TO: Recycled Water General Order Project File

DATE: July 25, 2014

SUBJECT: SUMMARY OF PERCHLORATE OCCURENCE IN SOURCES OF AGRICULTURAL WATER SUPPLIES

This memo summarizes information regarding perchlorate, its anthropogenic and natural sources, its occurrence in treated wastewater (recycled water), and its presence in surface and groundwater supply sources. Perchlorate is both a synthetic and a naturally occurring chemical that is soluble in water, mobile in groundwater, and persistent in groundwater. California regulates perchlorate in drinking water and established an MCL of 6 ug/L. There is currently no established federal MCL or agricultural water quality goal (published by the Food and Agriculture Organization of the United Nations) for perchlorate.

Review of recycled water use for agricultural irrigation indicates that the perchlorate originating from recycled water is a relatively insignificant source of perchlorate compared to other sources. This determination is summarized below:

1. Available data indicates the concentration of perchlorate in disinfected wastewater is nearly always less than the MCL.
2. Not all recycled water used for agricultural is disinfected. Some portion of recycled water used for agricultural use is either not disinfected, or is disinfected by means that do not result in perchlorate generation.
3. Recycled water makes up less than 1 percent of the agricultural water supply. In most cases, recycled water supplements the regular irrigation water supply.
4. Other sources of agricultural water supply contain perchlorate, often at concentrations higher than the recycled water perchlorate concentrations.
    - The Colorado River supplies 13 percent of the agricultural water in the state and it contains 5 to 9 ug/L perchlorate.
    - Groundwater in some areas of the state (especially Riverside, San Bernardino, and Los Angeles Counties) has been impacted with perchlorate. Typically, they are in areas near an industrial site that used perchlorate for an industrial purpose.
    - The volume of water exported through the Sacramento San Joaquin Delta (Delta) or locally pumped groundwater makes the contribution of perchlorate

from recycled water insignificant. If perchlorate is not present in either the water exported from the Delta or pumped from agricultural wells, the perchlorate in recycled water is significantly diluted. If perchlorate is present in either or both of the water supplies, the perchlorate contributed by recycled water is insignificant.

- Approximately 51 percent of agricultural water is delivered through the Sacramento-San Joaquin Delta. No perchlorate data is available for that water.
- Approximately 35 percent of agricultural water is delivered through agricultural production wells. No perchlorate data is available for that water.

5. Other sources of perchlorate may be contributing significant amounts of perchlorate to surface and groundwater supplies.

Additional discussion of the summary provided above is presented below.

1. Available data indicates the concentration of perchlorate in disinfected wastewater is nearly always less than the MCL.

Disinfection of Wastewater as a Perchlorate Source

Agricultural irrigation with recycled water is allowed under title 22. In general, higher levels of exposure to recycled water require higher levels of treatment and disinfection. Depending upon the crop irrigated, the recycled water may be undisinfected or meet specific disinfection criteria. Title 22 requires some recycled water to be disinfected. One way to disinfect recycled water is the use of sodium hypochlorite. However, sodium hypochlorite solutions may also contain perchlorate.[1] As a result, recycled water disinfected with sodium hypochlorite can add perchlorate to recycled water. (As will be discussed later in this memo, there are other sources of perchlorate in the environment.) To determine if perchlorate in recycled water is a significant source of perchlorate in the environment, State Water Board staff reviewed wastewater treatment system effluent data that is available electronically. The CIWQS database includes analytical data that has been electronically uploaded by major NPDES dischargers. (Major NPDES dischargers consist of NPDES permitted municipal wastewater facilities with flows greater than 1 MGD.)

CIWQS Review of Wastewater Treatment Plants with Perchlorate Data

Of the 214 major NPDES facilities listed in CIWQS (flows greater than 1 MGD), 17 facilities monitor for perchlorate concentrations in their effluent, 12 of the 17 facilities are water recycling facilities. A review of from January 2011 – July 2014 indicates perchlorate is sometimes present. When measureable perchlorate is present, it is generally below 2 ug/L. One facility reported a perchlorate concentration of 10 ug/L in a single sample event. (That was the only perchlorate data available for that discharger.)

[1] Perchlorate may form in hypochlorite solutions during manufacturing and storage. <http://www.forceflow.com/hypochlorite/Perchlorate_in_sodium_Hypo.pdf>

2. Not all recycled water used for agricultural is disinfected. Some portion of recycled water used for agricultural use is either not disinfected, or is disinfected by means that do not result in perchlorate generation.

Recycled water makes up a very small percentage (less than one percent) of the total water used for agriculture in California. Of that recycled water use, only some portion is disinfected with sodium hypochlorite, other disinfection methods are ultraviolet (UV) light, and chlorine gas (which is unlikely to create perchlorate in the treated wastewater). Furthermore, some portion of recycled water used for agricultural irrigation uses undisinfected secondary recycled water for irrigation of orchards where the recycled water does not come into contact with the edible portion of the crop, non-food bearing trees, fodder and fiber crops for animals not producing milk for human consumption, seed crops not eaten by humans, food crops that must undergo commercial pathogen-destroying processing, and ornamental nursery stock and sod farms. Disinfection derived perchlorate is not present in undisinfected secondary recycled water.

3. Recycled water makes up less than 1 percent of the agricultural water supply. In most cases, recycled water supplements the regular irrigation water supply.

California agricultural uses approximately 27 million acre feet of water per year. Approximately 51 percent of the water supply comes from the Sacramento – San Joaquin Delta and 35 percent comes from groundwater wells; the Colorado River supplies approximately 13 percent. Approximately 1 percent of irrigation water is supplied from recycled water. Table 1 presents estimates of sources of water used for agricultural in California.

4. Other sources of agricultural water supply contain perchlorate, often at concentrations higher than the recycled water perchlorate concentrations.

<u>Perchlorate in Surface Water Supply Sources</u>
There is no available data on perchlorate monitoring for the Sacramento-San Joaquin Delta water. Similarly, there is no perchlorate monitoring data for agricultural wells. Colorado River water sampling has shown perchlorate concentrations range from 5 – 9 ug/L. Table 2 presents a summary of perchlorate concentrations in various sources.

<u>Perchlorate in Groundwater Supply Sources</u>
Thousands of active and standby public water supply wells were sampled by the California Department of Public Health (CDPH) for perchlorate. As of February 2012, 312 active and standby public water supply wells out of 10,952 sampled had perchlorate concentrations above the MCL. Peak concentrations were reported as high as 108 ug/L in Los Angeles County, 68 ug/L in Riverside County, and 94 ug/L in San Bernardino County. CDPH maintains an updated summary of active and standby sources with perchlorate detections; Table 3 presents a summary of the 2010 – 2013 perchlorate data.

Although agricultural wells were not sampled in the CDPH investigation, it is reasonable to assume agricultural wells have the potential to contain perchlorate in areas where perchlorate containing fertilizer (explained in Item 5 below) was or is used. Agricultural wells are typically more vulnerable to contamination considering that agricultural wells may draw from shallower zones, the wells may be older and have deteriorated casings, or the wells may have been

constructed in a way that does not provide an effective sanitary seal (e.g. cable tool wells, well points, open borehole completions).

5. Other sources of perchlorate may be contributing significant amounts of perchlorate to surface and groundwater supplies.

Anthropogenic and Natural Sources of Perchorate

Common anthropogenic sources of perchlorate include perchlorate salts used in industrial or military applications, solid rocket fuels, explosives, fertilizers, automotive air bag inflators, electroplating, aluminum refining, fireworks, matches, road flares, and production of paints and enamels.

Perchlorate is naturally present in some fertilizers that have been used in the United States since the early 20th century. Chilean nitrate fertilizer containing naturally-occurring perchlorate has been widely used in American agriculture. Between 1923 and 1998, the reported usage of Chilean fertilizer in California was 477,061 metric tons. Though the quantities used today are smaller than the amounts applied earlier in the century, the use of Chilean nitrate fertilizer in California remains substantial. According to the 2000 United States Census, more than 6,600 tons of Chilean nitrate fertilizer was imported to California that year. ("Perchlorate Basics" 2010, Perchlorate Information Bureau. http://perchlorateinformationbureau.org/perchlorate-basics)

The USGS recently published a study reporting natural levels of perchlorate in desert soil, plants, and atmospheric materials. The research found shallow soils in the USGS Amargosa Desert Research Site in Nevada contained a high level of perchlorate, about 10 – 20 grams per hectare (0.1 – 0.3 ounce per acre) in the top one foot of soil. The equivalent amount, if flushed to groundwater, would be sufficient to result in a quarter million gallons of water per acre exceeding the California MCL. ("Natural Perchlorate Levels in a Desert Ecosystem." 3 April 2014. USGS Newsroom. http://www.usgs.gov/newsroom/article.asp?ID=3859#.U8_Dy_ldWhY)

Enc: Table Sheet and Notes Page

TABLE 1: ESTIMATE OF SOURCES OF WATER USED FOR AGRICULTURAL IN CALIFORNIA

Source	Flow	Proportion of Total Water Supply	Notes
Sacramento - San Joaquin Delta	14,090 TAF	50.8%	*(See Note 7)*
Colorado River	3,716 TAF	13.4%	*(See Note 6)*
Groundwater wells	9,660 TAF	34.9%	*(See Note 8)*
Municipal recycled water	245 TAF	0.9%	*(See Note 4)*
Total	27,711 TAF		*(See Note 9)*

TAF denotes thousands of acre feet.

TABLE 2: SUMMARY OF PERCHLORATE CONCENTRATION IN VARIOUS SOURCES

Source	Concentration	Notes
Sacramento - San Joaquin Delta	Not documented	*(See Note 1)*
Colorado River	5 - 9 ug/L	*(See Note 2)*
Municipal supply wells	up to 108 ug/L	*(See Note 3 & Table 3)*
Municipal wastewater	0 - 10 ug/L	*(See Note 5)*

TABLE 3: ACTIVE AND STANDBY GROUNDWATER SUPPLY SOURCES WITH PERCHLORATE DETECTIONS (2010 - 2013) (SEE NOTE 3)

	Peak detection at or above 4 ug/L		Peak detection above 6 ug/L		Peak Concentration
County	No. of Sources	No. of Systems	No. of Sources	No. of Systems	(ug/L)
Contra Costa	1	1	1	1	7.9
Fresno	1	1	-	-	4.5
Kern	2	2	1	1	14
Los Angeles	98	31	68	21	108
Monterey	1	1	-	-	4.8
Orange	11	7	3	2	9
Riverside	49	8	38	8	68
Sacramento	2	1	2	1	13
San Bernardino	57	19	37	16	94
San Diego	10	2	8	2	9.9
Santa Barbara	1	1	-	-	4.6
Santa Clara	5	4	3	3	10
Sutter	3	3	1	1	10
Tulare	6	3	5	3	20
Ventura	1	1	-	-	5.2
Total	248	85	167	59	-

NOTES:

1) There is currently no monitoring of Delta waters for perchlorate. http://www.waterrights.ca.gov/baydelta/docs/exhibits/append2/DK-02.pdf

2) Groundwater Information Sheet Perchlorate. State Water Resources Control Board. February 2012. http://www.waterboards.ca.gov/gama/docs/coc_perchlorate.pdf

3) Perchlorate in Drinking Water . California Department of Public Health. February 2014. http://www.cdph.ca.gov/certlic/drinkingwater/Pages/perchlorate.aspx

4) 2009 Municipal Wastewater Recycling Survey. State Water Resources Control Board. Data is for agricultural irrigation. http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/munirec.shtml

5) State Water Resources Control Board CIWQS data for NPDES Majors facilities (flow > 1 MGD) monitoring. Out of 214 facilities, 17 facilities have effluent monitoring for perchlorate. 12 out of 17 facilities are water recycling facilities. Discoverer Plus, accessed July 24, 2014.

6) Pacific Institute. Water to Supply the Land: Irrigated Agriculture in the Colorado River Basin. May 2013. pp 46-51 http://pacinst.org//wp-content/uploads/sites/21/2013/05/pacinst-crb-ag.pdf. Data is for 2005. USBR records of average annual consumptive use for years 2002-2005.

7) Lund, Jay et al. Envisioning Futures for the Sacramento-San Joaquin Delta. February 2007. Chapter 6. http://www.ppic.org/content/pubs/report/R_207JLChapter6R.pdf. Table 6.1 Estimated Average Consumptive Uses of Delta and Delta Tributary Waters, 1995-2005 (taf/year). Data is for total diversions of agricultural demand area.

8) Kenny, Joan, et al. USGS Circular 1344 Estimated Use of Water in the United States in 2005. Table 7 Irrigation water withdrawals, 2005. Table entry for California. http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf

9) Calculated total water supply is within 3% of USGS Circular 1344 Estimated Use of Water in the United States in 2005. Table 7 Irrigation water withdrawals, total 27,300 TAF. http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf