Salinas Valley Integrated Hydrologic Model (SVIHM)

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Model Development TAC
December 13, 2016
Agenda

• Introduction
• Outreach Summary
• Geologic Framework Analysis – Don Sweetkind
• Surface-Water and Climate Data Analysis – Joe Hevesi
• Integrated Hydrologic Model (IHM) of Salinas River Valley – Randy Hanson
Schematic of Model inputs and observations for SVIHM

- Streamflow from HSPF will be applied (via boundary conditions) along the edges of the MF-OWHM model, but will also be matched to the extent possible within the overlapping area of the HSPF and MF-OWHM domains as well.
- ET_{soil} and Local Recharge-MFR (i.e., recharge within the MF-OWHM domain) will be calculated by MF-OWHM within its domain, but the HSPF calculations of these outputs will be used to inform the MF-OWHM model.
- The streamflow outputs from HSPF will be utilized to determine inflow to the reservoirs, and reservoir releases will then be fed into the streamflow input to the MF-OWHM model based on the reservoir operation rules (implemented by SWOPS within MF-OWHM).
MODFLOW Model Construction

• Model extent, spatial & temporal resolution & model layering completed;
• Parameter Estimation Structure with PEST Completed
• Onshore Boundary & Offshore Boundary conditions located and defined
• Initial condition based on LSE and then simulated heads (SP 13/TS 2).
• Calibration observations -- GEMs Ag Pumpage, Heads, Head differences, streamflows, and streamflow differences completed.
One-Water Model Construction

• Landscape Features -- Water Balance Subregions, Crop/Land-Use Categories & Attributes ➔ completed
• Surface-Water Networks -- Network, Inflow and diversion points, & Network attributes, Reservoirs, Lakes, Canals, Drains, etc. ➔ completed
• Geologic/aquifer framework -- Extent, Layering, Faults, parameters and facies subregions for calibration ➔ completed
• Analysis of heads, head differences, streamflow, & Ag Pumpage, Zonebudget for Water budgets completed
Example Problem Design

**Identify Major Questions the study will analyze and answer for historical/future time**

**Determine Extent of Model Region** (Watershed/Basin/Subregion?)

**Determine Water-Balance Subregions & Super Groups** (SubWatersheds, Farms/Political or Jurisdictional subregions?)

**Determine Land-Use & Crop Groups** (Individual Crops, or Types of Land-Use subregions?) ➔ **Demand Sources** (Irrigations/Public Supply/Salinity)

**Build hydrologic Model Grid in GIS as polygon shape file for the area of interest**

**Build Geologic Model Grid in GIS as polygon shape file for the area of interest**

**Identify Sources of water and relate them to sources of demand for water**

**Design sources of water**:
- Surface-Water
- Groundwater
- Non-Routed Deliveries

**Estimate Climate Crop and Farming Attributes**

**Estimate Layers** tops/bottoms and hydraulic properties of aquifers

**Develop Surface-water Networks and Wells with attributes in GIS/spreadsheets**

**Develop Observations of surface flows, gw heads, etc.**

**Develop Parameter Estimation Input and Control**
Conjunctive-Use Simulated with Fully Coupled Groundwater-Surface Water-Landscape-Climate Linkages of MF-OWHM

- Head-dependent flow
- Flow-dependent flow
- Deformation-dependent flow
- Salinity-Dependent Flows Leaching Management to Full ET-Coupling

Irrigation for Strawberries: 25% Leaching Requirement ➞ 33% Increased Irrigation for 1,000 uS/cm groundwater

Embedded in a Physically-Based Supply-and-Demand Framework of Demand-Driven and Supply Constrained Use and Movement of Water
Salinas Valley Jurisdictional Units for Water-Budget Analysis and Sustainable Groundwater Management Act (SGMA) Compliance
<table>
<thead>
<tr>
<th>Number</th>
<th>Region</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Riparian Corridor (Monterey and SLO Counties)</td>
<td>Preserved Fish and Plant Habitat Salinas River</td>
</tr>
<tr>
<td>2</td>
<td>CSIP Area</td>
<td>Recycled Water Irrigation Region</td>
</tr>
<tr>
<td>3</td>
<td>Coastal Urban areas (Salinas, Castroville, Marina, parts of Monterey, Del Rey Oaks)</td>
<td>Urban Demand</td>
</tr>
<tr>
<td>4</td>
<td>Inland Urban areas (Chualar, Gonzales, Soledad, Greenfield, King City, &amp; San Ardo)</td>
<td>Urban Demand</td>
</tr>
<tr>
<td>5</td>
<td>Agriculture</td>
<td>Highlands South</td>
</tr>
<tr>
<td>6</td>
<td>Agriculture</td>
<td>Granite Ridge</td>
</tr>
<tr>
<td>7</td>
<td>Suburban</td>
<td>Corral De Tierra inside of Zone 2C</td>
</tr>
<tr>
<td>8</td>
<td>Agriculture</td>
<td>Blanco Drain Area (Not in CSIP)</td>
</tr>
<tr>
<td>9</td>
<td>Agriculture</td>
<td>Remainder of Zone2C – East Side</td>
</tr>
<tr>
<td>10</td>
<td>Agriculture</td>
<td>Remainder of Zone2C – Pressure NE of Salinas River</td>
</tr>
<tr>
<td>11</td>
<td>Agriculture</td>
<td>Remainder of Zone2C – Pressure SW of Salinas River</td>
</tr>
<tr>
<td>12</td>
<td>Agriculture</td>
<td>Remainder of Zone 2C – Forebay NE side of Salinas River</td>
</tr>
<tr>
<td>13</td>
<td>Agriculture</td>
<td>Remainder of Zone 2C – Forebay SW side of Salinas River</td>
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<td>14</td>
<td>Agriculture</td>
<td>Remainder of Zone 2C – Arroyo Secco</td>
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<td>15</td>
<td>Agriculture/SW Delivery</td>
<td>Clark Colony 1905 (non-urban)</td>
</tr>
<tr>
<td>16</td>
<td>Agriculture</td>
<td>Zone 2C – Upper Valley NE subregion East of Salinas R &amp; Northeast of King City</td>
</tr>
<tr>
<td>17</td>
<td>Agriculture</td>
<td>Zone 2C – Upper Valley NW subregion West of Salinas R &amp; West of King City</td>
</tr>
<tr>
<td>18</td>
<td>Agriculture</td>
<td>Zone 2C – Upper Valley SE subregion East of Salinas R &amp; East of King City</td>
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<tr>
<td>19</td>
<td>Agriculture</td>
<td>Zone 2C – Upper Valley SW subregion West of Salinas R &amp; West of King City</td>
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<tr>
<td>20</td>
<td>Agriculture</td>
<td>Zone 2C – Below Dam</td>
</tr>
<tr>
<td>21</td>
<td>Native</td>
<td>Westside Regions Active outside Zone 2C boundary in Monterey County for Inland Southwest of Arroyo Secco and Clark Colony</td>
</tr>
<tr>
<td>22</td>
<td>New Agriculture</td>
<td>Hames Valley – Monterey County</td>
</tr>
<tr>
<td>23</td>
<td>NE Quarries</td>
<td>Mining</td>
</tr>
<tr>
<td>24</td>
<td>Native</td>
<td>Boundary of Model outside of Zone 2C on the Northeast side of the remainder of the East Side, Granite Ridge, and Highlands South subregions</td>
</tr>
<tr>
<td>25</td>
<td>Native</td>
<td>Southwest side Region Active outside of Coastal Pressure subregion Zone 2C boundary in Monterey County</td>
</tr>
<tr>
<td>26</td>
<td>Native</td>
<td>Boundary of Model outside of Zone 2C on the Northeast side of the remainder of the Forebay subregion</td>
</tr>
<tr>
<td>27</td>
<td>Native</td>
<td>Boundary of Model outside of Zone 2C on the Southwest side of the Upper Valley, Arroyo Seco, and Forebay regions, Hames Valley, and SLO active Regions</td>
</tr>
<tr>
<td>28</td>
<td>Native</td>
<td>Eastside Regions Active East and outside of Below Dam and Upper Valley subregions of Zone2C boundary in Monterey County</td>
</tr>
<tr>
<td>29</td>
<td>Native</td>
<td>Remainder of Paso Robles Basin in active model grid in SLO County (SLO Model Active Grid Extent)</td>
</tr>
<tr>
<td>30</td>
<td>Seaside Adjudicated Basin (landward only)</td>
<td>Urban Demand</td>
</tr>
<tr>
<td>31</td>
<td>Offshore (gw analysis only)</td>
<td>Source of Seawater Intrusion</td>
</tr>
</tbody>
</table>
30 SVIHM Water-Balance Accounting Units

- Seaside Basin Included
- Coastal and Inland Urban areas grouped
- Zone 2C regions subdivided
- Additional regions added outside of Zone 2C
- Offshore region completed based on Geologic Framework Model
SURRGO Soils Distribution for use with MF-OWHM Farm Process (FMP) Distilled to four categories

- Silty Clay
- Silt
- Sandy Loam
- Sand and Gravel
7 DWR-CIMIS Climate Zones

- 1 Coastal Plains Heavy Fog Belt - Lowest ETo with dense fog
- 2 Coastal Mixed Fog Area – Less fog & more ETo
- 3 Coastal Valleys & Plains & North Coast Mountains – More sunlight
- 6 Upland Central Coast & LA Basin – Higher elevation coastal areas
- 10 North Central Plateau & Central Coast Range – Cool, high elevation area with strong summer sunlight
- 12 East Side Sacramento to San Joaquin Valley – Low winter & high summer ETo
- 16 Westside San Joaquin Valley & Mountains East & West of Imperial Valley
Simplified Climate Zones for SVIHM Crop categories

Coastal  ➔  1,2,3, & 6

Inland  ➔  10, 12, & 16

PET at Inland CIMIS Stations are about 20% more than Coastal stations annually for CIMIS and about 26% for BCM estimates ➔ rescale BCM monthly with CIMIS monthly averages.
Land Use Data Development

Review/Selection of Data Sources

**Land Use Maps:**
- Ambag Land Use Survey 1992
- DWR Land Use Surveys (1997 & 2000)
- SVIGSM 2012
- Agricultural Commissioner Ranch Maps (2002, -06, -08, -11, -12, -13, -14, -15)

**Crop Inventories:**
- Calif. Pesticide Info Portal (CalPIP) Data (Annual 1990-2013)
- Ag-Comm. Annual Crop Reports

**Native Vegetation/Urban:**
- Recent Imagery

**Generalized Land Use:** (too vague ➔ not used)
- Adopted 2010 General Plan (Urban and Vegetation Layers)
- FNMP (1992, -94, -96, -98, -00, -02, -03, -04, -06, -08, & -12)
SVIHM land use estimates are composites of multiple data sources.

<table>
<thead>
<tr>
<th>Land Use Period</th>
<th>Poor Data Resolution</th>
<th>NLCD (native veg.)</th>
<th>Current Imagery 2016 (urban)</th>
<th>AmBag (land use)</th>
<th>DWR (land use)</th>
<th>SVIGSM (land use)</th>
<th>Ranch Maps (crops)</th>
<th>CalPIP (crops)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>2011</td>
<td>X</td>
<td>2011</td>
<td></td>
<td></td>
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<td>2013</td>
<td>2011</td>
<td>X</td>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td>2012</td>
<td>X</td>
</tr>
</tbody>
</table>

The temporal discretization and crop distributions need some more work. Only 10-60% correlation between Ranch Maps and CalPIP!!
## Initial Crop/Land-Use Categories & Climate Zones Developed

- Selected Individual Crops
- Selected Crops Groupings
- Coastal and Inland Groups
- Early-year/SVIGSM Groups

### Rotational Crops/Land Use

1. **Spring Mix (Baby Crops)**: Coastal 30 Day
   - Sub-Group Components: Baby lettuce, baby kale, baby mustard

2. **Spring Mix (Baby Crops)**: Inland 30 Day
   - Sub-Group Components: Baby lettuce, baby kale, baby mustard

3. **Truck & Vegetables**: Coastal 60 Day
   - Sub-Group Components: Lettuce, Romaine, Pepper Spice, Endive Escarol, Cilantro, Peppers, Mustard, Parsley

4. **Truck & Vegetables**: Inland 60 Day
   - Sub-Group Components: Lettuce, Pepper Spice, Endive Escarol, Cilantro, Peppers, Mustard, Parsley

5. **Truck & Vegetables**: Coastal 90 Day
   - Sub-Group Components: Broccoli, Califlower, Kale, Peas, Asparagus, Cabbage, Cole Crops-Coastal, Leek, Swiss Chard

6. **Truck & Vegetables**: Inland 90 Day
   - Sub-Group Components: Broccoli, Califlower, Kale, Peas, Asparagus, Cabbage, Cole Crops-Inland, Leek, Swiss Chard

### Annual/Seasonal Crops/Land Use

11. **Carrots**
12. **Onions, Garlic, Corn**
13. **Brussel Sprouts**
14. **Potato, Sugarbeets**
15. **Celery, Green Beans, Squash, Cucumbers, Tomatoes - Coastal**
16. **Celery, Green Beans, Squash, Cucumbers, Tomatoes, Melons — Inland**

### Multi-year Crops/Land Use

19. **Deciduous Fruits and Nuts**
20. **Citrus and Subtropical**
21. **Vineyards**
22. **Pasture**
23. **Grain and Hay Crops**
24. **Cane/Bush Berries**
25. **Artichokes (Annual)**
26. **Strawberries-Coastal**
27. **Strawberries-Inland**
28. **Hand-Planted Trees**
29. **Cropland and Pasture**
30. **Non-Irrigated Row and Field Crops**
31. **Semi-Agricultural**
32. **Idle/Fallow**
33. **Ag Trees**
34. **Golf Course Turf/Parks**
35. **Riparian**
36. **Upland Grasslands/Shrub Lands**
37. **Woodlands**
38. **Beach-Dunes**
39. **Barren/Burned**
40. **Quarries Sand and Aggregate Mining**
41. **Urban**
42. **24 Urban**
43. **40 Quarries**
44. **27 Water**
45. **35 Riparian**
46. **36 Upland Grasslands/Shrub Lands**
47. **37 Woodlands**
48. **38 Beach-Dunes**
49. **39 Barren/Burned**
50. **31 Non-Irrigated**
51. **32 Semi-Agricultural**
52. **33 Idle/Fallow**
53. **34 Ag Trees**
54. **41 Golf Course Turf/Parks**

### Native-Urban Crops/Land Use

(4) **“Permanent” Native-Urban Crops/Land Use**

- **Turf, Landscape**
- **Sand and Aggregate mining**
- **Crop/Land-Use Group Color Codes**
- **Individual**
- **FOREST (Grouped)**
- **Native Vegetation/Undeveloped Land**
1967-1996 Land Use

- NLCD 1992,
- Urban from SVIHM WBS Cells,
- AmBag-1992,
- If needed ➔ SVIGSM-2012, & DWR-1997
- Too long a time period and needs to be segregated into at least 2 periods
Example Crop trends in Monterey County through time
Break Point ➔ 1983 (El Nino)?
1997-1999 Land Use

- NLCD 1992,
- Urban from SVIHIM WBS Cells,
- DWR 1997

Initial crop/land-use Properties (Kc’s, OFE’s, FTR’s, Root Depths, etc) used in SVIHIM from Pajaro/Cuyama and will now include localized data from

- Ag Extension (Crop Manage)
- Outreach Info
- Monthly/Annual CalPIP data
- CWQRCB-Tier 2 data
2000-2001 Land Use

- NLCD 2001,
- Urban from SVIHM WBS Cells,
- DWR 2000
2002 - 2005
2002 Ranch Map Land Use

- NLCD 2001,
- Urban from SVIHM WBS Cells,
- DWR 2000/2002 (Suppl.)
2006 – 2007
2006 Ranch Map Land Use

- NLCD 2006,
- Urban from SVIHM WBS Cells,
- DWR 2000/2002
2008 – 2010
2008 Ranch Map Land Use

- NLCD 2006,
- Urban from SVIHM WBS Cells,
- DWR 2000/2002
2012 Ranch Map Land Use

- NLCD 2011,
- Urban from SVIHM WBS Cells,
- DWR 2000/2002
2012 SVIGSM Land Use
- Less categories
- Less detail
- No explicit rotational crops
Land use representation is more detailed in the SVIHM.
2013 Ranch Map Land Use

- NLCD 2011,
- Urban from SVIHM WBS Cells,
- DWR 2000/2002
2014 Land Use Ranch Map Example

- NLCD 2011,
- Urban from SVIHM WBS Cells,
- 2014 Ranch Map,
- If needed ➔ SVIGSM-LU2012 Suppl.

Needs to be re-evaluated from original data received (ex. missing a lot of artichokes in CSIP area)
Additional land use Improvements are underway.

- Enhanced use of CalPIP data and CWQRCB Tier 2 Data
  - (e.g. township and range location, acreage, Apn #, temporal discretization)

- Improved correlation between CalPIP data and spatially distributed data (e.g. Ranch Map, Township and Range, parcels)

- Water balance region scale crop rotation themes that honor regional patterns from producer outreach efforts.
Crop grouping, distribution, and rotation themes were devised for model climate zones.
Crop rotation themes

These rotations are based upon stakeholder provided crop data

Currently evaluating whether rotational theme is evident in basin scale water use data

- Crop demand
- Pumping data
- Spatially distributed CalPIP data
- Link to Tier 2 Nitrate Reporting Data from CWQRCB for 2014-15

If rotation is evident in signals at larger spatial scale, crop rotations will be explicit.
Initial Climate Analysis for Salinas Valley

Cumulative Departure from Mean Precipitation, in inches

-140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140

1900 1920 1940 1960 1980 2000 2020

Calendar Year

PrecipCumDep_WY_curv_res

Value
-25.05 -20.05 -15.05 -10.05 -5.05 0 5.05 10.05 15.05 20.05 25.05

1873 1893 1913 1933 1953 1973 1993 2013

Date
**Percent Variation in Precipitation Cycles 1901 - 2015**

- AMO ➔ 115 years
- PDO ➔ 28.8 (28.3%) & 12.8 years (6.5%)
- PE/NAMS ➔ 7.7 years
- ENSO ➔ 2 - 4 years

**Percent Period from Preip Residuals 1873-1914**

- Longer Cycle of 142 years removed (Salinas Airport Gage)
- PDO ➔ 28.4 years (75.2%) & 12.9 (10%)
- PE/NAMS ➔ 8.4 years
- ENSO ➔ 5.3 – 2 years
MODFLOW Model Construction

SVIHM FMP3
CSIP Supply and Demand

Demand ➔ Land Use and irrigation requirement

Supply ➔ 3 sources of water to CSIP
- CSIP Wells (FMP wells)
- SRDF Diversions to CSIP region (FMP SRD from SFR)
- SVRP-Recycled Water (NRDs) 1998 - 2014

Recycled Water (Ac-Ft) vs. Time (Oct-95 to Sep-17)
MODFLOW Model Construction

SVIHM Boundary Conditions

Streamflow (SFR2)

- Stream Network extracted from NHDPlus consistent for both SVWM and SVIHM model frameworks & under construction
- Time series (TabFiles) Inflows/Outflows will include:
  1. Historical reservoir outflows and gaged inflows
  2. Estimates of runoff/recharge HSPF/BCM
  3. Reported Diversions ➔ SRDF, Clark Canal, & Tembladero (assumed flow/flood flow))
- Incised Channel Elevations derived from LiDAR
- Rating table Flow-stage-width relations from Manning Equation approximations for 29 Channel groups: Tidal, Arroyo Seco, San Antonio, Nacimiento, Big Sandy, San Lorenzo, Chalone, Salinas River (upper, central, lower valley, plus tidal, upper & lower coastal region), coastal region natural, coastal region canal/ditch, & natural & developed for headwater drainage in west-central, southwest, coastal, southeast, east-central, & diversion canals ➔ also scale-factor parameters for PE
SVIHM Streamflow Network

- 524 segments: river, tributary, canal, and drains
- 148 Inflow points ➔ 3 gaged and 145 estimated
- 3 diversions ➔ Arroyo Seco for Clark Colony, Salinas River for SRDF, & Tembladero Slough
- 3 Gaged Inflows ➔
  (a) “Nacimiento River 1” (USGS gage 11149500) below the Nacimiento reservoir,
  (b) “Arroyo Seco 1” (USGS gage 11152000) on Arroyo Secco, and
  (c) “San Lorenzo Creek 1” (USGS gage 11151300) on San Lorenzo Creek on the northern boundary of SVIHM
SVIHM Streamflow Network

- 524 Segments,
- 9,008 Reaches (Cells)
- 29 parameter Groups of Kv for PE
MODFLOW Model Construction

SVIHM Observations for Calibration

Streamflow Observations:
• Flow Observations from USGS stream gauges & diversions (SRDF, Clark Colony, Tembladerado)
• Additional observations as gains/losses for two reaches

Pumpage Observations:
• Additional observations as monthly reported agricultural pumpage summed for all wells serving each agriculture WBS

Seawater Intrusion:
• Water quality data compiled
• Qualitative comparisons with SWI comparisons
• Boundary Heads from Monterey Bay NOAA tidal gage
Salinas_Well_Build_Assumptions for missing construction Information:

- **Screened/Perforated Interval (Ztop and Zbot):**
  - Use perfs
  - If no perfs, use TD for Zbot
    - Assume Ztop:
      - Riparian (FID 1) and Upper Valley FIDs: Ztop = LS - 20'
      - Pressure FIDs: use salinity zones to define Ztop
        - If drilled seaward of 180’ salinity contour for drill year: Ztop = Elevation of top of 400’ aquifer
        - If drilled seaward of 400’ salinity contour for drill year: Ztop = Elevation of top of Paso Robles or Purisima Formations, whichever is present at the highest elevation
        - If drilled landward of 180’ and 400’ salinity contours for drill year: Ztop = LS - 50'
      - Other FIDs: Ztop = LS - 50'
    - If no TD
      - Assume Ztop same as above
    - Assume Zbot:
      - Riparian (FID 1) and Upper Valley FIDs: Zbot = LS - 100'
      - Pressure FIDs: use salinity zones to define Zbot
        - If drilled seaward of 180’ salinity contour for drill year: Zbot = Elevation of bottom of 400’ aquifer
        - If drilled seaward of 400’ salinity contour for drill year: Zbot = Elevation of bottom of Paso Robles or Purisima Formations, whichever is present at the highest elevation
        - If drilled landward of 180’ and 400’ salinity contours for drill year: Zbot = median TD of wells with TD in each FID
      - East Side and Forebay FIDs:
        - If construction < 1960 → Zbot = Elevation of bottom of 180’ aquifer
        - If construction >= 1960 → Zbot = Elevation of bottom of 400’ aquifer
        - If no construction → Zbot = Elevation of bottom of 400’ aquifer
      - Other FIDs: Zbot = median TD of wells with TD in each FID

- **Well Radius (Rw):**
  - Use radius
  - If no radius, assume based on median radius of wells with radius in each FID

- **Radius of Drill Hole (Rskin):**
  - If construction < 1960 → Rskin = Rw + 1/12
  - If construction >= 1960 → Rskin = Rw + 2/12

- **Well Construction:**
  - Use construction
  - If no construction, assume construction = 10/1/1967

- **Well Destruction:**
  - Use destruction
  - If no destruction, assume present through end of simulation
  - If FACILITY_S field indicates “BEING DEST.” or “DESTROYED”, look through pumping records to try to determine destruction date as date of 0 pumping
    - Else, assume present through end of simulation

- **Well Pumping Capacity (Ag wells only):**
  - Use capacity estimated from GEMS data reported pumpage. (Further scale Ag pumpage with QMAX Scale Factors 3-4 days/week pump on)
  - If no capacity, assume based on median capacity of wells with capacity in each FID
Agricultural Wells for FMP

GEMS ➔ 2,005 wells
USGS-NWIS ➔ 193 wells
DWR ➔ 200 wells

- The additional wells from USGS and DWR will be used to either supplement pre-1994 wells and to supplement regions outside of Zone 2C in the Granite Hills, Highlands South, Hames Valley, Other regions outside of Zone 2C, & SLO county portion
- Distribution of Ag Well pumpage is proportional to pumping capacities

**TOTAL MNW2 Wells ➔ 2,295 Wells**
- FMP Wells ➔ 2,004
- MnI Wells ➔ 291
Pumping Capacities required for all FMP Irrigation wells

Data from GEMS used to estimate actual maximum pumping capacities for Agricultural Wells only
Municipal & Industrial Wells
Specified Pumpage with MNW2
GEMS ➔ 192 wells
USGS-NWIS ➔ 229 wells
DWR ➔ 22 wells
Final Distribution Reduced to 291 Wells
Domestic Wells (WEL): ➔ Omitted from SVIHM
MODFLOW Model Construction

SVIHM Boundary Conditions
M&I Wells (MNW2):

• Pumpage data for M&I compiled by MC (completed for GEMS). M&I Pumpage may be an issue for the earlier decades (pre-1994)

• Locations and supporting Construction/Dates shape files prepared by MC (Completed)

• USGS Tools and scripts are used to generate MNW2 input file (locations and well attributes) and related FeedFiles for time series of specified pumpage and well occurrence.

• GEMS reported pumpage (1994 – 2014) are used as monthly Agricultural pumpage observations summed over all wells serving each WBS.

• Pumpage prior to 1994 estimated from Census data for MnI (MC assistance in progress)

• 2 Data Gaps ➔ Well construction Info & pre-1994 pumpage
SFR Streamflow Observations

- 13 Downstream gages
- 3 Diversions
- 2 reaches for stream gains/losses (Upstream-Downstream Positive diff → loss, Negative diff → gain)
  - (11152200 - 11152300) and (11152000 - 11152050)
- 12 Observation Groups for PE
- 6,266 SFR Obs (1967-2015)
Two SVIHM Water-Balance Accounting Units (WBS) With Monthly Reported Agricultural Pumpage
3,360 Monthly Ag Pumpage Obs ➔ for 15 Ag WBS2, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, & 21

**COASTAL** Farm Region 10 - Remainder of Zone2C ➔ Pressure NE of Salinas River

**INLAND** Farm Region 19 - Zone 2C -- Upper Valley ➔ SW subregion West of Salinas R & West of King City
MODFLOW Model Construction

SVIHM Observations for Calibration

Groundwater Head and Head Differences (in progress):

• Observation Wells ➔ 107 wells w/ 22 sites missing depth or perforation information -- Use groups of initial gw-levels and drawdown observations for different subregions/layers
  • Long-term monitoring wells
  • Wells near the Salinas River
  • Well pairs for head differences need to be identified

• Observations need relate ID for each site and time series & PE Obs names for each measurement

• USGS tool used to build HOB and HYD used to develop head differences for selected well pairs

• 51,431 HOB Obs & 1,739 Head Difference Obs from 8 piezometers sites
Groundwater Observation-well networks

- Annuals ➔ 452 wells
- Monthly ➔ 107 wells
- August Trough ➔ 162 wells
- Previous programs ➔ 31 wells

Explanation
- Wells_PreviousPrograms
- Wells_Monthlies
- Wells_Annuals
- Wells_AugustTrough
MODFLOW Model Construction

**SVIHM Boundary Conditions**

**Mountain Front Recharge** (RCH/FHB) as gw underflow will be explored based on results from HSPF and BCM sw-models and layering from Geologic Framework model ➔ Runoff and Mtn Rch combined as runoff

**Ocean Boundary** (GHB ➔ SWI)
- Bathymetry ➔ MBARI (10m) & Offshore Outcrops ➔ USGS Geology (Dartnell & others, 2015; Johnson and others, 2016)
- Final Boundary based on Geologic Framework Model
- Monthly Time Series from Monterey Bay or SF Bay NOAA Tidal Gage

**Upgradient Boundary** (GHB) ➔ Location determined along eastern boundary of active model grid, adjacent to PVHM for northern boundary, wells within Seaside Basin.
- Boundary Head ➔ Wells or Paso Robles Basin model results, Layers1,3,5, & 7 (28 cells- 7/layer)
- same wells as used for PVHM ➔ 4 wells over 4 layers (1,3,5,&7)

**Hydrologic Flow Barriers** (HFB) ➔ potential flow barriers from faults or discontinuities in layering ➔ 6 fault groupings for PE
Uppermost Layer
Onshore & Offshore

Offshore Model Cells used for Vertical GHBs:
Shallow Alluvium
LY1 ➔ 8,069
180-Ft Aquifer
LY3 ➔ 733
400-Ft Aquifer
LY5 ➔ 701
Purisma + others
LY8 ➔ 972
Bedrock Group
LY9 ➔ 576
Faults Onshore & Offshore

37 Individual Fault traces of varying Age (Recency)

6 Fault Groups by Recency/Rock Type:

- Offshore-H
- Offshore-QT
- 180-Ft Aquifer
- 400-Ft Aquifer
- Purisma (Los Lobos Thrust Fault only)
- Bedrock Group
Faults Onshore & Offshore Coastal Region:

- Shallow Offshore-H
- Offshore-QT
- 180-Ft Aquifer
- 400-Ft Aquifer
- Purisma (Los Lobos Thrust Fault only)
- Bedrock Group
Additional Drain Return Model Cells

- Small drainage ditches not part of SFR network
- Sloughs
- Coastal wetlands
- Minimum Elevation \( \leq 30 \text{ft above MSL} \) (4,306 cells)

- Drain cells for Agricultural regions at 6 ft below minimum land surface
- This Approach was not used initially because of the extensive coverage by other surface-water-related features
Additional Drain Return Model Cells

- Small drainage ditches not part of SFR network
- Sloughs
- Coastal wetlands

- 172 Drain Return Cells within WBS 2, 9, 10, & 11
- Supplement the existing Blanco Drain, Rec Ditch and other sloughs/tributaries in SFR network
SVIHM Model Framework ➔ Pest for Parameter Estimation

• Model Code ➔ MF-OWHM “One Water”
• Total Grid 976 rows by 272 columns cells are all 600’x600’ (40 acres/cell)
• Active area in uppermost layer ~5,637 square miles (~3.6 million acres)
• 9 layers, meant to represent (in the Pressure Subarea) the Shallow, Pressure-180, Pressure-400, upper Deep, and lower Deep Aquifers, Bedrock plus three confining layers
• Simulation period October, 1967- December, 2014 with monthly stress periods and biweekly/daily time steps.
• Initial Hydraulic parameters (Hk, Vk, Sy, Ss) taken from SVIGSM, being the most comprehensive parameter set in the Basin to date (missing for the new regions)
• Hydraulic properties redefined based on Texture and subregions and global properties/scale factors
CONSTRUCTION OF LAYER FLOW PROPERTIES
(Horizontal Hydraulic Conductivity (HK), Vertical Hydraulic Conductivity (VK), Specific Yield (SY), & Specific Storage (SS))

- Cell-by-Cell Fraction of Coarse-Grained Sediment Arrays for each Layer from HFM
- Cell-by-Cell Layer Elevation Arrays for each Layer from HFM

Multiplier Package Expression Parser
- Construction of Basic Layer Properties
- Definition of Global Scalar Values for HK, VK, SY, & SS
- Cell-by-Cell Calculation of HK, VK, SY, & SS for Coarse- & Fine-grained Fractions for each Layer
- Cell-by-Cell Calculation of Arithmetic sum for HK, SY, & SS, Power Mean for VK for each Layer

Zone Definition Files ➔ Defines arrays that represent cell-by-cell parameter definition of each zone in each layer (Indicator arrays)

Parameter Definition File ➔ Defines Parameter Value Multipliers for each subregion of each aquifer property for each layer

Layer Property Flow Package ➔ Construction of Cell-by-Cell Hydraulic Properties Used by MF-OWHM
Example of Alluvial Aquifer Texture Data:
Example of Purisima and related Formations Aquifer Zones:

<table>
<thead>
<tr>
<th>Zonecode</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>410</td>
<td>Purisima Fm mapped onshore in Pajaro area and offshore (by Johnson and others)</td>
</tr>
<tr>
<td>420</td>
<td>Purisima Fm in the subsurface</td>
</tr>
<tr>
<td>430</td>
<td>Pancho Rico Fm of central Salinas Valley</td>
</tr>
<tr>
<td>440</td>
<td>Pliocene marl sandstone mapped NE of Paso Robles</td>
</tr>
<tr>
<td>450</td>
<td>QT unit overlying Santa Margarita Fm in the El Toro area</td>
</tr>
<tr>
<td>-99999</td>
<td>Value assigned where HSU unit is absent with no overlying units present (thickness = 0)</td>
</tr>
<tr>
<td>1</td>
<td>Value assigned where HSU unit is absent but overlying units are present (thickness assigned as 1)</td>
</tr>
</tbody>
</table>
SVIHM Model Development Next Steps

Project Next Steps:
- January Model Calibration
- February: Model Analysis + Reservoir Operations Integration
- March: Operations Analysis
- April: Baseline and Build Out Model Construction/Analysis