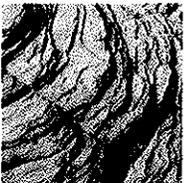
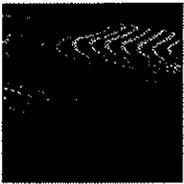
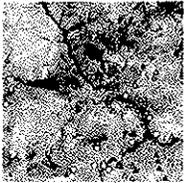


O-3





# Civic Center Hydrology Study

Consulting Team:

Stone Environmental, Inc.  
McDonald Morrissey Associates, Inc.  
Earth Consultants International, Inc.

Presented by:

Bruce F. Douglas  
Stone Environmental, Inc.

City of Malibu

Malibu, California  
May 25, 2010



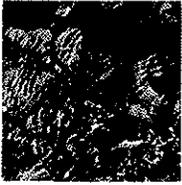
**STONE ENVIRONMENTAL INC**



# Study Objectives

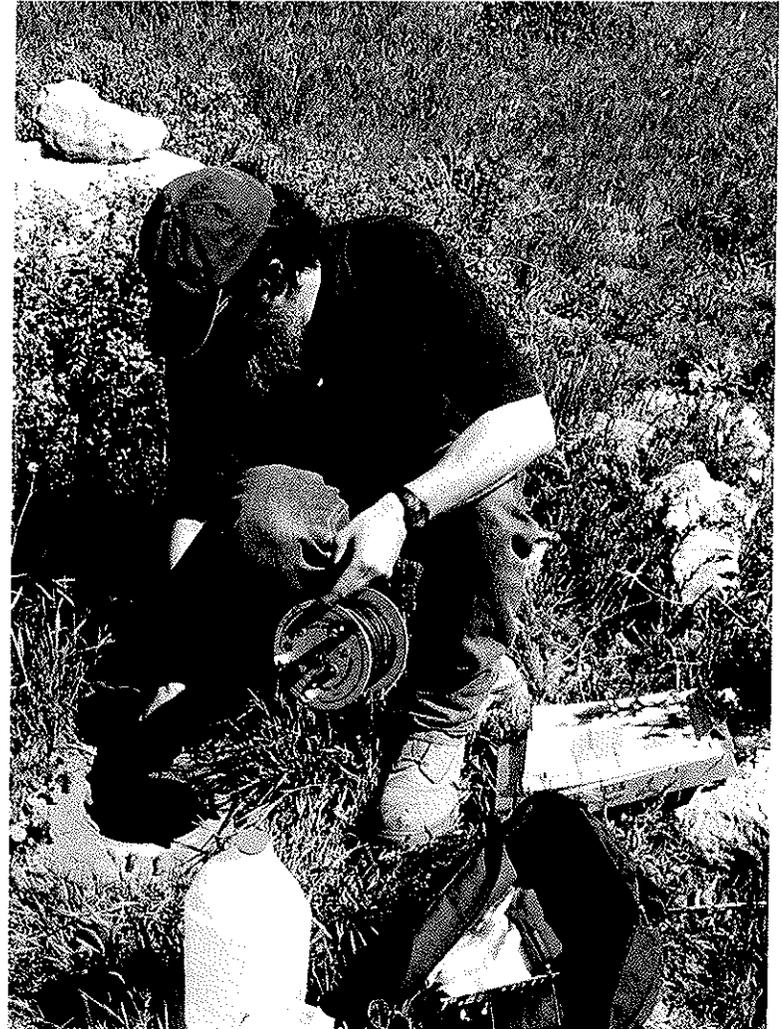
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- Evaluate the cumulative impact of subsurface waste water dispersal on ground water levels in the Civic Center area
- Refine existing numerical ground-water flow model with additional data
- Use the numerical model to evaluate hydrologic effects of waste water dispersal



# Past Modeling of Study Area

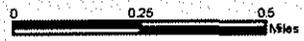
- Stone (2004) Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California.
- Questa (2005). Malibu Civic Center Integrated Water Quality Management Feasibility Study.





**MAP 2: STUDY AREA BASE MAP WITH 1-METER SATELLITE IMAGERY AND PARCEL BOUNDARIES**  
 Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas  
 in the City of Malibu, California

Source: Satellite Imagery Data, AirPhoto USA, November 2000;  
 Parcel Boundaries, City of Malibu, CA; Study Area Boundary, SEI.

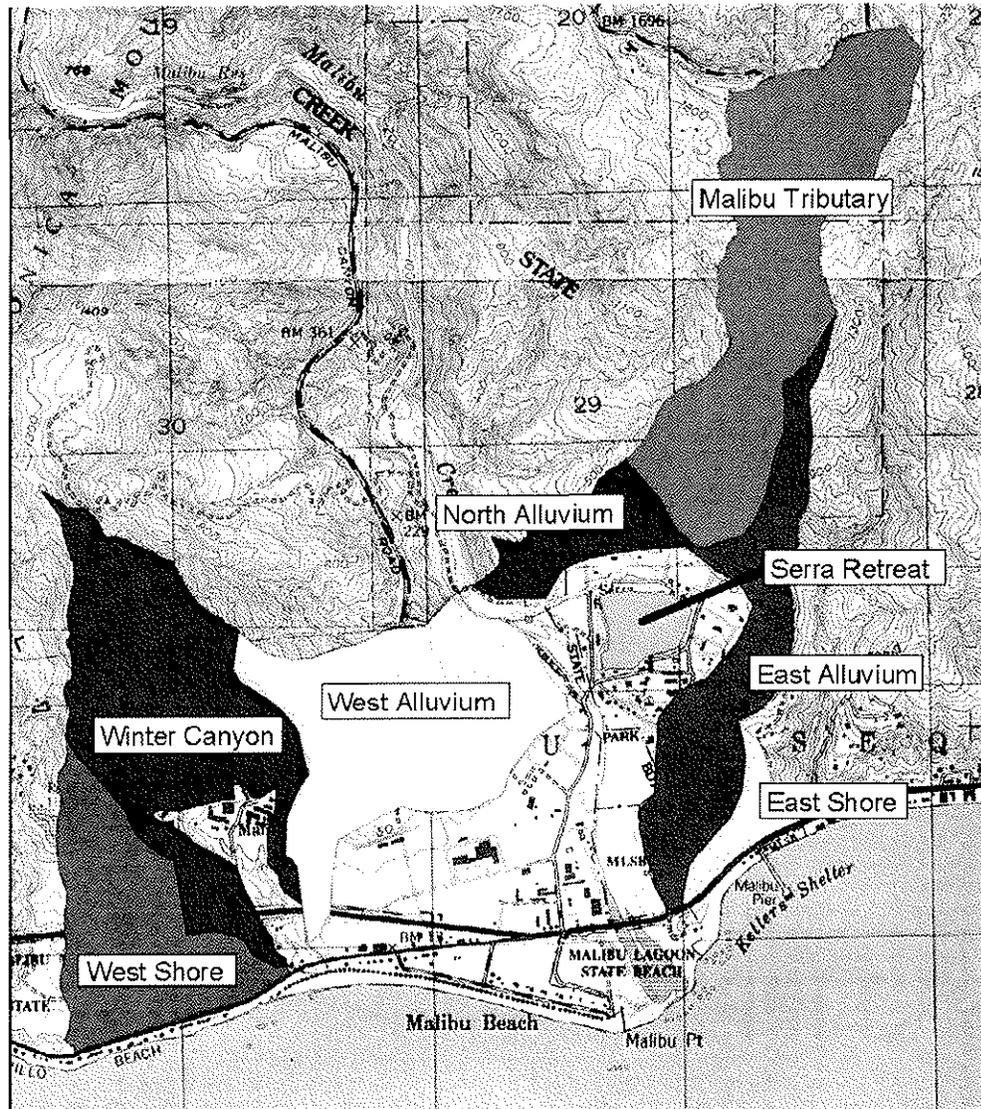


**STONE ENVIRONMENTAL INC**

C:\PDS\011376611\Malibu\Report\1\Map\Map2.mxd, Date: 11/13/00, Scale: 1:25000, Author: SEI

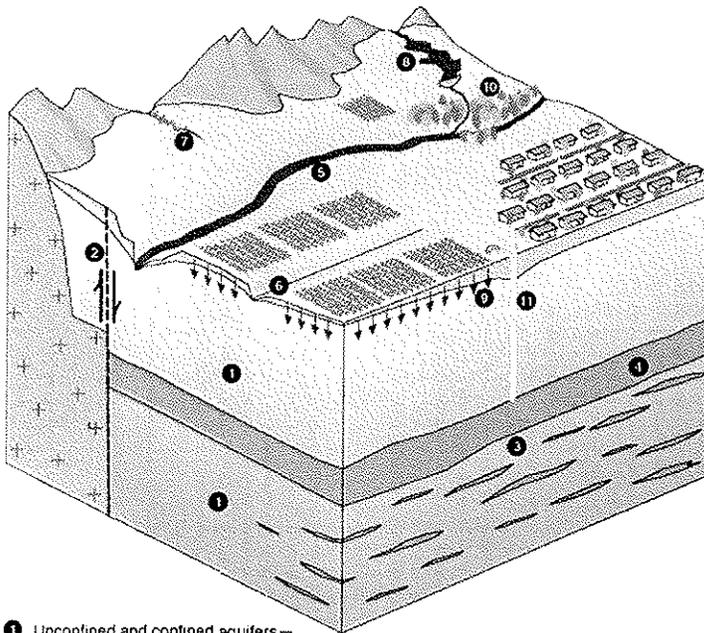


# Upland Recharge Areas



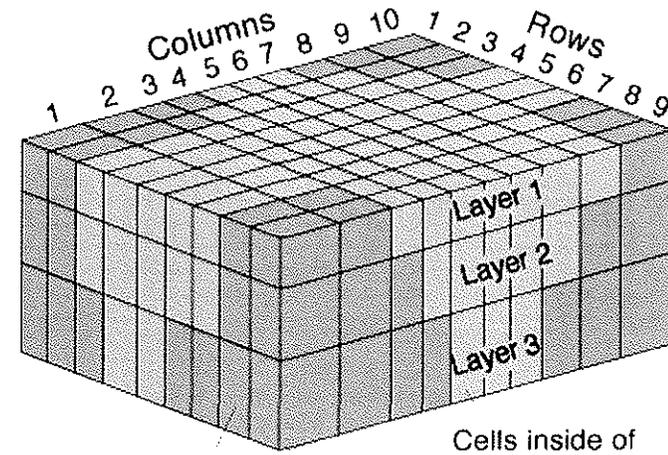


# Hydrogeologic Model Development



- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>① Unconfined and confined aquifers — Ground-water flow and storage changes</li> <li>② Faults and other barriers — Resistance to horizontal ground-water flow</li> <li>③ Fine-grained confining units and interbeds</li> <li>④ Confining units — Ground-water flow and storage changes</li> <li>⑤ Rivers — Exchange of water with aquifers</li> <li>⑥ Drains and springs — Discharge of water from aquifers</li> </ul> | <ul style="list-style-type: none"> <li>⑦ Ephemeral streams — Exchange of water with aquifers</li> <li>⑧ Reservoirs — Exchange of water with aquifers</li> <li>⑨ Recharge from precipitation and irrigation</li> <li>⑩ Evapotranspiration</li> <li>⑪ Wells — Withdrawal or recharge at specified rates</li> </ul> |
|--|--|

Figure 1. Features of an aquifer system that can be simulated by MODFLOW.



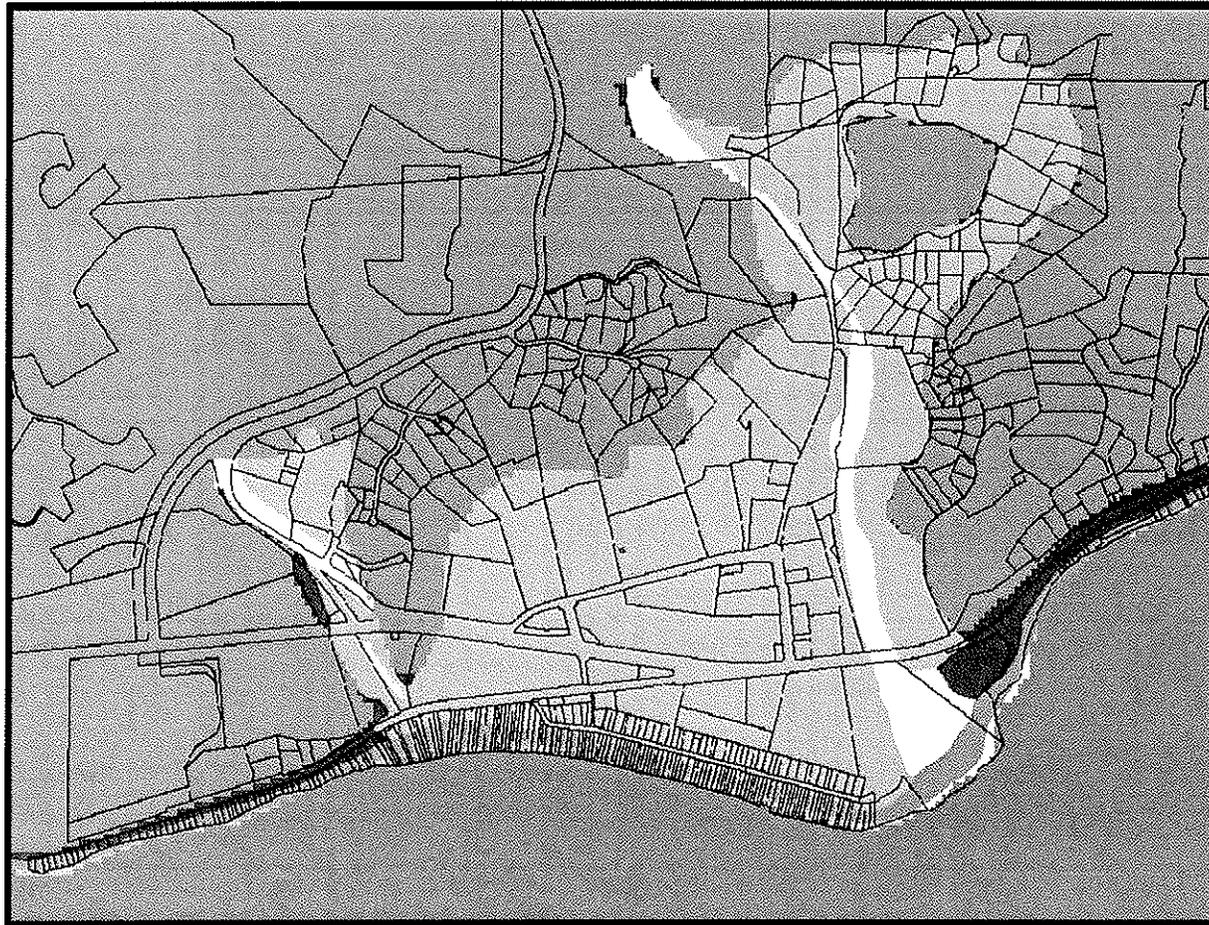
Cells outside of aquifer system

Cells inside of aquifer system

Figure 2. Example of model grid for simulating three-dimensional ground-water flow.



# Published Geology



## Explanation

-  Bedrock, Terrace, and Landslide Deposits
-  Floodplain Alluvium
-  Alluvium
-  Beach Deposits

Modified from  
Yerkes and Campbell, 1980



0 0.25 0.5  
Scale (miles)

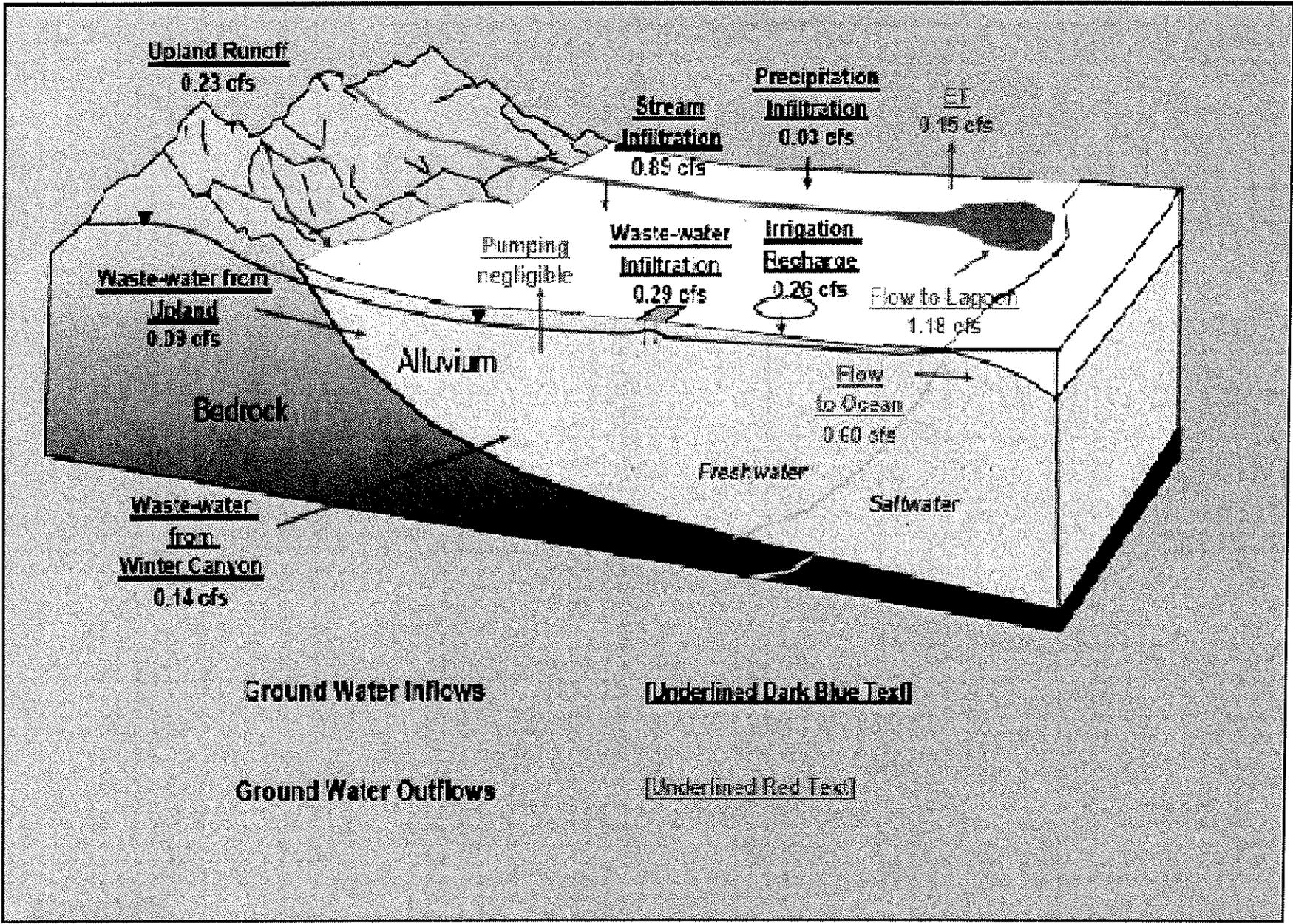
7

Map showing extent of alluvial deposits in the Civic Center area  
(Stone, 2004)



# Recharge from irrigated areas and precipitation

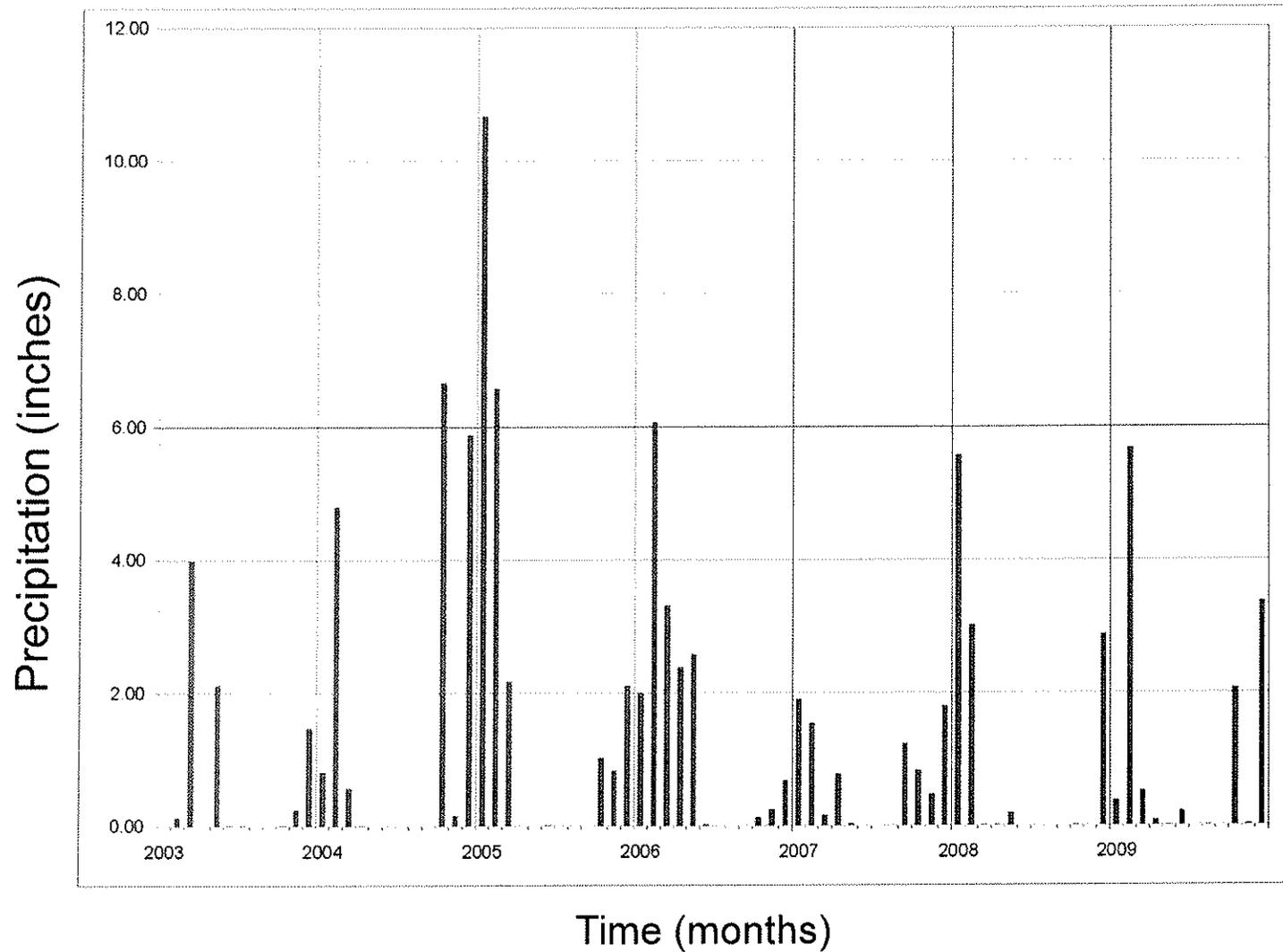


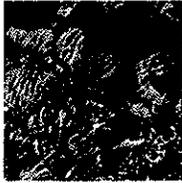


Sources and sinks for the Malibu alluvial ground-water flow system.

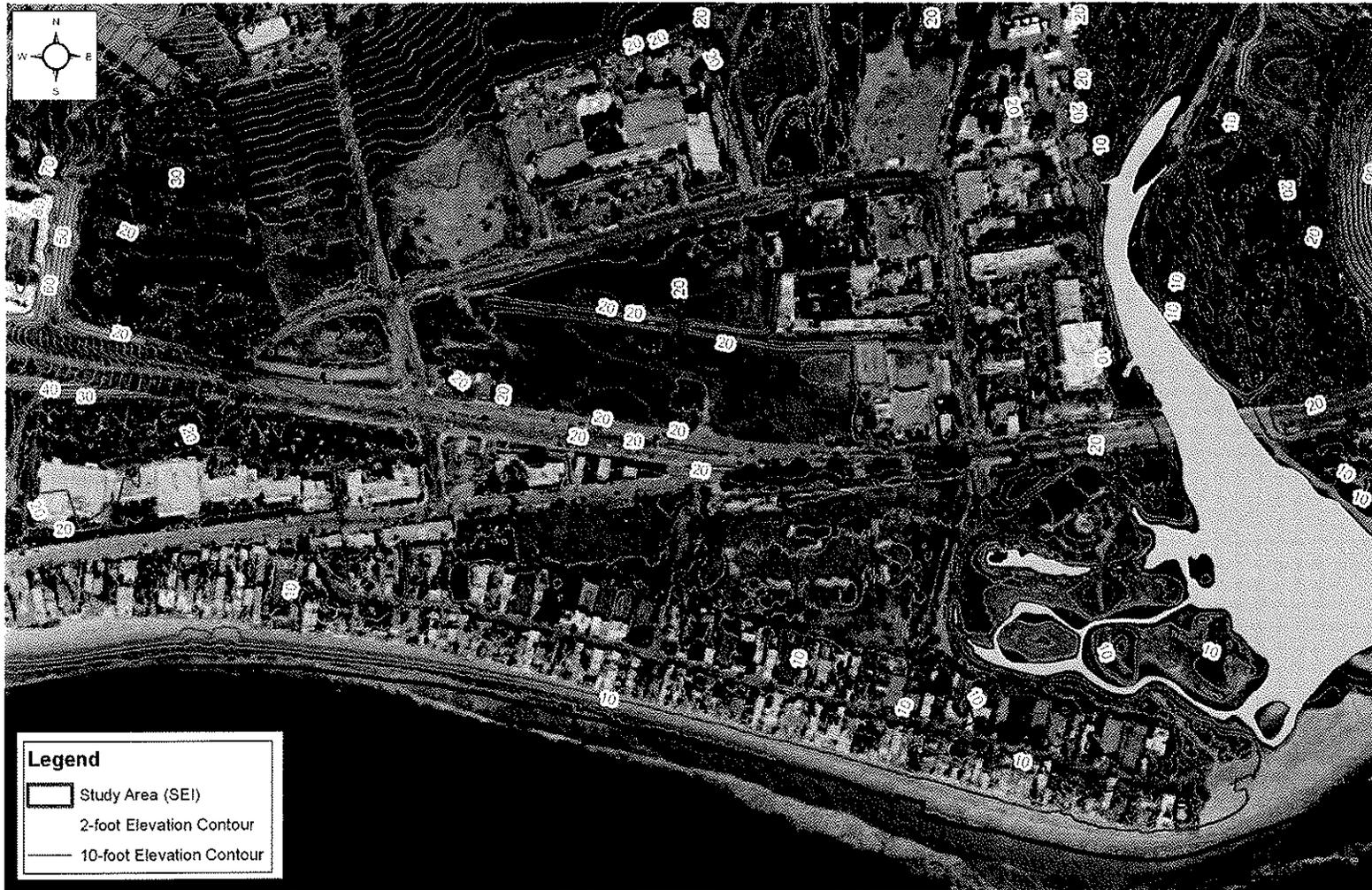


# Rainfall Measured at Pepperdine University





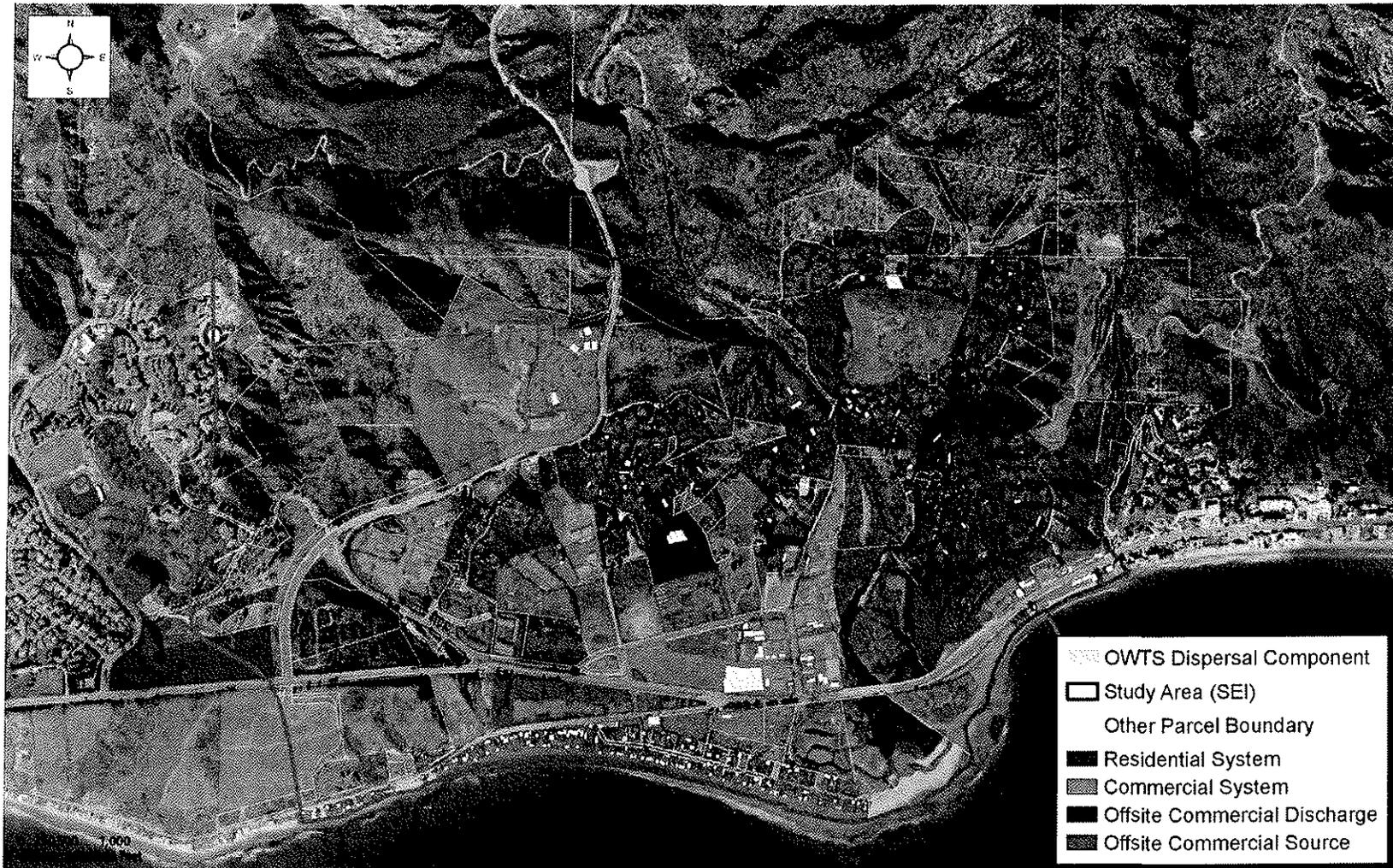
# Ground Surface in Study Area



Sources: Topographic contours generated from LAR-IAC 2006-2007 digital elevation model, 2009; Hydrography digitized by Stone using LAR-IAC 2006-2007 digital elevation model, 2009; Study area, Stone, 2004; Imagery, ESRI.



# Onsite Wastewater Treatment Systems in the Study Area



Sources: Dispersal components digitized by Stone, 2009; Study Area and Groundwater Recharge Areas, Stone, 2004; Parcel boundaries, LA County Assessor; Imagery, ESRI.



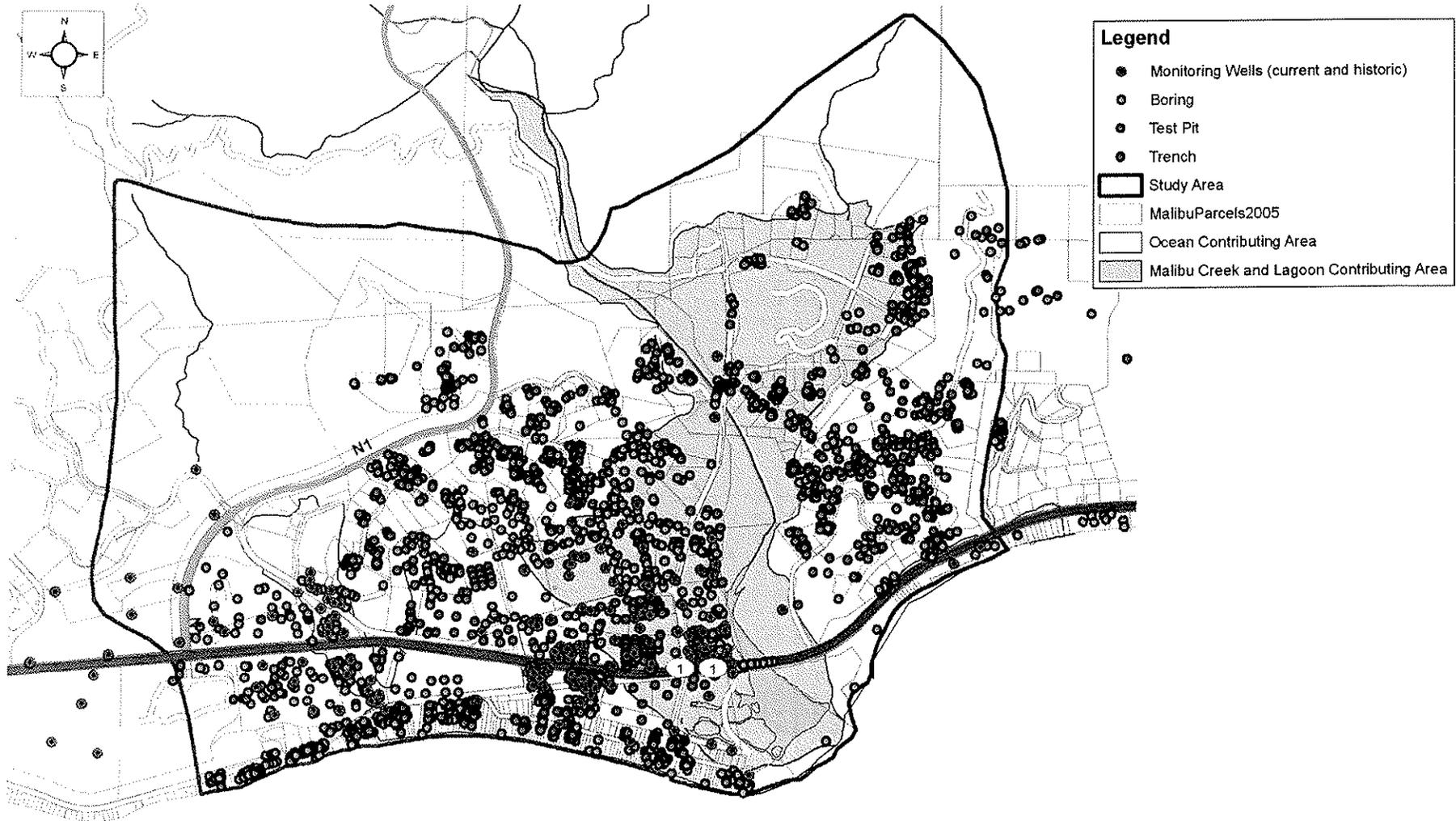
# Onsite Wastewater Treatment Systems in the Study Area – Close Up



Sources: Dispersal components digitized by Stone, 2009; Study Area and Groundwater Recharge Areas, Stone, 2004; Parcel boundaries, LA County Assessor; Imagery, ESRI.



# Monitoring Wells, Borings, and Test Pits in the Study Area

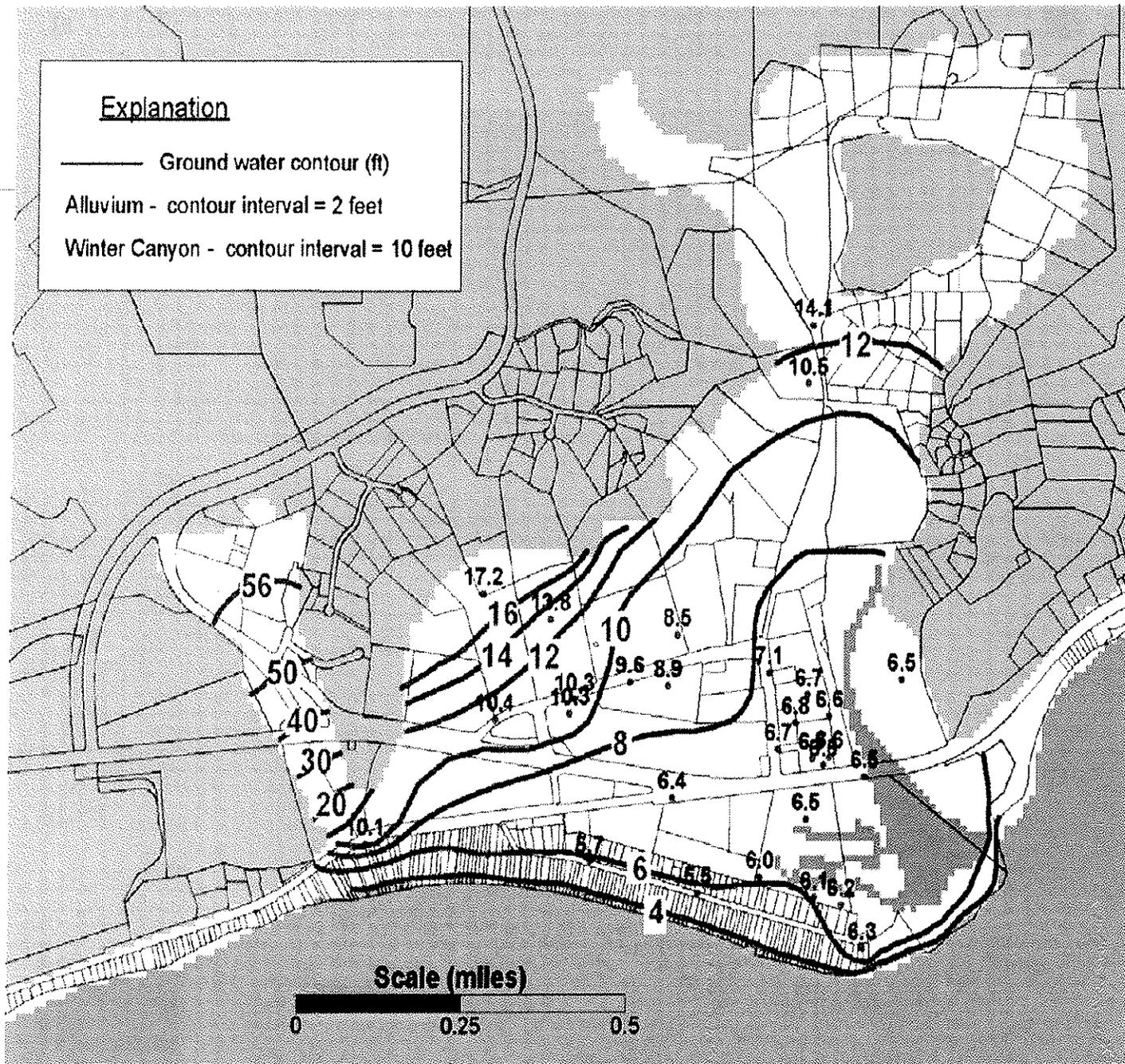


Sources: Groundwater well locations and soil boring locations digitized by Stone, 2002-2009; Hydrography digitized by Stone using LAR-IAC 2006-2007 topography, 2009; Study Area and Groundwater Recharge Areas, Stone and McDonald Morrissey Assoc., 2004.

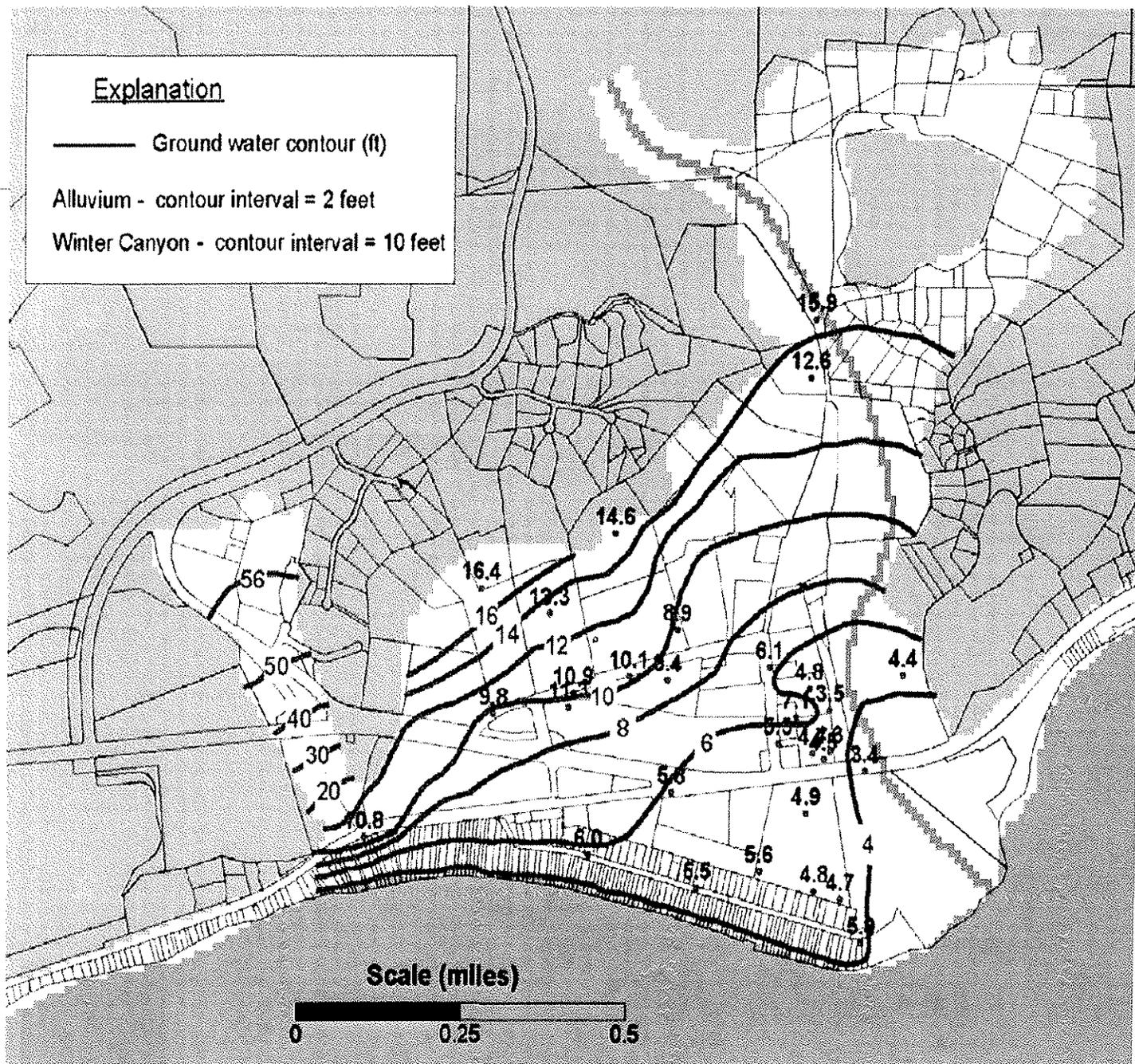


# Effect of Lagoon on Groundwater Elevation





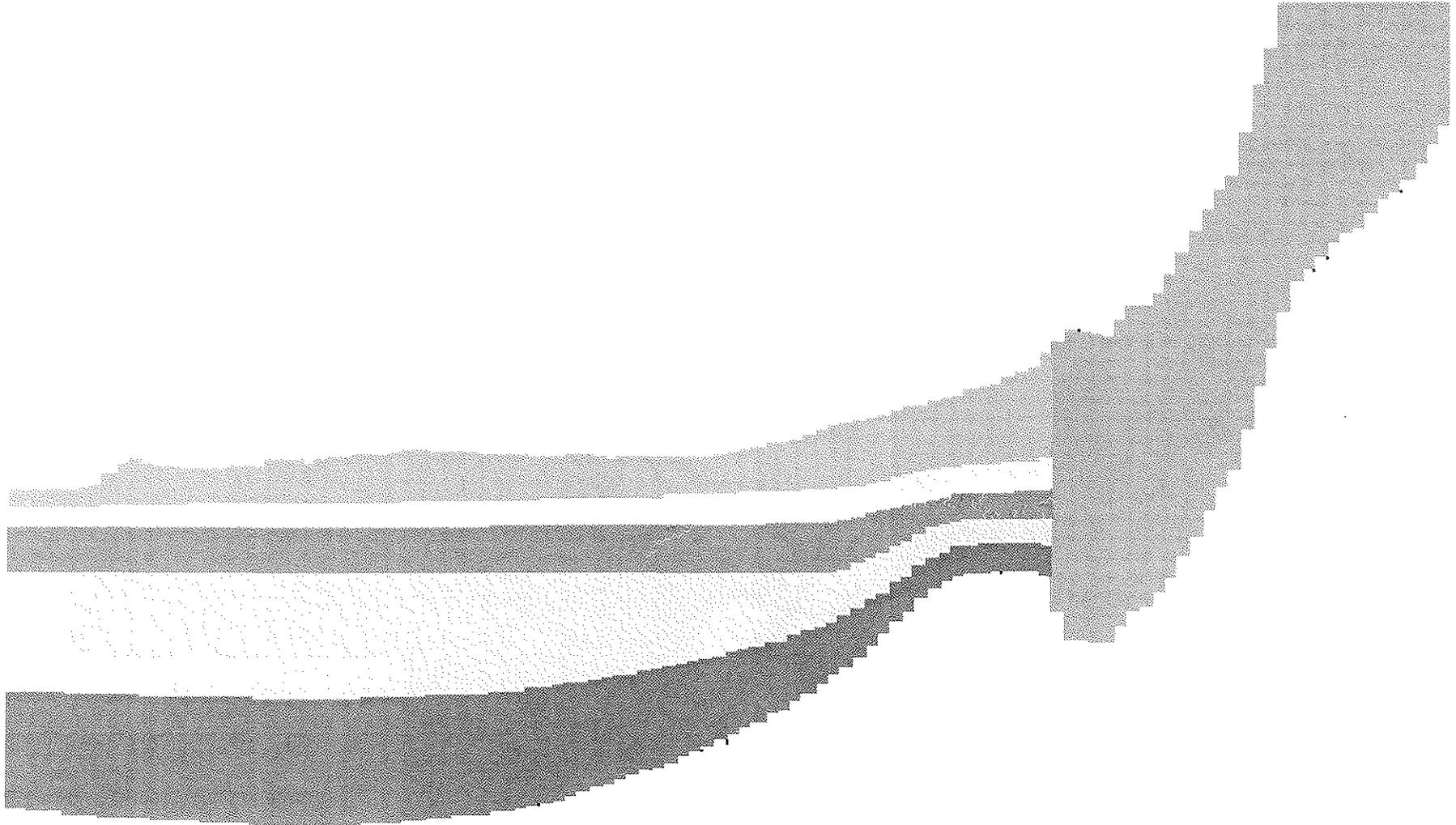
•Flooded Condition



•Breached  
Condition

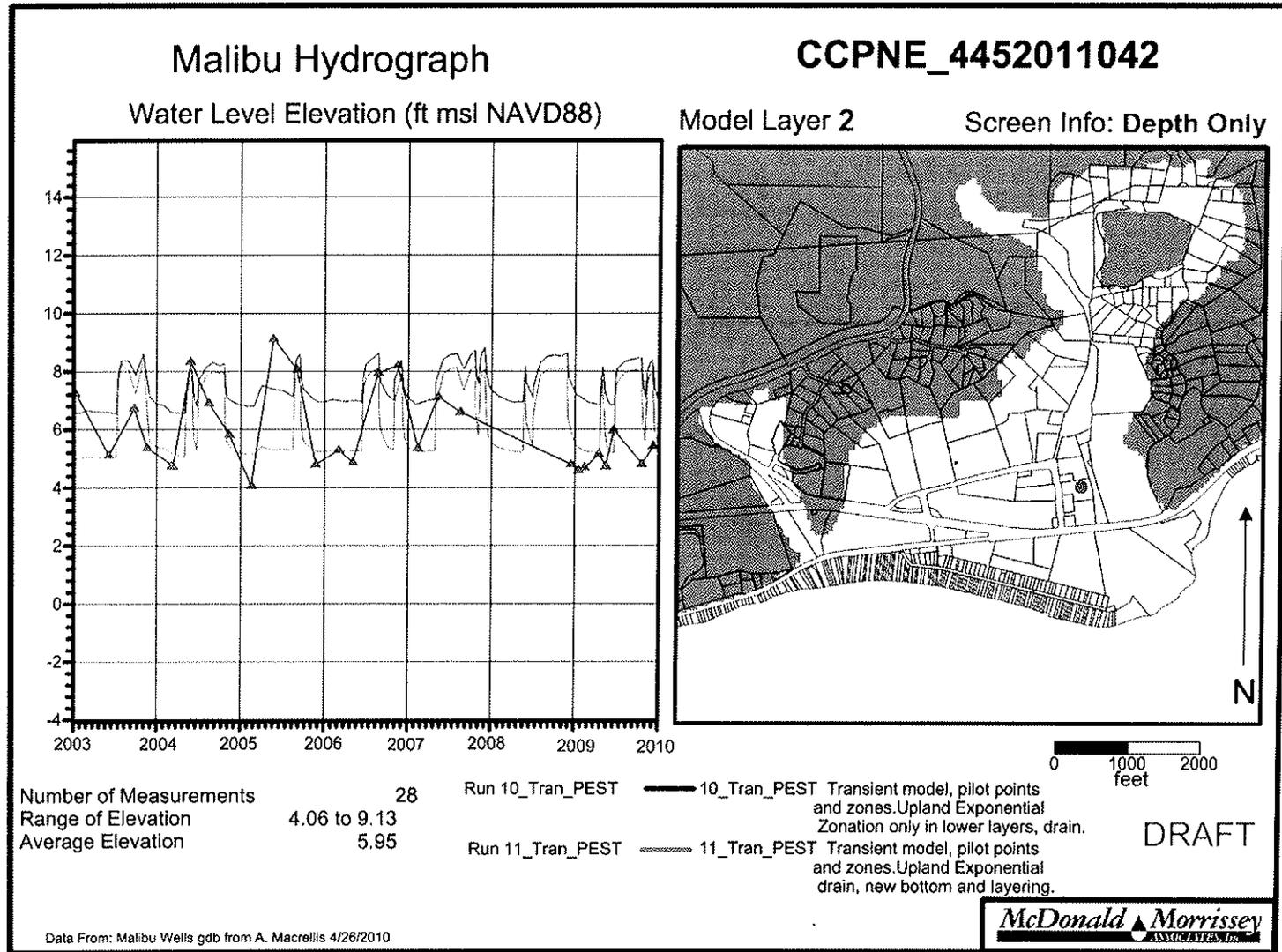


# Cross Section - Example of Generalized Layering



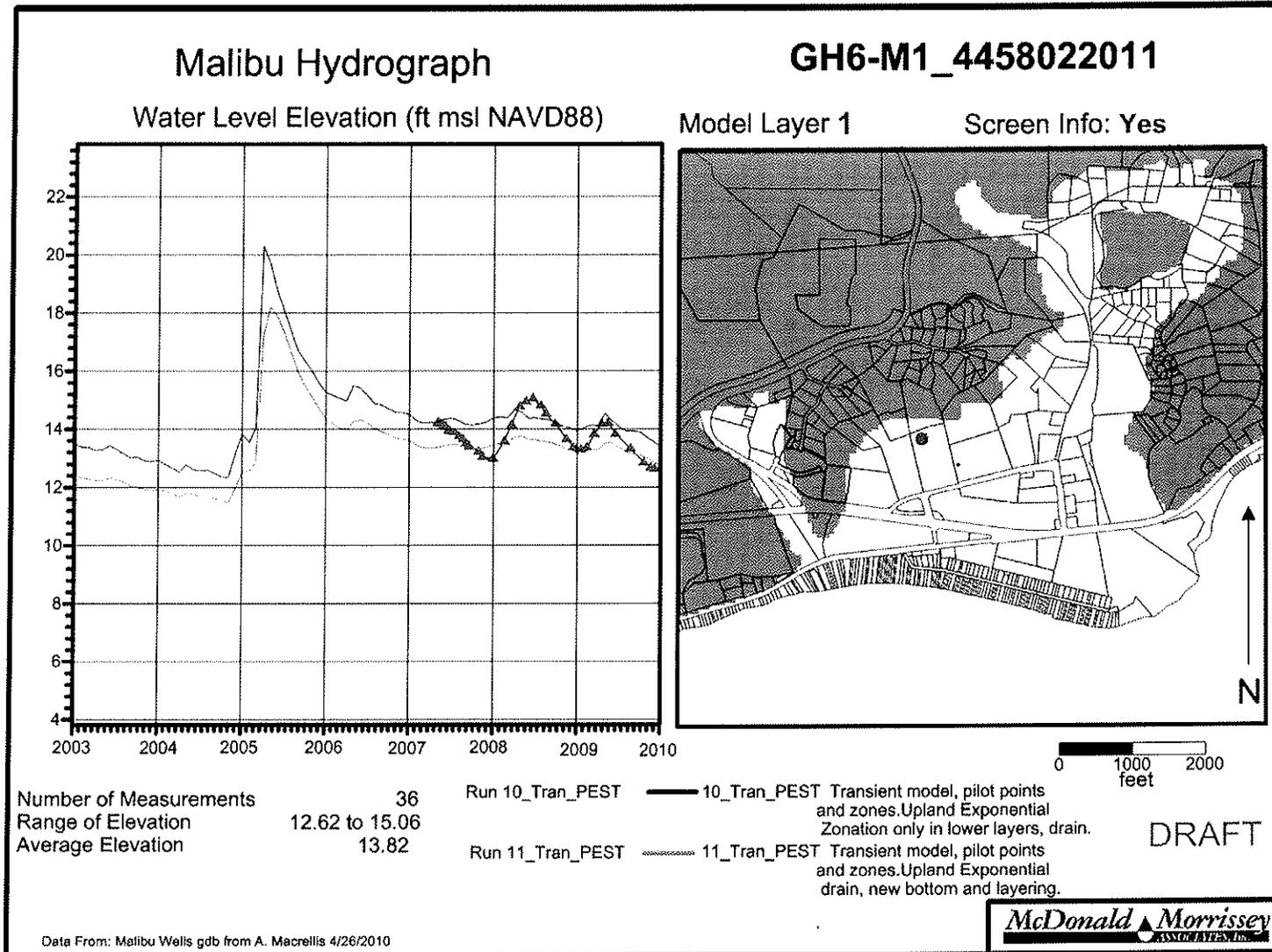


# Preliminary Calibration Result Near Lagoon



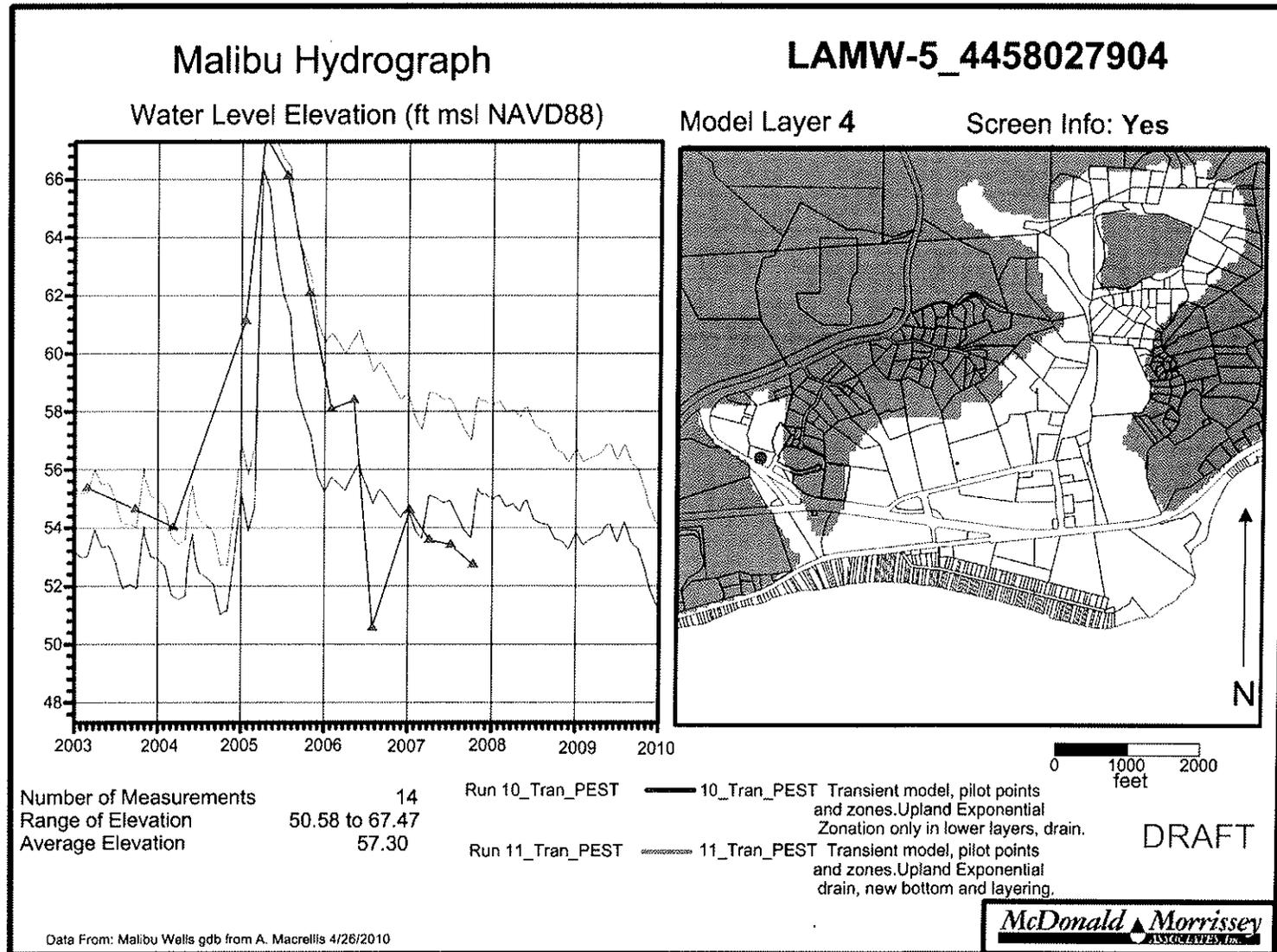


# Preliminary Calibration Result - Near Stuart Ranch Road





# Preliminary Calibration Result Winter Canyon





# Major Elements of Groundwater Flow Model

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## ■ Using

- New Surface Topography
- New Geologic Data
- New Surface Geophysics
- Closer Grid Spacing & Transient Approach

## ■ Incorporating

- Stormwater Drainage System
- 2003-2009 Recharge Data
- Water Level Elevations



# Project Schedule

