Methods for Hoffman Modeling  
Performed by Jim Brownell in July 2014  
Central Valley Water Quality Control Board  
Requested by the Lower San Joaquin River Committee  
August 28, 2014 Committee Meeting

In all of the 2014 Hoffman Model runs for prediction of almond soil water salinity, the same model spreadsheets were used that were used by Central Valley Water Board staff for modeling runs reported in the March 2010 Salt Tolerance of Crops in the Lower San Joaquin River (Stanislaus to Merced River Reaches (Draft Report). The Draft Report spreadsheets are equivalent to the spreadsheets utilized by Dr. Glenn Hoffman for his report titled Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta, January 5, 2010, developed for Delta salinity modeling.

The modeling and cropping assumptions made for the 2014 modeling are presented in Sections 5.1.1 and 5.1.2 of the Draft Report. References for setting model crop coefficients and growth periods for estimating crop evapotranspiration requirements are presented in Section 5.1.3 of the Draft Report. Figure 5.5 presents the almond crop coefficients and growth periods that were used in the 2014 modeling.

Daily climate data for various model runs presented in the Draft Report were taken from two weather stations: NCDC station no. 6168 (Newman C) for Crows Landing/Patterson modeling and NCDC station no. 5738 (Modesto C) for Maze modeling. The Crows Landing/Patterson model results were more conservative than the Maze results. That is, the Draft Report modeling predicted higher soil water salinity values using Crows Landing/Patterson climate records when all other parameters such as leaching fraction and irrigation water salinity were held constant. Therefore, only Newman C daily climate data for the 2014 model runs were utilized.

The Central Valley Water Board received many comments on the Draft Report in support of using the exponential crop water use uptake pattern rather than the 40-30-20-10 pattern and the CV-SALTS Policy Committee has also recommended exponential over 40-30-20-10. Therefore, only the exponential pattern for the 2014 modeling was utilized.

Following the recommendations of the Lower San Joaquin River Committee, The following parameters were modeled: almond soil water salinity to determine the irrigation water salinity that would result using 15 percent leaching fraction, 95 percent crop yield, and the fifth percentile of total annual precipitation recorded since the 1952 water year. The Draft Report modeling climate record extended from the 1952 through 2008 water years. For the 2014 modeling runs, I used climate records from the 1952 through the 2013 water years from the NCDC station no. 6168 (Newman C).
Attachment 1 presents a model output table for almond soil water salinity when the irrigation water EC is 1.55 S/cm and the leaching fraction is 15%. The far right column shows the soil water salinity for each water year between 1952 and 2013. At the bottom of that column, the soil water salinity results are presented for a year with median rainfall and for a year with 5th percentile rainfall. The 5th percentile value of 3.53 EC value is approximately the value predicted to result in a crop yield of 95%.

The top graph on Attachment 2 plots the resulting soil water salinity output table with irrigation water EC values between 0.5 and 2.0 S/cm are modeled, each at the same leaching fraction of 15%. The bottom graph plots the resulting crop yield against increasing irrigation water salinity.

The top graph on Attachment 3 plots the resulting soil water salinity at a constant leaching fraction of 15% and irrigation water EC of 1.55 S/cm, but a changing total annual precipitation amount. The 95% crop yield threshold is placed on the graph to show that the threshold is reached when the annual rainfall drops to the 5% driest years if the leaching fraction is 15% and the EC of irrigation water is 1.55 S/cm. The bottom graph plots the results with irrigation water EC at 1.32 S/cm, leaching fraction of 15% and the 100 percent yield salinity threshold of 3.0 S/cm.

Attachment 4 presents modeling results and assumptions presented to the LSJRC on June 26, 2014.
| Water Year | FEC | ECWa-1 | ECSWa-1 | I1 | ECSWb-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG | ES | PGS | PEFF | ETC | I1 | ECSWa-1 | ECSWb-1 | I2 | EC | ETC | i1 | i2 | PT | PNG |
|------------|-----|--------|---------|----|---------|---------|----|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---
Almonds, Exponential Uptake, 15% LF
Patterson Weather Station data 1952 - 2013

Soil Water Salinity (ECsw dS/m)
Irrigation Water Salinity (ECi dS/m)

- without precipitation
- median precipitation
- 5th percentile precip
- Almond Tolerance Threshold

Relative Crop Yield (%)

- without precipitation
- Median precipitation
- 5th percentile precipitation
- yield
This graph shows that an ECi of 1.55 returns the maximum ECsw at which crop yield is reduced by no more than 5% during a 5th percentile rainfall year.

This graph shows that an ECi of 1.31597 returns the maximum ECsw at which crop yield is not reduced during a year when rainfall is at the 5th percentile.
Hoffman Modeling of Almond Salinity Requirements
LSJRC Meeting
June 26, 2014
Jim Brownell

Model Parameters:
1. Patterson Weather Station
   data 01/01/52 thru 09/30/13
2. Median precipitation = 10.5 inches
3. 5th percentile precipitation = 6.1 inches
4. 15% leaching fraction
5. Exponential uptake
6. Crop soil water EC threshold = 3.0
7. 95% crop yield protection
8. Bare soil ET = 0.7 inches/month
9. Runoff coefficient = 77

Growth stage crop coefficients:
B  Kc1 = 0.5
C  Kc2 = 0.9
E  Kc3 = 0.5

Growth stage dates:
A  15-Feb
B  15-Feb
C  1-Jun
D  1-Sep
E  10-Nov

S = (1000/CN) - 10 = 3.0

Extraterrestrial radiation (mm/day) at 37º latitude

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<td>11</td>
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<tr>
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<td>6.31</td>
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Results:
The ECsw value necessary to obtain a crop yield of 95% is 3.53
At the ECsw value of 3.53, the ECi value is 1.55
Therefore, the ECi needed to obtain 95% crop yield in a 5th percentile rainfall year of 6.1 inches is 1.55

<table>
<thead>
<tr>
<th>Precipitation</th>
<th>100% Crop Yield (ECsw = 3.00)</th>
<th>95% Crop Yield (ECsw = 3.53)</th>
</tr>
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<td>1.71</td>
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<tr>
<td>5th percentile</td>
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