Attachment 2
Water Balance and Perennial Yield Estimation Presentation

PASO ROBLES GROUNDWATER BASIN MODEL UPDATE

County of San Luis Obispo
Flood Control & Water Conservation District

Water Balance Estimation
December 5, 2013

Todd Engineers

Overview

- Objectives and Approach
- Watershed Model Calibration
- Water Balance Estimation
- Comparisons of Water Balance with Original Model
- Perennial Yield of Historical Conditions
- Findings
- Recommendations

Draft

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Task B – Water Balance Estimation

Objectives

- Update the water balance to reflect current conditions
- Improve the water balance analysis
  - Evaluate rainfall recharge with the watershed model
  - Apply new data

Approach

- Evaluate each equation component independently
- Apply use of modern geospatial and modeling software

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Draft

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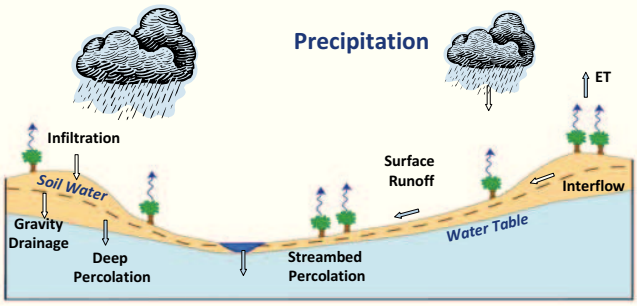
Schematic Diagram of Surface Water Model (HSPF)



Surface Water Model HSPF (Hydrological Simulation Program FORTRAN) is a model evolved from the "Stanford Watershed Model."
It continues to undergo refinement and enhancement of its capabilities along with user support and code maintenance activities under joint sponsorship of both the EPA and USGS.

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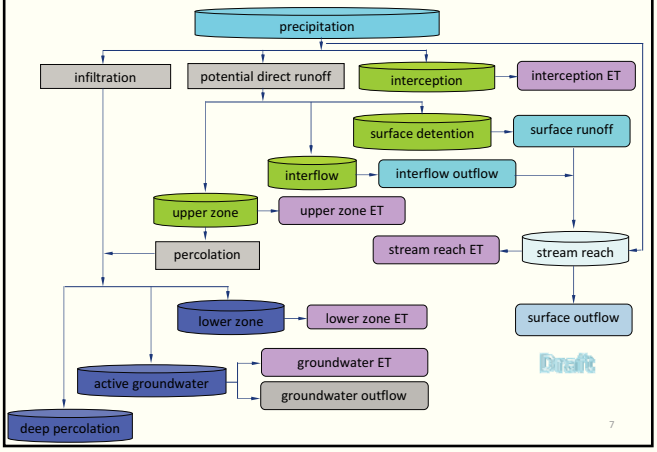
Algorithm of HSPF Model



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Statistical Measure of Model Calibration

Type of Flow Data	Goodness-of-Fit (R^2)	Calibration Performance
Daily Flow	$R^2 < 0.60$	Poor
	$0.60 < R^2 < 0.70$	Fair
	$0.70 < R^2 < 0.80$	Good
	$R^2 > 0.80$	Very Good
Monthly Flow	$R^2 < 0.65$	Poor
	$0.65 < R^2 < 0.75$	Fair
	$0.75 < R^2 < 0.85$	Good
	$R^2 > 0.85$	Very Good

Source: AQUA TERRA Consultants (EPA HSPF maintenance contractor)

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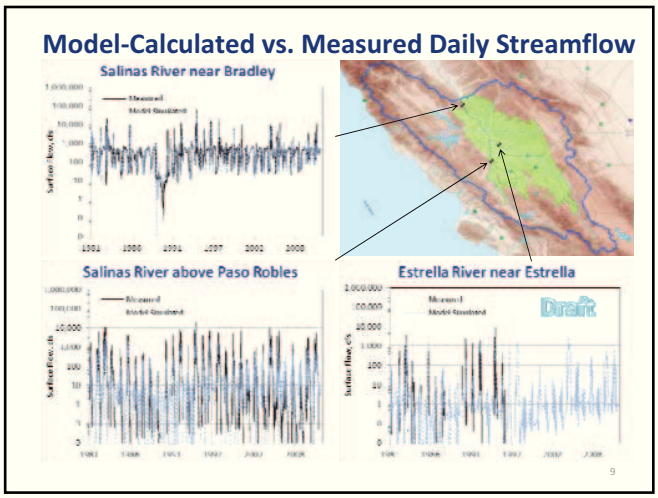
Model-Calculated vs. Measured Daily Streamflow
Salinas River near Bradley
Salinas River above Paso Robles
Estrella River near Estrella
Draft
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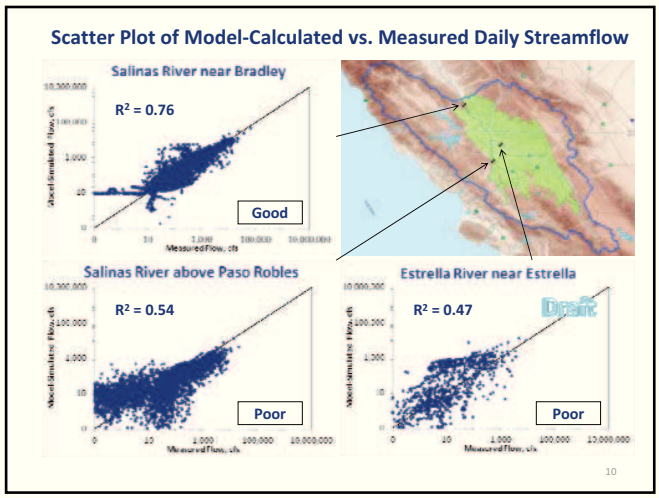
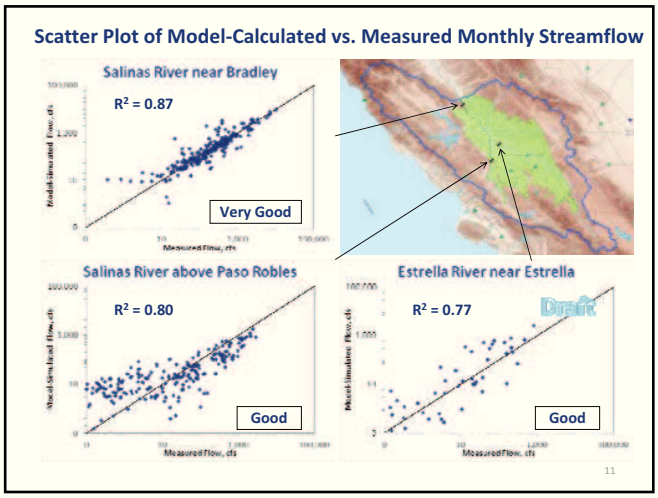
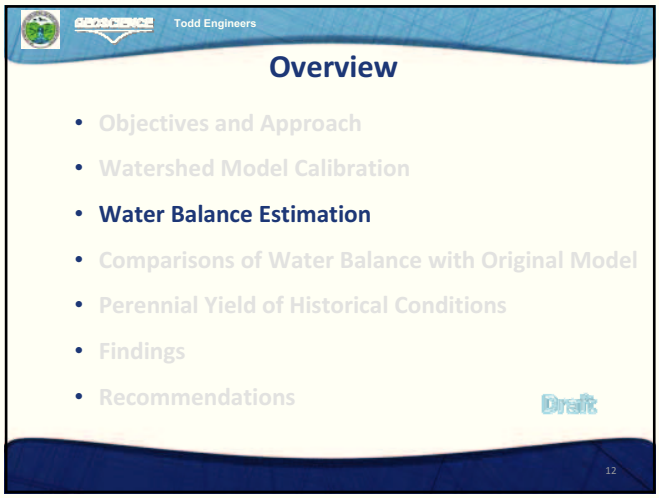

Scatter Plot of Model-Calculated vs. Measured Daily Streamflow
Salinas River near Bradley
R² = 0.76
Good
Salinas River above Paso Robles
R² = 0.54
Poor
Estrella River near Estrella
R² = 0.47
Poor
Draft
10


Scatter Plot of Model-Calculated vs. Measured Monthly Streamflow
Salinas River near Bradley
R² = 0.87
Very Good
Salinas River above Paso Robles
R² = 0.80
Good
Estrella River near Estrella
R² = 0.77
Good
Draft
11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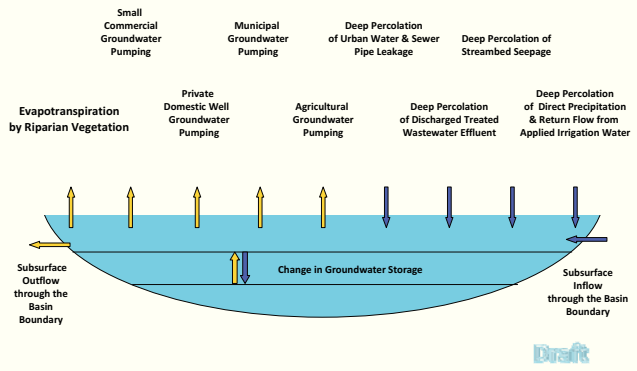
Groundwater Recharge and Discharge Terms



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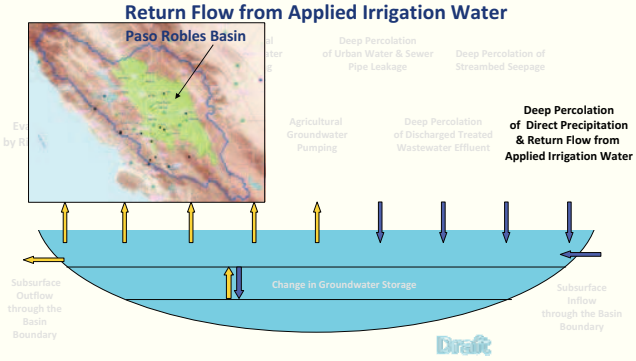
Deep Percolation of Direct Precipitation and Return Flow from Applied Irrigation Water



Deep percolation of direct precipitation and return flow from applied irrigation water was calculated based on the results of deep percolation within the Paso Robles Basin from the calibrated watershed model.

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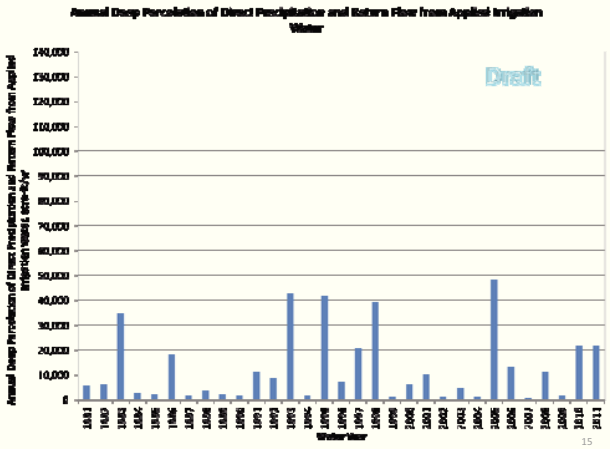

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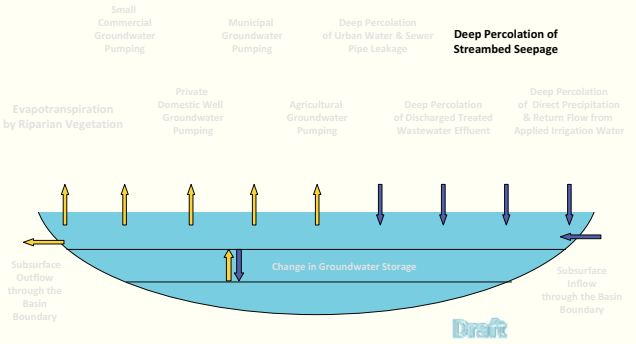
Deep Percolation of Streambed Seepage



Deep percolation of streambed seepage was calculated based on the results of streambed seepage within the Paso Robles Basin from the calibrated watershed model.

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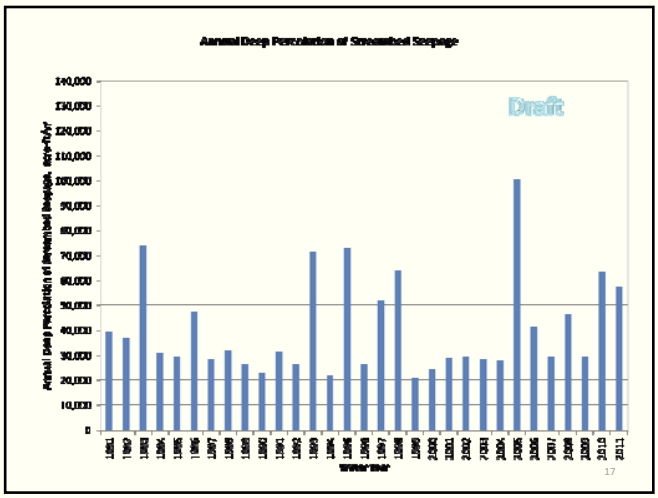
Annual Deep Percolation of Streambed Seepage
Draft
Water Year
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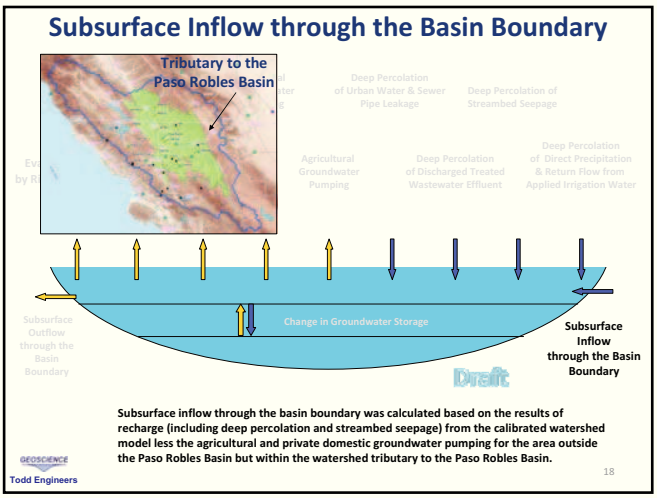
Subsurface Inflow through the Basin Boundary
Tributary to the Paso Robles Basin
Deep Percolation of Urban Water & Sewer Pipe Leakage
Deep Percolation of Streambed Seepage
Agricultural Groundwater Pumping
Deep Percolation of Discharged Treated Wastewater Effluent
Deep Percolation of Direct Precipitation & Return Flow from Applied Irrigation Water
Change in Groundwater Storage
Subsurface Outflow through the Basin Boundary
Subsurface Inflow through the Basin Boundary
Draft
Subsurface inflow through the basin boundary was calculated based on the results of recharge (including deep percolation and streambed seepage) from the calibrated watershed model less the agricultural and private domestic groundwater pumping for the area outside the Paso Robles Basin but within the watershed tributary to the Paso Robles Basin.
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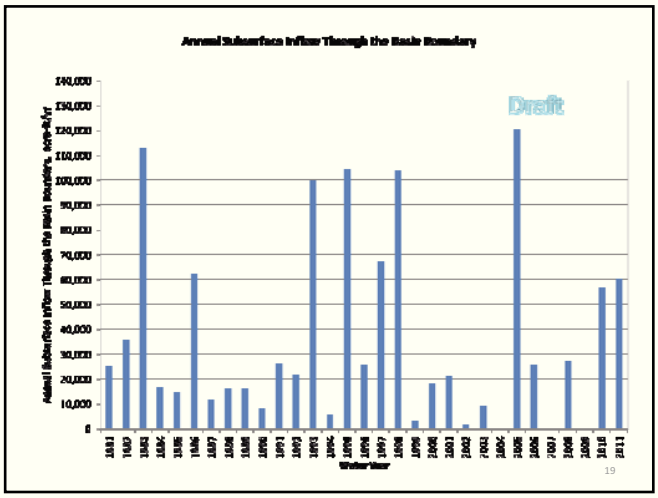
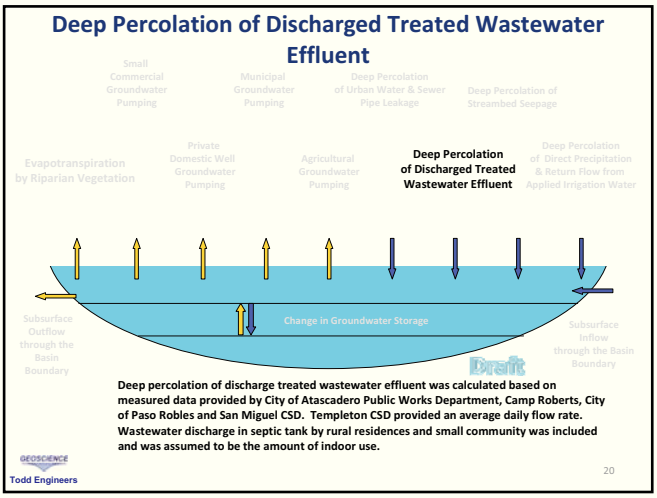

Annual Subsurface Inflow Through the Basin Boundary
Draft
Water Year
19


Deep Percolation of Discharged Treated Wastewater Effluent
Small Commercial Groundwater Pumping
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Subsurface Inflow through the Basin Boundary
Draft
Deep percolation of discharge treated wastewater effluent was calculated based on measured data provided by City of Atascadero Public Works Department, Camp Roberts, City of Paso Robles and San Miguel CSD. Templeton CSD provided an average daily flow rate. Wastewater discharge in septic tank by rural residences and small community was included and was assumed to be the amount of indoor use.
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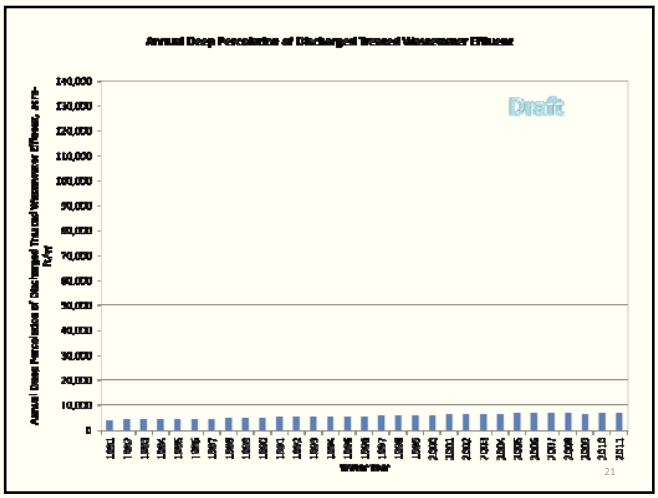
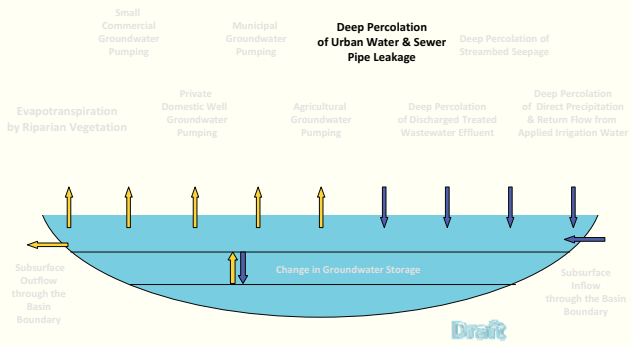


Deep Percolation of Urban Water and Sewer Pipe Leakage



Deep percolation of urban water and sewer pipe leakage was assumed to be 2% of urban water and sewer pipes based on Paso Robles 2010 Urban Master Plan.

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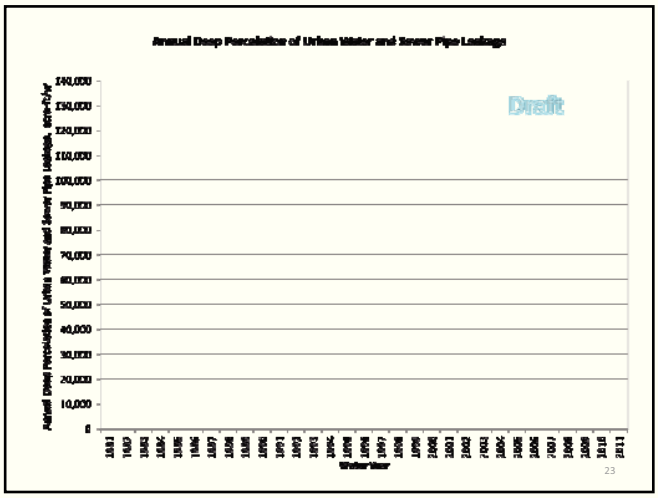
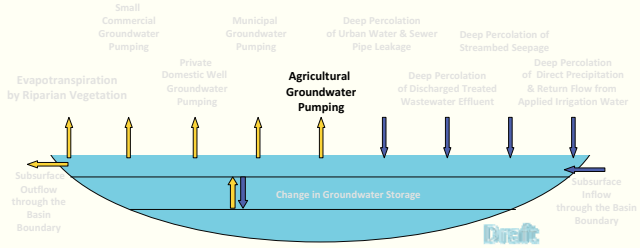


Agricultural Groundwater Pumping



Agricultural groundwater pumping was estimated based on results of crop-specific daily soil moisture water balances accounting for soil available water capacity, daily rainfall and reference evapotranspiration, crop water coefficient, bare soil evaporation, and increasing irrigation efficiency over time.
Additional factors considered for vineyards include evapotranspiration of row crops, frost protection water demand and effect on soil moisture, reduced deficit irrigation (RDI) management, and increasing use of RDI management over time.
Annual crop acreages estimated from 1) DWR land use maps of South Central Coast (San Luis Obispo County) and Monterey County for 1985/89 and 1996/97, 2) digital SLO crop coverage maps provided by SLO County ACO from 2000 through 2011, and 3) digital coverage of Monterey County 2012 crops based on Ranch Map Atlas (Monterey County ACO).
Discussions with SLO County ACO on historical regional crop patterns used to refine interpolation of selected crop acreages over time. Vineyard acreages within groundwater basin boundaries from 2000 to 2010 were corrected/verified based on review of historical aerial photography provided in Google Earth.

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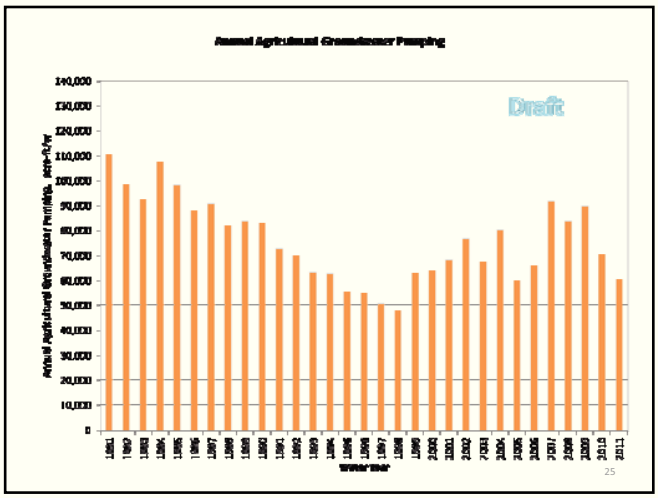
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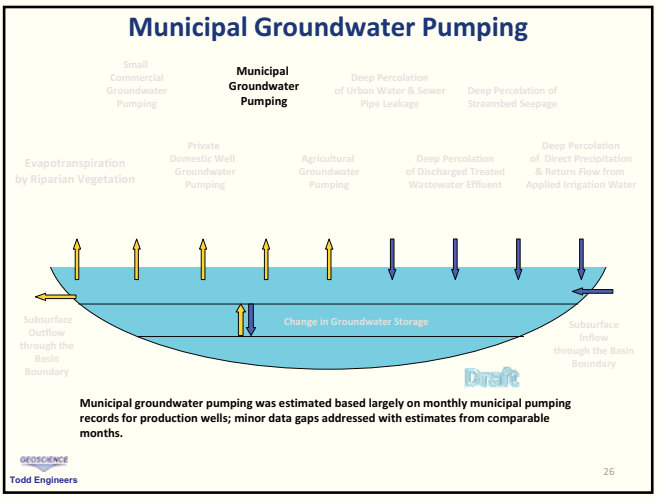
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Subsurface Inflow through the Basin Boundary
Draft
Municipal groundwater pumping was estimated based largely on monthly municipal pumping records for production wells; minor data gaps addressed with estimates from comparable months.
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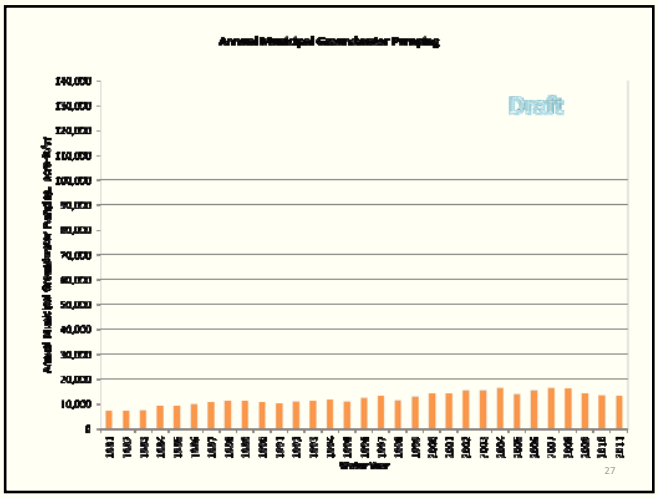
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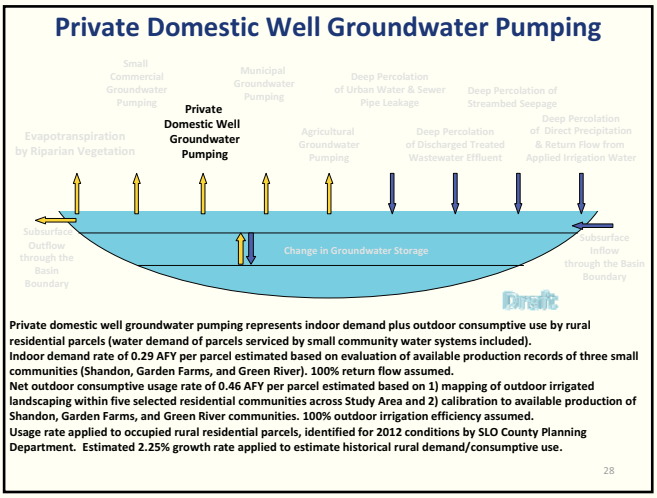
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Draft
Private domestic well groundwater pumping represents indoor demand plus outdoor consumptive use by rural residential parcels (water demand of parcels serviced by small community water systems included).
Indoor demand rate of 0.29 AFY per parcel estimated based on evaluation of available production records of three small communities (Shandon, Garden Farms, and Green River). 100% return flow assumed.
Net outdoor consumptive usage rate of 0.46 AFY per parcel estimated based on 1) mapping of outdoor irrigated landscaping within five selected residential communities across Study Area and 2) calibration to available production of Shandon, Garden Farms, and Green River communities. 100% outdoor irrigation efficiency assumed.
Usage rate applied to occupied rural residential parcels, identified for 2012 conditions by SLO County Planning Department. Estimated 2.25% growth rate applied to estimate historical rural demand/consumptive use.
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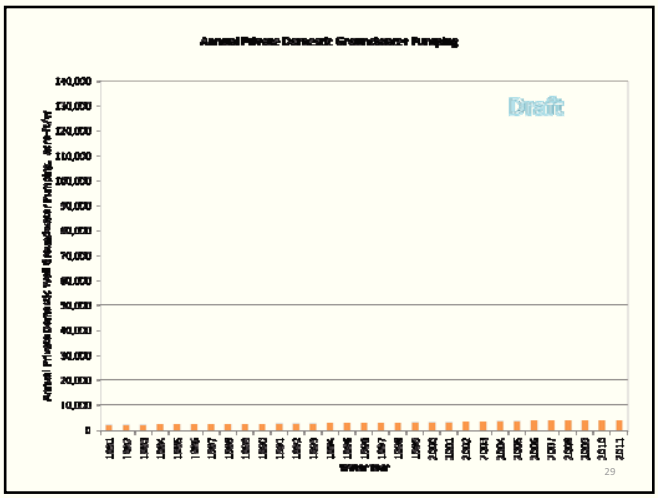
Annual Private Domestic Groundwater Pumping
Draft
Water Year
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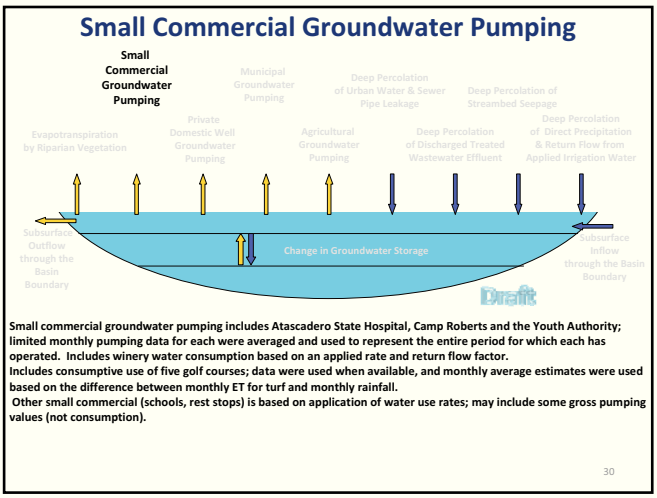
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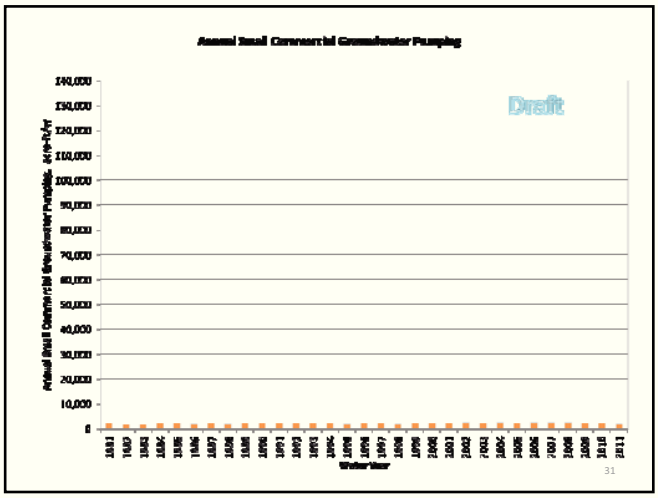
Draft
Small commercial groundwater pumping includes Atascadero State Hospital, Camp Roberts and the Youth Authority; limited monthly pumping data for each were averaged and used to represent the entire period for which each has operated. Includes winery water consumption based on an applied rate and return flow factor.
Includes consumptive use of five golf courses; data were used when available, and monthly average estimates were used based on the difference between monthly ET for turf and monthly rainfall.
Other small commercial (schools, rest stops) is based on application of water use rates; may include some gross pumping values (not consumption).
30


Annual Small Commercial Groundwater Pumping
Draft
Water Year
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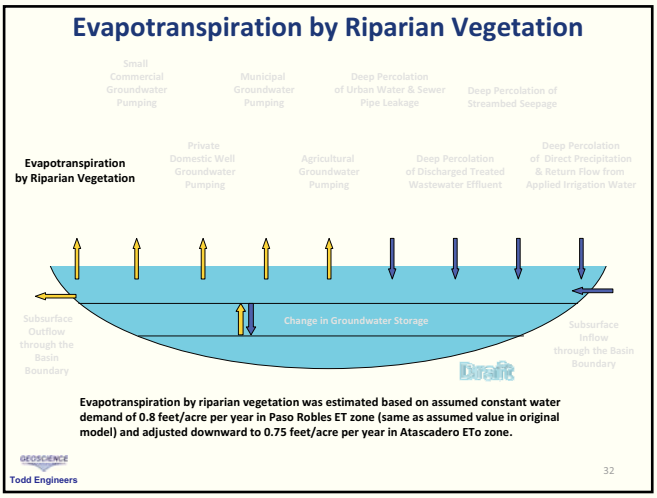
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Evapotranspiration by riparian vegetation was estimated based on assumed constant water demand of 0.8 feet/acre per year in Paso Robles ET zone (same as assumed value in original model) and adjusted downward to 0.75 feet/acre per year in Atascadero ETo zone.
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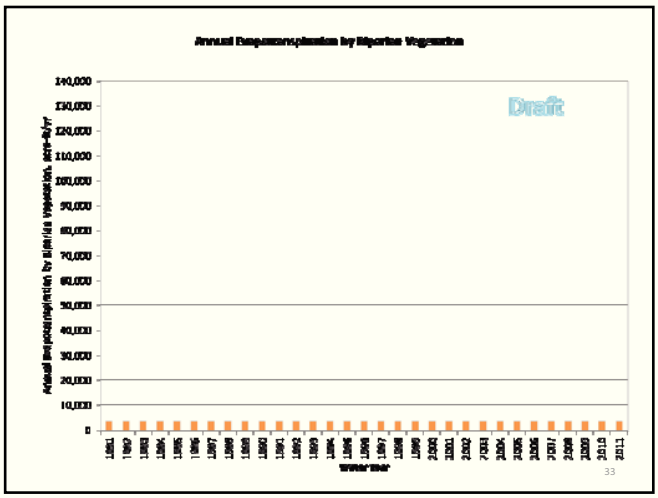
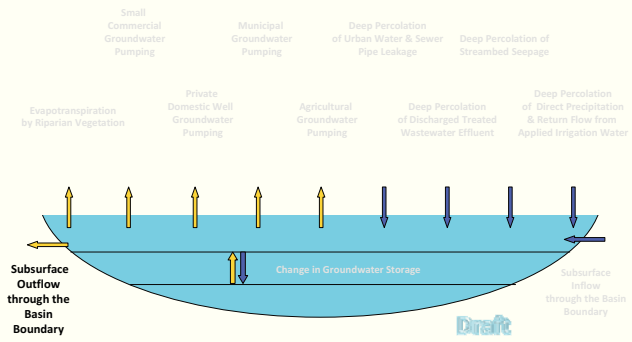


Subsurface Outflow through the Basin Boundary



Subsurface outflow through the basin boundary was estimated based on the results from the groundwater model (Fugro West, Inc., 2005).

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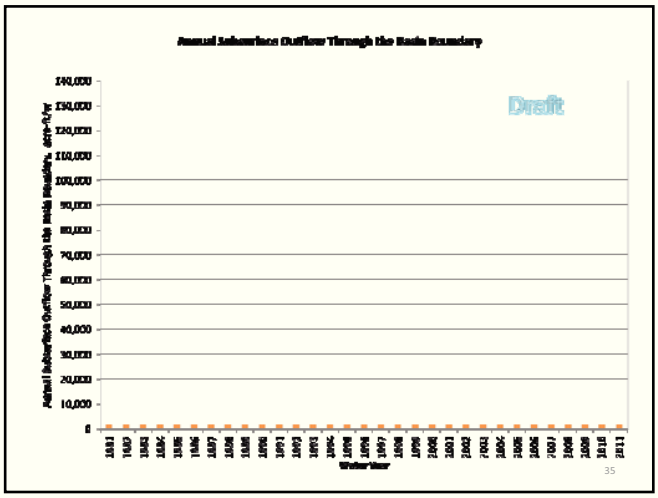
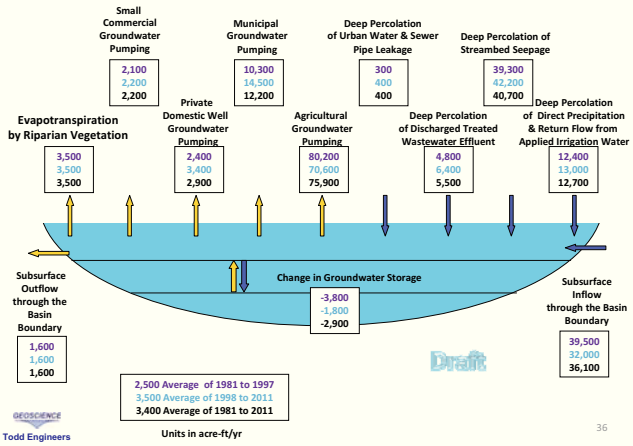


Average Annual Water Balance – Paso Robles Basin



2,500 Average of 1981 to 1997
3,500 Average of 1998 to 2011
3,400 Average of 1981 to 2011

Units in acre-ft/yr

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Water Level Trends

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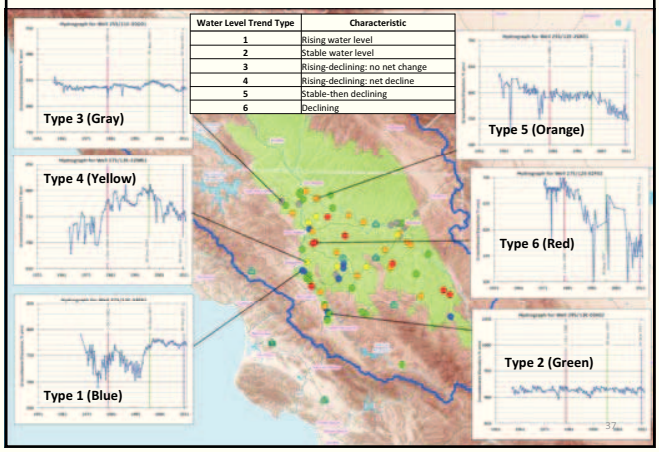
Water Level Trend Type	Characteristic
1	Rising water level
2	Stable water level
3	Rising-declining: no net change
4	Rising-declining: net decline
5	Stable-then declining
6	Declining



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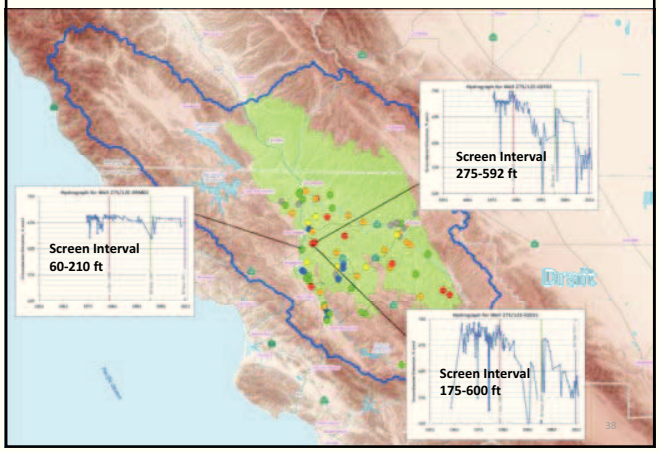
Water Level Trends in Unconfined and Confined Aquifers



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- Objectives and Approach
- Watershed Model Calibration
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- **Comparisons of Water Balance with Original Model**
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Draft

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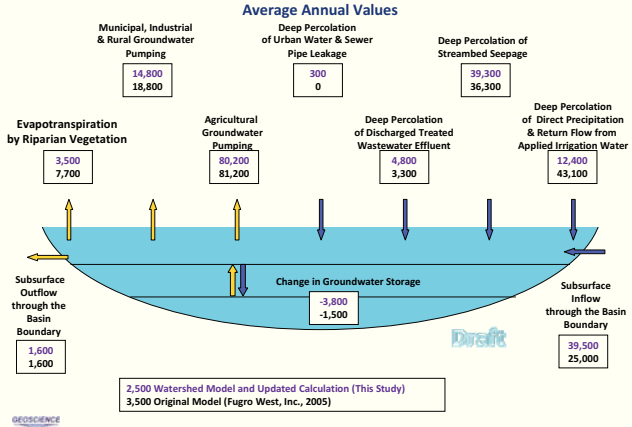
Comparison of Water Balance – 1981 to 1997

Average Annual Values



2,500 Watershed Model and Updated Calculation (This Study)
3,500 Original Model (Fugro West, Inc., 2005)

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Units in acre-ft/yr

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Draft

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Perennial Yield Calculation

- **Selection of Representative Hydrologic Base Period**
- **Perennial Yield = Groundwater Pumping + Change in Groundwater Storage**

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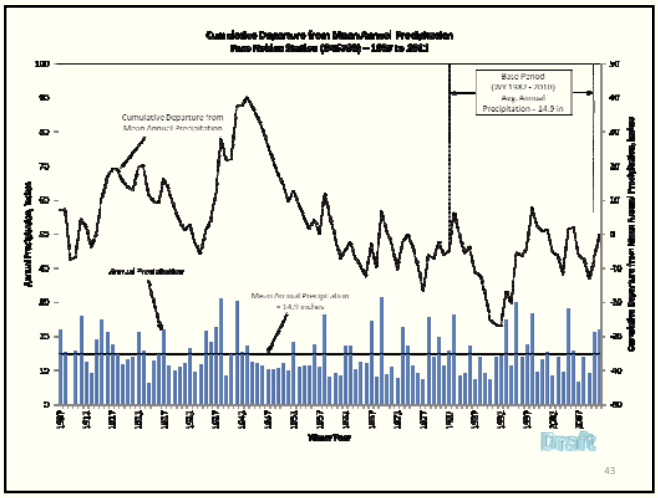

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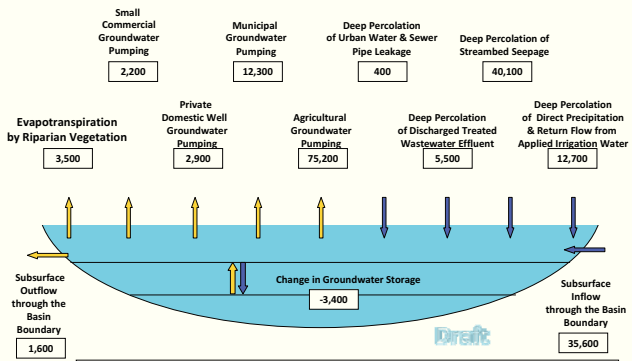
Average Annual Water Balance - Base Period 1982 to 2010



Perennial Yield (Historical Conditions) = Groundwater Pumping + Change in Groundwater Storage

= 75,200 + 12,300 + 2,900 + 2,200 + (-3,400) = 89,200

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Units in acre-ft/yr

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- **Findings**
- Recommendations

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Findings

- The Paso Robles Watershed Model was successfully developed and calibrated over the period from 1-Oct-80 through 30-Sep-11
- Noticeable declines occur in the confined portion of the aquifer but do not reflect a large volume of change in storage

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Findings (Continued)

- Change in Storage:

  1981-1997: -3,800 afy

  1998-2011: -1,800 afy

  1981-2011: -2,900 afy

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Findings (Continued)

- Significant Term Value Change as Compared to Original Model:
  - Deep Percolation (Average of 1981-1997):
    - Original Model: 43,100 afy
    - This study: 12,400 afy
  - Subsurface Inflow (Average of 1981-1997):
    - Original Model: 25,000 afy
    - This study: 39,500afy

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Findings (Continued)

- Perennial Yield:
  - Fugro 2002: 94,000 afy
  - Original Model (Fugro, 2005): 97,700 afy
  - This Study: 89,200 afy
- The Water Balance Terms and Perennial Yield are preliminary and need to be validated during Task D – Model Update and Post-Audit

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Overview

- Objectives and Approach
- Watershed Model Calibration
- Water Balance Estimation
- Comparisons of Water Balance with Original Model
- Perennial Yield of Historical Conditions
- Findings
- **Recommendations**

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Recommendations

Further Evaluation of the Water Level Decline with respect to extractions from the confined portion of the Ground water Basin should be conducted by:

- Obtaining and reviewing well screen intervals for active wells in the confined portion of the ground water basin
- Using model to match extracted volumes and water level declines to consider a mitigating management strategy

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QUESTIONS?