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August 27, 2015

Frazier Park Public Utility District
4020 Park Drive
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Re: Regional Water Supply Study

Ladies and Gentlemen:

The following report discusses the availability of groundwater in the Frazier Park – Lake of the Woods portion of the Cuddy Canyon Groundwater Basin. It presents the current understanding of the hydro-geology of the groundwater basin and evaluates the effect of municipal water demands on groundwater storage in the basin.

The report draws on four reports:

1. "Groundwater Conditions in the Frazier Park Area" by Kenneth D. Schmidt & Associates - 2015

2. "Groundwater Conditions in the Frazier Park/Lebec Specific Plan Area" by Kenneth D. Schmidt & Associates – 2003

3. "Regional Groundwater Assessment Report for Cuddy Canyon Groundwater Basin" by the Galli Group – 2008

4. "Estimate of Water Demands for the Study Area" by Dee Jaspar & Assoc., Inc. - 2015

This report utilizes information from the four reports and develops estimates for the combined communities' water demands and the effects of these demands on the groundwater basin.

Dee Jaspar, P.E.

REPORT ON
GROUNDWATER AVAILABILITY
FOR THE
FRAZIER PARK/LAKE OF THE WOODS PORTION
OF CUDDY CANYON

July 2015

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Introduction

The appended report on "Groundwater Conditions in the Frazier Park Area' by Ken Schmidt and Associates (KDSA) discusses the subsurface geologic conditions, water levels, well data, well production, groundwater in storage, and sources of recharge, in the Cuddy Creek Canyon Groundwater Basin, and recommends favorable locations for new wells in the Frazier Park area. This report is herein referred to as the "2015 KDSA Report", to distinguish it from the aforementioned "2003 KDSA Report".

The communities of Lake of the Woods and Frazier Park, along with many other communities in California, have experienced the damaging effects of the recent four-year drought. It is not certain at this writing when the drought will be broken, or at least, when the state will experience a brief period of wet weather interspersed within the drought period. However, it has been observed that the groundwater basin reacts rapidly to the inflow of water from Cuddy Creek, even during a brief wet period, with the shallow alluvium experiencing various degrees of re-filling depending on creek flow.

Cuddy Canyon Groundwater Basin

The Cuddy Canyon Groundwater Basin was divided into three segments by the Galli Group (2008). These are shown on the attached map. Lake of the Woods is in the West Sub-basin, Frazier Park is in the Middle Sub-basin, and Lebec is in the East Sub-basin. See the appended map. Of interest for this study are the conditions in the West and Middle Sub-basins. These are discussed in the 2015 KDSA Report.

Lake of the Woods has experienced a significant dewatering of the alluvium in the west half of the West Basin with wells penetrating the alluvium showing water levels near or below the base of the alluvium. Water production in the Lake of the Woods wells is currently principally from hard rock underlying the alluvium. The effects of the drought are not as pronounced in Frazier Park. Water levels indicate that the groundwater levels are below what has been termed a "full basin" by Galli, which is 15 feet below ground surface. Levels have remained about 30 feet below ground surface in the Middle Basin over the past year, and they have remained stable at the depth over the past year. This is likely due to adequate recharge and the existence of a restriction to groundwater outflow to the east as described in the 2008 Galli Report. This restriction is near the intersection of the Garlock and the San Andreas Faults. The evidence of this is the difference in water levels west and east of this restriction, with the higher levels being on the west (Frazier Park) side of the restriction and the lower levels being on the east side.

Groundwater Recharge

Groundwater recharge occurs in several ways: 1. Infiltration from Cuddy Creek streamflow, 2. Tributary streams entering from the north and south sides of Cuddy Canyon, 3. Mountain front recharge (underground) from both sides of the valley, 4. Downgradient (easterly) groundwater inflow from the Cuddy Valley Groundwater Basin.

Galli observed that moderate to very large amounts of recharge occurred during small to moderate streamflow events. This happens when rainfall values of 1 to 2 inches occur. The West and Middle Sub-basins benefit the most from these short, powerful storms. Galli also cites the existence of numerous springs and seeps as evidence of significant mountain front recharge, and that this mountain front recharge is a significant contributor to the groundwater basin, particularly in the Frazier Park area. Galli postulated that mountain front recharge is the reason that groundwater levels in the Middle sub-basin remain relatively high, even in periods of drought.

Galli correlated annual rainfall to theoretical basin recharge using infiltration percentages. The data appears in the following tabulation.

Table 1

Rainfall Year	Rainfall (in/yr)	Infiltration %	Computed Recharge (acre-feet/year)	Percent of Normal
Drought	0-6	0	0	0
Below Normal	7-11	2-4	350 – 1,100	35%
Normal	12-15	5-7	1,500 – 2,600	100%
Above Normal	16-20	10-15	4,000 – 7,500	280%
Extreme	20+	20+	>7,500	365%

Galli states that even in years of lower than normal rainfall, but with a day or series of days with 3" – 6" of rainfall, recharge takes place, and therefore the recharge amounts derived in the above table are conservative.

Basin recharge lags behind the rainfall event by a certain time, depending on the configuration of the basin, character of the deposits, and the amount of rainfall. The lag time for the Cuddy Creek Subbasin was calculated as 3 to 4 weeks after significant rainfall event. The basin therefore exhibits the effects of rainfall events relatively quickly.

The 2003 KDSA Report estimated that the average annual groundwater recharge is between 2,000 and 4,000 acre-feet (af) for the Cuddy Canyon Groundwater Basin (Lake of the

Woods to Interstate 5). The recharge computed by Galli (above) of between 1,500 and 2,600 acre-feet per year compares favorably to the amounts estimated by KDSA. If the recharge amounts are proportioned by length of sub-basin, the annual average recharge for the West and Middle Sub-basins amounts to about 1,050 acre-feet per year, based on the low range of KDSA's estimate of recharge (2,000 acre-feet per year for the Cuddy Canyon Groundwater Basin).

Net demand reflects the estimated consumptive use of water that is pumped from the aquifer. It is estimated that household uses return about 75% of the water pumped to the underlying groundwater basin and landscape irrigation returns about 25% of the applied water to the basin. Further, it is estimated that 65% of the water use in the area is household use and 35% is landscape irrigation. Therefore 58% of the water pumped or derived from springs returns to the basin. Barto (1985) used an estimate of 50% for net consumptive use, which is in good agreement.

Water Budget

This firm estimated the total demands for the Lake of the Woods – Frazier Park area in a memorandum dated April 23, 2015. The six-year annual average pumping for Lake of the Woods was 117 acre-feet per year and for Frazier Park the annual average was 360 acre-feet per year, for a combined total of 477 acre-feet per year. 300 additional connections were added to this total to reflect some infill in each entity and existing uses that are not a part of the two entities, bringing the annual water demand to 561 acre-feet for the West and Middle Sub-basins.

The following Demand and Supply tabulation reflects a normal year for the West and Middle Sub-basins. Reference is made to Table 1 for determination of the type of rainfall year.

Table 2
Normal Year – West and Middle Sub-basins

Year / Rainfall	Recharge (af)	Total Demand (af)	Net Demand (af)	Change in Basin Storage (af)	Basin Storage (af)
Normal	1,050	560	280	*	Full (8,300)

*The difference between recharge and net demand (770 af) is groundwater outflow.

A five-year multiple dry year scenario is presented in Table 3. This table reflects the dry period of 1984 to 1988, one of the driest on record as of now. The basins start the sequence full.

Table 3

Five Year Dry Period – West and Middle Sub-basins

Year / Rainfall	Recharge (af)	Total Demand (af)	Net Demand (af)	Change in Basin Storage (af)	Basin Storage (af)
Normal					8,300
Dry	0	560	280	-280	8,020
Dry	0	560	280	-280	7,740
Below Normal*	180	560	280	-100	7,640
Below Normal*	180	560	280	-100	7,540
Below Normal*	180	560	280	-100	7,440

*As defined by Galli (Table 1). Recharge assumed to be 17% of normal (17% of 1,050 af) due to mountain front recharge. The recharge percentage used herein is less than predicted by Galli (35%) to reflect conditions between "Dry" and "Below Normal".

The following Table 4 reflects the effects of an on-going five-year drought, assuming minimal recharge to the groundwater basin, beginning in Year 2014. West Sub-basin dewatered, Middle Sub-basin at 30 feet average depth.

Table 4

Ongoing Drought – West and Middle Sub-basins

Year / Rainfall	Recharge (af)*	Total Demand (af)	Net Demand (af)	Change in Basin Storage (af)	Basin Storage (af)
2014					6,500**
2015	0	560	280	-280	6,220
2016	0	560	280	-280	5,940
2017	180	560	280	-100	5,840
2018	180	560	280	-100	5,740
2019	180	560	280	-100	5,640***

* See footnote, Table 3. Reduced the mountain front recharge to 180 af/yr.

** Current condition in Middle Basin (water levels at 30 feet).

*** Basin 86% full.

Summary and Conclusions

1. The Cuddy Canyon Groundwater Basin is divided into three sub-basins: the West, Middle and East Sub-basins. The Cuddy Canyon Groundwater Basin begins at Lake of the Woods and terminates at Interstate 5 in Lebec. It is approximately 36,000 feet long.

2. The two sub-basins of concern in this report are the West and Middle Sub-basins.
3. The West Sub-basin begins at Lake of the Woods and ends just west of Frazier Park. The Middle Sub-basin begins at the east end of the West Sub-basin and ends just east of Frazier Park. The East Sub-basin begins at the east end of the Middle Sub-basin and ends at Interstate 5.
4. Estimated groundwater storage in the Cuddy Canyon Groundwater Basin is 19,600 acre-feet. The groundwater storage in the sub-basins is: West = 1,300 acre-feet, Middle = 7,000 acre-feet, East = 11,300 acre-feet. This reflects "normal" basin conditions as defined by Galli.
5. Groundwater recharge is principally from streamflow in Cuddy Creek, from valley side streams, and from Mountain Front recharge.
6. Groundwater recharge for the Cuddy Canyon Groundwater Basin in a Normal year has been estimated to be between 1,500 – 2,600 acre-feet per year (Galli Group) to 2,000 - 4,000 acre-feet per year (KDSA). Annual recharge for this study was selected to be the low range of KDSA's report, 2,000 acre-feet per year. This was used because it is a conservative value and is within the range developed by the Galli Group.
7. Existing water demands are 360 acre-feet / year for Frazier Park, 117 acre-feet per year for Lake of the Woods, and 84 acre-feet per year for infill projects and for existing properties between the two entities, bringing the total demands for the West and Middle Sub-basins to 561 acre-feet per year.
8. The recharge value is for the entire basin and therefore the recharge value for the combined West and Middle Sub-basins was taken as a ratio of the lengths of the two sub-basins to the full length of the basin. This value was determine to be about 1,050 acre-feet per year for the combined West and Middle Sub-basins.
9. In a "Normal" year there is an excess of groundwater from recharge of about 770 acre-feet per year for the West and Middle Sub-basins, which flows underground and into the East Sub-basin.
10. A five-year period replicating the Year 1984 – 1988 drought reduces the amount of groundwater in storage from 8,300 acre-feet to 7,440 acre-feet.
11. A five-year period of continuing drought beginning in 2015 under current conditions reduces the amount of groundwater in storage in the West and Middle Sub-basins from 6,500 acre-feet to 5,640 acre-feet. Therefore the Middle Basin is 86% full at the end of this period. This demonstrates that the demands created by the combination of the two communities, together with the demands between the two communities, can be met for the next five years if the drought continues and there will be significant storage remaining.
12. The Cuddy Canyon Groundwater Basin is sufficient to meet the demands of the combined communities of Frazier Park and Lake of the Woods.

Kenneth D. Schmidt & Associates, Inc.

Report

Groundwater Conditions in the
Frazier Park Area

GROUNDWATER CONDITIONS IN THE FRAZIER PARK AREA

INTRODUCTION

Two groundwater studies that contain relevant information for this evaluation are:

1. "Groundwater Conditions in the Frazier Park/Lebec Specific Plan Area" by Kenneth D. Schmidt & Associates (KDSA), 2003.

2. "Regional Groundwater Assessment Report for Cuddy Canyon Groundwater Basin" by the Galli Group (2008).

The first of these reports discusses subsurface geologic conditions, water levels, well data, recharge and discharge, well yields and aquifer characteristics, and groundwater quality. The study area for that report extended along the Cuddy Creek from about a mile west of Frazier Park to east of I-5. The second of these reports evaluated groundwater in storage in three sub-basins. The West Sub-basin extends along an 8,500-foot long reach between Lake of the Woods and just upstream of Frazier Park. The Middle Sub-basin extends along a 10,500-foot long reach between the east edge of the West Sub-basin and a point

not far east of Frazier Park. The East Sub-basin extends along a 17,000-foot long reach that extends from the downstream end of the Middle Sub-basin to east of Lebec. The sub-basins of importance for this evaluation are the middle and west ones.

SUBSURFACE GEOLOGIC CONDITIONS

Water-production in Cuddy Canyon is primarily from alluvial deposits. Alluvial deposits occur along Cuddy Creek along a width that averages about 600 feet in the West Basin and 1,200 feet in the Middle Basin. The Galli Group determined the approximate thickness of the alluvial deposits based on a review of drillers logs for wells and the slopes of the adjoining hardrock terraine. They used an average maximum depth of 200 feet for the West Sub-basin and 400 feet for the Middle Sub-basin. The surface area of the alluvial deposits is about 115 acres in the West Sub-basin and 290 acres in the Middle Sub-basin.

Dee Jaspar & Associates (2015) prepared two subsurface cross sections extending from north to south through the central part of Frazier Park. The maximum depth of the alluvial deposits was indicated to range from about 290 to 500 feet, with the greater depth being at the downstream section.

WATER LEVELS

Water levels in wells tapping alluvial deposits in the Valley generally fall during periods of no streamflow in Cuddy Creek, and rise quickly and substantially during periods of such flow. The Galli Group used an average of from 30 to 90 feet for the average depth to water in the West Sub-basin for the "basin full condition" and at the end of a five-year drought, respectively. At Lake of the Woods a recent test hole confirmed that the alluvial deposits (170 feet thick at that site) had been dewatered (i.e. were above the water level). Historical records indicate ranges in streamflow from about 40 feet in 1999 to 120 feet in 1991. At these time, there was groundwater in the alluvial deposits. For the Middle Sub-basin, The Galli Group used a range in water levels for these two conditions of 15 to 60 feet. Recent water-level measurements for the Frazier Park wells indicate a depth to water of about 30 feet. KDSA (2003) indicated that the depth to water in three wells at Frazier Park ranged from 16 to 21 feet deep in March 2002, apparently representative of the near basin full condition.

WELL DATA

Three of the active Frazier Park PUD wells range from 126 to 193 feet in depth, whereas the fourth (Well 5) is 641 feet deep. A subsurface geologic cross section prepared by KDSA (2003) indicated that only one well taps the full thickness of the saturated alluvial deposits in Frazier Park. This well also apparently taps some material below these deposits.

WELL PRODUCTION

Pump tests were conducted at the Frazier Park PUD wells in April 2002. Pumping rates ranged from 205 to 515 gpm and the specific capacities from about 13 to 69 gpm per foot. The deeper wells generally had higher pumping rates. These values are indicated to be representative of most conditions. The amount of groundwater delivered for Frazier Park was about 360 acre-feet in 2014. Groundwater pumped in Lake of the Woods was about 120 acre-feet in 2013.

be spaced at least one quarter mile apart. The most important groundwater quality constituents are fluoride and uranium. It would be useful to obtain information on the vertical distribution of these when a test hole is done.

Map of Sub-Basins