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SECRETARY FOR
ENVIRONMENTAL PROTECTION

Central Valley Regional Water Quality Control Board

TO: Wendy Wyels
Supervisor
Compliance and Enforcement Unit
Central Valley Regional Water Quality Control Board

FROM: Howard Hold, P.G. #7466
Senior Engineering Geologist
WDRs and Title 27 Compliance and Enforcement Unit
Central Valley Regional Water Quality Control Board

Mike Fischer
Water Resource Control Engineer
Compliance and Enforcement Section
Central Valley Regional Water Quality Control Board

DATE: 16 November 2015

SUBJECT: Settling Pond Seepage Increase Estimate, Morning Star Packing Company, Williams Facility, Colusa County

Purpose

This technical memorandum was prepared to explain the attached settling pond seepage estimate calculations. The calculations estimate the increase in seepage of the current pond in comparison to the pond described in the 2013 WDRs.

Background

On 13 November 2015, we were asked to estimate the increase in the seepage rate from the current settling pond in comparison to the permitted settling pond at the Morning Star Packing facility. We used Morning Star's 13 November 2015, 13267 Order response (13267 Response)[1] and quarterly groundwater monitoring data from monitoring wells MW-2 and MW-4 for information used in the estimate. Boring logs included in Morning Star's 1 October 2015 NOV response[2] were also used to estimate the type of soil found beneath the settling pond.

Seepage Rate Increase Estimate

We assumed that as solids build up in the settling pond during the processing season, the depth of water in the pond decreases, reducing the pressure exerted by the water and therefore the seepage rate from the pond. To account for this change in seepage rates over time, two seepage rates were estimated for the both the permitted and current settling ponds. One estimate was for the onset of the production season when the pond had full capacity to capture solids (i.e., deeper water) and a second estimate was for the end of the production season when the pond contained several feet of solids (i.e., less water). We assumed that the rate of solids entering the pond was constant, therefore over the production season, the reduction in seepage rates would be linear. An average

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[1] *Technical Report requested by letter dated 11-3-15, Morning Star Packing Company, L.P., Colusa County*

[2] Boring logs found in Wallace and Kuhl 15 April 2015 *Morning Start Packing Company Cooling Pond Expansion Geotechnical Engineering Report*

seepage rate for each pond was calculated based on the two seepage rate estimates. To be consistent with the methodology used in the cooling pond seepage estimate, we then calculated the difference between the permitted pond seepage rate and current pond seepage rate.

We calculated the estimated seepage rates based on the following inputs and assumptions:

Permitted Pond Area
The settling pond volume described in the 2013 WDRs is 5 acre-feet. Based on the area provided in the 1995 Report of Waste Discharge of 40,000 feet, the pond depth was assumed to be 5.445 feet (40,000 ft^2 * 5.445 ft = 217,800 ft^3 or 5 acre-feet) for the seepage estimate at the onset of a processing season.

Current Pond Area
Based on the *Morning Star Settling Pond Water Volume Exhibit* prepared by Siegfried Engineering and included in the 13267 Response, the settling pond currently has an area of approximately 59,000 ft^2. This number was estimated by measuring the pond width at 30 foot intervals (based on the scale pond drawing provided in the 13267 response) and calculating the area of each 30-foot trapezoid. The individual trapezoids were summed to calculate the total area of the pond. Assuming a water depth of 7.5 feet at the onset of the production season, the total pond volume is approximately 10.16 acre-feet.

Hydraulic Conductivity or the Current and Permitted Settling Ponds
According to the 13267 Response, the bottom of the pond was likely compacted when constructed and has been further compacted over the years from annual solids removal with heavy equipment. Board staff does not have a construction report to verify that this was done, but for the purpose of this estimate, we assumed this to be true. Based on boring logs from borings advanced in 2015 prior to the expansion of adjacent cooling pond, the native material below the settling pond is assumed to be clay from the ground surface to groundwater. Based on groundwater monitoring data from MW-2 and MW-4 between December 2013 and February 2015, the groundwater elevation averages 88.4 ft mean sea level (msl) or 13.6 feet below the bottom of the pond. A hydraulic conductivity of $1X10^{-6}$ cm/sec was assumed for the one-foot thick compacted layer and $1X10^{-5}$ cm/sec was assumed for the 12.6 foot thick layer of native soil between the compacted layer and the top of groundwater. An average hydraulic conductivity (k) of $7.58X10^{-6}$ cm/sec was calculated based on the following formula[3] and used in the seepage estimate.

$$k_{average} = \frac{d}{\frac{D_1}{k_1} + \frac{D_2}{k_2}}$$

Where:
d = total thickness of soil liner
D_1 = thickness of soil horizon 1
k_1 = hydraulic conductivity of horizon 1
D_2 = thickness of soil horizon 2
k_2 = hydraulic conductivity of horizon 2

[3] United States Department of Agriculture, Natural Resources Conservation Service, 2008, *Part 651, Agricultural Waste Management Field Handbook, Appendix 10D, Design and Construction Guidelines for Waste Impoundments Lined with Clay or Amendment-Treated Soil.* Rev.1, March 2008.

Depth of Water in the Current Pond
The base of the pond at the onset of the production season was assumed to be level and at an elevation of 102 ft msl. At the end of the production season, the bottom elevation of the pond accounting for solids buildup was assumed to be 107.4 ft msl (based on the 13267 Response). Solids accumulation on the bottom of the pond was not likely uniform; however, a constant 5.4 ft of solids equally distributed across the entire bottom of the pond was used to simplify the calculation and provide a conservative seepage estimate.

The water level in the pond was assumed to be equal to the high water mark reported in the 13267 Response of 109.5 ft msl.

A water depth of 7.5 ft (109.5-102) was used for the seepage estimate for the onset of the production season. A water depth of 2.1 ft was used for the seepage estimate for the end of the production season to account for solids accumulation in the pond.

Depth of Water in the Permitted Pond
We assumed that the pond base elevation did not change when the pond was expanded. Based on the permitted volume of 5 acre-feet and the 1995 Report of Waste Discharge area of 40,000 ft^2, we assumed that the water depth at the onset of the production season was 5.445 feet (5 acre-feet = 217,800 ft^3 / 40,000 ft^2 = 5.445 ft). A water depth of 2 ft was used for the seepage estimate for the end of the production season to account for solids accumulation in the pond.

Calculation
The seepage rates were calculated using the following equation[1] derived from Darcy's Law.

$$Q = k * \frac{H + d}{d} * A$$

Where:
Q = total seepage through area A
k = hydraulic conductivity
H = vertical distance between the top of the pond water to the base of the pond
d = thickness of soil layer
A = cross sectional area perpendicular to the flow

Conclusion
Board staff calculated that the seepage rate from the current pond is approximately 3,672 gallons per day higher than that of the permitted pond (10,150 gal/day vs. 6,478 gal/day). Calculations used to prepare this estimate are found in Attachment A.

In addition, the 13267 Response recommends that a geotechnical engineer perform soil borings to determine actual infiltration rates. We agree that this information could be used to more accurately estimate the actual pond seepage rate.

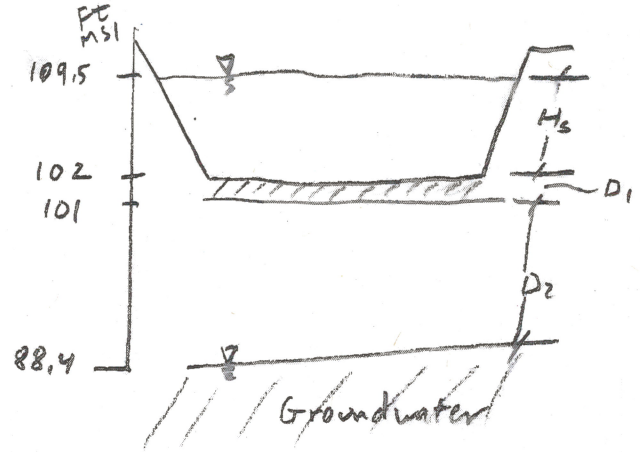
Attachment A: 11/16/2015 Morning Star Settling Pond Seepage Estimate Calculations

Morning Star Settling Pond Seepage Estimate – Attachment A 11/16/2015

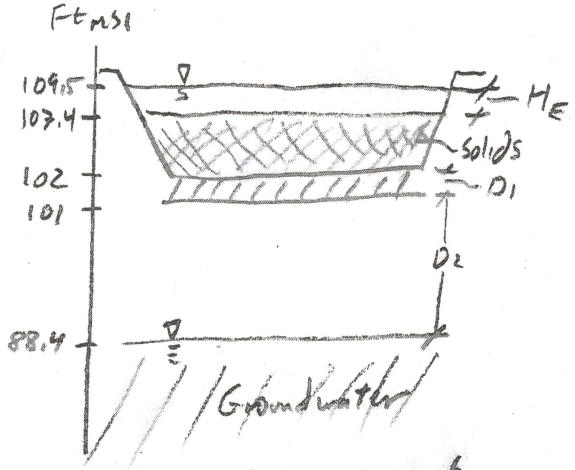
Mike Fischer

Current Pond

Start of Production Season



End of Production Season



$H_s = 7.5$ ft

$D_1 = 1$ ft $\quad k_1 = 1 \times 10^{-6}$ cm/sec

$D_2 = 12.6$ ft $\quad k_2 = 1 \times 10^{-5}$ cm/sec

$d = 13.6$ ft $\quad A = 59{,}000$ ft^2

$H_E = 2.1$ ft $\quad k_1 = 1 \times 10^{-6}$ cm/sec

$D_1 = 1$ ft $\quad k_2 = 1 \times 10^{-5}$ cm/sec

$D_2 = 12.6$ ft $\quad A = 59{,}000$ ft^2

$d = 13.6$ ft

Calculate k_{ave} (start of season = end of season)

$$k_{ave} = \frac{d}{\frac{D_1}{k_1} + \frac{D_2}{k_2}} = \frac{13.6}{\frac{1}{1\times10^{-6}} + \frac{12.6}{1\times10^{-5}}} = \frac{13.6}{2{,}260{,}000} = 6.02 \times 10^{-6} \text{ cm/sec}$$

convert to ft/day → 0.017 ft/day

Calculate Q_s (Start of season)

$$Q_s = k_{ave}\left(\frac{H_s + d}{d}\right) \times A = 0.017 \text{ ft/day}\left(\frac{7.5 \text{ ft} + 13.6 \text{ ft}}{13.6 \text{ ft}}\right) \times 59{,}000 \text{ ft}^2 = 1{,}556 \text{ ft}^3/\text{day}$$

$$Q_s = \left(1{,}556 \frac{\text{ft}^3}{\text{day}}\right)\left(\frac{7.48 \text{ gal}}{\text{ft}^3}\right) = 11{,}639 \text{ gal/day}$$

Calculate Q_E (End of season)

$$Q_E = k_{ave}\left(\frac{H_E + d}{d}\right) \times A = 0.017 \text{ ft/day}\left(\frac{2.1 \text{ ft} + 13.6 \text{ ft}}{13.6 \text{ ft}}\right) \times 59{,}000 \text{ ft}^2 = 1{,}158 \text{ ft}^3/\text{day}$$

$$Q_E = \left(1{,}158 \frac{\text{ft}^3}{\text{day}}\right)\left(\frac{7.48 \text{ gal}}{\text{ft}^3}\right) = 8{,}662 \text{ gal/day}$$

$$Q_{ave} = \left(\frac{11{,}639 \text{ gal/day} + 8{,}662 \text{ gal/day}}{2}\right) = 10{,}150 \text{ gal/day}$$

Morning Star Settling Pond seepage Estimate

11/16/2015

Permitted Pond

Start of Production Season

$H_s = 5.445$ ft
$D_1 = 1$ ft $k_1 = 1 \times 10^{-6}$ cm/sec
$D_2 = 12.6$ ft $k_2 = 1 \times 10^{-5}$ cm/sec
$d = 13.6$ ft $A = 40{,}000$ ft^2

End of Production Season

$H_E = 2$ ft
$D_1 = 1$ ft $K_1 = 1 \times 10^{-6}$ cm/sec
$D_2 = 12.6$ ft $K_2 = 1 \times 10^{-5}$ cm/sec
$d = 13.6$ ft $A = 40{,}000$ ft^2

$K_{ave} = 0.017$ ft/day (see page 1)

Calculate Q_S (Start of season)

$$Q_S = K_{ave}\left(\frac{H_S + d}{d}\right) \times A = 0.017 \text{ ft/day}\left(\frac{5.445 \text{ ft} + 13.6 \text{ ft}}{13.6 \text{ ft}}\right) \times 40{,}000 \text{ ft}^2 = 952 \text{ ft}^3/\text{day}$$

$$Q_S = \left(952 \text{ ft}^3/\text{day}\right)\left(7.48 \text{ gal/ft}^3\right) = 7{,}121 \text{ gal/day}$$

Calculate Q_E (End of Season)

$$Q_E = K_{ave}\left(\frac{H_E + d}{d}\right) \times A = 0.017 \text{ ft/day}\left(\frac{2 \text{ ft} + 13.6 \text{ ft}}{13.6 \text{ ft}}\right) \times 40{,}000 \text{ ft}^2 = 780 \text{ ft}^3/\text{day}$$

$$Q_E = \left(780 \text{ ft}^3/\text{day}\right)\left(7.48 \text{ gal/ft}^3\right) = 5{,}834 \text{ gal/day}$$

$$Q_{ave} = \left(\frac{7{,}121 \text{ gal/day} + 5834 \text{ gal/day}}{2}\right) = 6{,}478 \text{ gal/day}$$

Calculate Q Increase

$$Q_{current\ pond} - Q_{permitted\ pond} = 10{,}150 \text{ gal/day} - 6{,}478 \text{ gal/day} = 3{,}672 \text{ gal/day}$$