Technical Memorandum

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Prepared for: Monterey County Water Resources Agency

Project Title: Salinas River Groundwater Basin Investigation

Project No.: 146430.103

Technical Memorandum No. 1

Subject: Groundwater Usage Analysis

Date: October 21, 2014

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From: Les Chau, Managing Geologist

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Section 1: Introduction

As part of the Salinas River Groundwater Basin Investigation, Brown and Caldwell (BC) was tasked with analyzing groundwater usage and how it has changed over time. This Technical Memorandum (TM) presents the results of this analysis. This analysis is part of a larger investigation into the groundwater and surface water resources of the Salinas River Groundwater Basin (Basin) that will be discussed in several subsequent reports. As such, this TM will not provide an exhaustive description of the hydrogeologic background of the study area; such a description can be found in various existing reports and will be provided in the State of the Basin report, to be released in late 2014.

1.1 Scope and Purpose

The Scope of Work presented to the Monterey County Water Resources Agency (MCWRA) and the County of Monterey Resource Management Agency (RMA) by BC included a task (Task 3) on the usage of groundwater in Zone 2C. This task examines how groundwater usage has changed over time throughout Zone 2C and within the individual subareas that compose it. The discussion covers the history of development of water resources in Zone 2C, how groundwater is used today, and projections of groundwater usage in the future. The purpose of this TM is to provide (1) a history of groundwater usage in the study area, (2) a snapshot of current groundwater usage conditions, and (3) an estimate of future groundwater usage.

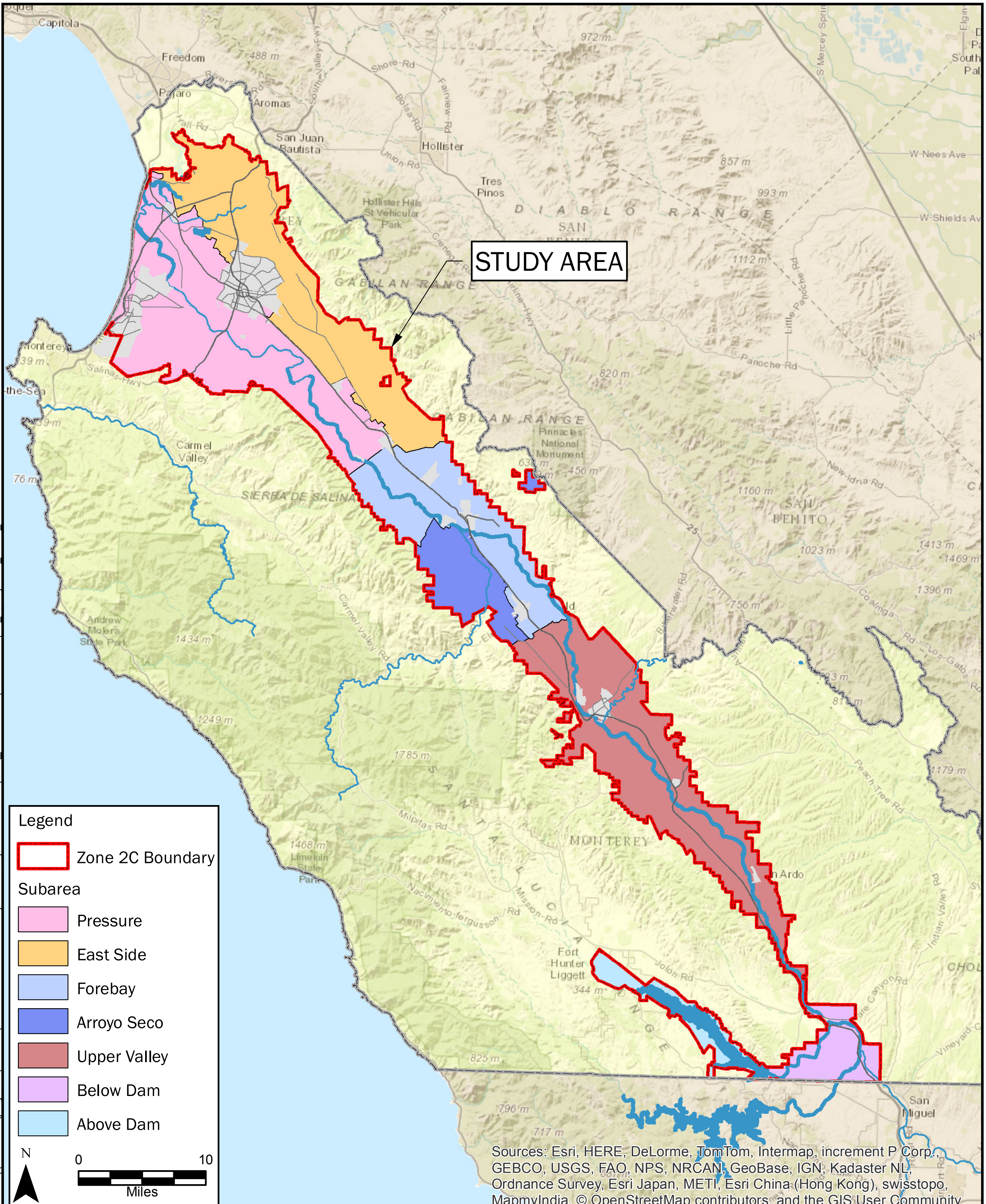
1.2 Study Area

The study area for the groundwater usage analysis of the Basin Investigation is defined by Zone 2C of the Salinas River Valley, shown on Figure 1. This study area consists of an alluvial basin straddling the Salinas River, which runs northwest from near Santa Margarita in San Luis Obispo County to where it drains into Monterey Bay. Zone 2C extends from the Monterey-San Luis Obispo County Line to Monterey Bay, and lies entirely within Monterey County. Zone 2C consists of 7 subareas, as shown on Figure 1; the analysis presented in this TM evaluates conditions in the four largest subareas (Pressure, East Side, Forebay, and Upper Valley), with the Forebay subarea including the area designated on Figure 1 as the Arroyo Seco subarea. These four subareas provide the bulk of groundwater storage and have been the heaviest utilized for groundwater production. Subareas were defined by the California Department of Water Resources (DWR), based on the sources of recharge to groundwater within each subarea (DWR, 1946).

The Basin consists of alluvium eroded from the surrounding highlands by the Salinas River and its tributaries. The alluvium contains extensive, relatively homogenous, coarse-grained deposits forming aquifers, which bear and yield useful quantities of water, and also extensive deposits of relatively fine-grained sediments forming aquitards, which act to slow groundwater flow. The depositional environment in which the sediments were laid down determines the distribution of course- and fine-grained sediments and the continuity and interconnectedness of the aquifers.

The depositional history of the study area has been detailed in previous reports, particularly Tinsley (1975) and Kennedy/Jenks (2004). The sediments that make up the aquifers and aquitards were laid down in a mixture of fluvial (river generated) and alluvial fan settings. The sediments in the Pressure subarea are typically fluvial in origin, and made up of coarse- and fine-grained layers that are somewhat extensive and continuous. The sediments in the East Side subarea, on the other hand, are thinner-bedded and more discontinuous (Kennedy/Jenks, 2004).

Despite the generally discontinuous nature of the sedimentary layers in the alluvial deposits, sediments have been classified into multiple aquifers in the Pressure and East Side subareas (Figure 2). In the Pres-



DATE	PROJECT	SITE	
10/21/14	146430	**Salinas River Groundwater Basin Investigation**	**Figure 1**
Brown AND Caldwell		TITLE **Study Area Map**	

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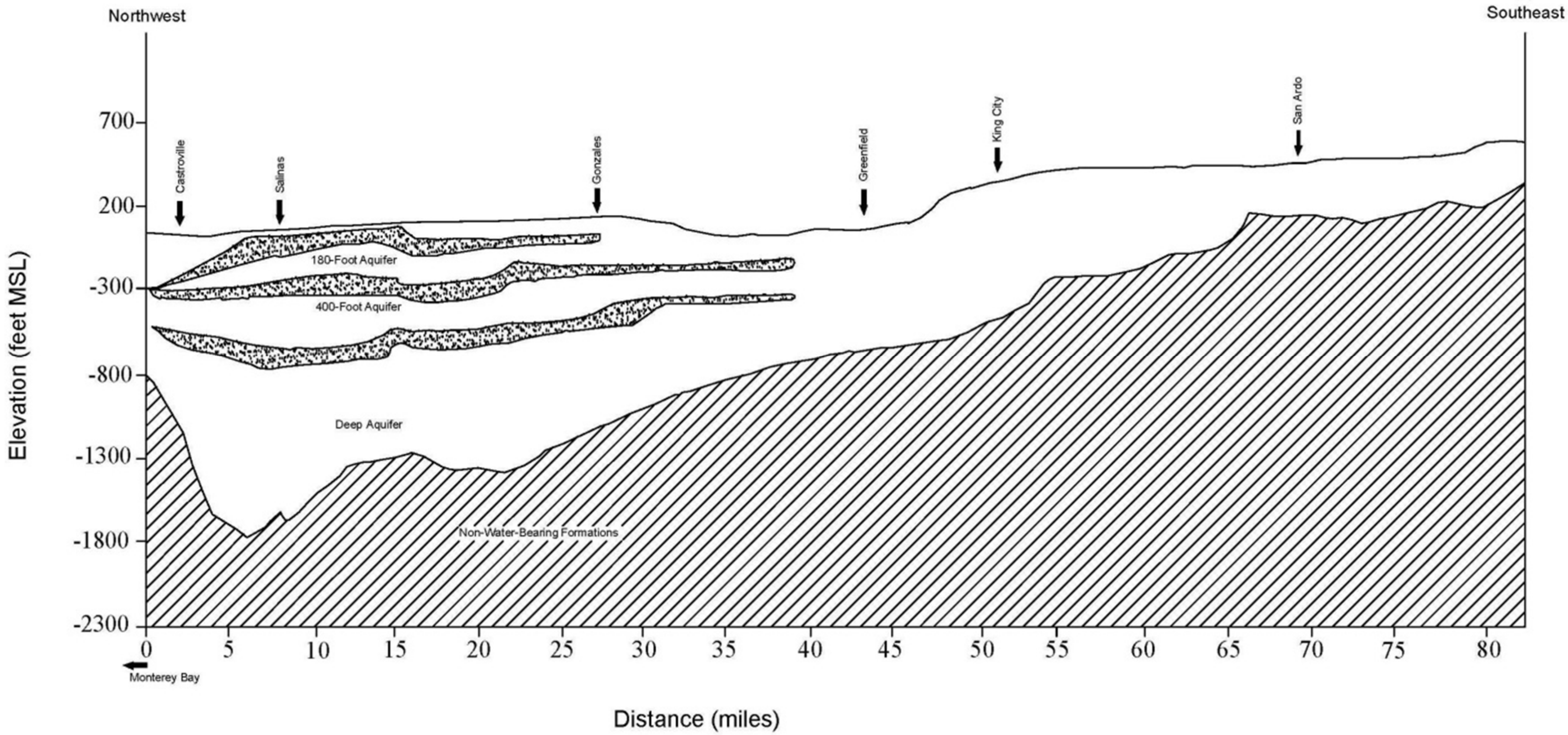


Modified from MCWRA, 2006

Brown AND Caldwell	DATE 10/21/14	SITE Salinas River Groundwater Basin Investigation	Figure 2
	PROJECT 146430	TITLE Schematic Depiction of the Pressure Subarea Aquifers	

sure subarea, aquifer designations are based largely on the locations of extensive, mostly continuous aquitards; there are up to four aquifers present in the subsurface (the Shallow Aquifer, the 180-Foot Aquifer, the 400-Foot Aquifer, and the Deep Aquifer), separated by three aquitards (the Salinas Valley Aquitard, the 180-Foot/400-Foot Aquitard, and the 400-Foot/Deep Aquitard) made up of blue clay layers deposited during marine transgressions (Tinsley, 1975). In the East Side subarea, there is no extensive, continuous aquitard layer, and the blue clays typical of the Pressure subarea aquitards are largely absent. Still, some authors have divided the sediments of the East Side subarea into a Shallow Aquifer and a Deep Aquifer (note that the Shallow and Deep Aquifers in the East Side subarea do not correlate to the Shallow and Deep Aquifers in the Pressure subarea). The Pressure Deep Aquifer is also present within the East Side subarea. Sediments in the Forebay and Upper Valley subareas are not divided into separate aquifers.

The existence or lack of continuous aquitards largely determines the confinement of the aquifers present in the study area. In the Pressure subarea, all of the aquifers except for the Shallow Aquifer are overlain by extensive, continuous blue clay aquitards, and are therefore confined (except in the 180-Foot Aquifer, where a few gaps in the Salinas Valley Aquitard may create unconfined to semi-confined conditions; MCWRA, 2006). In the East Side subarea, the deposits are generally unconfined to locally confined (MCWRA, 2006), with confinement increasing with depth due to the combined effect of numerous fine-grained interbeds (Kennedy/Jenks, 2004). The Forebay and Upper Valley subarea aquifers are unconfined.

1.3 Previous Investigations

Numerous investigators have studied the water resources and groundwater usage of Zone 2C in the past. The reports resulting from these previous studies are listed below. More detailed citations are available in the References section included after the text of this TM.

- Hamlin, 1904, Water Resources of the Salinas Valley, California
- DWR, 1946, Salinas Basin Investigation
- MWH, 1997, Salinas Valley Integrated Ground Water and Surface [sic] Model Update
- Kennedy/Jenks, 2004, Hydrostratigraphic Analysis of the Northern Salinas Valley
- MCWRA, 2006, Monterey County Groundwater Management Plan

1.4 Data

The various data sets utilized in the preparation of this TM are noted below.

- Monthly Groundwater Pumping Data: provided by MCWRA on a well-by-well basis from November 1994 to October 2013
- Annual Groundwater Pumping Data: provided by MCWRA on a subarea basis from 1949 to 2012; pre-1994 pumping was estimated during development of the Salinas Valley Integrated Ground and Surface Water Model (SVIGSM)
- Monthly Precipitation Data: provided by MCWRA for the Salinas Municipal Airport gauge from July 1872 to September 2014
- Groundwater Hydraulic Head Elevations: provided by MCWRA on a well-by-well basis. Data are predominantly from 1944 to present, although a few earlier measurements exist.
- Volume Change of Groundwater in Storage: calculated based on data provided by MCWRA and documented in TM2 of this investigation (Brown and Caldwell, 2014).
- Reservoir Releases: provided by MCWRA from October 1958 onward on a daily basis.

- Streamflow: available publicly from the U.S. Geological Survey (USGS) (http://nwis.waterdata.usgs.gov/nwis).

The data listed above were used to perform the groundwater usage analysis, as described in the following sections.

Section 2: Historical Groundwater Usage Development

This section describes the historical development of groundwater usage in the study area. The reader is referred to previous investigations (Hamlin, 1904; DWR, 1946) for additional information. The focus of this section is on the qualitative development of water resources prior to 1949 and a quantitative analysis subsequently.

2.1 Early Groundwater Development

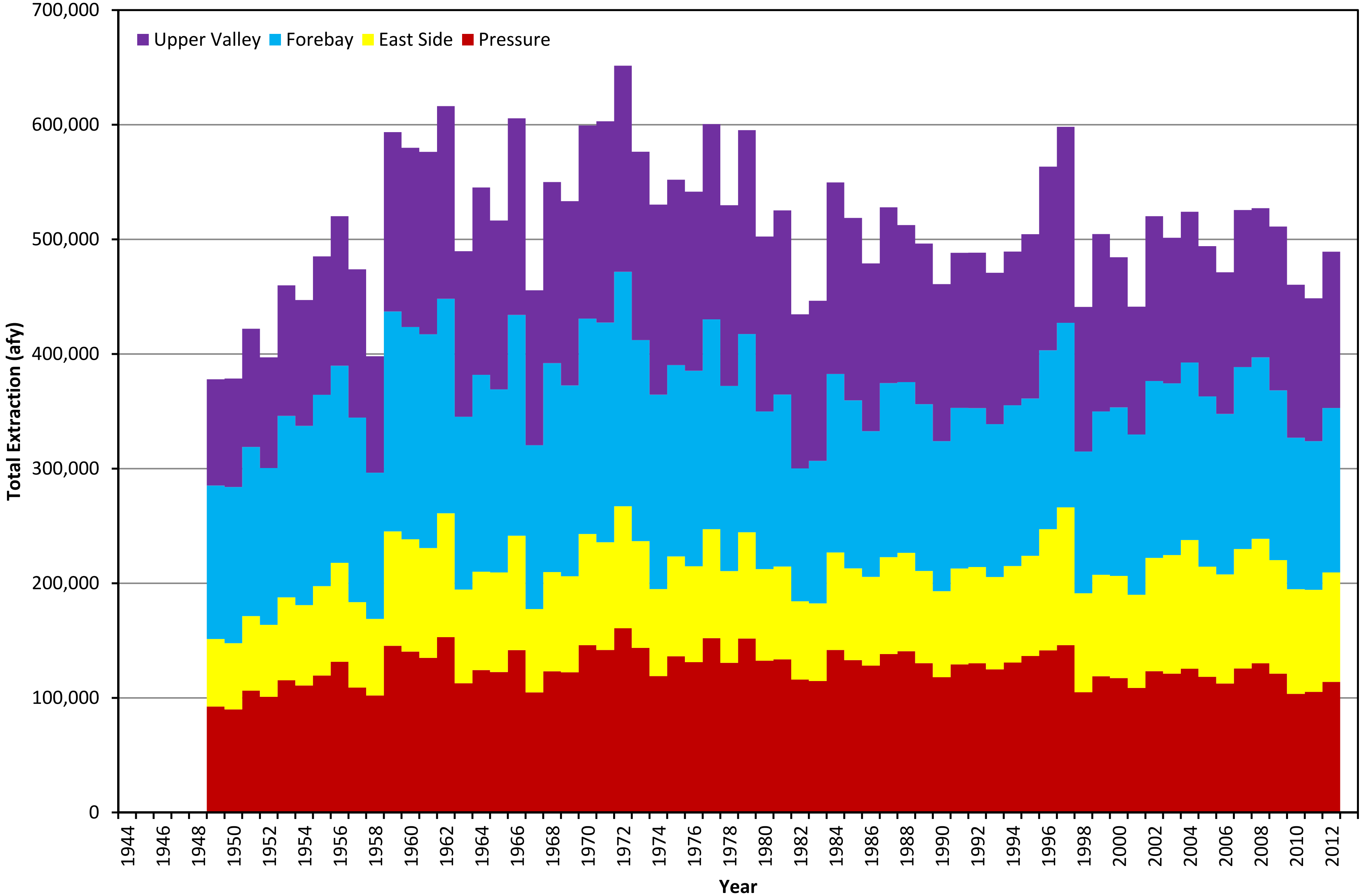
Groundwater has been pumped in the Basin since at least as early as 1890, when a census reported 60 flowing wells in the area of the Salinas River mouth near Castroville (DWR, 1946). Hamlin (1904) noted an area of wells located west of Salinas that had formerly been flowing and still did when pumping was not active. At the time of the fieldwork of the Hamlin study (1901), the USGS was able to locate some 270 wells in their study area which covered the alluvial basin up to about King City. Hamlin (1904) noted several pumping plants located along the Salinas River that each pumped up to about 10,000 gallons per minute from the River and the near-river fluvial deposits.

According to the history presented in DWR (1946), surface water diversions were utilized earlier and more extensively than groundwater pumping to assist irrigation of agricultural lands in the Basin with the first surface water claims filed in 1877. A total of 70 surface water claims were filed before 1901, with most of them never being utilized. Localized groundwater use started around 1897 with operations by the Spreckels Sugar Company near King City and Soledad, and expanded in leaps over the next 25 years due to several developments (widespread electrical lines, development of better well pumps, and the replacement of grain crops with vegetable crops). According to records collected during census investigations, the number of reported active wells increased from 102 in 1909 (it is not stated why this is much lower than the number of wells located by Hamlin) to 606 in 1919 and 1,176 in 1929.

By 1944, Groundwater pumping in the entire valley was estimated to be about 350,000 acre-feet per year (afy), with about 30% in the Pressure subarea, 10% in the East Side subarea, 35% in the Forebay subarea (including the Arroyo Seco cone), and 25% in the Upper Valley subarea. The total number of irrigation, municipal, and industrial wells had increased to approximately 1,300 by 1945, with about half of them located in the Pressure subarea; the wells located in the Pressure subarea were estimated to have pumped about 116,000 acre-feet (af) in 1944 and 120,000 af in 1945 (for comparison, 120,000 af equates to a continuous pumping rate of 74,000 gallons per minute for a whole year).

2.2 Groundwater Development After 1949

Over the period from 1949 to 1994, groundwater pumping data are available on a subarea basis, as estimated for the existing SVIGSM (MWH, 1997). These data represent model inputs that were estimated outside of the model, and modified during the calibration process. Figure 3 shows a time series of pumping by subarea covering the period from 1949 to 2012. Figure 4 shows a map with time series of pumping for each of the four main subareas, which shows that the general pattern of pumping over time has been fairly similar between subareas.



Brown AND Caldwell	DATE 10/21/14	SITE Salinas River Groundwater Basin Investigation	Figure 3
	PROJECT 146430	TITLE Groundwater Pumping Time Series	

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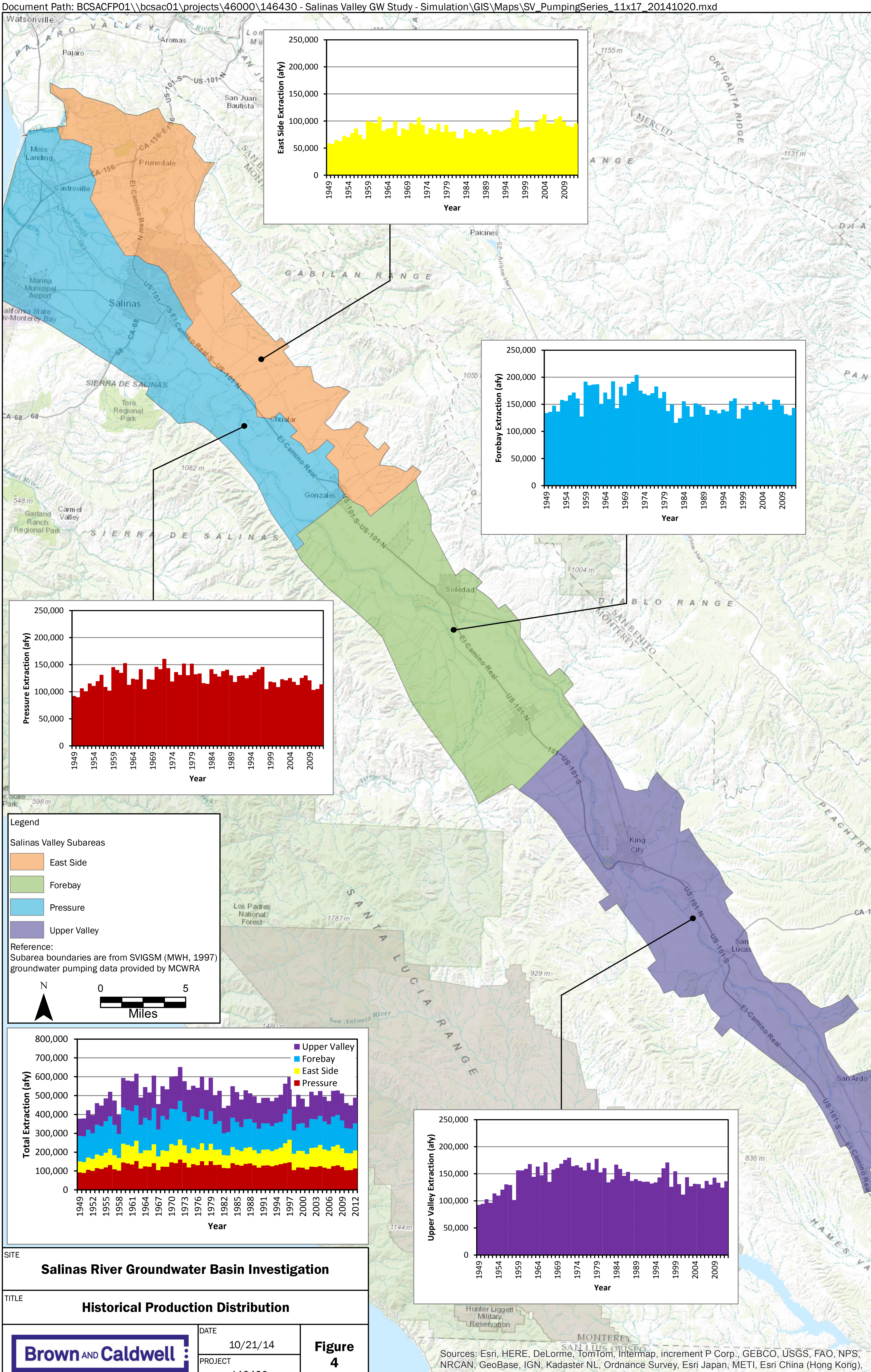

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Salinas River Groundwater Basin Investigation

TITLE

Historical Production Distribution

Brown AND Caldwell

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Figure 4

In general, Zone 2C pumping increased over the first 14 years of the period presented in Figure 3, from about 380,000 afy in 1949 to about 620,000 afy in 1962, the highest reported pumping year on record. Zone 2C pumping began to decline after about 1972 (when pumping was about 530,000 afy), falling to about 430,000 afy by 1982 before averaging about 500,000 afy over the rest of the period of record. Groundwater usage in Zone 2C from 1963 to 1994 averaged about 530,000 afy. The pumping rate for 2012 was about 136,000 afy.

Groundwater pumping was approximately steady in the Pressure and East Side subareas after about 1962. Pumping in the Forebay and Upper Valley subareas continued to increase until the early 1970s, then decreased slightly through the mid-1980s (from about 170,000 to 130,000 afy in the Forebay subarea and from about 150,000 to 130,000 afy in the Upper Valley subarea). On average, from 1949 to 1994 25% of the pumping occurred in the Pressure subarea, 16% in the East Side subarea, 31% in the Forebay subarea, and 28% in the Upper Valley subarea.

MWH (1997) presented an approximate distribution of pumping by aquifer within the Pressure and East Side subareas for the period from 1970 to 1994 (Table 1). It is noted that the Pressure Deep aquifer extends into the East Side subarea; hence, the Pressure Deep aquifer is included in both the Pressure and East Side subareas in Table 1.

The Pressure 180-Foot Aquifer has supplied up to about a third of the pumping in the Pressure subarea, with the bulk of the rest coming from the Pressure 400-Foot Aquifer. After 1985, pumping from the Pressure Deep aquifer supplied a large portion of the pumping during certain years.

In the East Side subarea, the Shallow Aquifer supplied generally half or less of the pumping, while the Deep Aquifer supplied the majority. The Pressure Deep Aquifer, which continues into the East Side subarea, was largely unutilized in this subarea.

Table 1. Vertical Distribution of Pumping, 1970-1994

Pressure Subarea			
Aquifer	**Pressure 180**	**Pressure 400**	**Pressure Deep**
1970-1980	15% - 35%	60% - 80%	5%
1980-1985	0% - 35%	60% - 94%	5% - 6%
1985-1994	0% - 35%	0% - 60%	5% - 100%
East Side Subarea			
Aquifer	**Shallow Aquifer**	**Deep Aquifer**	**Pressure Deep**
1970-1994	10% - 60%	35% - 85%	5%

Note: Modified from MWH (1997).

As detailed in an accompanying TM (TM2; Brown and Caldwell, 2014), annual storage changes were calculated for each of the four main subareas within Zone 2C (Pressure, East Side, Forebay, and Upper Valley) over the period from 1944 to 2013, based on published aquifer parameters and subarea-averaged groundwater head elevation changes provided by MCWRA (it must be noted that the storage change analysis relies on storage coefficient values that may be too large to properly represent the conditions in the study area aquifers, which would result in unrealistically large estimates of changes in storage; Brown and Caldwell, 2014). The results of these calculations indicated that, as of 2013, cumulative storage losses were about 110,000 af in the Pressure subarea and about 330,000 af in the East Side subareas, and that the cumulative storage change showed consistent storage losses (i.e. the subareas never returned to their starting storage volume over the period of record). In contrast, the Forebay and Upper Valley subareas have periodically been "reset" to the storage volume represented by the 1944 groundwater head elevations; although the cumulative storage loss in the Forebay subarea is of the same magnitude in 2013 as in the Pressure subarea (about 110,000 af), the average annual storage loss in this subarea is much smaller than in the Pressure subarea and its storage was equal to the 1944 level as recently as 1998. In the Upper Valley subarea, the cumulative storage loss was only about 10,000 af as of 2013.

Groundwater pumping totals by subarea are shown in Table 2. Totals indicate that the magnitude of pumping is not very different from subarea to subarea, with the average percentage of total pumping ranging from 16% to 31%. The subarea with the smallest percentage of the total pumping, the East Side subarea, has experienced by far the largest cumulative storage loss. This indicates that certain subareas (such as the Upper Valley subarea) tend to recover more readily from groundwater pumping than others. This resilience seems to be correlated with the degree to which each subarea is believed to be connected to flow in the Salinas River (River). There are no known extensive confining layers in the Upper Valley and Forebay subareas, indicating that the aquifers in these subareas are likely to be directly connected to the River. The Pressure subarea is believed to be largely disconnected from the River by the Salinas Valley Aquitard, although gaps do exist that allow for communication between the River and the Pressure 180-Foot Aquifer. The East Side subarea does not coincide spatially with the trace of the Salinas River (see Figure 1), and it is not connected to the River. This relationship will be discussed more fully in subsequent reports.

Table 2. Groundwater Pumping by Subarea, 1949-1994

Subarea	Pressure	East Side	Forebay	Upper Valley	Total
Absolute (acre-feet)					
Minimum	90,000	60,000	120,000	90,000	380,000
Maximum	160,000	110,000	200,000	180,000	650,000
Average	130,000	80,000	160,000	140,000	510,000
Standard Deviation	16,000	12,000	22,000	23,000	66,000
Percentage of Total Pumping					
Minimum	22%	14%	27%	24%	--
Maximum	27%	18%	36%	31%	--
Average	25%	16%	31%	28%	--
Standard Deviation	1.3%	0.7%	2.4%	2.1%	--

Note: Subarea numbers may not sum to total due to rounding.

Section 3: Current Groundwater Usage Patterns

Since November 1995, MCWRA has collected groundwater usage data from individual well owners through a County of Monterey ordinance. Under this ordinance, well owners are required to report monthly pumping volumes for every well with a discharge pipe diameter of 3 inches or greater. The time series of the annual pumping volume by subarea utilizes these data for the period from 1995 to present (Figure 3). In general, little changed in terms of pumping and pumping distribution from the pre-1995 estimates to the reported pumping values that started in 1995 (Table 3; compare to Table 2).

Figure 5 shows a map of pumping by Public Land Survey System section for the reporting year 2013 (November 2012 to October 2013), demonstrating the general pattern of groundwater usage in the study area. This map shows that pumping is distributed fairly evenly (green colors) across much of the valley floor of the

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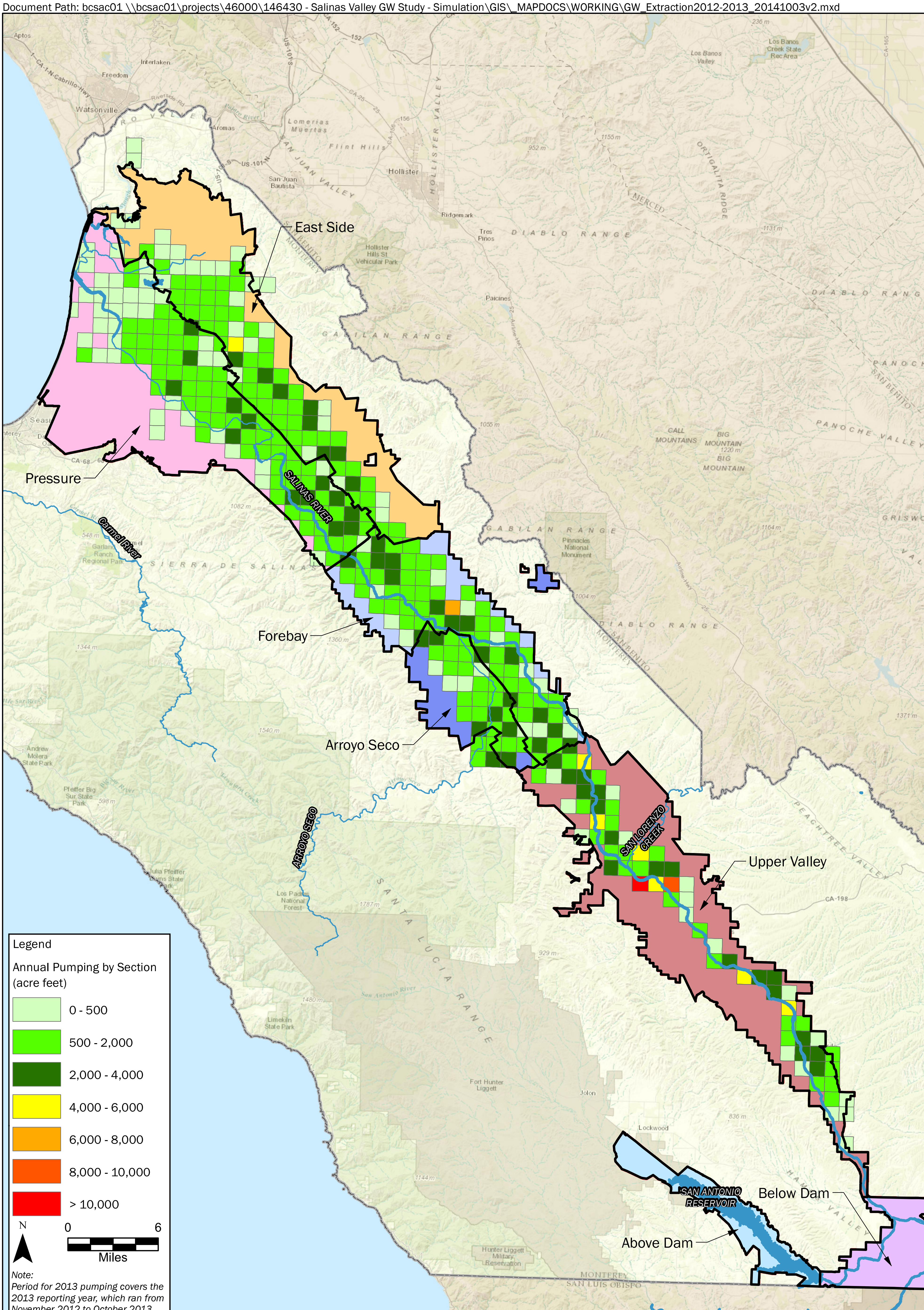

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Salinas River Groundwater Basin Investigation

TITLE

2013 Groundwater Extraction Map by Section

Brown AND Caldwell

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PROJECT 146430

Figure 5

Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Pressure, East Side, and Forebay subareas, with a few isolated locations of higher, concentrated pumping (yellow to red). In the Upper Valley subarea, pumping is confined to a relatively narrow band along the Salinas River, concentrating the pumping in a smaller number of sections and leading to more sections with high pumping compared to the other subareas. The majority of sections in the Pressure, East Side, and Forebay subareas had annual pumping of between 500 and 2,000 af (green) per section. The majority of the sections with the lowest pumping (less than 500 af per section, light green) occurred in the coastal areas of the Pressure and East Side subareas. In the Upper Valley subarea, pumping is spatially variable, ranging from zero (light green) to more than 10,000 af (red) per section.

Table 3. Pumping by Subarea, 1995-2012

Subarea	Pressure	East Side	Forebay	Upper Valley	Total
Absolute (Acre-feet)					
Minimum	100,000	80,000	120,000	110,000	440,000
Maximum	150,000	120,000	160,000	170,000	600,000
Average	120,000	100,000	150,000	140,000	500,000
Standard Deviation	12,000	10,000	11,000	14,000	41,000
Percentage of Total Pumping					
Minimum	22%	17%	27%	25%	--
Maximum	27%	21%	32%	31%	--
Average	24%	19%	29%	27%	--
Standard Deviation	0.9%	1.1%	1.2%	1.6%	--

Note: Subarea numbers may not sum to total due to rounding.

Figure 6 is a map of the average annual pumping by section over the reporting years 2009 through 2013 (November 2008 to October 2013), which provides more insight into the recent pattern of pumping without being as strongly affected by year-to-year variability in pumping. The pattern of this five-year average pumping is mostly very similar to that of 2013 pumping as shown on Figure 5, with a few small differences. Pumping over the last five years has been slightly higher near the coast in the Pressure and East Side subareas (four sections very close to the coast are green in Figure 6 and light green in Figure 5), and slightly lower in the upper ends of the Pressure and East Side subareas and in the Forebay subarea (several sections that were dark green in Figure 5 are green in Figure 6) as compared to a single year of pumping in 2013. Although individual sections showed changes in each subarea, the general pattern of variability was unchanged.

Section 4: Future Groundwater Usage Patterns

Groundwater usage is not expected to change substantially over the coming several years. Almost all of the irrigable acreage in the study area is already under cultivation, so it is assumed that irrigation pumping is not expected to notably increase. The irrigated acreage may decrease as it is replaced through urbanization if in fact urban areas continue to expand. Residential units require less water than does an equivalent agricultural area, so the groundwater pumping may actually decrease over time.

According to projections by the Association of Monterey Bay Area Governments (AMBAG), the population in Monterey County is expected to rise by about 7% from 2010 to 2020, a growth rate of about 0.7% per year

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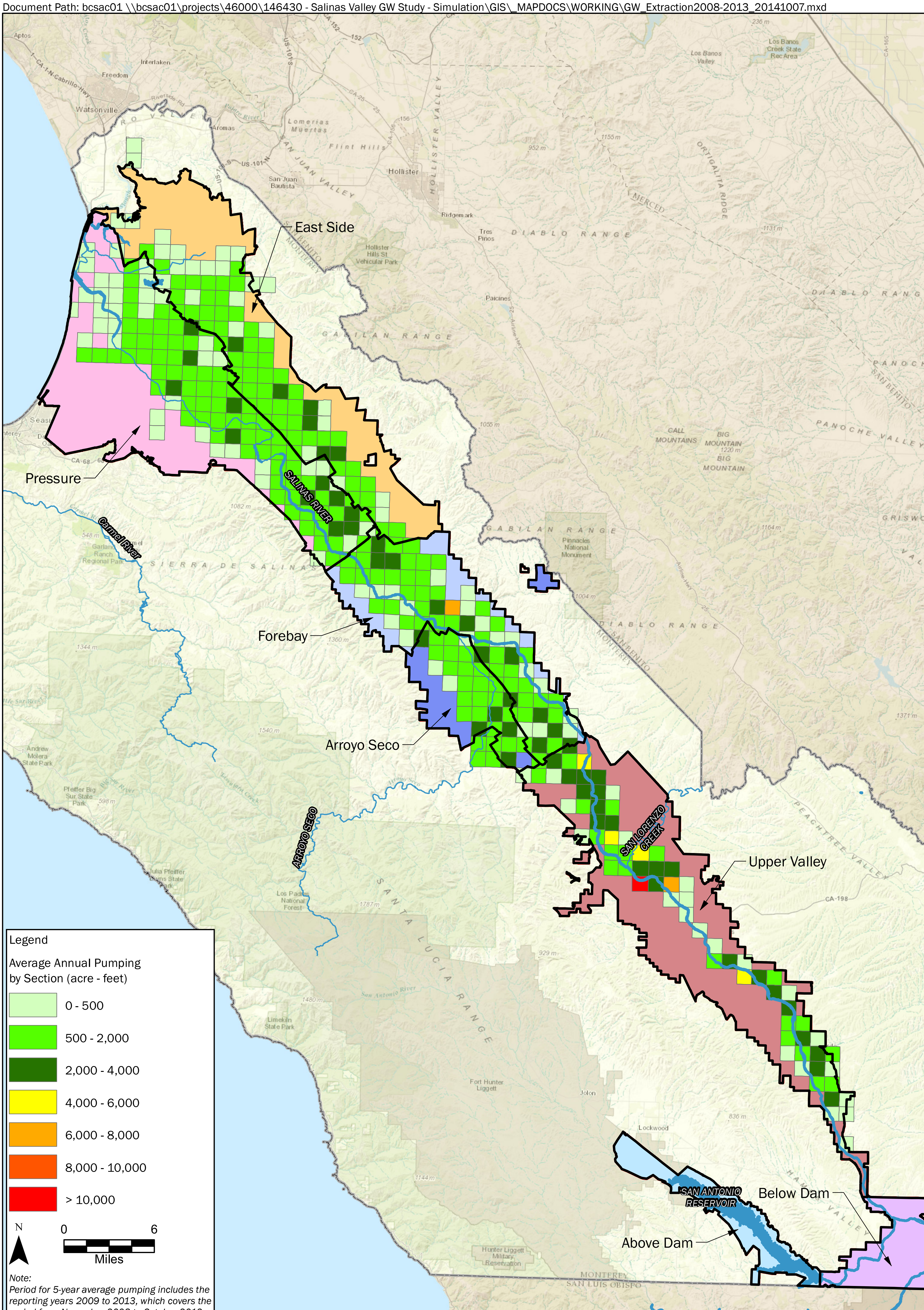

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Salinas River Groundwater Basin Investigation

TITLE

5-Year Average Groundwater Extraction Map by Section

Brown AND Caldwell

DATE 10/21/14	**Figure 6**
PROJECT 146430	

(AMBAG, 2014). We conservatively assume that the entire projected county-wide population growth will occur within the study area, since a majority of Monterey County residents live within Zone 2C.

Applying the 0.7% per year linear growth rate to subarea-wide groundwater pumping from 2012 results in the annual pumping rates presented in Table 4 for the years 2014 to 2020. These rates ignore both the urbanization of current agricultural areas and the year-to-year variability in groundwater pumping seen in Figure 3; hence, they should be considered general projections only. These projections do not indicate major changes in pumping over the coming years. The spatial pattern of future pumping can be assumed to be fairly similar to that shown in Figure 6, which shows the average annual pumping for the past five years.

Table 4. Subarea Groundwater Pumping Projections

Subarea	Pressure	East Side	Forebay	Upper Valley	Total
2010	104,000	91,000	132,000	133,000	460,000
2012	114,000	96,000	143,000	136,000	489,000
2014	116,000	97,000	146,000	138,000	496,000
2015	116,000	98,000	147,000	139,000	500,000
2016	117,000	98,000	148,000	140,000	504,000
2017	118,000	99,000	149,000	141,000	507,000
2018	119,000	100,000	150,000	142,000	511,000
2019	120,000	100,000	151,000	143,000	515,000
2020	121,000	101,000	152,000	144,000	518,000

Note: 2010 and 2012 pumping volumes as reported by MCWRA. 2014 through 2020 pumping volumes projected based on 2012 volumes and assumed increased water demands due to population growth estimated in AMBAG, 2014. Subarea numbers may not sum to total due to rounding.

Section 5: Data Gaps

Few data gaps exist in terms of groundwater usage in Zone 2C. MCWRA already implements a program whereby monthly pumping is reported by owners of all wells with discharge pipes of 3” diameter or greater, with a compliance rate of about 95% to 97% (G. Criollo, MCWRA, personal communication, 21 August 2014).

Well owners currently have three options for how they may collect the pumping information provided to MCWRA:

- Direct measurement by a water meter
- A pump efficiency test (performed about every 5 years) combined with metered energy use
- Well capacity (as determined by a pump efficiency test) combined with an hour meter

Of these three options, the first is the most direct measure of groundwater pumpage, and the least prone to estimation errors. The degree to which the method employed affects the accuracy of the reported pumping volumes is unknown.

The main data gap identified during this investigation is a general lack of information on well construction, which leads to a great deal of uncertainty regarding how most of the wells fit into the hydrogeologic framework of the Basin. This is less of an issue within the Forebay and Upper Valley subareas, where widespread aquifer separation does not exist. However, in the Pressure and East Side subareas multiple aquifers have been defined and it is important to understand how much groundwater is being extracted from each aquifer, and which wells are screened across (and extracting from) more than one of the defined aquifers. Table 5 shows the distribution of well aquifer assignments as they are currently defined by MCWRA for the 2,427 wells in the MCWRA groundwater extraction database.

Table 5. Number of Wells by Subarea and Aquifer					
Subarea	Pressure	East Side	Forebay	Upper Valley	Unknown
1. Number of Wells	753	640	569	448	17
East Side Subarea					
Aquifer	East Side Shallow	East Side Deep	East Side Both	East Side Unknown	Total
2. Number of Wells	25	126	86	187	424
Pressure Subarea					
Aquifer	Pressure 180-Foot	Pressure 400-Foot	Pressure Deep	Pressure Both	Total
3. Number of Wells	180	341	20	16	557

Note: See text for explanation on why well totals are different in the top section of the table from the lower sections.

The total number of reported wells located in the Pressure and East Side subareas (Row 1 of Table 5) does not match the total number of wells assigned to aquifers within those subareas (Rows 2 and 3 of Table 5). This is due to differences between data sources; Row 1 includes all 2,427 of the wells in the MCWRA groundwater extraction database (GEMS), whereas Rows 2 and 3 are derived from the 1,485 total wells (about 60% of the GEMS total) that actually have aquifer assignments. This demonstrates that there are significant gaps in knowledge about where individual wells are screened.

Section 6: Summary and Conclusions

This TM presented a discussion of groundwater usage patterns in the Salinas River Groundwater Basin to support the Salinas River Groundwater Basin Investigation in Zone 2C. Groundwater extraction in the study area began in the late 19th century, increased through the middle of the 20th century, and has been fairly steady since then. The average annual groundwater extraction for Zone 2C has been about 500,000 afy in recent years. This has been divided up fairly evenly between the four subareas composing Zone 2C: Pressure (24%), East Side (19%), Forebay (29%) and Upper Valley (27%). Because the Salinas Valley becomes narrower moving from north to south, the pumping is currently most intense (in the sense of pumping being concentrated in a small area) and most spatially variable in the Upper Valley subarea, and less intense and less spatially variable in the Pressure, East Side, and Forebay subareas.

Certain subareas tend to recover more readily from groundwater pumping than others. This resilience seems to be determined by the degree to which each subarea is connected to flow in the Salinas River. The aquifers in the Upper Valley and Forebay subareas seem to be directly connected to the River with no intervening confining layers. The Pressure subarea is disconnected from the Salinas River by confining layers along most of its length, except in isolated areas. The River does not run through the East Side subarea. Despite the approximately equal distribution of pumping between the subareas, calculated storage losses have been highly concentrated in the Pressure and East Side subareas, with little cumulative storage loss in the Forebay and Upper Valley subareas.

The distribution of groundwater pumping in 2013 (Figure 5) was quite similar to the distribution of average annual pumping over the past five years (2008 to 2013; Figure 6). This indicates that the magnitude and pattern of groundwater pumping have remained fairly steady in recent years, despite the fact that 2013 was the third year of an extended drought. The magnitude and pattern of groundwater usage are not expected to change drastically in the coming years, even under continued dry years. The projected population growth in Monterey County from 2010 to 2020 is about 7%. Future groundwater usage should, at most, increase by this amount, or it may stay steady or decline due to the shift of land from agricultural to urban uses. This indicates that storage can be expected to decrease by amounts similar to recent years, depending on other factors (e.g. climate, reservoir releases, etc.) that also affect storage.

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