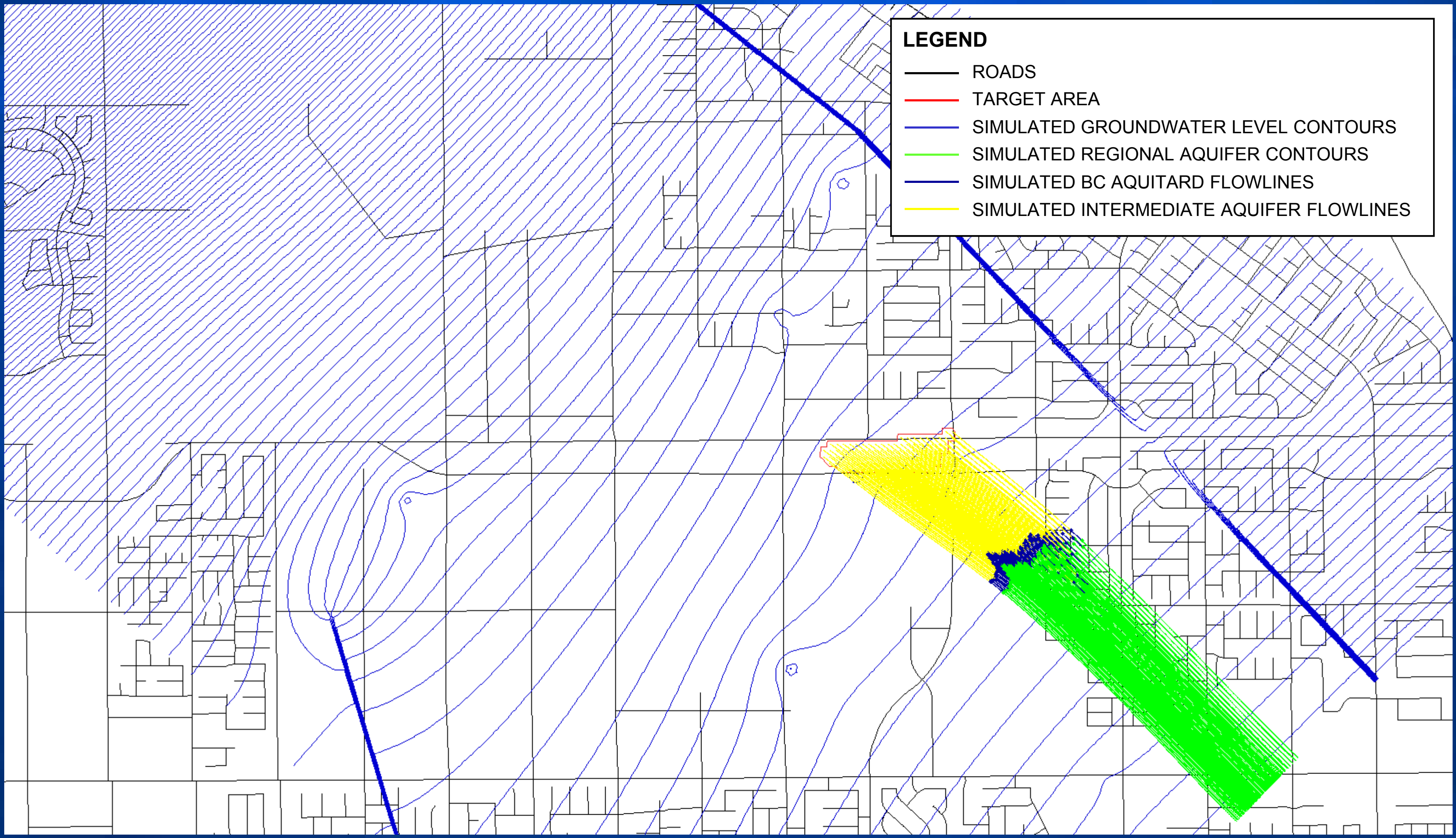
100 percent capture for intermediate aquifer (excess pumping).

Figure A-42: 1,500 gpm Pumping 2001 Conditions – Intermediate Aquifer



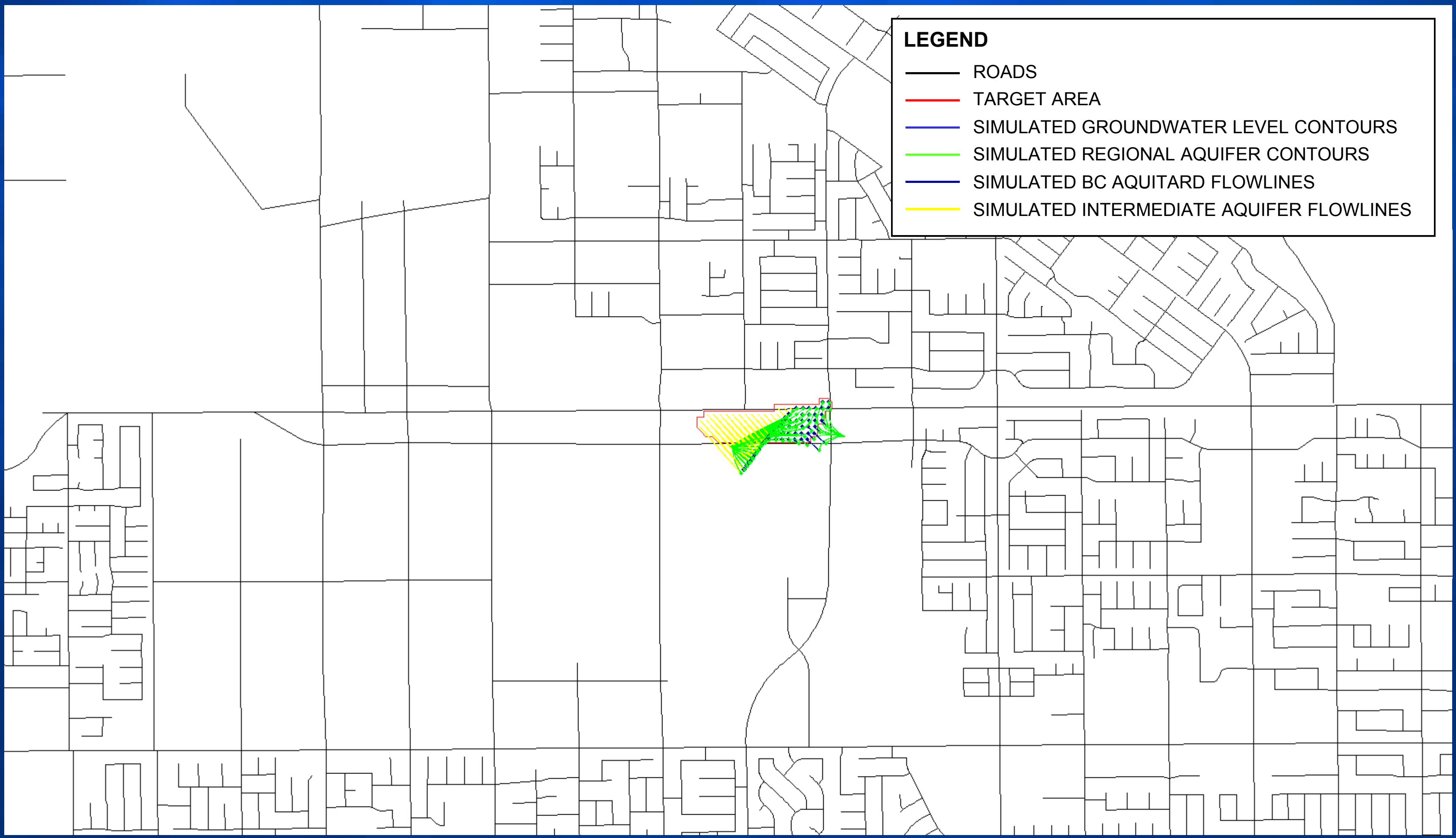
100 percent capture for intermediate aquifer (excess pumping).

Figure A-43: 1,500 gpm Pumping 1998 Conditions – Intermediate Aquifer



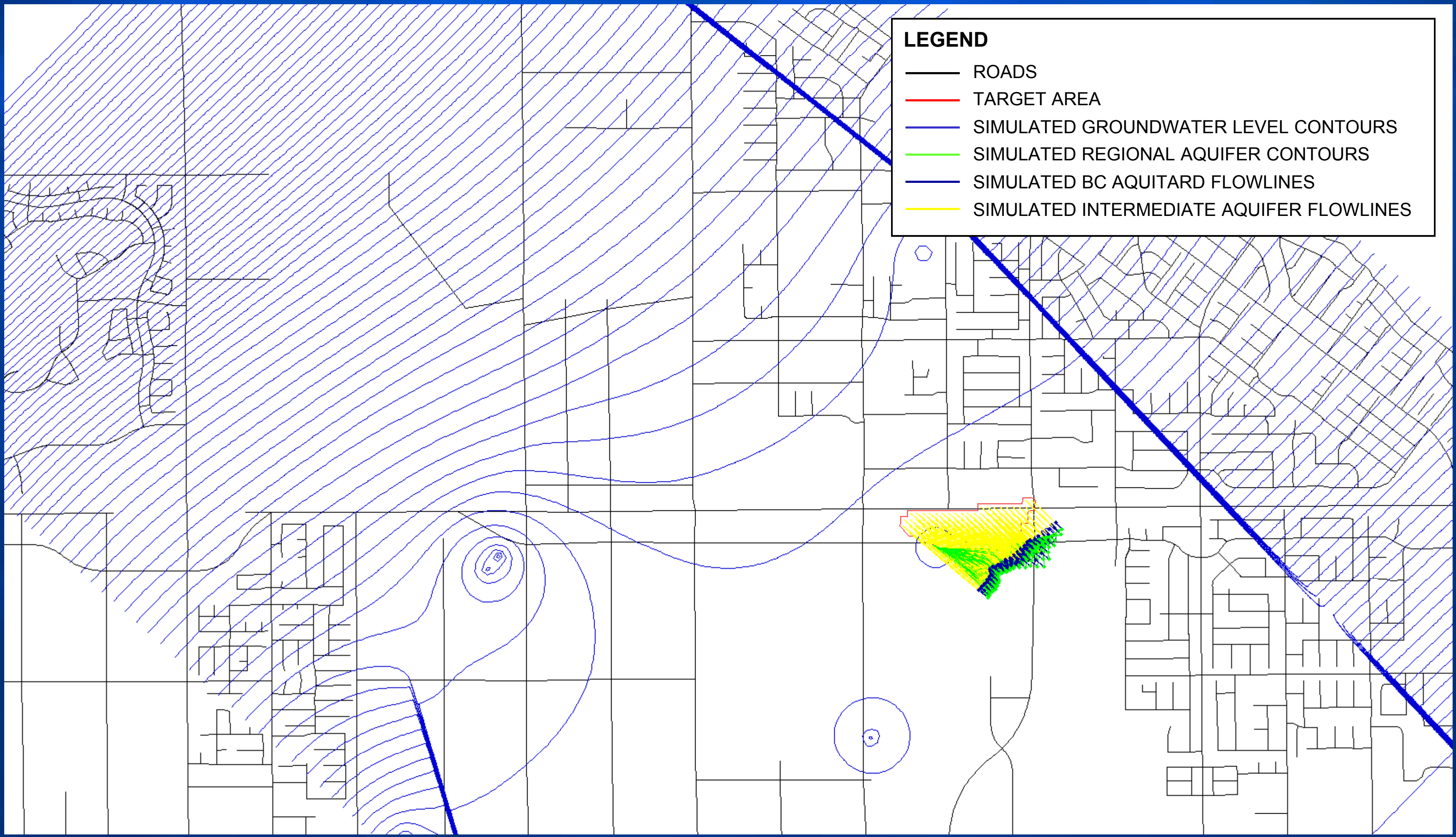
0 percent capture for intermediate aquifer.

Figure A-44: 1,650 gpm Pumping 2004 Conditions – Intermediate Aquifer



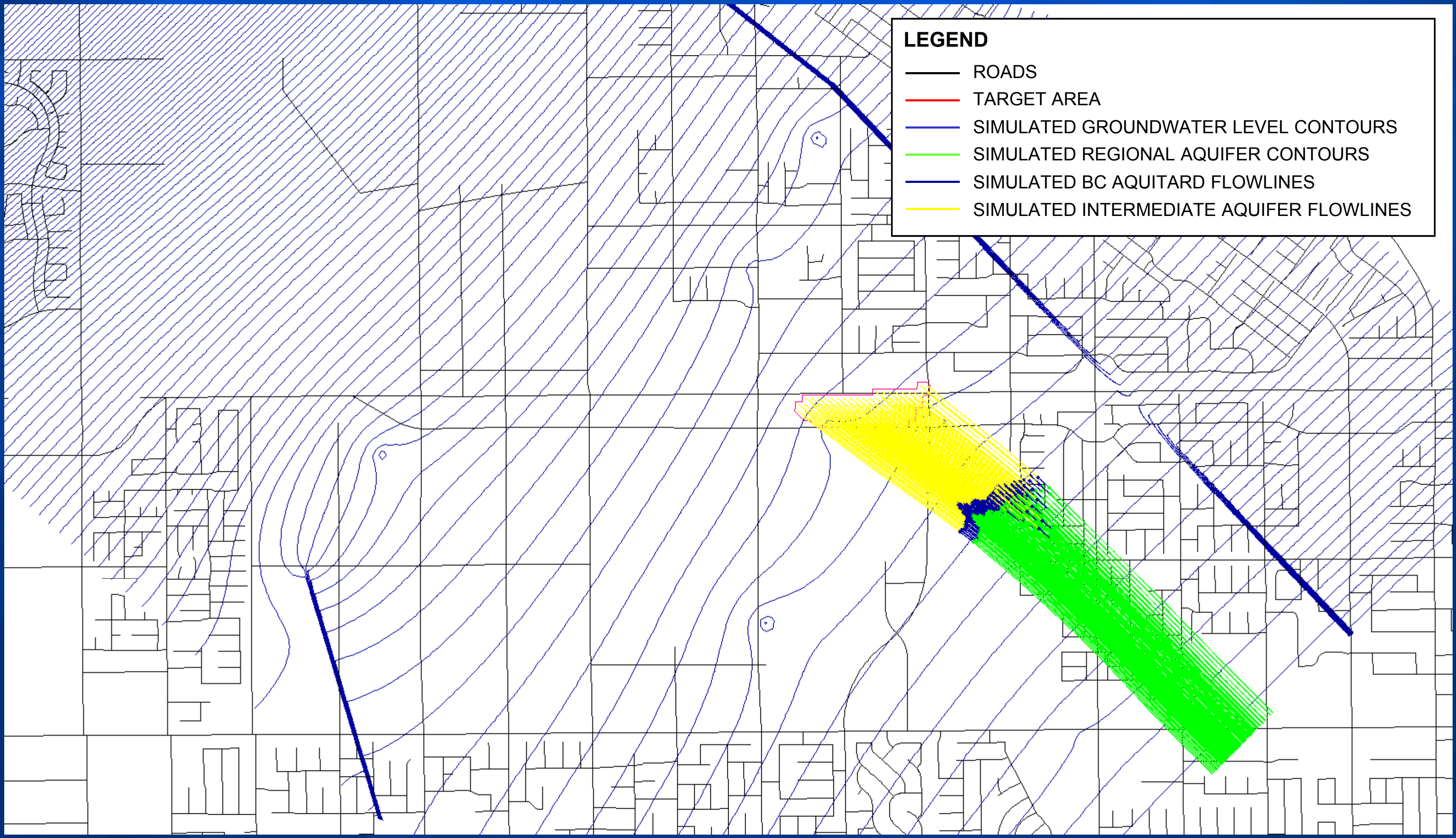
100 percent capture for intermediate aquifer (excess pumping).

Figure A-45: 1,650 gpm Pumping 2001 Conditions – Intermediate Aquifer



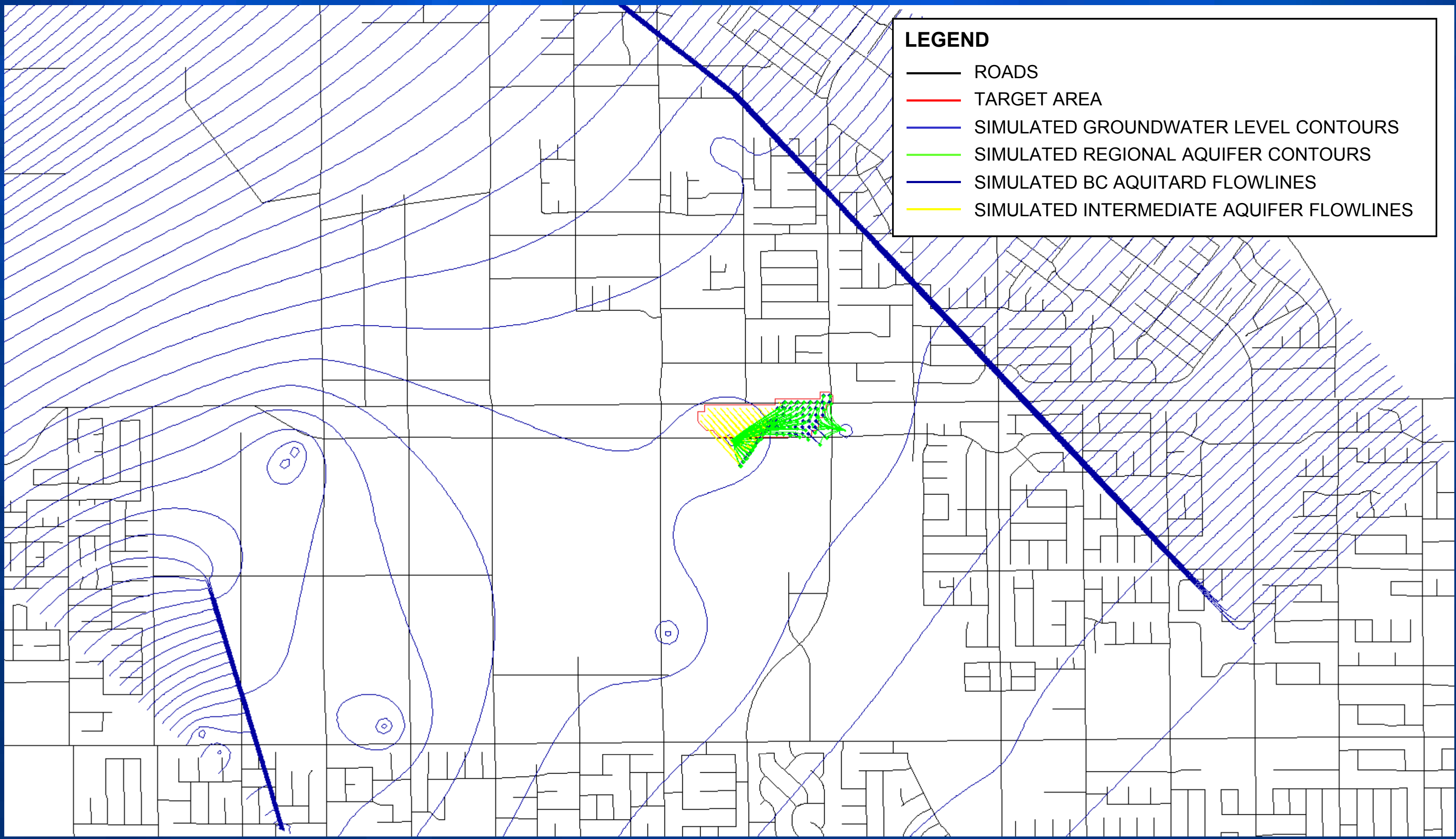
100 percent capture for intermediate aquifer (excess pumping).

Figure A-46: 1,650 gpm Pumping 1998 Conditions – Intermediate Aquifer



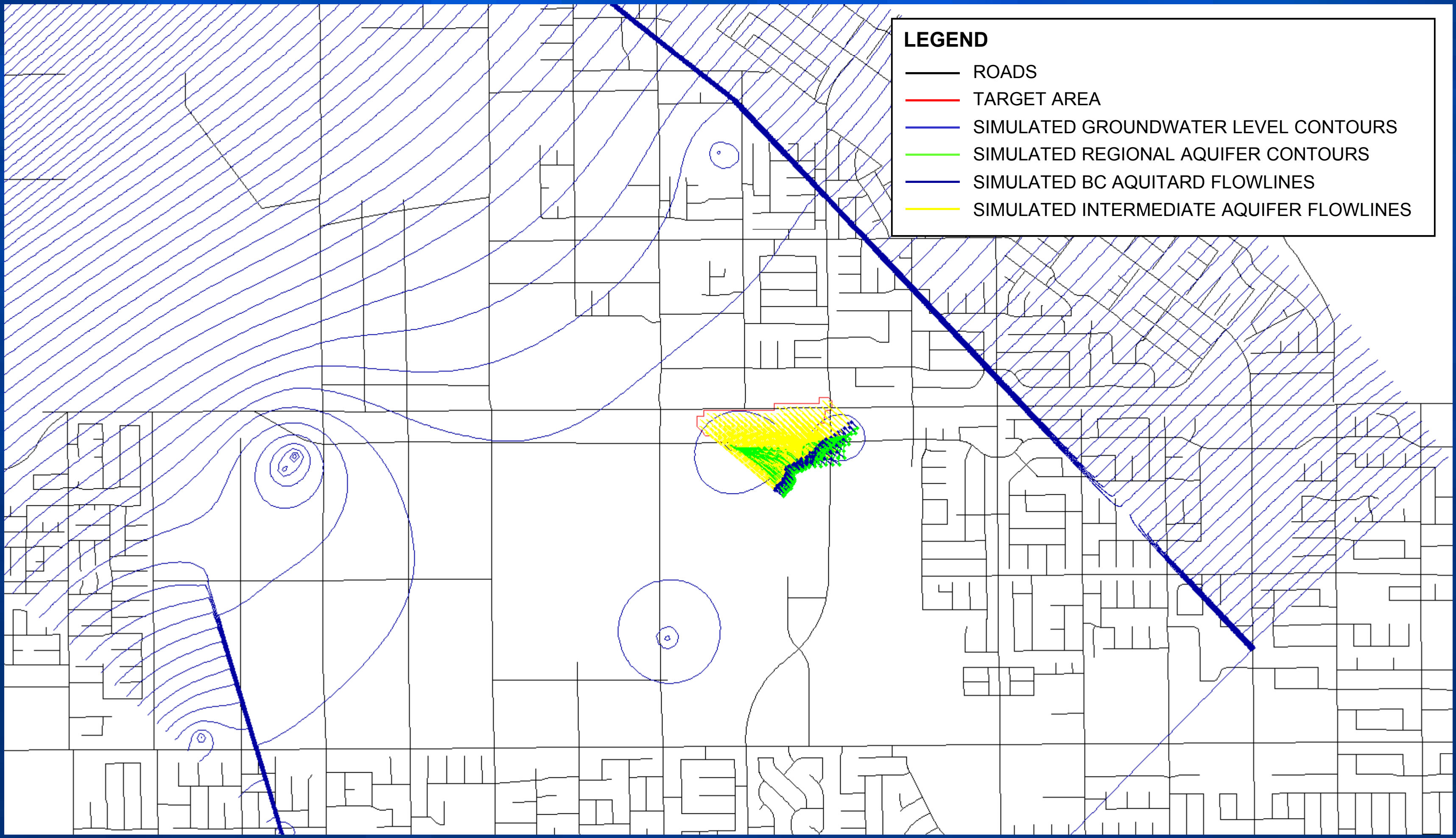
0 percent capture for intermediate aquifer.

Figure A-47: 1,825 gpm Pumping 2004 Conditions – Intermediate Aquifer



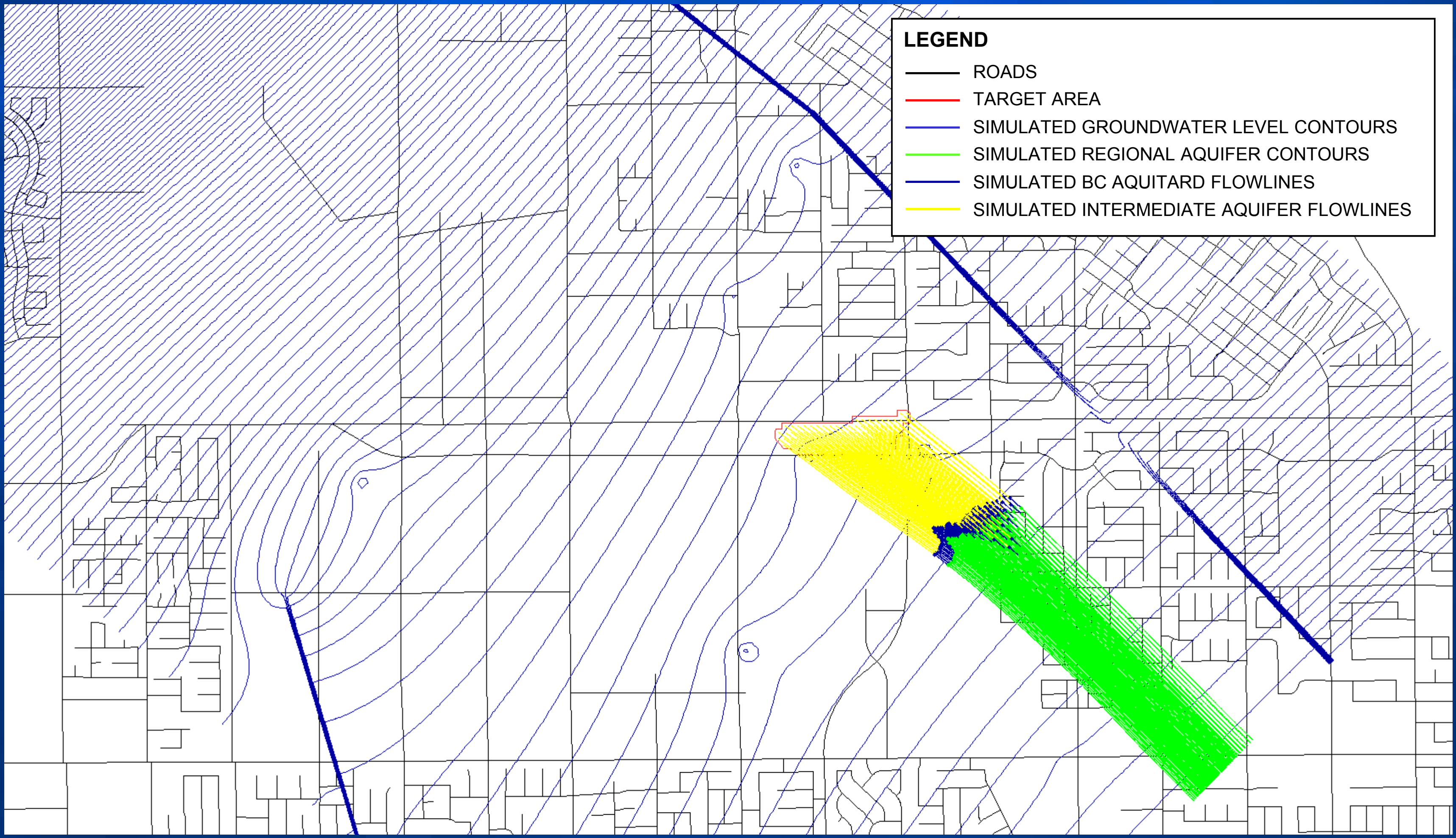
100 percent capture for intermediate aquifer (excess pumping).

Figure A-48: 1,825 gpm Pumping 2001 Conditions– Intermediate Aquifer



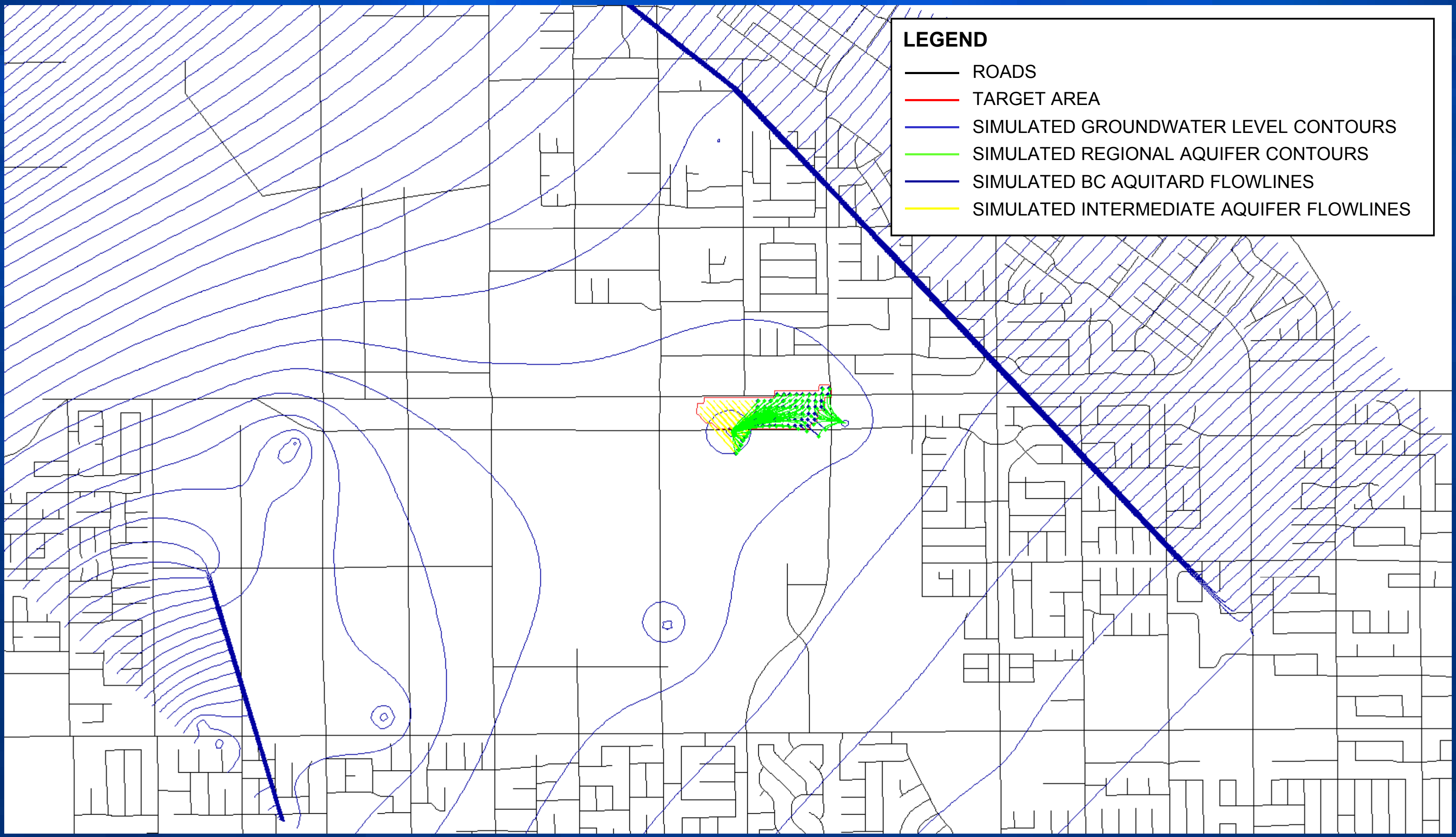
100 percent capture for intermediate aquifer (excess pumping).

Figure A-49: 1,825 gpm Pumping 1998 Conditions – Intermediate Aquifer



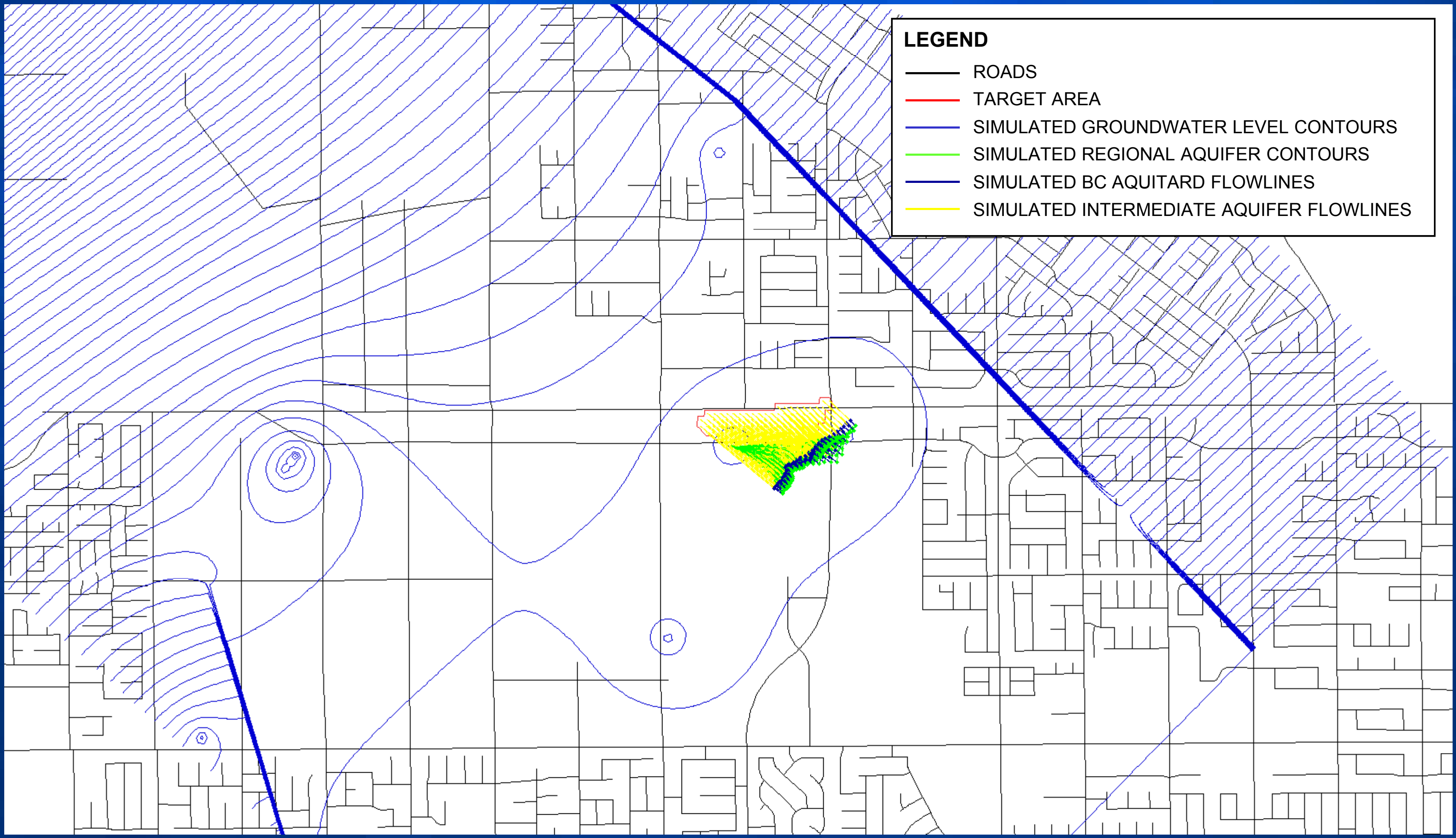
0 percent capture for intermediate aquifer.

Figure A-50: 2,175 gpm Pumping 2004 Conditions – Intermediate Aquifer



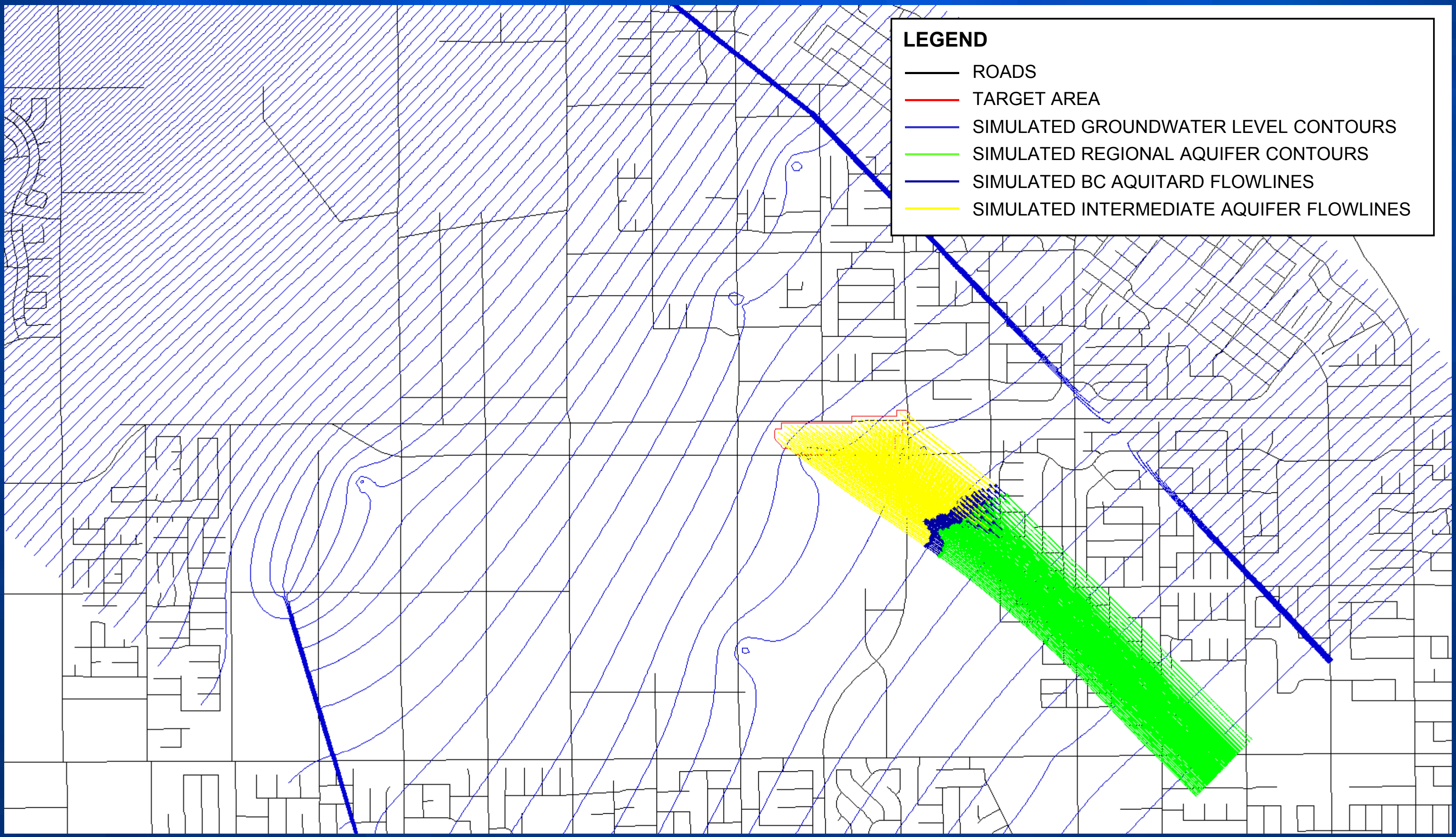
100 percent capture for intermediate aquifer (excess pumping).

Figure A-51: 2,175 gpm Pumping 2001 Conditions – Intermediate Aquifer



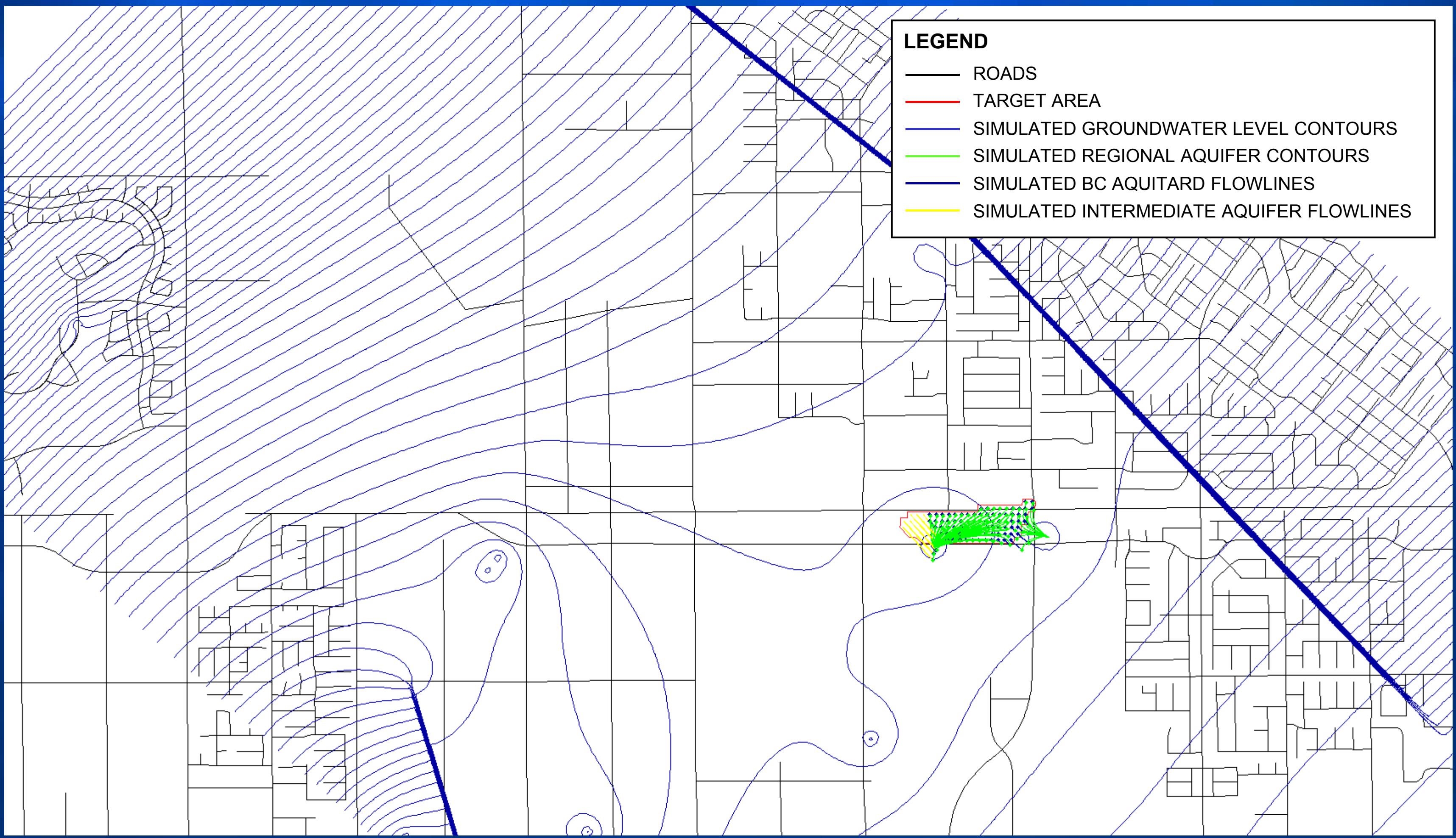
100 percent capture for intermediate aquifer (excess pumping).

Figure A-52: 2,175 gpm Pumping 1998 Conditions – Intermediate Aquifer



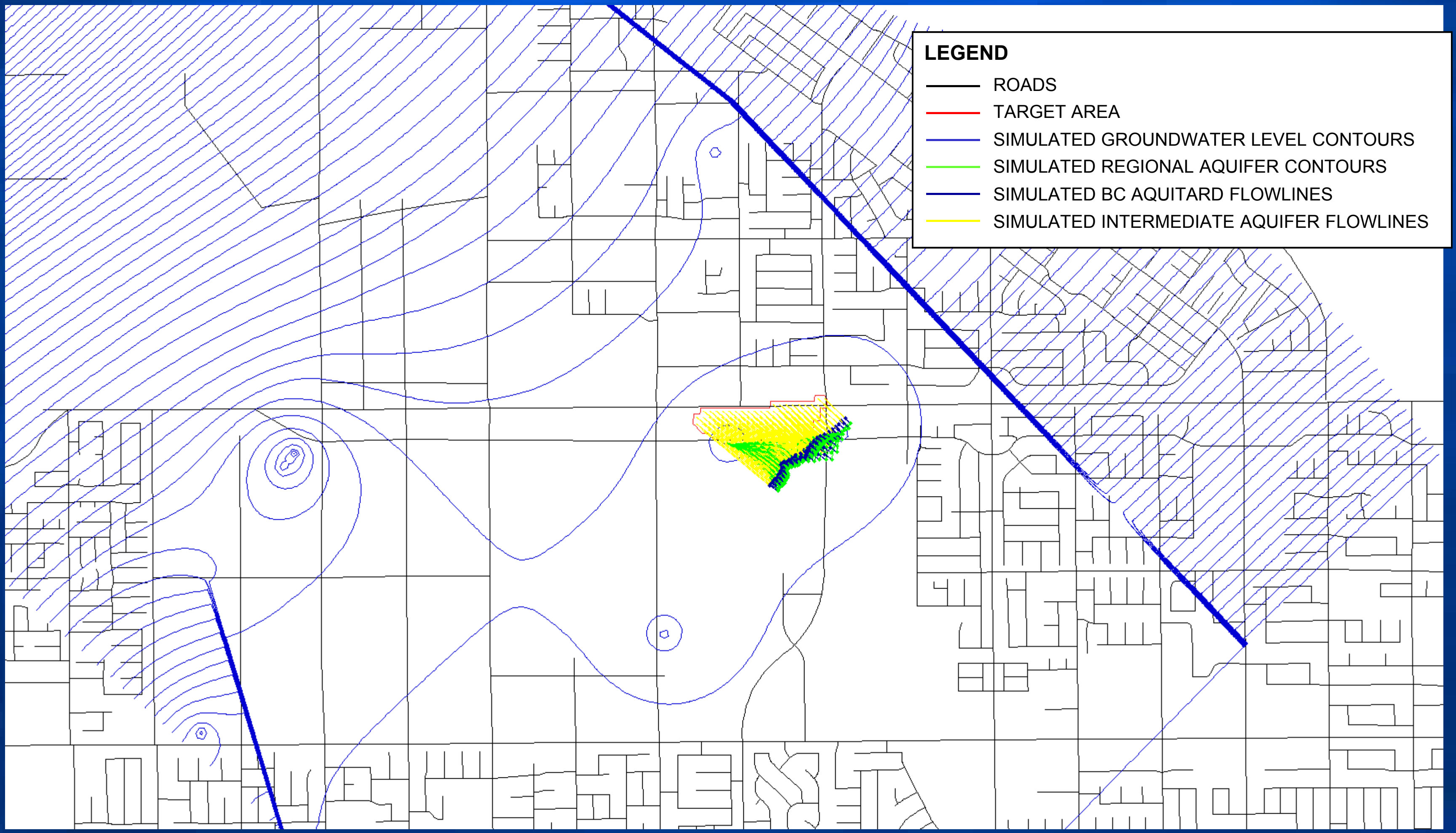
0 percent capture for intermediate aquifer.

Figure A-53: 2,500 gpm Pumping 2004 Conditions – Intermediate Aquifer



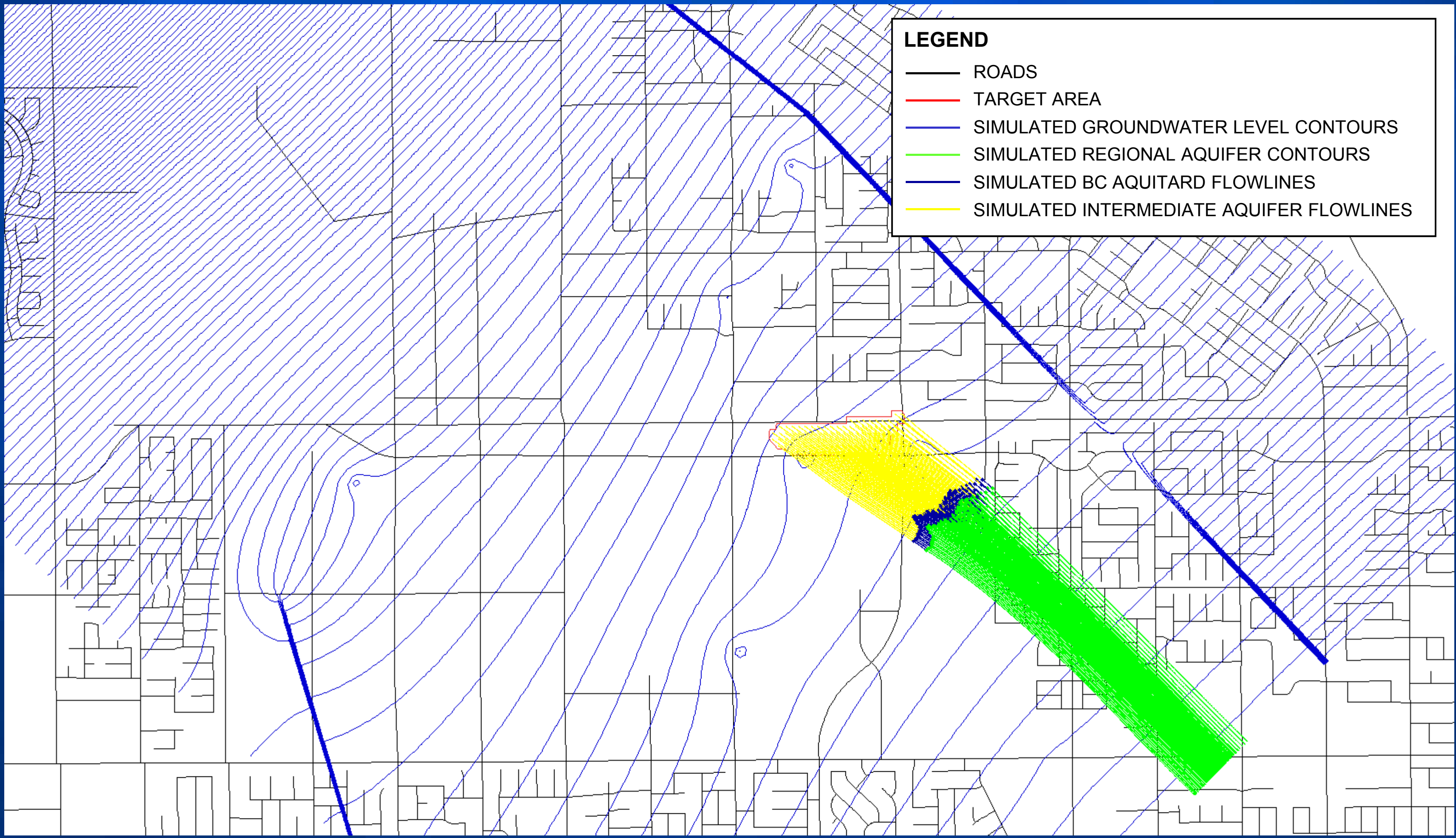
100 percent capture for intermediate aquifer (excess pumping).

Figure A-54: 2,500 gpm Pumping 2001 Conditions – Intermediate Aquifer



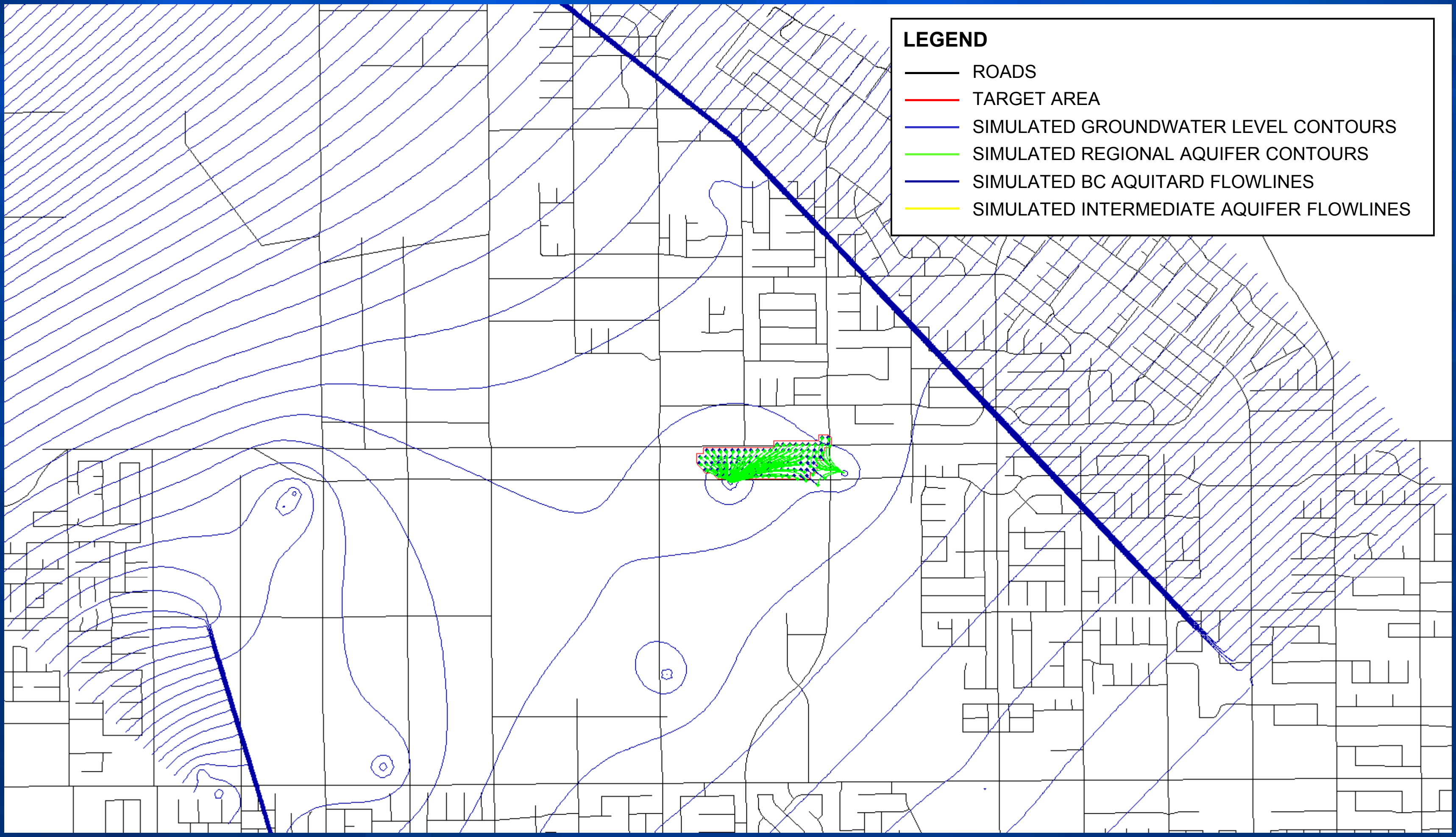
100 percent capture for intermediate aquifer (excess pumping).

Figure A-55: 2,500 gpm Pumping 1998 Conditions – Intermediate Aquifer



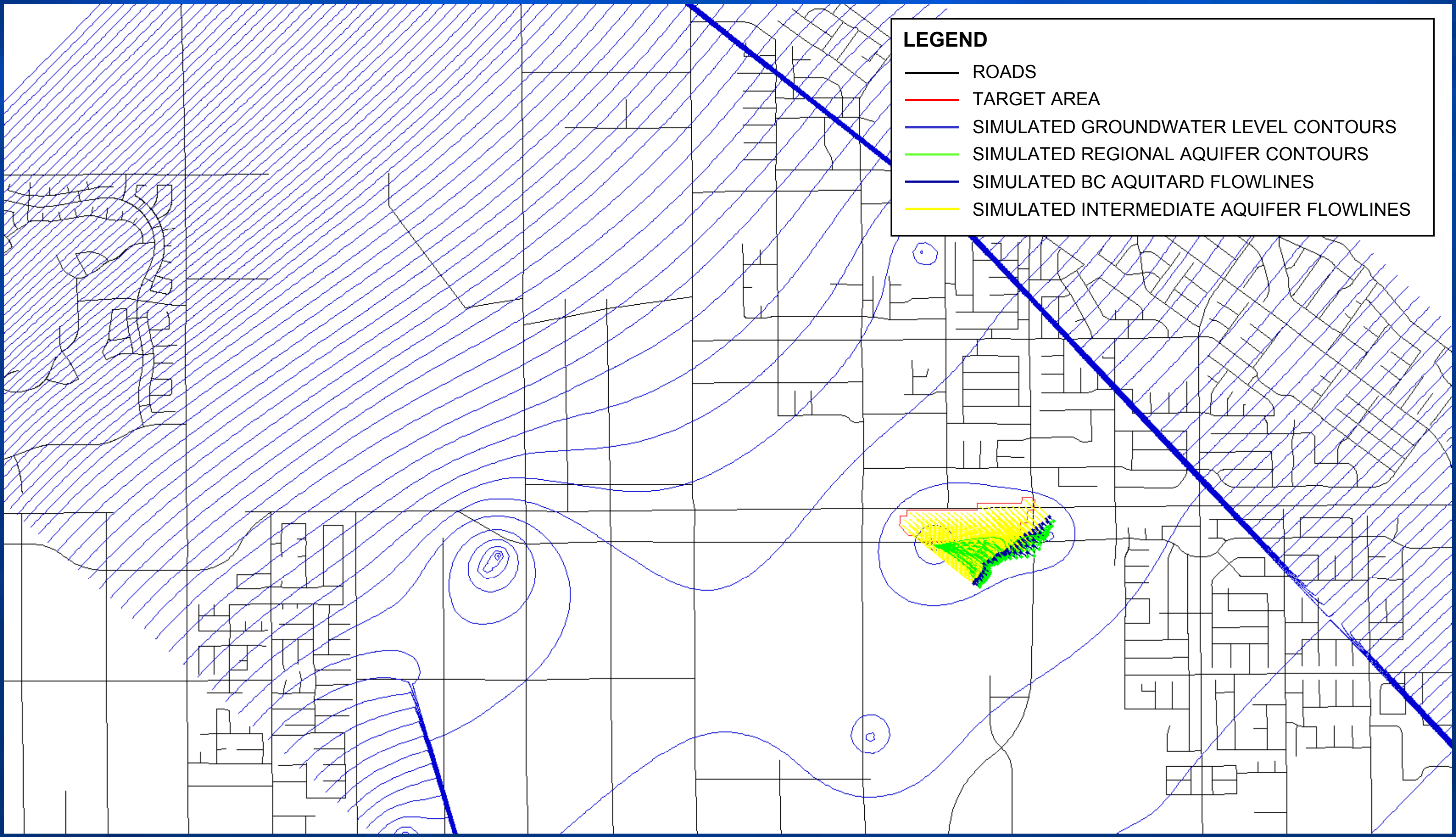
0 percent capture for intermediate aquifer.

Figure A-56: 3,200 gpm Pumping 2004 Conditions – Intermediate Aquifer



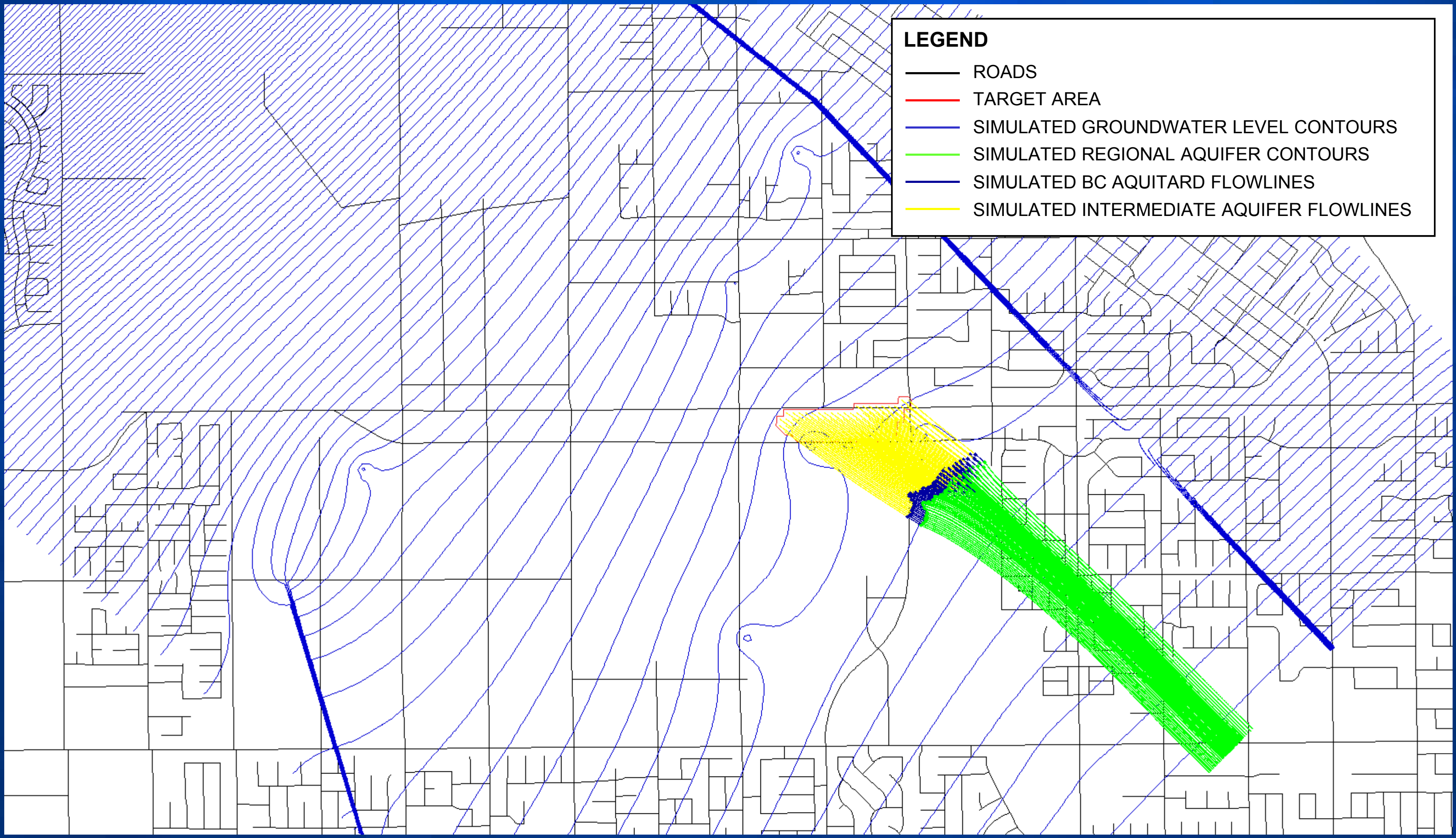
100 percent capture for intermediate aquifer (excess pumping).

Figure A-57: 3,200 gpm Pumping 2001 Conditions – Intermediate Aquifer



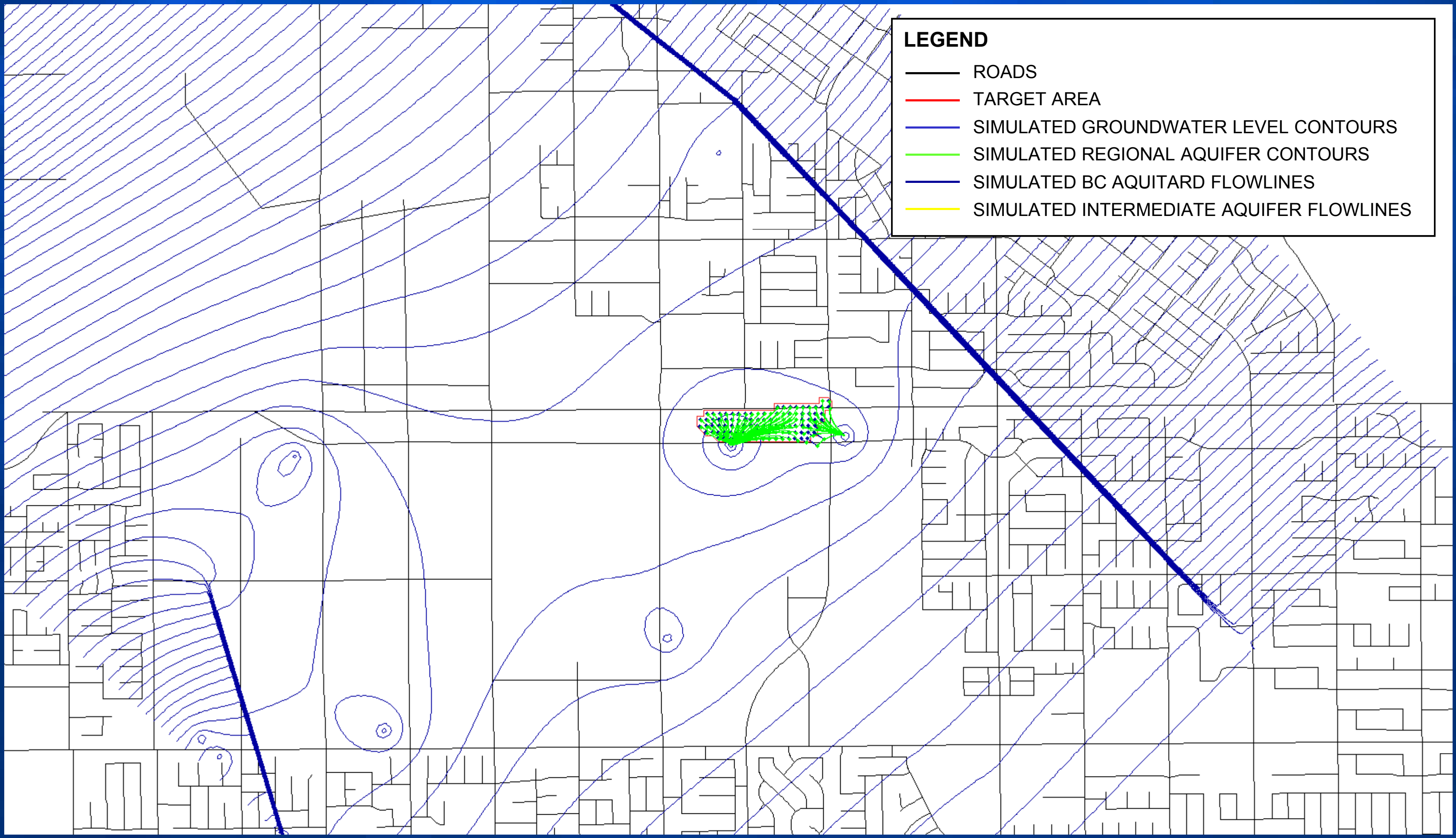
100 percent capture for intermediate aquifer (excess pumping).

Figure A-58: 3,200 gpm Pumping 1998 Conditions – Intermediate Aquifer



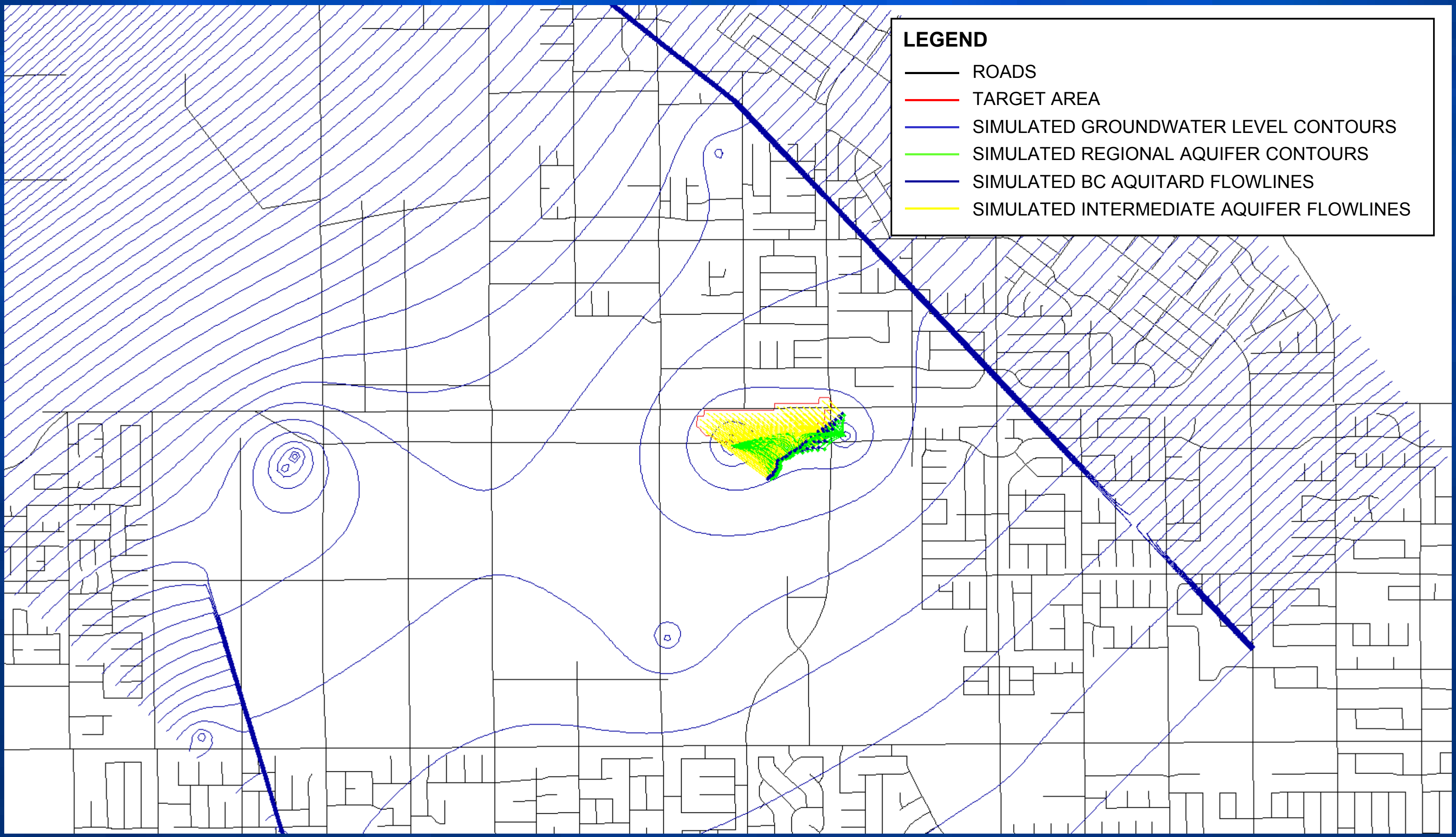
0 percent capture for intermediate aquifer.

Figure A-59: 5,000 gpm Pumping 2004 Conditions – Intermediate Aquifer



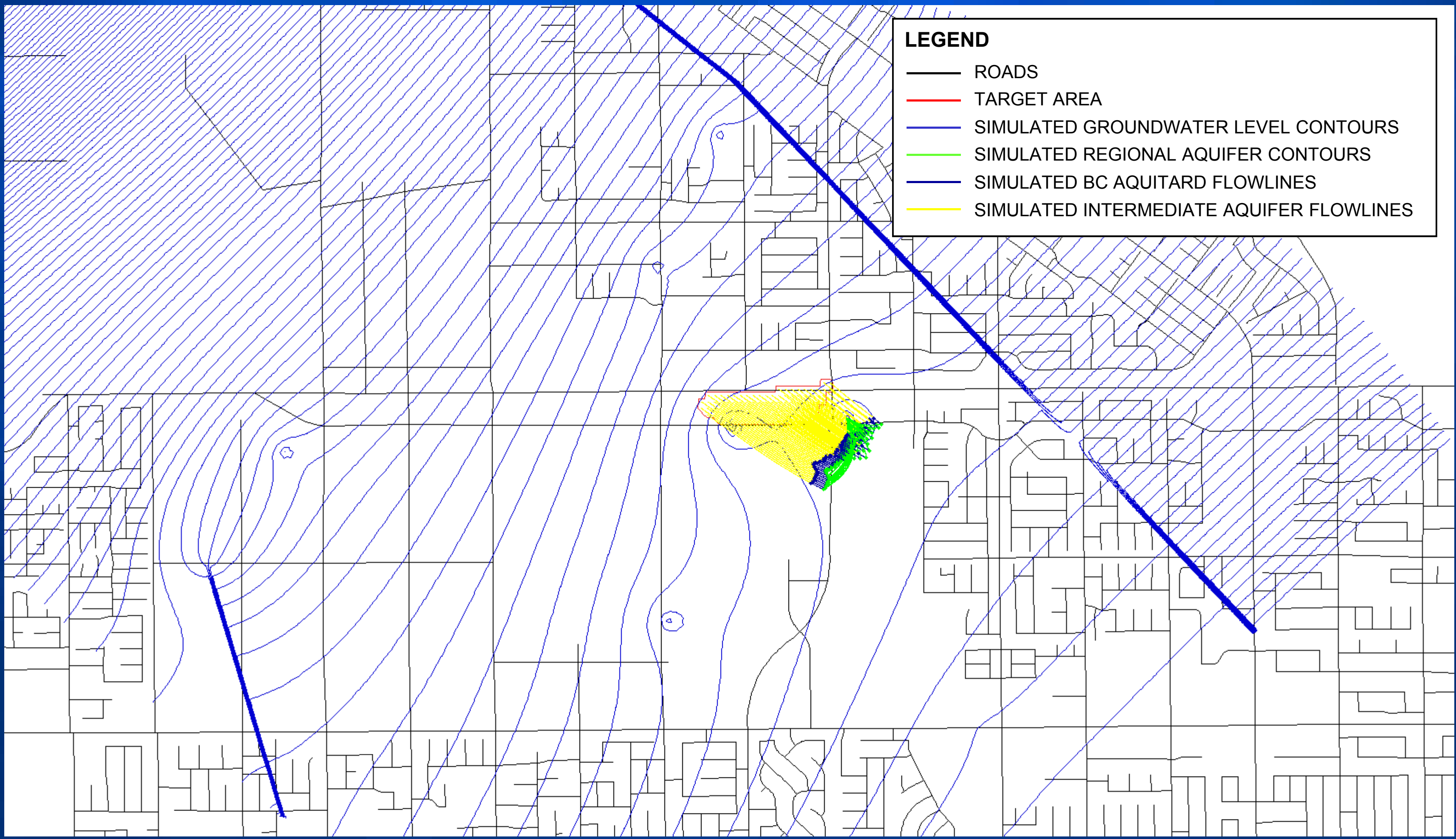
100 percent capture for intermediate aquifer (excess pumping).

Figure A-60: 5,000 gpm Pumping 2001 Conditions – Intermediate Aquifer



100 percent capture for intermediate aquifer (excess pumping).

Figure A-61: 5,000 gpm Pumping 1998 Conditions – Intermediate Aquifer



100 percent capture for intermediate aquifer.

Appendix B
Cost Estimate Details

Table B-1
Alternative 1 – Pump and Treat 1,500 to 1,650 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-1650 GPM; Avg. Flow-1500 gpm
Process Scheme: LGAC, Ion Exchange

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
CONVEYANCE & WELL SYSTEM COSTS						
Water Pipelines (base)						
	8" Pipeline to TP	CR-2 to TP		100	$ 55.80	$ 5,580
	10" Pipeline to TP	EW-1 to TP		3100	$ 72.36	$ 224,316
	12" Pipeline to WVWD Zone 4	TP to Cactus		3600	$ 81.65	$ 293,940
Extraction Wells						
	New EW-1 system	18" casing X 650'		1	$ 425,032	$ 425,032
	Investigation Derived Waste Mgmt			1	$ 60,523	$ 60,523
	Piezometers (2 clusters per extraction well)	4" casing x 650' deep	Approx. $150/foot	4	$ 100,000	$ 400,000
Extraction Well Pumps and Well Head Ancillaries						
	New EW-1 system	Pumps, Vaults, Valves, Gauges, Flowmeters/totalizers, relief valves, power supply, etc.)		1	$ 133,024	$ 133,024
	Extraction Well VFDs and PLC			2	$ 35,000	$ 70,000
Booster Pump Station						
	Pump to WVWD Reservoir (Includes pumps & wet well)	1650 gpm @ 115 ft H2O	CI/SS trim	1	$ 140,370	$ 140,370
	CONVEYANCE & WELL SYSTEM SUBTOTAL A					**$ 1,752,785**
	Engineering- Design and Technical Support			8%		**$ 140,223**
	Contractors Overhead, General Conditions, Mob/Demob, Temp Facilities			15%		**$ 262,918**
	Contractors Profit			8%		**$ 161,256**
	Construction Management			5%		**$ 108,848**
	Construction Contingency			25%		**$ 606,507**
	Conveyance and Extraction Well System Cost					**$ 3,032,500**
GROUNDWATER TREATMENT PLANT						
Untreated Water Tank						
	Holding Tank	5,000 gallon	CS, Epoxy coated	1	$ 32,077	$ 32,077
	Level Switch			1	$ 365	$ 365
Treatment Plant Feed Pump						
	Feed Pump	1650 gpm @ 280 ft H2O	CI/SS trim	2	$ 71,476	$ 142,952
	Flow indicating totalizer	8-inch		1	$ 4,000	$ 4,000
Bag Filter System						
	Bag Filters	1650 gpm	CS, Epoxy coated	2	$ 20,403	$ 40,806
	Differential pressure switch	0 - 30 psig	Brass	1		included above
LGAC Adsorber System						
	LGAC adsorber columns (1 pair)	20,000 lbs, 120"Dia x 144"SS each	CS, Epoxy coated	4	$ 177,674	$ 710,694
	Differential Pressure Switch	0-30 psig	Brass	8	$ 590	$ 4,720
	Flow indicating totalizer	8-inch		8	$ 4,000	$ 32,000
	BW and Rinse Recovery					
	-- Sloped bottom holding tank	30,000 gal	FRP	1	$ 77,111	$ 77,111
	-- VGAC Drum			1	$ 300	$ 300
	-- Diaphragm-type sludge pump			2	$ 2,000	$ 4,000
	-- Polymer tank with mixer	50 gal	SS	1	$ 3,845	$ 3,845
	-- Polymer feed pump	10 gph	316 SS	2	$ 10,000	$ 20,000

Table B-1
Alternative 1 – Pump and Treat 1,500 to 1,650 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-1650 GPM; Avg. Flow-1500 gpm
Process Scheme: LGAC, Ion Exchange

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
	-- Tank level switch			1	$ 1,500	$ 1,500
	-- Backwash Tank Decant Pump			1	$ 3,000	$ 3,000
	-- Backwash Pump	950 gpm, 15 hp		1	$ 8,825	$ 8,825
Ion Exchange System						
	Resin adsorber columns (2 pair)	Lead/lag config; 12' Dia ea.; 350 cu.ft resin ea vessel		2	$ 305,288	$ 610,576
	Initial Resin Charge	4 vessesl @ 350 Cu.Ft. ea	Cu. FT of resin	1400	$ 333.00	$ 466,200
Chlorination System						
	Holding Tank, metering pumps, chlorine analyzer, mixer, etc.			Lump	$ 50,000	$ 50,000
	TREATMENT PLANT Equipment Material Only "B"					**$ 2,212,971**
Installation	**Labor For Equipment Installation**					**$ 331,946**
	TREATMENT PLANT SUBTOTAL "B"					**$ 2,544,916**
	Sitework			2.5%	of SubTotal "B"	$ 63,623
	Mechanical Piping			15.0%	of SubTotal "B"	$ 381,737
	I&C			5.0%	of SubTotal "B"	$ 127,246
	Electrical			10.0%	of SubTotal "B"	$ 254,492
	Common Facilities			Lump		$ 226,100
	Building/Lab & Site Improvements			Lump		$ 100,700
	Metals			5.0%	of SubTotal "B"	$ 127,246
	TREATMENT PLANT SUBTOTAL "C"					**$ 3,826,060**
	Engineering- Design and Technical Support			8%		$ 306,085
	Contractors Overhead,General Conditions, Mob/Demob,Temp Facilities			15%		$ 573,909
	Contractors Profit			8%		$ 351,998
	Construction Management			5%		$ 237,598
	Construction Contingency			25%		$ 1,247,391
	TOTAL TREATMENT PLANT COST					**$ 6,543,000**
	GRAND TOTAL CONVEYANCE, WELL SYSTEM AND TREATMENT PLANT COST					**$ 9,576,000**

NOTES:
1. All equipment cost adjustments for size based on the formula: Adjusted Cost = Orig. Cost * (Adjusted Size/Orig. Size) EXP X where "X" is 0.33 for pumps, 0.57 for Tanks, 0.62 for towers, and 0.6 for other process equipment.
2. Cost escalation adjustments from the following time periods were used, if needed, as appropriate.

Escalation Factors
2000-2009: 36.02%
2003-2009: 31.61%
2004-2009: 25.74%
2005-2009: 17.72
2008-2009: 4.21%

Table B-2
Alternative 1 – Pump and Treat 1,500 to 1,650 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Operations and Maintenance Cost Estimate Summary
B.F. Goodrich Site RI/FS, Rialto, California
Process Scheme: LGAC, Ion Exchange

O&M Category	Equip. Name	Equip. Description	O&M Requirement per Unit	Number of Units	Total Requirements	Units	Unit Cost	Cost
Electrical Power	Well Pumps to Treatment Sys - CR-2	900 gpm @ 500'	931,529	1	931,529	kW-hr		
	Well Pumps to Treatment Sys - EW-1	600 gpm @ 500'	621,019	1	621,019	kW-hr		
	Well Pumps, Incremental	1500 gpm @ 25'	77,627	1	77,627	kW-hr		
	Backwash Decant Pump	200 gpm @ 30', 10% time	62	1	62	kW-hr		
	Treatment Plant Feed Pump	1500 gpm @ 270'	838,376	1	838,376	kW-hr		
	LGAC Backwash Pumps	1500 gpm @ 75', 1%	4,347	2	8,694	kW-hr		
	Booster Pump Station	1500 gpm @ 96'	298,089	1	298,089	kW-hr		
	Misc. Controls/Lights	1,500 W	16,466	1	16,466	kW-hr		
	Total				2,791,863	kW-hr	$ 0.12	$ 335,024
Carbon Make-up								
	LGAC	200 lb/day	73,000	1	73,000	lb C	$ 0.80	$ 58,400
Chemicals/Materials								
	Ion Exchange Resin		2419	1	2419	acre-ft	$ 145.00	$ 350,827
	NaOH	0 ppm as CaCO3 (Contingency)	-	1	-	lb dry	$ 0.11	$ -
	Chlorine	1 ppm dosage	6,575	1	6,575	lb	$ 0.50	$ 3,288
	Filter Bags		288	12	3,456	ea	$ 5.00	$ 17,280
Residuals Disposal								
	LGAC	Included above						
	LGAC Backwash Sludge	0.5% of carbon as 30% sludge	2.5	1	2.5	tons	$ 500.00	$ 1,250
Analytical								
	Treatment Plant	Effluent and Mid-Process	Weekly	104		ea	$ 300.00	$ 31,200
	Extraction Wells		Monthly	24		ea	$ 300.00	$ 7,200
	Monitoring Wells		Semiannual/Annual	100		ea	$ 300.00	$ 30,000
	Water Samples - Additional Annual Tests			4		ea.	$ 1,000.00	$ 4,000
Labor								
	Well Operating			200		hrs	$ 35.00	$ 7,000
	Well Maintenance			200		hrs	$ 42.00	$ 8,400
	Operating			2500		hrs	$ 30.00	$ 75,000
	Maintenance			1040		hrs	$ 34.50	$ 35,880
	Supervisory			1040		hrs	$ 40.50	$ 42,120
	Clerical			360		hrs	$ 19.50	$ 7,020
Subcontracts								
	Monitoring Wells Sampling (Subcontract)			1		lot	$ 90,000.00	$ 90,000
	Regulatory Monitoring reports (RWQCB, EPA, Air Emissions Inventory)			1		lot	$ 25,000.00	$ 25,000
Parts								
	2% of TP Capital				2%		$ 3,826,060	$ 76,521
								$ 1,237,000
Contingency on Materials/Services					10%			$ 123,700
	TOTAL BEFORE PURVEYOR REIMBURSEMENT							**$ 1,360,700**
	Purveyor Reimbursement at $75 per acre-foot		**1,500 gpm**	**2,420**	**acre-feet**		**$75**	**$ 181,500**
	TOTAL AFTER PURVEYOR REIMBURSEMENT							**$ 1,179,000**

Table B-3
Alternative 2a – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-3200 GPM; Avg. Flow-1840 gpm
Process Scheme: LGAC, Ion Exchange

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
CONVEYANCE & WELL SYSTEM COSTS						
Water Pipelines						
	10" Pipeline to TP	CR-2 to TP		100	$ 72.36	$ 7,236
	12" Pipeline to TP	EW-1 to TP		3100	$ 81.65	$ 253,115
	18" Pipeline to WVWD Zone 4	TP to Cactus		3600	$ 117.12	$ 421,632
Extraction Wells						
	New EW-1 system	18" casing X 650'		1	$ 425,032	$ 425,032
	Investigation Derived Waste Mgmt			1	$ 60,523	$ 60,523
	Piezometers (2 clusters per extraction well)	4" casing x 650' deep	Approx. $150/foot	4	$ 100,000	$ 400,000
Extraction Well Pumps and Well Head Ancillaries						
	New EW-1 system	Pumps, Vaults, Valves, Gauges,		1	$ 133,024	$ 133,024
	Extraction Well VFDs and PLC			2	$ 40,000	$ 80,000
Booster Pump Station						
	Pump to WVWD Reservoir (Includes pumps & wet well)	3200 gpm @ 96 ft H2O	CI/SS trim	1	$ 186,294	$ 186,294
	CONVEYANCE & WELL SYSTEM SUBTOTAL A					**$ 1,966,856**
	Engineering- Design and Technical Support			8%		**$ 157,348**
	Contractors Overhead, General Conditions, Mob/Demob, Temp Facilities			15%		**$ 295,028**
	Contractors Profit			8%		**$ 180,951**
	Construction Management			5%		**$ 122,142**
	Construction Contingency			25%		**$ 641,244**
	GRAND TOTAL CONVEYANCE & WELL SYSTEM COST					**$ 3,363,600**
GROUNDWATER TREATMENT PLANT						
Untreated Water Tank						
	Holding Tank	10,000 gallon	CS, Epoxy coated	1	$ 47,619	$ 47,619
	Level Switch			1	$ 365	$ 365
Treatment Plant Feed Pump						
	Feed Pump	3200 gpm @ 280 ft H2O	CI/SS trim	2	$ 88,939	$ 177,877
	Flow indicating totalizer	8-inch		1	$ 4,000	$ 4,000
Bag Filter System						
	Bag Filters	1650 gpm	CS, Epoxy coated	3	$ 20,403	$ 61,209
	Differential pressure switch	0 - 30 psig	Brass	1		included above
LGAC Adsorber System						
	LGAC adsorber columns (1 pair)	20,000 lbs, 120"Dia x 144"SS eac	CS, Epoxy coated	7	$ 177,674	$ 1,243,715
	Differential Pressure Switch	0-30 psig	Brass	14	$ 590	$ 8,260
	Flow indicating totalizer	8-inch		14	$ 4,000	$ 56,000
	BW and Rinse Recovery					
	-- Sloped bottom holding tank	30,000 GAL	FRP	1	$ 77,111	$ 77,111
	-- VGAC Drum			1	$ 300	$ 300
	-- Diaphragm-type sludge pump			2	$ 2,000	$ 4,000
	-- Polymer tank with mixer	50 gal	SS	1	$ 3,845	$ 3,845
	-- Polymer feed pump	10 gph	316 SS	2	$ 10,000	$ 20,000
	-- Tank level switch			1	$ 1,500	$ 1,500

Table B-3
Alternative 2a – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-3200 GPM; Avg. Flow-1840 gpm
Process Scheme: LGAC, Ion Exchange

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
	-- Backwash Tank Decant Pump			1	$ 3,000	$ 3,000
	-- Backwash Pump	950 gpm, 15 hp		1	$ 8,825	$ 8,825
Ion Exchange System						
	Resin adsorber columns (3 pairs.)	Lead/lag config; 12' Dia ea.; 350 cu.ft resin ea vessel		3	$ 305,288	$ 915,864
	Initial Resin Charge	6 vessels @ 350 Cu.Ft. ea	Cu. FT of resin	2100	333.00	$ 699,300
Chlorination System						
	Holding Tank, metering pumps, chlorine analyzer, mixer, etc.			Lump	$ 75,000	$ 75,000
	TREATMENT PLANT Equipment Material Only "B"					**$ 3,407,789**
Installation	**Labor For Equipment Installation**					**$ 511,168**
	TREATMENT PLANT SUBTOTAL "B"					**$ 3,918,958**
	Sitework			2.5%	of SubTotal "B"	$ 97,974
	Mechanical - Piping			15.0%	of SubTotal "B"	$ 587,844
	I & C			5.0%	of SubTotal "B"	$ 195,948
	Electrical			10.0%	of SubTotal "B"	$ 391,896
	Common Facilities			Lump		$ 226,100
	Building/Lab & Site Improvements			Lump		$ 100,700
	Metals			5.0%	of SubTotal "B"	$ 195,948
	TREATMENT PLANT SUBTOTAL "C"					**$ 5,715,367**
	Engineering- Design and Technical Support			8%		$ 457,229
	Contractors Overhead, General Conditions, Mob/Demob, Temp Facilities			15%		$ 857,305
	Contractors Profit			8%		$ 525,814
	Construction Management			5%		$ 354,924
	Construction Contingency			25%		$ 1,863,353
	GRAND TOTAL TREATMENT PLANT COST					**$ 9,774,000**
	GRAND TOTAL CONVEYANCE, WELL SYSTEM AND TREATMENT PLANT COST					**$ 13,138,000**

NOTES:
1. All equipment cost adjustments for size based on the formula: Adjusted Cost = Orig. Cost * (Adjusted Size/Orig. Size) EXP X
where "X" is 0.33 for pumps, 0.57 for Tanks, 0.62 for towers, and 0.6 for other process equipment.
2. Cost escalation adjustments from the following time periods were used, if needed, as appropriate.

Escalation Factors
2000-2009: 36.02%
2003-2009: 31.61%
2004-2009: 25.74%
2005-2009: 17.72
2008-2009: 4.21%

Table B-4
Alternative 2a – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Operations and Maintenance Cost Estimate Summary
B.F. Goodrich Site RI/FS, Rialto, California
Process Scheme: LGAC, Ion Exchange

O&M Category	Equip. Name	Equip. Description	O&M Requirement per Unit	Number of Units	Total Requirements	Units	Unit Cost	Cost
Electrical Power								
	CR-2 Well Pumps to TP	740 gpm @ 500'	765,924	1	765,924	kW-hr		
	EW-1 Well Pump to TP	1100 gpm @ 500'	1,138,535	1	1,138,535	kW-hr		
	Well Pumps, Incremental	1840 gpm @ 25'	95,223	1	95,223	kW-hr		
	Backwash Decant Pump	200 gpm @ 30', 10% time	75	1	75	kW-hr		
	Treatment Plant Feed Pump	1840 gpm @ 185'	704,650	1	704,650	kW-hr		
	LGAC Backwash Pumps	1840 gpm @ 75', 1%	2,857	2	5,713	kW-hr		
	Booster Pump Station	1840 gpm @ 82'	312,331	1	312,331	kW-hr		
	Misc. Controls/Lights	1,500 W	16,466	1	16,466	kW-hr		
	Total				3,038,917	kW-hr	$ 0.12	$ 364,670
Carbon Make-up								
	LGAC	240 lb/day	87,600	1	87,600	lb C	$ 0.80	$ 70,080
Chemicals/Materials								
	Ion Exchange Resin		2968	1	2968	acre-ft	$ 145.00	$ 430,348
	NaOH	0 ppm as CaCO3 (Contingency)	-	1	-	lb dry	$ 0.11	$ -
	Chlorine	1 ppm dosage	8,066	1	8,066	lb	$ 0.50	$ 4,033
	Filter Bags		288	12	3,456	ea	$ 5.00	$ 17,280
Residuals Disposal								
	LGAC	Included above						
	LGAC Backwash Sludge	0.5% of carbon as 30% sludge	2.5	1	2.5	tons	$ 500.00	$ 1,250
Analytical								
	Treatment Plant	Effluent and Mid-Process	Weekly	104		ea	$ 300.00	$ 31,200
	Extraction Wells		Monthly	24		ea	$ 300.00	$ 7,200
	Monitoring Wells		Semiannual/Annual	100		ea.	$ 300.00	$ 30,000
	Water Samples - Additional Annual Tests			4		ea.	$ 1,000.00	$ 4,000
Labor								
	Well Operating			200		hrs	$ 35.00	$ 7,000
	Well Maintenance			200		hrs	$ 42.00	$ 8,400
	Operating			2600		hrs	$ 30.00	$ 78,000
	Maintenance			1250		hrs	$ 34.50	$ 43,125
	Supervisory			1250		hrs	$ 40.50	$ 50,625
	Clerical			430		hrs	$ 19.50	$ 8,385
Subcontracts								
	Monitoring Wells Sampling (Subcontract)			1		lot	$ 90,000.00	$ 90,000
	Regulatory Monitoring reports (RWQCB, EPA, Air Emissions Inventory)			1		lot	$ 25,000.00	$ 25,000
Parts								
	2% of TP Capital				2%		$ 5,715,367	$ 114,307
								$ 1,385,000
Contingency on Materials/Services					10%			$ 138,500
	TOTAL BEFORE PURVEYOR REIMBURSEMENT							**$ 1,523,500**
	Purveyor Reimbursement at $75 per acre-foot		**1,840 gpm**	**2,970**	**acre-feet**		**$75**	**$ 222,750**
	TOTAL AFTER PURVEYOR REIMBURSEMENT							**$ 1,301,000**

Table B-5
Alternative 2b – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-3200 GPM; Avg. Flow-1840 gpm
Process Scheme: FBR, Multimedia Filtration, LGAC

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
CONVEYANCE & WELL SYSTEM COSTS						
Water Pipelines						
	10" Pipeline to TP	CR-2 to TP		100	$ 72.36	$ 7,236
	12" Pipeline to TP	EW-1 to TP		3100	$ 81.65	$ 253,115
	18" Pipeline to Injection Wells	FBR to north of 160-Acre Area		17600	$ 117.12	$ 2,061,312
	Freeway Crossing w/18" HDPE		HDPE	500	$ 534.78	$ 267,391
Extraction and Injection Wells						
	New EW-1 system	18" casing X 650'		1	$ 425,032	$ 425,032
	Investigation Derived Waste Mgmt	Injection and Extraction Wells		3	$ 60,523	$ 181,570
	Piezometers (2 clusters per extraction well)	4" casing x 650' deep		4	$ 100,000	$ 400,000
	Injection Wells	18" x 700'		2	$ 370,053	$ 740,107
Extraction Well Pumps and Well Head Ancillaries						
	New EW-1 system	Lot(pumps, Vaults, Valves, Gauges, Flowmeters/totalizers, relief valves, power supply, etc.)		1	$ 133,024	$ 133,024
	New Injection Wells	Lot(Vaults, Valves, Gauges, Flowmeters/totalizers, relief valves, power supply, etc.)		2	$ 52,500	$ 105,000
Booster Pump Station						
	Pump to Injection Wells	3200 gpm to injection wells	CI/SS trim	1	$ 288,899	$ 288,899
	CONVEYANCE & WELL SYSTEM SUBTOTAL A					**$ 4,862,686**
	Engineering- Design and Technical Support			8%		**$ 389,015**
	Contractors Overhead, General Conditions, Mob/Demob, Temp Facilities			15%		**$ 729,403**
	Contractors Profit			8%		**$ 447,367**
	Construction Management			5%		**$ 301,973**
	Construction Contingency			25%		**$ 1,585,357**
	GRAND TOTAL CONVEYANCE & WELL SYSTEM COST					**$ 8,315,800**
GROUNDWATER TREATMENT PLANT						
Ex-situ Biological Anoxic Treatment System						
	Fluidized Bed Treatment System					
	-- Fluidized bed tanks (incl. internals, biomass control unit, fluidization pumps, I&C panel, nutrient feed pumps, aeration tank)			1	$ 1,291,000	$ 1,291,000
	-- Flow indicating totalizer			2	$ 1,500	$ 3,000
	Acetate/Alcohol Feed System					
	-- Slant bottom holding tank	20,000 gal	FRP	1	$ 52,000	$ 52,000
	-- Tank level switch			1	$ 1,500	$ 1,500
	-- Metering Pumps				$ 3,000	
	-- Pulsation dampener		Acid Spec	1	$ 3,000	$ 3,000
	Nutrient Feed System					
	-- Tote bin	250 gal	FRP		Vendor supplied	
	-- Tank level switch			2	$ 1,500	$ 3,000
	-- Metering Pumps	up to 1 gpm	Acid Spec		included above	
	-- Pulsation dampener		Acid Spec	2	$ 3,000	$ 6,000
	BW and Rinse Recovery					
	-- Slopped bottom holding tank	25,000 gal	FRP	1	$ 69,500	$ 69,500
	-- VGAC Drum			2	$ 300	$ 600
	-- Diaphragm-type sludge pump			2	$ 2,000	$ 4,000
	-- Polymer tank with mixer	50 gal	SS	1	$ 3,845	$ 3,845

Table B-5
Alternative 2b – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-3200 GPM; Avg. Flow-1840 gpm
Process Scheme: FBR, Multimedia Filtration, LGAC

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
	-- Polymer feed pump	10 gph	316 SS	2	$ 10,000	$ 20,000
	-- Backwash recirculation pump	200 gpm @ 30'	CS, SS Impeller	2	$ 5,300	$ 10,600
	-- Plate and frame filter press	20 cu. ft..	PVC	2	$ 129,994	$ 259,987
	-- Tank level switch			2	$ 1,500	$ 3,000
Pump Station						
	Bioreactor Overflow Tank	40,000 gal	FRP	1	$ 100,000	$ 100,000
	Tank level switch			1	$ 1,500	$ 1,500
	Multimedia Filter Feed Pumps	3200 gpm @ 150 ft H2O	CI/SS trim	2	$ 72,383	$ 144,766
Polymer Feed System						
	Make down System			1	$ 6,000	$ 6,000
	Static Mixer			1	$ 5,000	$ 5,000
Multimedia Filter System						
	Multimedia filter vessels and media	500 gpm (7 oper +1 backwashing)	CS, Epoxy coated	8	$ 102,015	$ 816,120
	Differential pressure switch	0 - 30 psig	Brass	1	included above	
	Modulating Valve			1	$ 4,000	$ 4,000
	Backwash Pump and auxiliary			1	$ 10,000	$ 10,000
	Air Scour System			1	$ 18,000	$ 18,000
Untreated Water Tank						
	Holding Tank	10,000 gallon	CS, Epoxy coated	1	$ 47,619	$ 47,619
	Level Switch			1	$ 500	$ 365
Treatment Plant Feed Pump						
	Feed Pump	3200 gpm @ 70 ft H2O	CI/SS trim	2	$ 56,287	$ 112,575
	Flow indicating totalizer	8-inch		1	$ 4,000	$ 4,000
LGAC Adsorber System						
	LGAC adsorber columns (1 pair)	20,000 lbs, 120"Dia x 144"SS each	CS, Epoxy coated	7	$ 177,674	$ 1,243,715
	Differential Pressure Switch	0-30 psig	Brass	14	$ 590	$ 8,260
	Flow indicating totalizer	8-inch		14	$ 4,000	$ 56,000
	BW and Rinse Recovery					
	-- Sloped bottom holding tank	30,000 gal	FRP	1	$ 77,111	$ 77,111
	-- VGAC Drum			1	$ 300	$ 300
	-- Tank level switch			1	$ 1,500	$ 1,500
	-- Backwash Tank Decant Pump			1	$ 3,000	$ 3,000
	-- Backwash Pump	950 gpm, 15 hp		1	$ 8,825	$ 8,825
pH Adjustment System						
	-- Treated Water Tank	40,000 gal	FRP	1	$ 100,000	$ 100,000
	-- Tank level switch			1	$ 1,500	$ 1,500
	-- Caustic Tote Bin					
	-- Acid Storage Tank	10,000 gal	FRP	1	$ 35,028	$ 35,028
	-- Ferric Chloride Storage Tank	10,000 gal	FRP	1	$ 35,028	$ 35,028
	-- Metering Pumps	0.5 gpm	Acid Spec	6	$ 10,000	$ 60,000
	-- Pulsation dampener		Acid Spec	6	$ 3,000	$ 18,000
	-- Static Mixer	12-inch	Acid Spec	1	$ 10,000	$ 10,000
	-- pH Probes		Acid Spec	2	$ 1,200	$ 2,400
Cartridge Filters						
	Cartridge Filters	1650 gpm	CS, Epoxy coated	3	$ 20,403	$ 61,209
	Differential pressure switch	0 - 30 psig	Brass	1		included above
Chlorination System						
	Holding Tank, metering pumps, chlorine analyzer, mixer, etc.			Lump	$ 75,000	$ 75,000

Table B-5
Alternative 2b – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-3200 GPM; Avg. Flow-1840 gpm
Process Scheme: FBR, Multimedia Filtration, LGAC

Major System	Component	Size	Material	Quantity	Unit Cost		Cost
	TREATMENT PLANT Equipment Material Only "B"					**$**	**4,797,853**
Installation	**Labor For Equipment Installation**					**$**	**719,678**
	TREATMENT PLANT SUBTOTAL "B"					**$**	**5,517,531**
	Sitework			2.5%	of SubTotal "B"	$	137,938
	Mechanical - Piping			15.0%	of SubTotal "B"	$	827,630
	I & C			5.0%	of SubTotal "B"	$	275,877
	Electrical			10.0%	of SubTotal "B"	$	551,753
	Common Facilities			Lump		$	226,100
	Building/Lab & Site Improvements			Lump		$	100,700
	Metals			5.0%	of SubTotal "B"	$	275,877
	TREATMENT PLANT SUBTOTAL "C"					**$**	**7,913,405**
	Engineering- Design and Technical Support			8%		$	633,072
	Contractors Overhead,General Conditions, Mob/Demob,Temp Facilities			15%		$	1,187,011
	Contractors Profit			8%		$	728,033
	Construction Management			5%		$	491,422
	Construction Contingency			25%		$	2,579,968
	GRAND TOTAL TREATMENT PLANT COST					**$**	**13,532,900**
	GRAND TOTAL CONVEYANCE, WELL SYSTEM AND TREATMENT PLANT COST					**$**	**21,849,000**

NOTES:
1. All equipment cost adjustments for size based on the formula: Adjusted Cost = Orig. Cost * (Adjusted Size/Orig. Size) EXP X
where "X" is 0.33 for pumps, 0.57 for Tanks, 0.62 for towers, and 0.6 for other process equipment.
2. Cost escalation adjustments from the following time periods were used, if needed, as appropriate.

Escalation Factors
2000-2009: 36.02%
2003-2009: 31.61%
2004-2009: 25.74%
2005-2009: 17.72
2008-2009: 4.21%

Table B-6
Alternative 2b – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater
Operations and Maintenance Cost Estimate Summary
B.F. Goodrich Site RI/FS, Rialto, California
Process Scheme:FBR, Ion Exchange

O&M Category	Equip. Name	Equip. Description	O&M Requirement per Unit	Number of Units	Total Requirements	Units	Unit Cost	Cost
Electrical Power	CR-2 Well Pumps to TP	740 gpm @ 500'	765,924	1	765,924	kW-hr		
	EW-1 Well Pump to TP	1100 gpm @ 500'	1,138,535	1	1,138,535	kW-hr		
	Well Pumps, Incremental	1840 gpm @ 25'	95,223	1	95,223	kW-hr		
	Bioreactor System	20 hp each	345,700	1	345,700	kW-hr		
	Bioreactor-Pump Stn	1840 gpm @ 125'	476,115	1	476,115	kW-hr		
	Ethanol Metering Pumps	1 hp each	8,189	1	8,189	kW-hr		
	Nutrient Metering Pumps	0.5 hp each	4,095	1	4,095	kW-hr		
	Polymer Metering Pumps	0.5 hp each, 50% time	2,047	1	2,047	kW-hr		
	Polymer Tank Mixer	1 hp, 10% time	49	1	49	kW-hr		
	Backwash Decant Pump	400 gpm @ 30', 10% time	149	1	149	kW-hr		
	Treatment Plant Feed Pump	1840 gpm @ 75'	285,669	1	285,669	kW-hr		
	LGAC Backwash Pumps	1840 gpm @ 75', 1%	2,857	1	2,857	kW-hr		
	Booster Pump Station	1840 gpm @ 275'	1,047,452	1	1,047,452	kW-hr		
	Misc. Controls/Lights	1,500 W	16,466	1	16,466	kW-hr		
	Total				4,188,470	kW-hr	$ 0.12	$ 502,616
Carbon Make-up								
	LGAC	240 lb/day	87,600	1	87,600	lb C	$ 0.80	$ 70,080
	Bioreactor Carbon Media	1773 /lb/yr	1,773.00	1	1773	lb C	1.25	$ 2,216
	VGAC	4 drums/yr	1	4	4	drums	$ 300.00	$ 1,200
Chemicals/Materials								
	Acetic Acid--50% soln	149 gal/day	54,385	1	54,385	gal	$ 2.80	$ 152,278
	Phosphoric Acid--75% soln	3.3 gal/day	1,205	1	1,205	gal	$ 14.90	$ 17,947
	NaOH	0 ppm as CaCO3 (Contingency)	-	1	-	lb dry	$ 0.11	$ -
	Chlorine	1 ppm dosage	8,066	1	8,066	lb	$ 0.50	$ 4,033
	Filter Bags		288	12	3,456	ea	$ 5.00	$ 17,280
Residuals Disposal								
	LGAC	Included above						
	LGAC Backwash Sludge	0.5% of carbon as 30% sludge	2.5	1	2.5	tons	$ 500.00	$ 1,250
	Bioreactor Sludge	20 ppm @ 30% solids	361	1	361	tons	$ 105.00	$ 37,937
	VGAC	4 drums per year	4.0	1	4.0	drums	$ 200.00	$ 800
Analytical								
	Treatment Plant	Effluent	Weekly	52		ea	$ 300.00	$ 15,600
	Extraction Wells		Quarterly	8		ea	$ 300.00	$ 2,400
	Monitoring Wells		Semiannual/Annual	100		ea.	$ 300.00	$ 30,000
	Water Samples - Additional Annual Tests			4		ea.	$ 1,000.00	$ 4,000
	Air Samples			12		ea	$ 250.00	$ 3,000
Labor								
	Well Operating			200		hrs	$ 35.00	$ 7,000
	Well Maintenance			200		hrs	$ 42.00	$ 8,400
	Operating			3120		hrs	$ 30.00	$ 93,600
	Maintenance			1660		hrs	$ 34.50	$ 57,270
	Supervisory			1400		hrs	$ 40.50	$ 56,700
	Clerical			480		hrs	$ 19.50	$ 9,360
Subcontracts								
	Monitoring Wells Sampling (Subcontract)			1		lot	$ 90,000.00	$ 90,000

Table B-6
Alternative 2b – Pump and Treat 1,500 to 3,200 gpm of Contaminated Groundwater and Reinject the Treated Groundwater
Operations and Maintenance Cost Estimate Summary
B.F. Goodrich Site RI/FS, Rialto, California
Process Scheme:FBR, Ion Exchange

O&M Category	Equip. Name	Equip. Description	O&M Requirement per Unit	Number of Units	Total Requirements	Units	Unit Cost	Cost
	Regulatory Monitoring reports (RWQCB, EPA, Air Emissions Inventory)			1		lot	$ 25,000.00	$ 25,000
Parts								
	2% of TP Capital				2%		$ 7,913,405	$ 158,268
								$ 1,368,000
Contingency on Materials/Services					10%			$ 136,800
	GRAND TOTAL							**$ 1,505,000**

Table B-7
Alternative 3 - Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-5000 GPM; Avg. Flow-2200 gpm
Process Scheme: LGAC, Ion Exchange

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
CONVEYANCE & WELL SYSTEM COSTS						
Water Pipelines						
	12" Pipeline to TP	CR-2 to TP		100	$ 81.65	$ 8,165
	14" Pipeline to TP	EW-1 to TP		3100	$ 95.88	$ 297,228
	16" Pipeline to WVWD Zone 4	TP to Cactus		3600	$ 106.35	$ 382,860
	16" Pipeline, Fontana Water Co.	TP to Fontana Water Co.		9600	$ 117.12	$ 1,124,352
Extraction Wells						
	New EW-1 system	18" casing X 650'		1	$ 425,032	$ 425,032
	Investigation Derived Waste Mgmt			1	$ 60,523	$ 60,523
	Piezometers (2 clusters per extraction well)	4" casing x 650' deep	Approx. $150/foot	4	$ 100,000	$ 400,000
Extraction Well Pumps and Well Head Ancillaries						
	New EW-1 system	Pumps, Vaults, Valves, Gauges, Flowmeters/totalizers, relief		1	$ 133,024	$ 133,024
	Extraction Well VFDs and PLC			2	$ 45,000	$ 90,000
Booster Pump Station						
	Pump to WVWD and/or FWC Reservoir/s	5,000 gpm @ 90 ft H2O	CI/SS trim	1	$ 290,561	$ 290,561
	CONVEYANCE & WELL SYSTEM SUBTOTAL A					**$ 3,211,745**
	Engineering- Design and Technical Support			8%		**$ 256,940**
	Contractors Overhead, General Conditions, Mob/Demob, Temp Facilities			15%		**$ 481,762**
	Contractors Profit			8%		**$ 295,481**
	Construction Management			5%		**$ 199,449**
	Construction Contingency			25%		**$ 1,047,109**
	GRAND TOTAL CONVEYANCE & WELL SYSTEM COST					**$ 5,492,500**
GROUNDWATER TREATMENT PLANT						
Untreated Water Tank						
	Holding Tank	15,000 gallon	CS, Epoxy coated	1	$ 60,000	$ 60,000
	Level Switch			1	$ 365	$ 365
Treatment Plant Feed Pump						
	Feed Pump	5,000 gpm @ 280 ft H2O	CI/SS trim	2	$ 103,051	$ 206,101
	Flow indicating totalizer	8-inch		1	$ 4,000	$ 4,000
Bag Filter System						
	Bag Filters	5,000 gpm	CS, Epoxy coated	4	$ 20,403	$ 81,612
	Differential pressure switch	0 - 30 psig	Brass	1		included above
LGAC Adsorber System						
	LGAC adsorber columns (1 pair)	20,000 lbs, 120"Dia x 144"SS each	CS, Epoxy coated	10	$ 177,674	$ 1,776,735
	Differential Pressure Switch	0-30 psig	Brass	20	$ 590	$ 11,800
	Flow indicating totalizer	8-inch		20	$ 3,000	$ 60,000
	BW and Rinse Recovery					
	-- Sloped bottom holding tank	30,000 gal	FRP	1	$ 77,111	$ 77,111
	-- VGAC Drum			1	$ 300	$ 300
	-- Diaphragm-type sludge pump			2	$ 2,000	$ 4,000
	-- Polymer tank with mixer	50 gal	SS	1	$ 3,845	$ 3,845
	-- Polymer feed pump	10 gph	316 SS	2	$ 10,000	$ 20,000
	-- Tank level switch			1	$ 1,500	$ 1,500
	-- Backwash Tank Decant Pump			1	$ 3,000	$ 3,000

Table B-7
Alternative 3 - Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Materials List and Capital Cost Table
B.F. Goodrich Site RI/FS, Rialto, California
Design Flow-5000 GPM; Avg. Flow-2200 gpm
Process Scheme: LGAC, Ion Exchange

Major System	Component	Size	Material	Quantity	Unit Cost	Cost
	-- Backwash Pump	950 gpm, 15 hp		1	$ 8,825	$ 8,825
Ion Exchange System						
	Resin adsorber columns (4 pairs)	Lead/lag config; 12' Dia ea.; 350 cu.ft resin ea vessel		4	$ 305,288	$ 1,221,152
	Initial Resin Charge	8 vessels @ 350 cu. Ft. ea.	Cu. FT of resin	2800	$ 333	$ 932,400
Chlorination System						
	Holding Tank, metering pumps, chlorine analyzer, mixer, etc.			Lump	$ 75,000	$ 75,000
	TREATMENT PLANT Equipment Material Only "B"					**$ 4,547,746**
Installation	**Labor For Equipment Installation**					**$ 682,162**
	TREATMENT PLANT SUBTOTAL "B"					**$ 5,229,908**
	Sitework			2.5%	of SubTotal "B"	$ 130,748
	Mechanical - Piping			15.0%	of SubTotal "B"	$ 784,486
	I & C			5.0%	of SubTotal "B"	$ 261,495
	Electrical			10.0%	of SubTotal "B"	$ 522,991
	Common Facilities			Lump		$ 226,100
	Building/Lab & Site Improvements			Lump		$ 100,700
	Metals			5.0%	of SubTotal "B"	$ 261,495
	TREATMENT PLANT SUBTOTAL "C"					**$ 7,517,924**
	Engineering- Design and Technical Support			8%		$ 601,434
	Contractors Overhead, General Conditions, Mob/Demob, Temp Facilities			15%		$ 1,127,689
	Contractors Profit			8%		$ 691,649
	Construction Management			5%		$ 466,863
	Construction Contingency			25%		$ 2,451,031
	GRAND TOTAL TREATMENT PLANT COST					**$ 12,856,600**
	GRAND TOTAL CONVEYANCE, WELL SYSTEM AND TREATMENT PLANT COST					**$ 18,349,000**

NOTES:
1. All equipment cost adjustments for size based on the formula: Adjusted Cost = Orig. Cost * (Adjusted Size/Orig. Size) EXP X
where "X" is 0.33 for pumps, 0.57 for Tanks, 0.62 for towers, and 0.6 for other process equipment.
2. Cost escalation adjustments from the following time periods were used, if needed, as appropriate.

Escalation Factors
2000-2009: 36.02%
2003-2009: 31.61%
2004-2009: 25.74%
2005-2009: 17.72
2008-2009: 4.21%

Table B-8
Alternative 3 – Pump and Treat 1,500 to 5,000 gpm of Contaminated Groundwater and Use Treated Water as Drinking Water Supply
Operations and Maintenance Cost Estimate Summary
B.F. Goodrich Site RI/FS, Rialto, California
Process Scheme: LGAC, Ion Exchange

O&M Category	Equip. Name	Equip. Description	O&M Requirement per Unit	Number of Units	Total Requirements	Units	Unit Cost	Cost
Electrical Power								
	CR-2 Well Pumps to TP	880 gpm @ 500'	910,828	1	910,828	kW-hr		
	EW-1 Well Pump to TP	1320 gpm @ 500'	1,366,242	1	1,366,242	kW-hr		
	Well Pumps, Incremental	2200 gpm @ 30'	136,624	1	136,624	kW-hr		
	Backwash Decant Pump	200 gpm @ 30', 10% time	93	1	93	kW-hr		
	Treatment Plant Feed Pump	2200 gpm @ 150'	683,121	1	683,121	kW-hr		
	LGAC Backwash Pumps	2200 gpm @ 75', 1%	34,156	1	34,156	kW-hr		
	Booster Pump Station	2200 gpm @ 70'	318,790	1	318,790	kW-hr		
	Misc. Controls/Lights	1,500 W	16,466	1	16,466	kW-hr		
	Total				3,466,321	kW-hr	$ 0.12	$ 415,959
Carbon Make-up								
	LGAC	300 lb/day	109,500	1	109,500	lb C	$ 0.80	$ 87,600
Chemicals/Materials								
	Ion Exchange Resin		3549	1	3549	acre-ft	$ 145.00	$ 514,546
	NaOH	0 ppm as CaCO3 (Contingency)	-	1	-	lb dry	$ 0.11	$ -
	Chlorine	1 ppm dosage	9,644	1	9,644	lb	$ 0.50	$ 4,822
	Filter Bags		288	12	3,456	ea	$ 5.00	$ 17,280
Residuals Disposal								
	LGAC	Included above						
	LGAC Backwash Sludge	0.5% of carbon as 30% sludge	2.5	1	2.5	tons	$ 500.00	$ 1,250
Analytical								
	Treatment Plant	Effluent and Mid-Process	Weekly	104		ea	$ 300.00	$ 31,200
	Extraction Wells		Monthly	24		ea	$ 300.00	$ 7,200
	Monitoring Wells		Semiannual/Annual	100		ea.	$ 300.00	$ 30,000
	Water Samples - Additional Annual Tests			4		ea.	$ 1,000.00	$ 4,000
Labor								
	Well Operating			200		hrs	$ 35.00	$ 7,000
	Well Maintenance			200		hrs	$ 42.00	$ 8,400
	Operating			2700		hrs	$ 30.00	$ 81,000
	Maintenance			1460		hrs	$ 34.50	$ 50,370
	Supervisory			1460		hrs	$ 40.50	$ 59,130
	Clerical			480		hrs	$ 19.50	$ 9,360
Subcontracts								
	Monitoring Wells Sampling (Subcontract)			1		lot	$ 90,000.00	$ 90,000
	Regulatory Monitoring reports (RWQCB, EPA, Air Emissions Inventory)			1		lot	$ 25,000.00	$ 25,000
Parts								
	2% of TP Capital				2%		$ 7,517,924	$ 150,358
								$ 1,594,000
Contingency on Materials/Services					10%			$ 159,400
	TOTAL BEFORE PURVEYOR REIMBURSEMENT							**$ 1,753,400**
	Purveyor Reimbursement at $75 per acre-foot		**2,200 gpm**	**3,550**	**acre-feet**		**$75**	**$ 266,250**
	TOTAL AFTER PURVEYOR REIMBURSEMENT							**$ 1,487,000**

Table B-9
Capital Cost – New Extraction Well
B.F. Goodrich Site RI/FS, Rialto, California

Item	Description	Estimated Depth/Quantity	Number of Locations	Estimated Total Quantity	Unit	Unit Cost	Total Cost
Installation of a New Extraction Well							
	Mobilization/Demobilization/Cleanup (one-time charge)			1	Lump Sum	$32,783.33	$32,783
	Sound Control	1	1	1	Each	$20,000.00	$20,000
	Conductor Casing and Sanitary Seal - drill 30-inch (minimum) hole and furnish and install 24-inch conductor casing	50	1	50	Linear foot	$500.00	$25,000
	Drilling Reverse Mud Rotary/Ream (24-inch)	700	1	700	Linear foot	$125.00	$87,500
	Geophysical	1	1	1	Each	$5,100.00	$5,100
	Steel Well Casing - 18-inch	475	1	475	Linear foot	$150.00	$71,250
	Stainless Steel Screen - 18-inch	200	1	200	Linear foot	$250.00	$50,000
	Dissimilar Metals Connector	1	1	1	Each	$2,800.00	$2,800
	Gravel Tube	425	1	425	Linear foot	$23.00	$9,775
	Sound Tube	600	1	600	Linear foot	$17.00	$10,200
	Filter Pack	250	1	250	Linear foot	$17.00	$4,250
	Annular Grout or Neat Cement	425	1	425	Linear foot	$28.00	$11,900
	Well Development - Primary & Secondary	24	1	24	Hours	$230.00	$5,520
	Development Rig Mobilization/Demobilization/Cleanup			1	Lump Sum	$3,825.00	$3,825
	Step-Rate Aquifer Test	8	1	8	Hours	$230.00	$1,840
	Constant-Rate Aquifer Test	72	1	72	Hours	$230.00	$16,560
	Video Camera Survey	1	1	1	Each	$1,100.00	$1,100
	Disinfect Well	1	1	1	Each	$1,650.00	$1,650
Pump and Power Service Connection							
	Well Head, including piping, valves, meters, etc	1	1	1	Each	$20,000.00	$20,000
	Submersible Pump/Motor include install.	1	1	1	Each	$65,000.00	$65,000
	Power service connection and panel	1	1	1	Each	$28,000.00	$28,000

Table B-9
Capital Cost – New Extraction Well
B.F. Goodrich Site RI/FS, Rialto, California

Scope Item	Description	Estimated Quantity	Units	Unit Costs	Single Well Costs	No. of Wells	Total Costs
Task - Extraction Well							
	Mobilization/demobilization of roll off bins (10 CY bins)	11	EA	$600.00	$6,600.00	1	$6,600
	Rental of roll off bins (75 day average)	825	DAY	$18.00	$14,850.00	1	$14,850
	Mobilization/demobilization of tanks for liquid waste	3	EA	$1,000.00	$3,000.00	1	$3,000
	Rental of tanks for liquids (75 day average)	225	DAY	$35.00	$7,875.00	1	$7,875
	Offsite disposal of soil cuttings as non-hazardous waste	36	TON	$58.00	$2,088.00	1	$2,088
	Disposal of drilling mud and high solids water as non-hazardous waste	40,000	GAL	$0.30	$12,000.00	1	$12,000
	Construct Basin for Settling/ Infiltration of Well Development Water	1	EA	$5,000.00	$5,000.00	1	$5,000
	SubTotal "A"						$ 618,579

NOTES:
1. All cost escalation adjustments assumed 3% inflation per year.
2. All equipment cost adjustments for size based on the formula: Adjusted Cost = Orig. Cost * (Adjusted Size/Orig. Size)^x
where "x" is 0.33 for pumps, 0.57 for Tanks, 0.62 for towers, and 0.6 for other process equipment.

Table B-10
Capital Cost – Injection Wells
B.F. Goodrich Site RI/FS, Rialto, California

Item	Description	Estimated Depth/Quantity	Number of Locations	Estimated Total Quantity	Unit	Unit Cost	Total Cost
Installation of a New Injection Well							
	Mobilization/Demobilization/Cleanup (one-time charge)			1	Lump Sum	$32,783.33	$32,783
	Sound Control	1	1	1	Each	$20,000.00	$20,000
	Conductor Casing and Sanitary Seal - drill 30-inch (minimum) hole and furnish and install 24-inch conductor casing	50	1	50	Linear foot	$500.00	$25,000
	Drilling Reverse Mud Rotary/Ream (24-inch)	725	1	725	Linear foot	$125.00	$90,625
	Geophysical	1	1	1	Each	$5,100.00	$5,100
	Steel Well Casing - 18-inch	500	1	500	Linear foot	$150.00	$75,000
	Stainless Steel Screen - 18-inch	200	1	200	Linear foot	$250.00	$50,000
	Dissimilar Metals Connector	1	1	1	Each	$2,800.00	$2,800
	Gravel Tube	475	1	475	Linear foot	$23.00	$10,925
	Sound Tube	600	1	600	Linear foot	$17.00	$10,200
	Filter Pack	225	1	225	Linear foot	$17.00	$3,825
	Annular Grout or Neat Cement	475	1	475	Linear foot	$28.00	$13,300
	Well Development - Primary & Secondary	24	1	24	Hours	$230.00	$5,520
	Development Rig Mobilization/Demobilization/Cleanup			1	Lump Sum	$3,825.00	$3,825
	Step-Rate Aquifer Test	8	1	8	Hours	$230.00	$1,840
	Constant-Rate Aquifer Test	72	1	72	Hours	$230.00	$16,560
	Video Camera Survey	1	1	1	Each	$1,100.00	$1,100
	Disinfect Well	1	1	1	Each	$1,650.00	$1,650
Wellhead and Drop Pipe							
	Well Head, including piping, valves, meters, etc	1	1	1	Each	$20,000.00	$20,000
	Pump Riser Pipe (stainless steel)	500	1	500	LF	$ 35.00	$17,500
	Power service connection and panel	1	1	1	Each	$15,000.00	$15,000

Table B-10
Capital Cost – Injection Wells
B.F. Goodrich Site RI/FS, Rialto, California

Scope Item	Description	Estimated Quantity	Units	Unit Costs	Single Well Costs	No. of Wells	Total Costs
Task - Injection Well							
	Mobilization/demobilization of roll off bins (10 CY bins)	11	EA	$600.00	$6,600.00	1	$6,600
	Rental of roll off bins (75 day average)	825	DAY	$18.00	$14,850.00	1	$14,850
	Mobilization/demobilization of tanks for liquid waste	3	EA	$1,000.00	$3,000.00	1	$3,000
	Rental of tanks for liquids (75 day average)	225	DAY	$35.00	$7,875.00	1	$7,875
	Offsite disposal of soil cuttings as non-hazardous waste	36	TON	$58.00	$2,088.00	1	$2,088
	Disposal of drilling mud and high solids water as non-hazardous waste	40,000	GAL	$0.30	$12,000.00	1	$12,000
	Construct Basin for Settling/ Infiltration of Well Development Water	1	EA	$5,000.00	$5,000.00	1	$5,000
	SubTotal "A"						$ 473,966

NOTES:
1. All cost escalation adjustments assumed 3% inflation per year.
2. All equipment cost adjustments for size based on the formula: Adjusted Cost = Orig. Cost * (Adjusted Size/Orig. Size)^x
where "x" is 0.33 for pumps, 0.57 for Tanks, 0.62 for towers, and 0.6 for other process equipment.