GROUNDWATER FLOW MODEL WORKING GROUP MEETING NO. 10

RED HILL BULK FUEL STORAGE FACILITY

APRIL 13, 2018

AGENDA

0830-0835	Introductions (*Travis Hylton*)
0835-0840	Objectives, Intent, and Overview of Modeling Schedule *(Curt Stanley)*
0840-0915	Issues and Action Items *(Curt Stanley)*
	Outstanding data to be received
0915-1045	Interim Modeling *(Sorab Panday)*
	Modeling issues and action items from previous meeting
	Sensitivity analyses continued:
	– Low hydraulic conductivity of the caprock;
	– Influence of GHB stage along the northwest boundary of the model;
	– Saprolite with same properties as basalt;
	– Integrating Red Hill and Halawa Shafts (revised) elevations
	– Low hydraulic conductivity rind on caprock
1045-1100	Synoptic Monitoring Update *(Delwyn Oki and Jeff Johnson)*
1100-1115	Break to Summarize New Issues and Action Items
1115-1130	Summary and Next Steps (*Jeff Johnson, Curt Stanley, and Travis Hylton*)
	Overview of technical feedback, decisions, and action items

Proposed next working group meeting: June 7, 2018 (changed from June 5, 2018)

NAVY'S MODELING OBJECTIVES

The objective of groundwater modeling is to help ascertain potential risk to water supply wells as a result of a potential range of releases from the Red Hill Bulk Fuel Storage Facility under a range of reasonable pumping conditions within the model domain. The results of this modeling effort will then be used to:

1. **Inform decisions related to the Tank Upgrade Alternatives (TUA), and**
2. **Inform decisions related to potential remedial alternatives**

***Pursuant to the Administrative Order on Consent Statement of Work Section 6, Investigation & Remediation of Releases, and Section 7, Groundwater Protection and Evaluation**

ED_006532_00001954-00003

GROUNDWATER FLOW MODELING WORKING GROUP INTENT

The intent of the GWFM Working Group is to support the Navy's objectives relative to developing timely and technically defensible groundwater flow and contaminant fate & transport (F&T) models for Red Hill.

- Technical feedback from Subject Matter Experts (SMEs) for consideration by the Navy on key elements of model development
- Provide assistance in ensuring that all appropriate data are considered in development of the model
- Provide assistance in collecting relevant data

***The GWFM Working Group focus is on the deep technical issues related to technically defensible model development**

ED_006532_00001954-00004

FLOW MODEL APPLICATIONS FOR MEETING NAVY'S OBJECTIVES

- **Evaluate flow field and capture zones of wells within the model domain as well as contaminant F&T**
  - Scenarios of different combinations of possible future pumping and varying source considerations
    - Long-term analysis
    - Impact of seasonal changes
    - Impact of uncertainty in parameters or stresses
- **Help evaluate containment/remediation/monitoring strategies for contingency planning**
- **Not to predict future but to evaluate impact of potential scenarios**
  - Modeling (achieves our goal) – Constructing a model to answer a specific objective
  - Simulation (this is not our goal) – Constructing a model to mimic as many aspects of a portion of the natural world as possible
    - Henk Haitjema, 1999 AGU Meeting
- **Groundwater Modeling Progress Report No. 4 submitted April 5, 2018**
- **Groundwater Modeling Progress Report No. 5 to be submitted by August 5, 2018**
- **Groundwater Flow Modeling and Investigation & Remediation of Releases Reports to be submitted by December 5, 2018**

MISCELLANEOUS

- Data differences on material provided to EPA/DOH and BWS
- Gyroscopic survey corrections
- Groundwater Flow Model Progress Report #4

INTERIM MODELING

Modeling issues and action items

- Compile table showing elevations of the top and bottom of model layers where well screen intervals are located
- Correct/check:
  - Spring/Summer 2015 synoptic monitoring
  - Units and values for annual average pumping data (e.g., Lau Farm)
- Evaluate
  - Ways to concisely summarize all sensitivity analyses results
  - Effective porosities (estimated from specific yield) from synoptic data for final model

ED_006532_00001954-00007

INTERIM MODELING (CONT.)

Modeling issues and action items

- Take slope of regression lines from 2006 and 2017 synoptic study figures (Slide #10 from March 16, 2018 GWFMWG meeting) and plot them on the 2015 study figure
- Provide details of synoptic pumping/drawdown data used for Hālawa Shaft and Red Hill Shaft scatter plots
- Provide meeting attendees with recalibration values for sensitivity run where saprolite had the same properties as basalt (Slide #108 from March 16, 2018 GWFMWG meeting)
- Sensitivity analyses:
  - Low hydraulic conductivity of the caprock
  - Influence of GHB stage along the northwest boundary of the model
  - Saprolite with same properties as basalt
  - Integrating Red Hill and Hālawa Shafts as-built elevations
  - Low hydraulic conductivity rind in caprock

ED_006532_00001954-00008

TABLE SHOWING ELEVATIONS OF THE TOP AND BOTTOM OF MODEL LAYERS WHERE WELL SCREEN INTERVALS ARE LOCATED

Well Name	Well ID	Screen Elevation (ft msl)		Related Model Layer(s)	Related Model Layer Elevations (ft msl)					
		Top	Bottom		Top Layer 1	Bottom Layer 1 = Top Layer 2	Bottom Layer 2 = Top Layer 3	Bottom Layer 3 = Top Layer 4	Bottom Layer 4 = Top Layer 5	Bottom Layer 5
Kalihi Shaft	2052-08	30	6	2	N/A	116.98	-15.25	N/A	N/A	N/A
Kalihi	2053-08	-500	-663	1	0	-772.57	N/A	N/A	N/A	N/A
Fort Shafter	2053-11	-154	-309	2, 3, 4	100	-157.39	-187.39	-247.39	-367.39	N/A
Hickam AF Base	2057-04	20	-20	1	0	-87.98	N/A	N/A	N/A	N/A
Moanalua	2153-02	-59	-269	2, 3, 4	99.96	-72.56	-102.56	-162.56	-282.56	N/A
Moanalua Deep	2153-05	-30	-1218	3, 4, 5, and below	N/A	N/A	-21.33	-81.33	-201.33	-780.14
TAMC 1	2153-07	-22	-272	2, 3, 4, 5	N/A	41.56	-22.93	-82.93	-202.93	-799.57
Moanalua 1	2153-10	-114	-264	4, 5	N/A	N/A	N/A	-84.75	-204.75	-772.35
Moanalua 2	2153-11	-115	-265	4, 5	N/A	N/A	N/A	-84.75	-204.75	-772.35
Moanalua 3	2153-12	-150	-300	4, 5	N/A	N/A	N/A	-84.61	-204.61	-772.67
Honolulu International Country Club	2154-01	-89	-280	2, 3, 4	100	-184.48	-214.48	-274.48	-394.48	N/A
Kalihi Aerator	2250-01	514	464	1	600	249.07	N/A	N/A	N/A	N/A
Red Hill Shaft	2254-01	24	-10	2	N/A	W (212.63) E (301.2)	W (-13) E (-13)	N/A	N/A	N/A
Navy Hālawa	2255-32	95	-4	2	N/A	100	-13	N/A	N/A	N/A
Hālawa 2	2255-37	-29	-89	3, 4	N/A	N/A	-13	-73	-193	N/A
Hālawa 3	2255-38	-44	-89	3, 4	N/A	N/A	-13	-73	-193	N/A
Hālawa 1	2255-39	-18	-141	3, 4	N/A	N/A	-13	-73	-193	N/A
Hālawa Shaft	2354-01	10	-18	3	N/A	N/A	N (-13) S (-17.8)	N (-73) S (-77.8)	N/A	N/A
'Aiea Gulch 1	2355-03	16	-38	2, 3	N/A	306.15	-13	-73	N/A	N/A
'Aiea Gulch 2	2355-05	18	-40	2, 3	N/A	306.15	-13	-73	N/A	N/A
'Aiea 1	2355-06	-32	-102	3, 4	N/A	N/A	-13	-73	N/A	N/A

TABLE SHOWING ELEVATIONS OF THE TOP AND BOTTOM OF MODEL LAYERS WHERE WELL SCREEN INTERVALS ARE LOCATED

Well Name	Well ID	Screen Elevation (ft msl)		Related Model Layer(s)	Related Model Layer Elevations (ft msl)					
		Top	Bottom		Top Layer 1	Bottom Layer 1 = Top Layer 2	Bottom Layer 2 = Top Layer 3	Bottom Layer 3 = Top Layer 4	Bottom Layer 4 = Top Layer 5	Bottom Layer 5
'Aiea 2	2355-07	-30	-100	3, 4	N/A	N/A	-13	-73	N/A	N/A
Kalauao P1	2355-09	-61	-253	3, 4, 4	N/A	N/A	-15.12	-75.12	-195.12	-540.57
Kalauao P4	2355-10	-63	-254	3, 4, 5	N/A	N/A	-13.44	-73.44	-193.44	-641.06
Kalauao P2	2355-11	-60	-254	3, 4, 5	N/A	N/A	-13.2	-73.2	-193.2	-642.09
Kalauao P3	2355-12	-61	-253	3, 4, 5	N/A	N/A	13.06	-73.06	-193.06	-643.79
Kalauao P5	2355-13	-68	-254	3, 4, 5	N/A	N/A	-13.56	-73.56	-193.56	-647.9
Kalauao P6	2355-14	-70	-253	3, 4, 5	N/A	N/A	-13.01	-73.01	-193.01	-642.34
WG Minami 2007	2355-16	20	-20	2, 3	N/A	120.15	-14.45	-74.45	N/A	N/A
Waimalu I-1	2356-49	-27	-225	3, 4, 5	N/A	N/A	-18.95	-78.95	-198.95	-640
Waimalu I-2	2356-50	-25	-225	3, 4, 5	N/A	N/A	-18.95	-78.95	-198.95	-640
Pearl Country Club	2356-54	-21	-178	3, 4	N/A	N/A	-13	-73	-193	
Kaonohi I-2	2356-55	-37	-290	3, 4, 5	N/A	N/A	-13	-73	-193	-640
Kaonohi I-1	2356-56	-44	-297	3, 4, 5	N/A	N/A	-13	-73	-193	-640
Ka'amilo 1	2356-58	-43	-193	3, 4	N/A	N/A	-13	-73	-193	N/A
Ka'amilo 2	2356-59	-42	-192	3, 4	N/A	N/A	-13	-73	-193	N/A
Waimalu II-1	2356-60	-77	-217	3, 4	N/A	N/A	-45.8	-105.8	-225.8	N/A
Kaonohi II-1	2356-61	-78	-218	4, 5	N/A	N/A	N/A	-73.8	-193.8	-636.25
Kaonohi II-2	2356-62	-83	-223	4, 5	N/A	N/A	N/A	-76.02	-196.02	-624.18
Waimalu II-2	2356-63	-74	-214	3, 4, 5	N/A	N/A	-27.38	-87.38	-207.38	-594.65
Waimalu II-3	2356-64	-143	-220	3, 4	N/A	N/A	-127.15	-187.15	-307.15	N/A
Kaonohi II-3	2356-65	-83	-223	4, 5	N/A	N/A	N/A	-76.58	-196.58	-620.41
Lau Farm	2356-70	-152	-202	4	N/A	N/A	N/A	-88.68	-208.68	N/A
Waimalu	2455-02	-12	-78	1, 2, 3	200	-89.86	-119.86	-179.86	N/A	N/A
Waimalu	2455-03	-80	-120	1, 2, 3	200	-89.86	-119.86	-179.86	N/A	N/A

EXAMPLE STEADY-STATE MODEL PUMPING AND LAYERING DATA (FROM MARCH GWFMWG MEETING)

Well Name	well_id	2006 Pumping rate, MGD	2015 Pumping rate, MGD	2017 Pumping rate, MGD	Screen top elevation, ft msl	Screen bottom elevation, ft msl	related model (CLN cell) layers
Pearl CC	2356-54	0.28	0.42	0.23	-21	-178	3, 4
Kaonohi I-2	2356-55	1.07	0.84	0.78	-37	-290	3, 4, 5
Kaonohi I-1	2356-56	0	0	0	-44	-297	3, 4, 5
Ka'amilo 1	2356-58	1.82	0	0	-43	-193	3, 4
Ka'amilo 2	2356-59	0	0	0	-42	-192	3, 4
Waimalu II-1	2356-60	0	0	0	-77	-217	3, 4
Kaonohi II-1	2356-61	0	0	0	-78	-218	4, 5
Kaonohi II-2	2356-62	0	0	0	-83	-223	4, 5
Waimalu II-2	2356-63	0	0	0	-74	-214	3, 4, 5
Waimalu II-3	2356-64	0	0	0	-143	-220	3, 4
Kaonohi II-3	2356-65	0	0	0	-83	-223	4, 5
Lau Farm	2356-70	0.050	0.050	0.050	-152	-202	4
Waimalu	2455-02	0.0023	0	0.0023	-12	-78	1, 2, 3
Waimalu	2455-03	0.00052	0.00032	0.00032	-80	-120	1, 2, 3
Halawa Shaft	2354-01	12.16	5.91	8.06	-	-18	3
Red Hill Shaft	2254-01	2.87	4.15	3.76	-	-10	2

ED_006532_00001954-00011

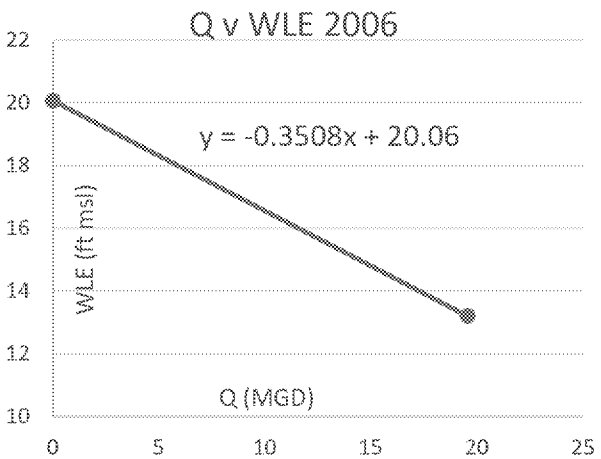
EVALUATE

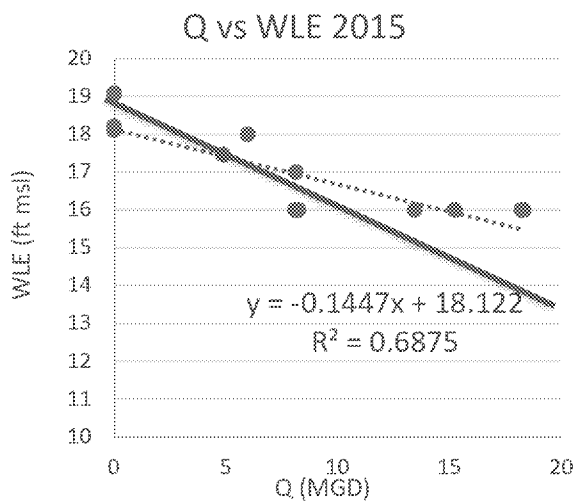
- Ways to concisely summarize all sensitivity analyses results
  - Plot all capture zones on one plot
  - Compute frequency of particles movement through all cells for all sensitivity simulations (weighted if needed)
    - Cell ID is an output for each particle track which can be post-processed to compute frequency
- Effective porosities (estimated from specific yield) from synoptic data for final model
  - Will be done with the final model evaluations

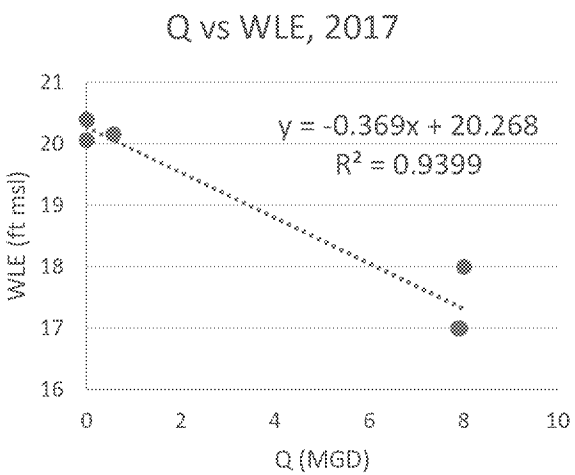
ED_006532_00001954-00012

IMPACT OF WITHDRAWALS ON WATER LEVELS IN PUMPING WELLS – RED HILL SHAFT

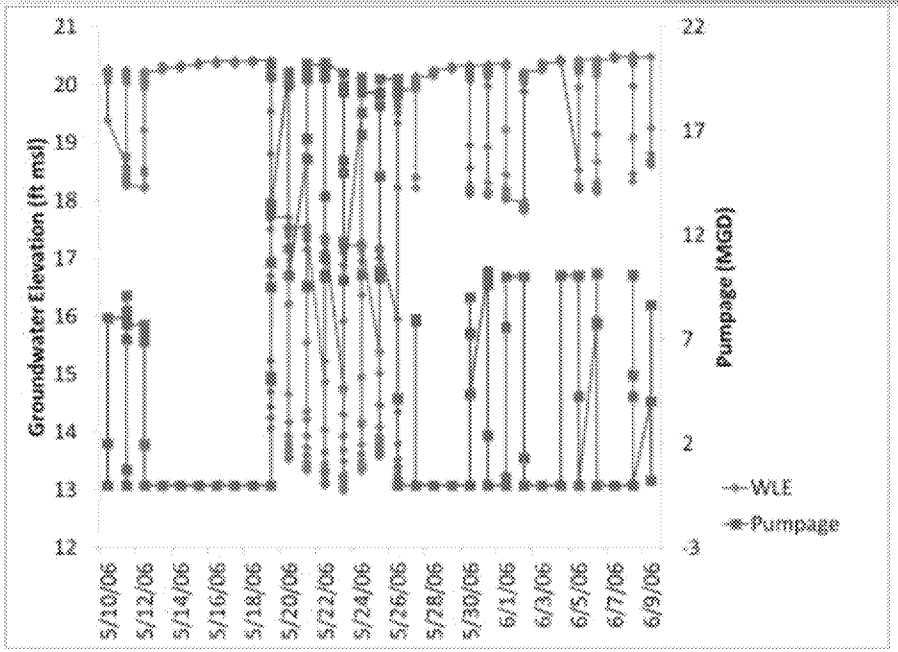
- Extracted data only when pumping and water levels are reported
- Only 2 synoptic data points in 2006 which were 2 weeks apart
- Water level measurements at time of 0:00
  - Don't know if data were collected when well was pumping or not
  - Water levels depend on how long the pumps have been steady
- Evaluate correlation

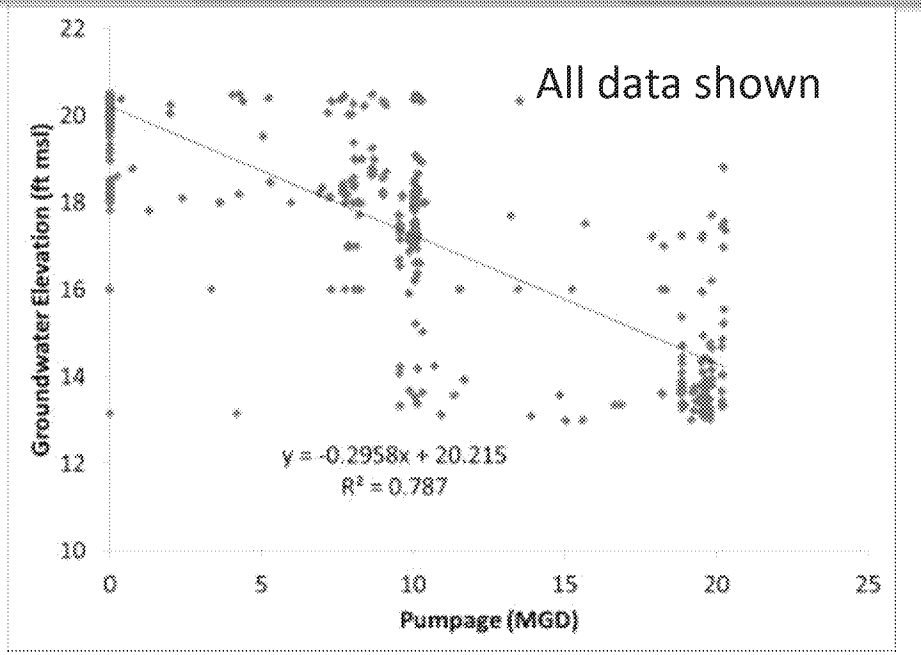






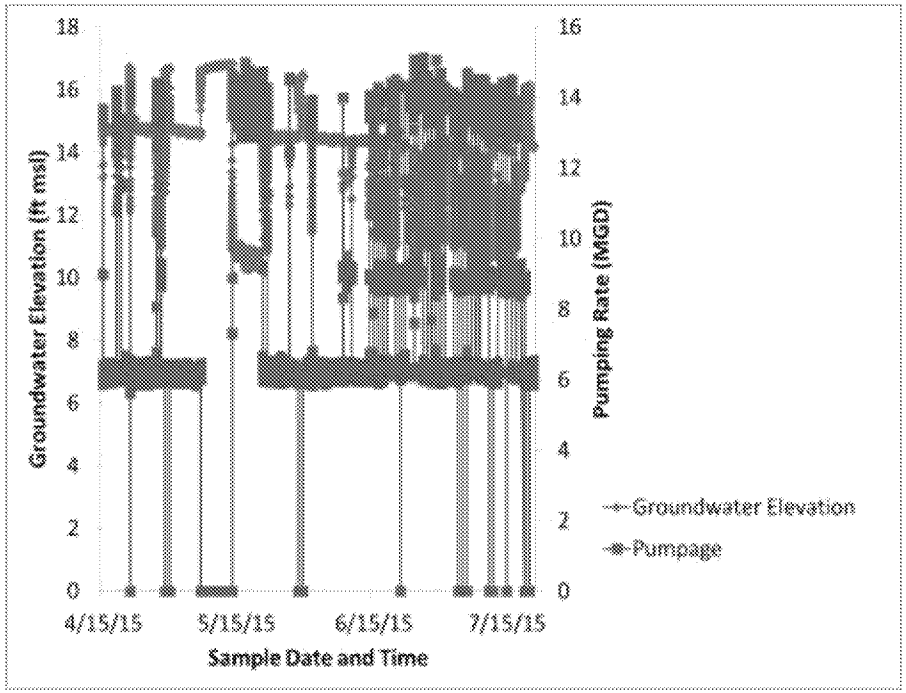
MORE SYNOPTIC DATA AT RED HILL SHAFT

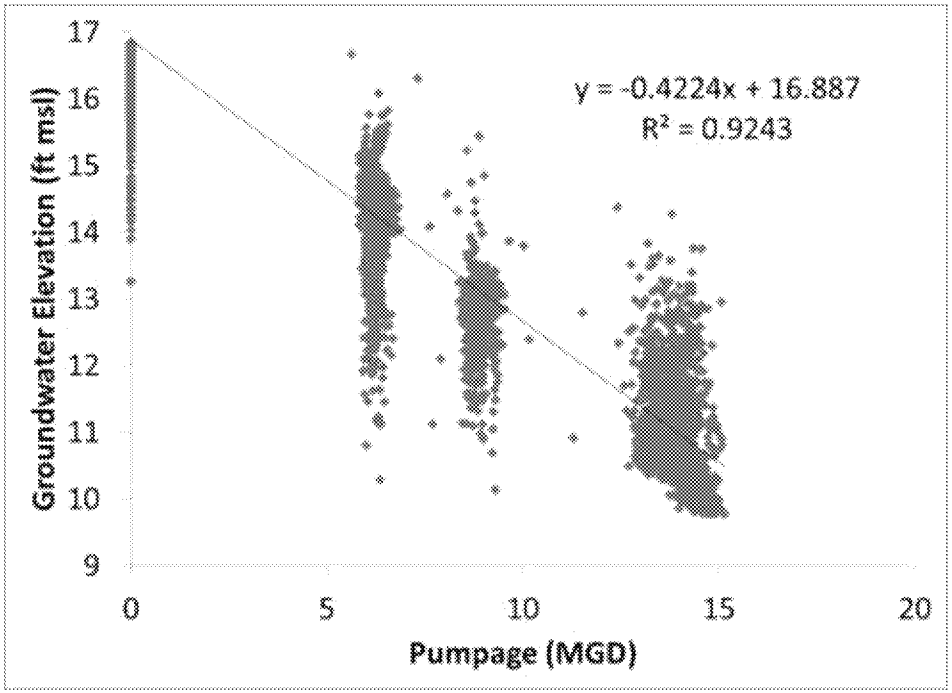




- Previously presented data
  - As available for 2006 (2 data points), 2015 (16 data points), and 2017 (9 data points)
  - ~3.5 feet drawdown for 10 MGD of pumping
- Current data
  - At hourly intervals from 05-10-2006 through 06-09-2006; monthly from Jan 2013 through March 2017
  - 768 data points; 2.96 feet drawdown for 10 MGD of pumping

MORE SYNOPTIC DATA AT HALAWA SHAFT





- Previously presented data
  - At hourly intervals from 05-01-2015 through 05-31-2015
  - 743 data points; $R^2 = 0.98$; 4.38 feet drawdown for 10 MGD of pumping
- Current data
  - At 10-minute intervals from 04-15-2015 through 07-21-2015
  - 13,945 data points; 4.22 feet drawdown for 10 MGD of pumping

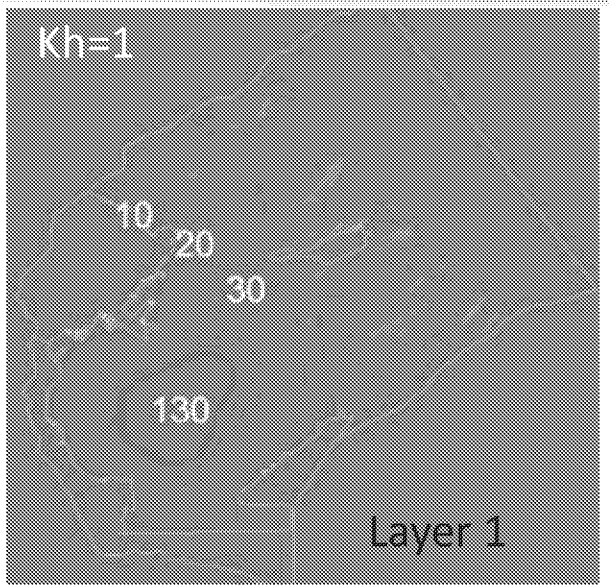
SENSITIVITY TO HORIZONTAL HYDRAULIC CONDUCTIVITY OF CAPROCK

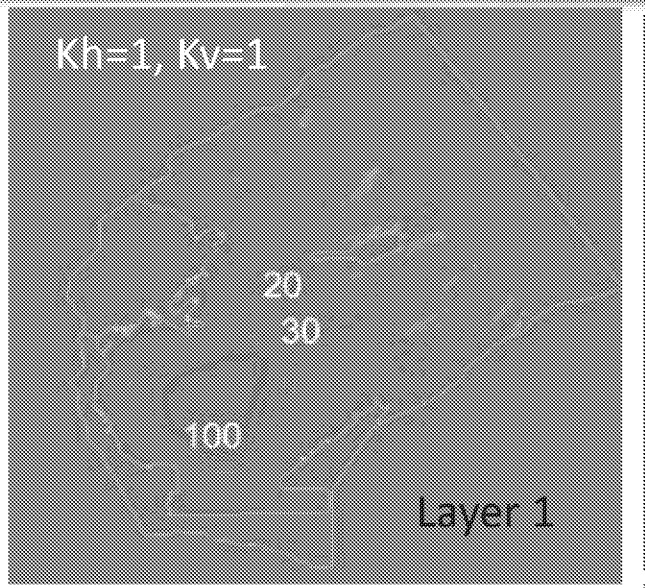
ED_006532_00001954-00016

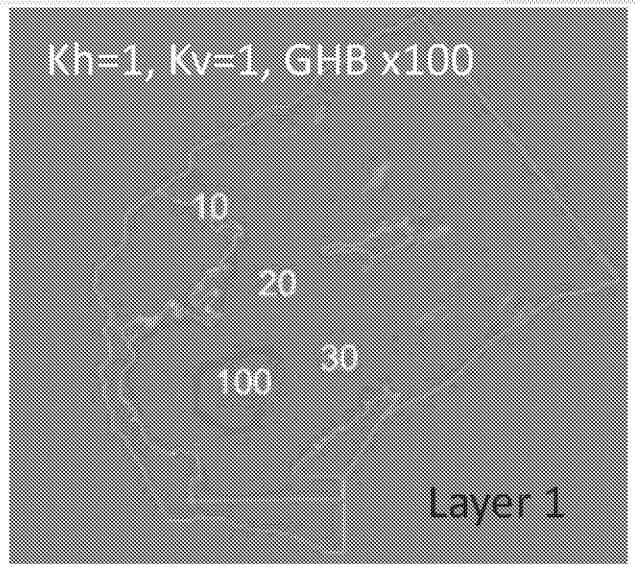
SENSITIVITY TO KH OF CAPROCK – PARAMETER CHANGE

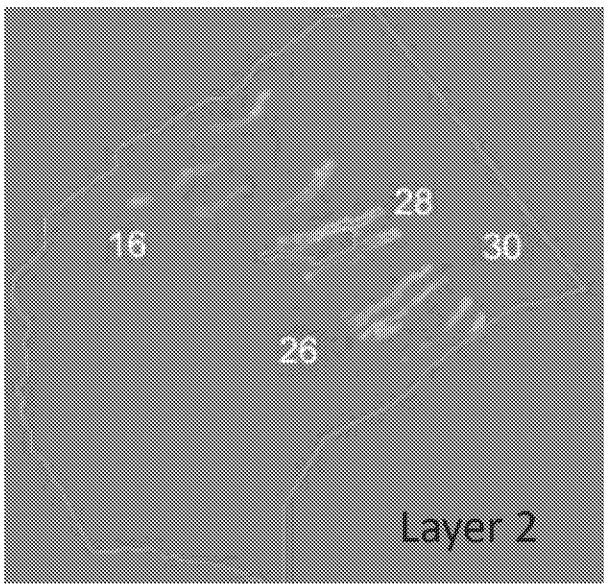
Caprock Kh	Kh (ft/d)
Base	1,208
Lowest Kh	1
Low Kh	100
High Kh	2,400

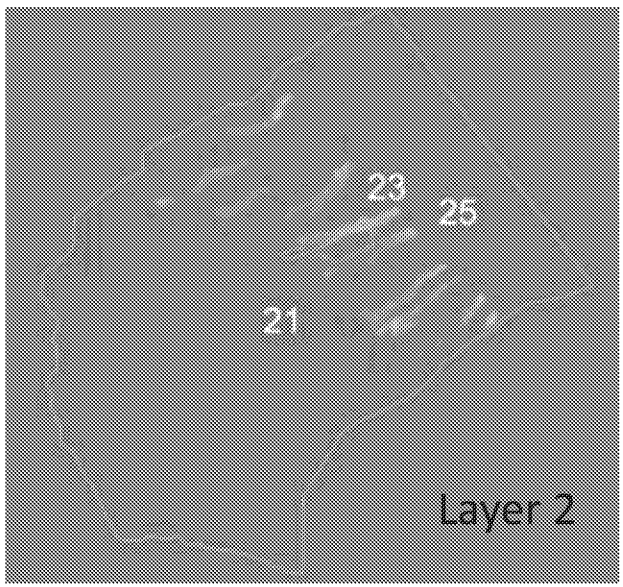
SENSITIVITY TO TO KH OF CAPROCK
2017 WATER LEVELS

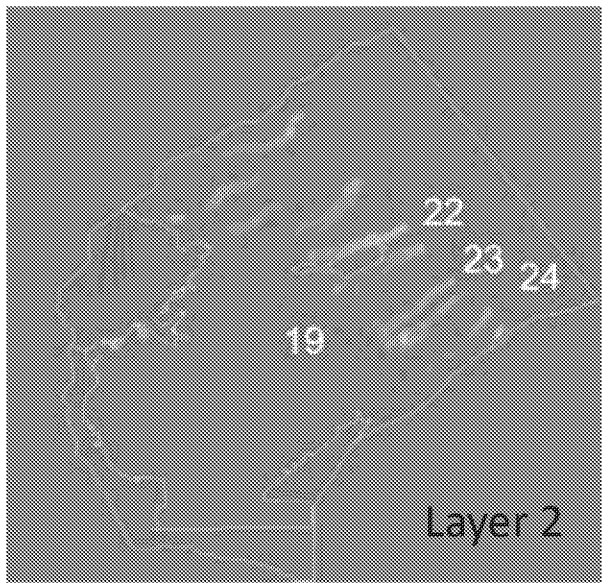




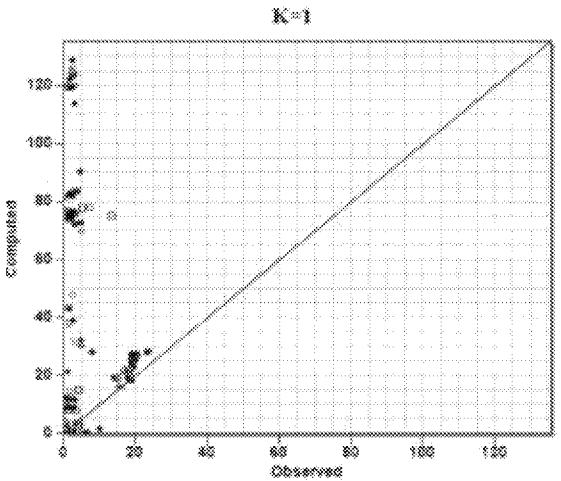


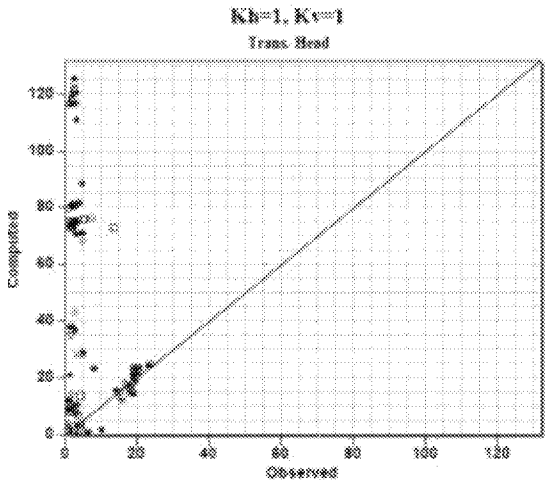


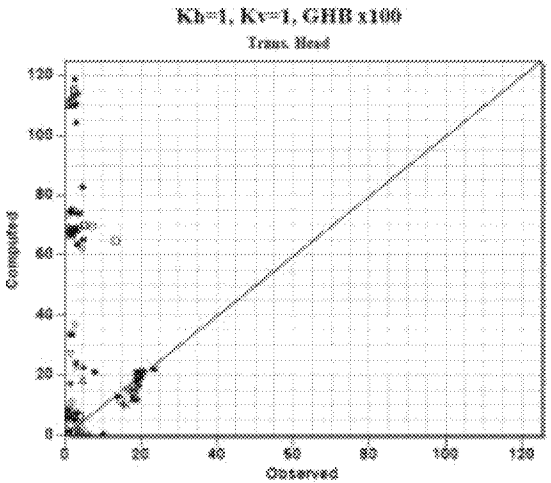




SENSITIVITY TO TO KH OF CAPROCK 2017 SCATTER PLOTS







SENSITIVITY TO KH OF CAPROCK SIMULATION STATISTICS SUMMARY

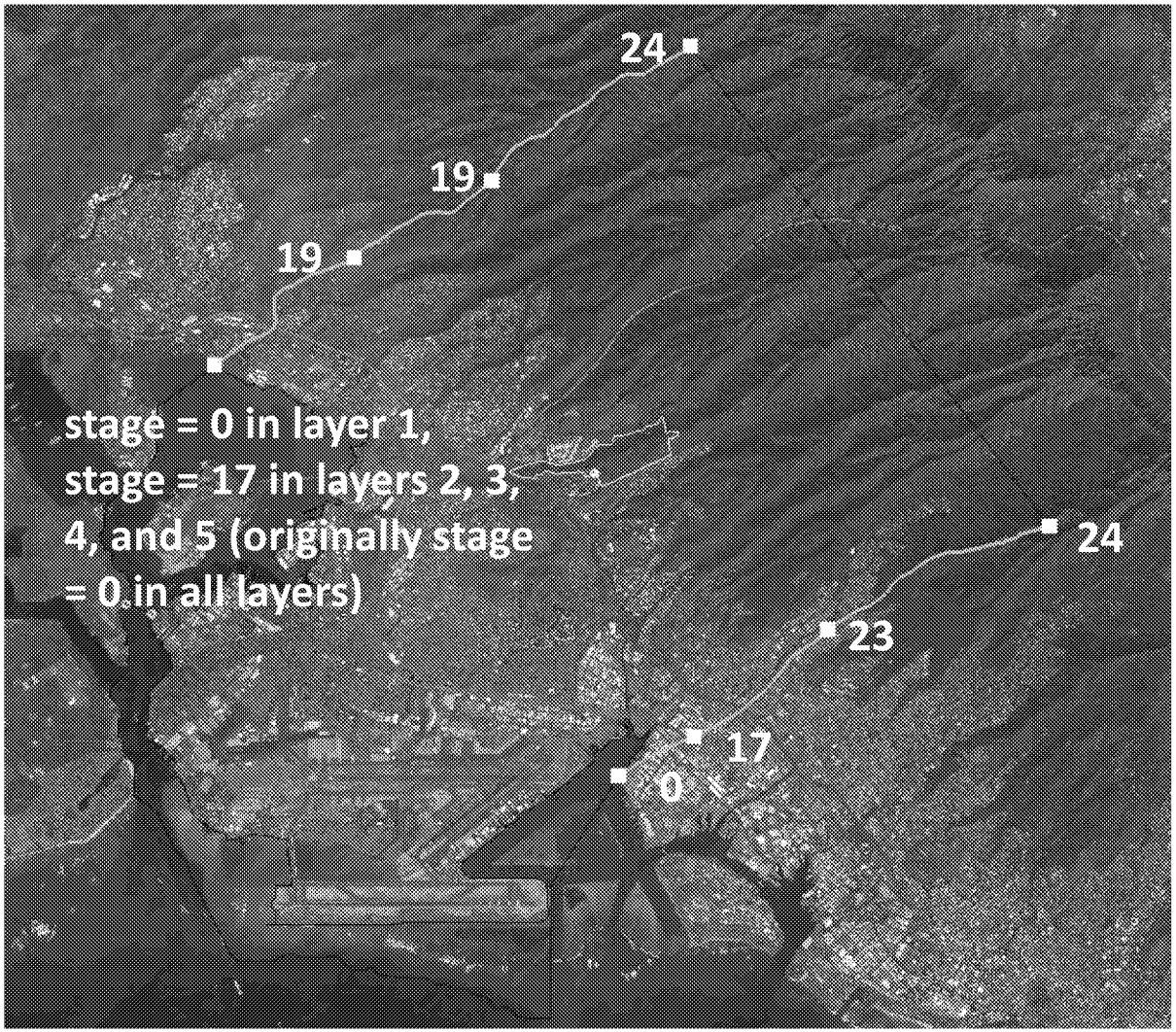
			Pearl Harbor Spring at Kalauao Flux (MGD)			Kalauao Spring Flux (MGD)		
	ME (ft)	RMS (ft)	2006	2015	2017	2006	2015	2017
Original: Caprock Kh = 1208 (ft/d)	-0.25	1.23	10.9	9.4	11.3	0.12	0.10	0.12
Sensitivity Analysis: Caprock Kh = 100 (ft/d)	-2.67	2.93	15.7	13.8	15.8	0.17	0.15	0.17
Sensitivity Analysis: Caprock Kh = 100 ft/d + Caprock Kv = 0.18 (orig = 0.08)	-1.23	1.74	11.1	9.3	11.2	0.12	0.11	0.13
Sensitivity Analysis: Caprock Kh = 1 (ft/d), + Caprock Kv=1 (orig=0.08)	-2.12	2.47	8.0	6.1	7.9	0.1	0.09	0.1
Sensitivity Analysis: Caprock Kh = 1 (ft/d), + Caprock Kv=1 (orig=0.08), +GHB=x100	-1.75	2.12	0.5	0.0	0.4	0.03	0	0.03

Key observations

- Model severely out of calibration with Kh of caprock = 1 ft/d

SENSITIVITY TO INFLUENCE OF GHB STAGE ALONG NW BOUNDARY (1B)

SENSITIVITY TO GHB STAGE: 1B



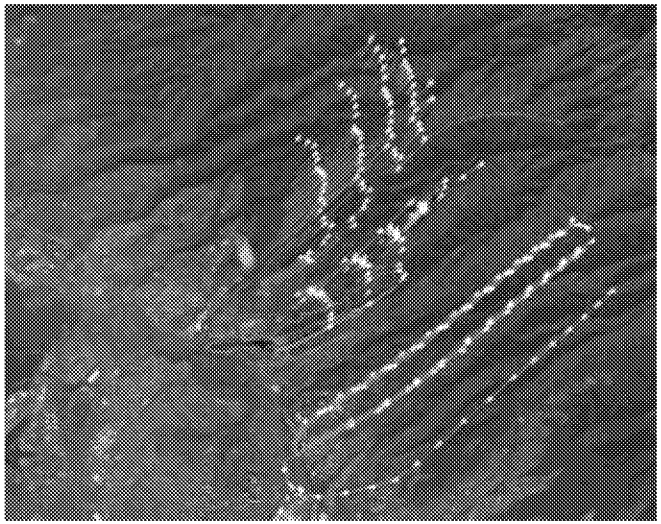
Additional sensitivity to GHB stage.

NW boundary WLE does not reduce to 0 (as per original GHB stage 1 sensitivity) in basalt

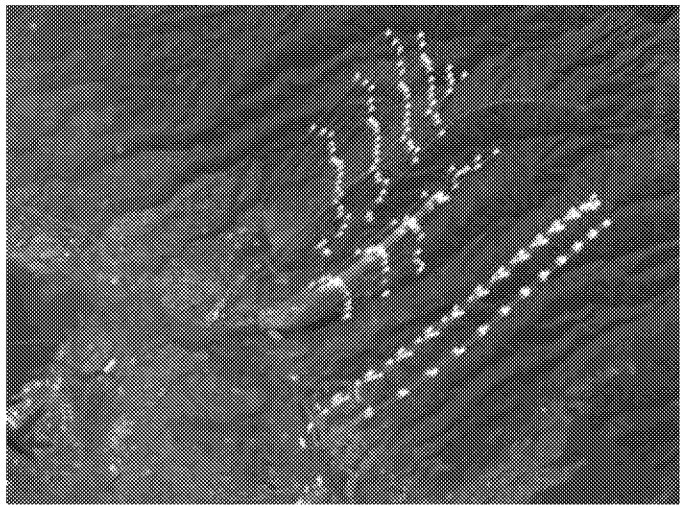
SENSITIVITY OF GHB STAGE: 1B SIMULATION STATISTICS SUMMARY

			Pearl Harbor Spring at Kalauao Flux (MGD)			Kalauao Spring Flux (MGD)		
	ME (ft)	RMS (ft)	2006	2015	2017	2006	2015	2017
Original: GHB=1E-7 ft^2/day/ft	-0.25	1.20	10.9	10.0	11.6	0.12	0.11	0.12
Sensitivity Analysis: GHB=1E7 ft^2/day	-1.05	1.8	10.6	10.8	11.1	0.14	0.14	0.15
Sensitivity Analysis: GHB=1E7 ft^2/day, + stage = 17 ft at PH Bay in layers 2, 3, 4, and 5	-1.75	2.12	21.2	21.4	21.7	0.2	0.2	0.21
Sensitivity Analysis: GHB=1E7 ft^2/day, + stage = 17 ft at PH Bay in layers 2, 3, 4, and 5, + drain conductance=10,000 ft^2/d	-1.82	2.18	11.2	11.3	11.4	0.23	0.24	0.24

SENSITIVITY TO GHB STAGE: 1B
RED HILL SHAFT ON



GHB Stage 1



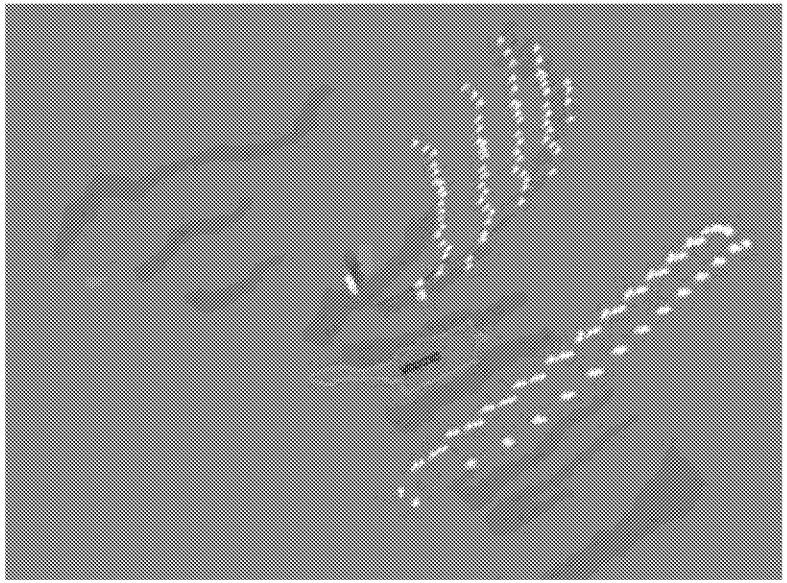
GHB Stage 1B

Arrows are 1-year time interval markers
Pathline colors,
Layer 1,
Layer 2,
Layer 3,
Layer 4,
Layer 5

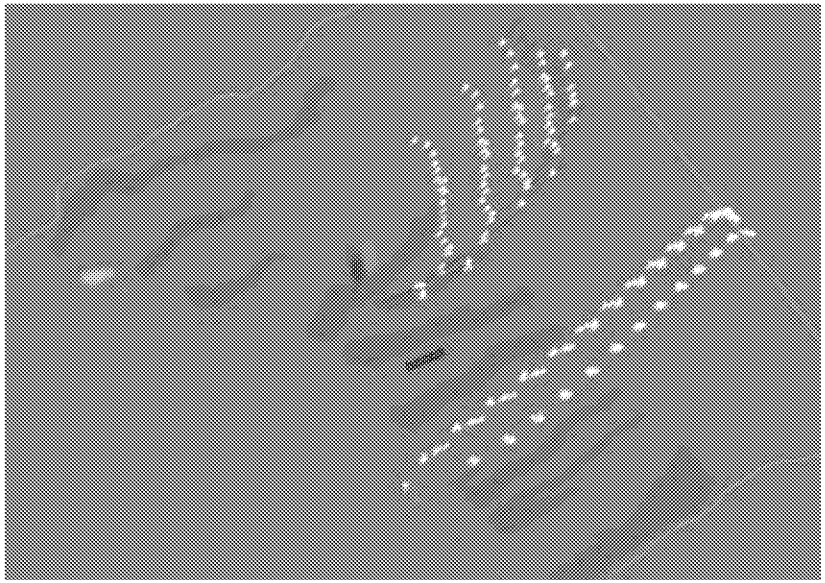
Key Observations

- Capture zones are not sensitive to GHB stage along NW within basalt at Pearl Harbor
- Red Hill Shaft captures water originating from the water table beneath tanks at Red Hill Storage Facility footprint

SENSITIVITY TO GHB STAGE: 1B
RED HILL SHAFT OFF



GHB Stage 1



GHB Stage 1B

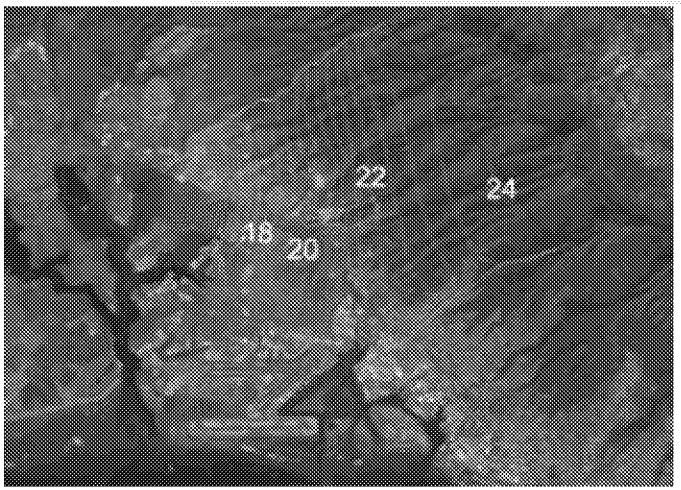
Arrows are 1-year time interval markers

Pathline colors,
Layer 1,
Layer 2,
Layer 3,
Layer 4,
Layer 5

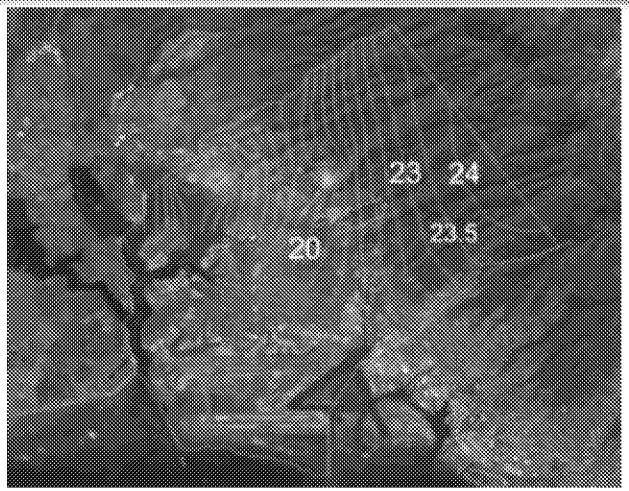
Key Observation

- Capture zones are not sensitive to GHB stage along NW within basalt at Pearl Harbor
- Halawa Shaft does not capture water originating from the water table underneath Red Hill Storage Facility tanks

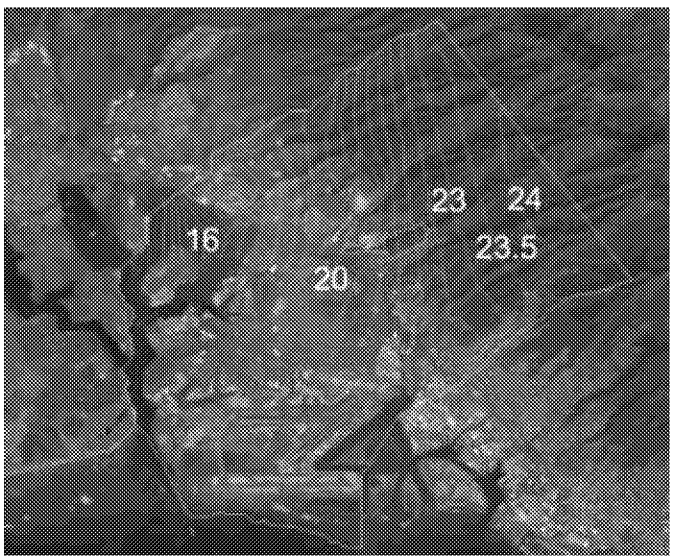
SENSITIVITY OF GHB STAGE: 1B
WATER LEVELS IN LAYER 3 (0.5 FT INTERVAL)



GHB Stage: 1



GHB Stage: 1B without drain conductance adjustment



GHB Stage: 1B with drain conductance =10,000 ft^2/d

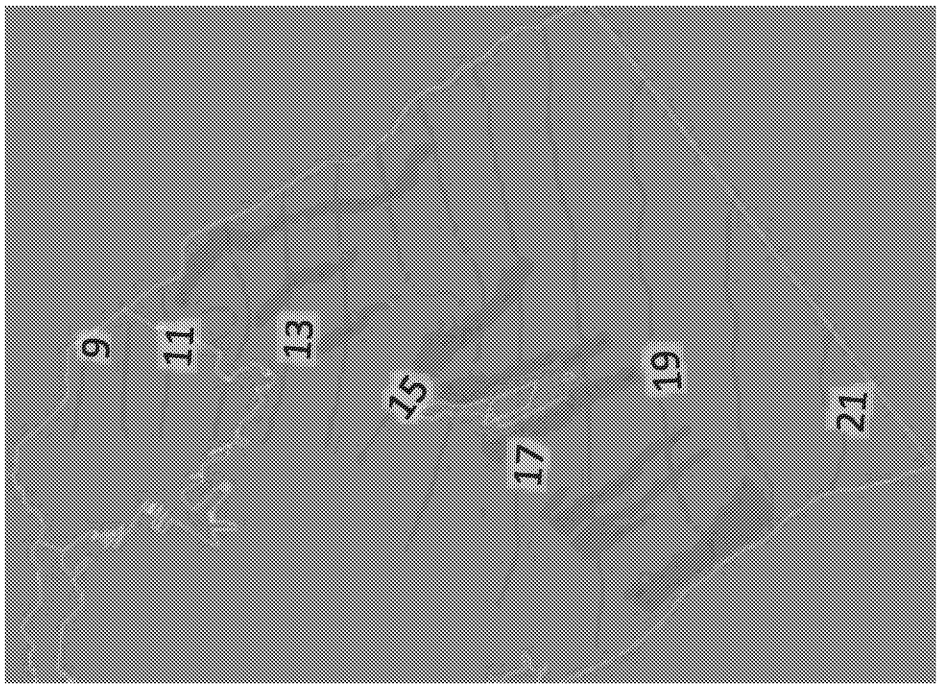
SENSITIVITY TO SAPROLITE PROPERTIES SAME AS BASALT – STATISTICS SUMMARY INCLUDING RECALIBRATED MODEL

			Pearl Harbor Spring at Kalauao Flux (MGD)			Kalauao Spring Flux (MGD)		
	ME (ft)	RMS (ft)	2006	2015	2017	2006	2015	2017
Original: Layer 2 Saprolite Kh = 0.1 ft/d; Kv = 0.01 ft/d; HANI = 1.0; n = 0.15 Layer 3 Saprolite Kh = 10 ft/d; Kv = 1 ft/d; HANI = 1.0; n = 0.15	-0.25	1.23	10.9	9.4	11.3	0.12	0.10	0.12
Sensitivity Analysis: Layer 2 Saprolite Kh = 2000 ft/d; Kv = 20 ft/d; HANI = 0.33; n = 0.04 (same as Basalt) Layer 3 Saprolite Kh = 2000 ft/d; Kv = 20 ft/d; HANI = 0.33; n = 0.04 (same as Basalt)	1.61	2.15	7.6	6.3	8.1	0.09	0.07	0.09
Sensitivity Analysis: Layer 2 Saprolite Kh = 2000 ft/d; Kv = 20 ft/d; HANI = 0.33; n = 0.04 (same as Basalt), Layer 3 Saprolite Kh = 2000 ft/d; Kv = 20 ft/d; HANI = 0.33; n = 0.04 (same as Basalt), + caprock Kv=0.05 ft/d	0.66	1.56	10.2	8.8	10.7	0.21	0.19	0.22

SENSITIVITY TO SAPROLITE PROPERTIES SAME AS BASALT

SENSITIVITY TO SAPROLITE PROPERTIES SAME AS BASALT – 2017 WATER LEVEL ELEVATIONS IN LAYER 2

Base Case, 2017



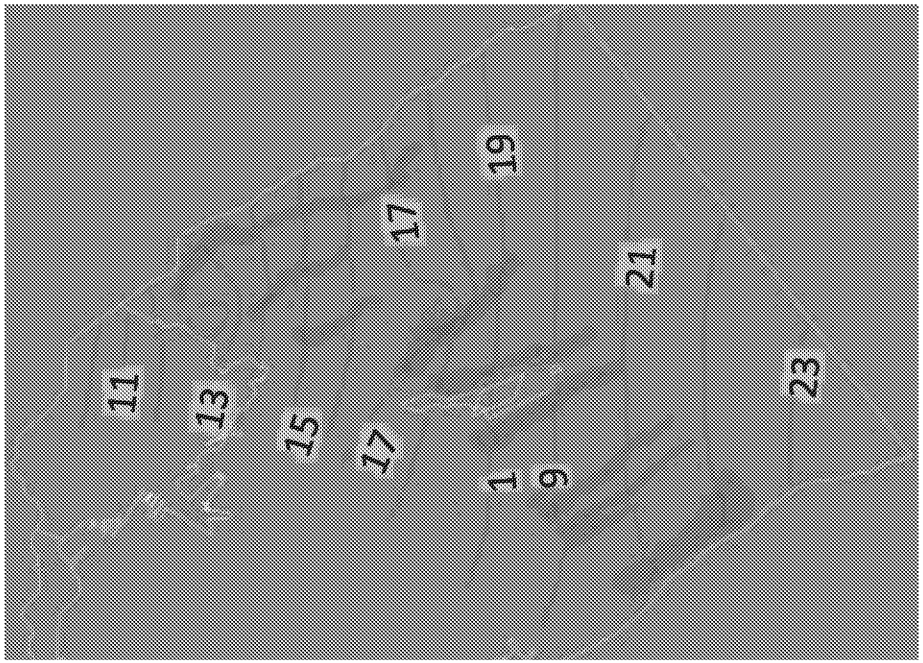
Saprolite same as basalt, 2017

Key Observations:

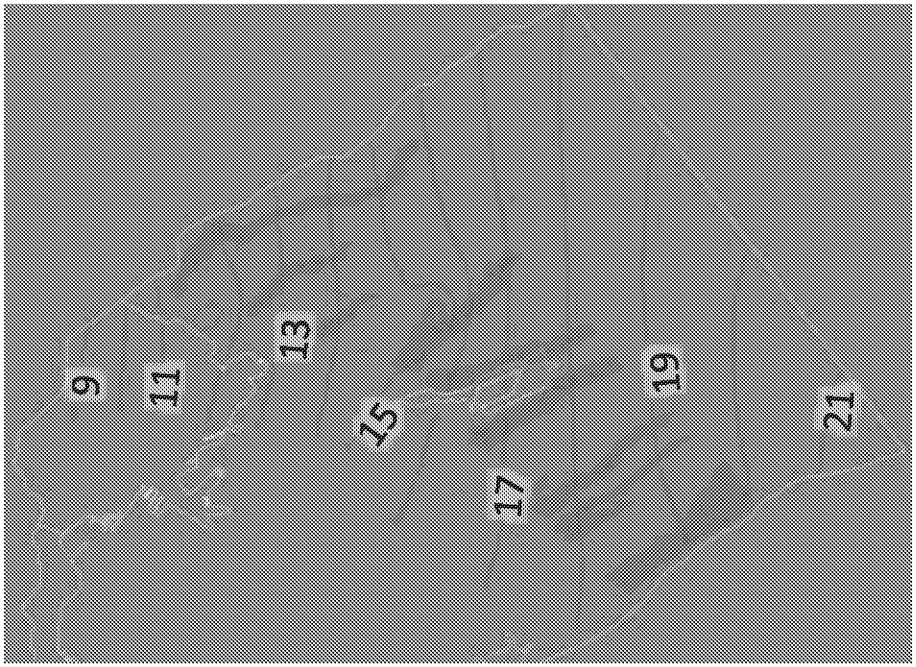
- No mounding within saprolite as in base case
- Water levels in basalt are lower than for base case by about 2 feet

ED_006532_00001954-00029

SENSITIVITY TO SAPROLITE PROPERTIES SAME AS BASALT – 2017 WATER LEVEL ELEVATIONS IN LAYER 3



Base Case, 2017



Saprolite same as basalt, 2017

Key Observations:

- Water levels are lower than for base case by about 2 feet

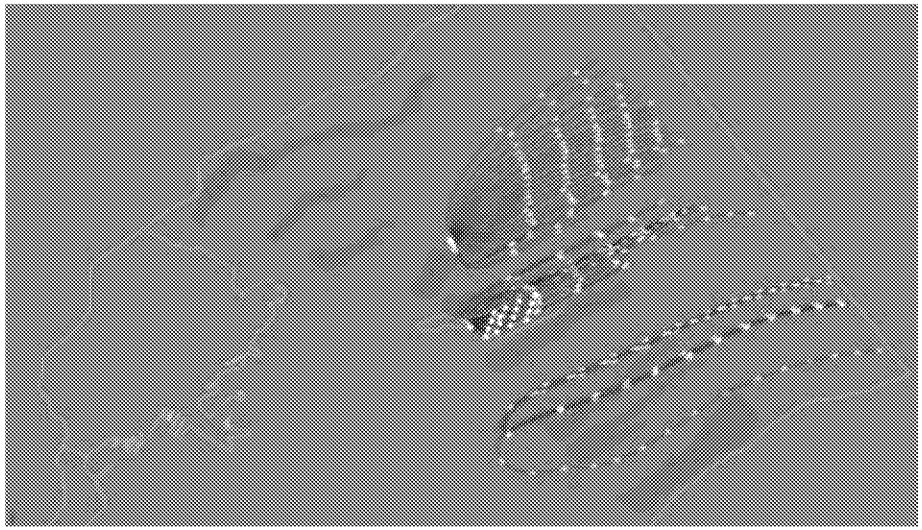
SENSITIVITY TO SAPROLITE PROPERTIES SAME AS BASALT – SIMULATION STATISTICS SUMMARY

			Pearl Harbor Spring at Kalauao Flux (MGD)			Kalauao Spring Flux (MGD)		
	ME (ft)	RMS (ft)	2006	2015	2017	2006	2015	2017
Original: Layer 2 Saprolite Kh = 0.1 ft/d; Kv = 0.01 ft/d; HANI = 1.0; n = 0.15 Layer 3 Saprolite Kh = 10 ft/d; Kv = 1 ft/d; HANI = 1.0; n = 0.15	-0.25	1.23	10.9	9.4	11.3	0.12	0.10	0.12
Sensitivity Analysis: Layer 2 Saprolite Kh = 2000 ft/d; Kv = 20 ft/d; HANI = 0.33; n = 0.04 (same as Basalt) Layer 3 Saprolite Kh = 2000 ft/d; Kv = 20 ft/d; HANI = 0.33; n = 0.04 (same as Basalt)	1.61	2.15	7.6	6.3	8.1	0.09	0.07	0.09

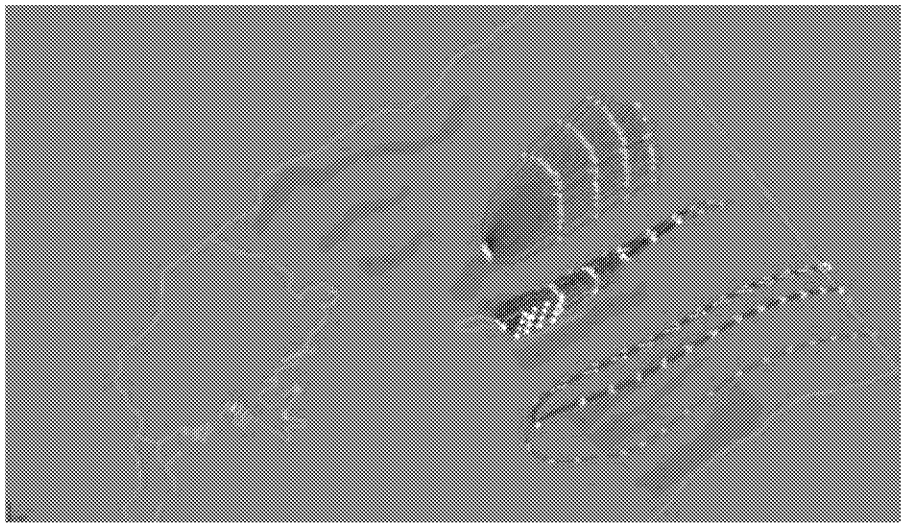
Key observations

- Calibration statistics and drain fluxes slightly sensitive to saprolite properties being same as basalt

SAPROLITE PROPERTIES SAME AS BASALT
RED HILL SHAFT ON



Base Case



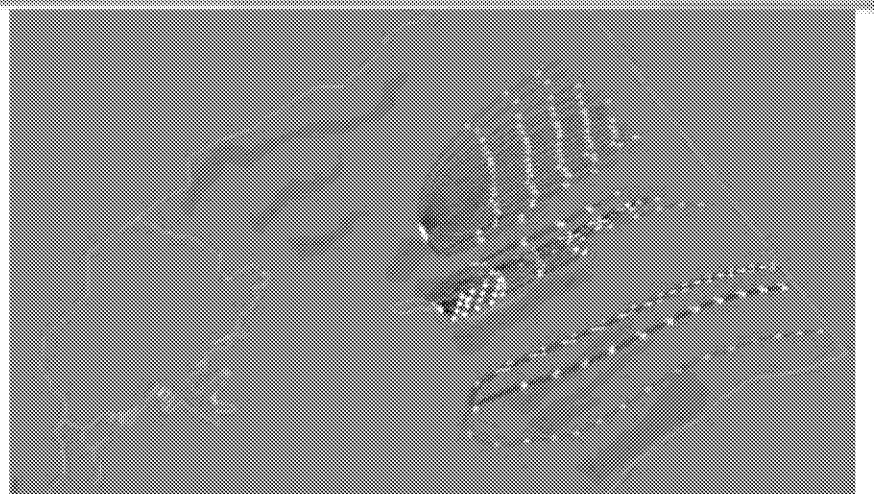
Saprolite same as basalt

Arrows are 1-year time interval markers

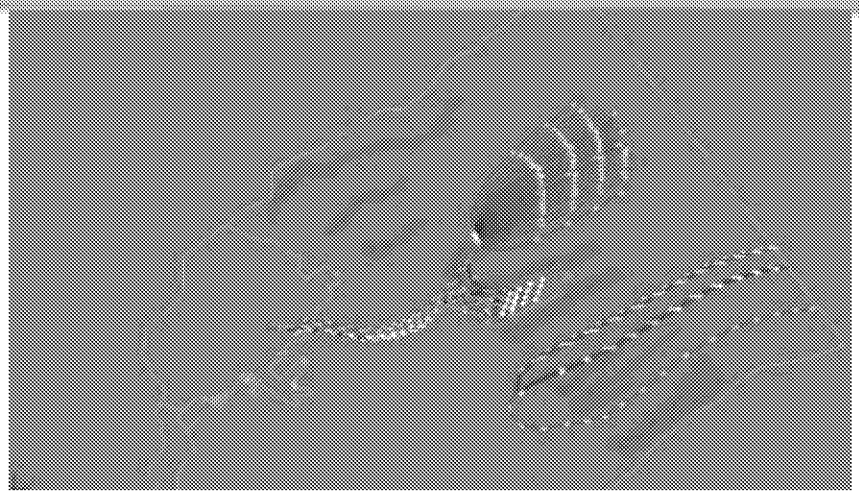
Key Observations

- Predictions are highly sensitive to saprolite properties being same as basalt
- Red Hill Shaft captures water traveling beneath Red Hill Storage Facility

SAPROLITE PROPERTIES SAME AS BASALT
RED HILL SHAFT OFF – PARTICLE TRACKS



Base Case



Saprolite same as basalt

Arrows are 1-year time interval markers

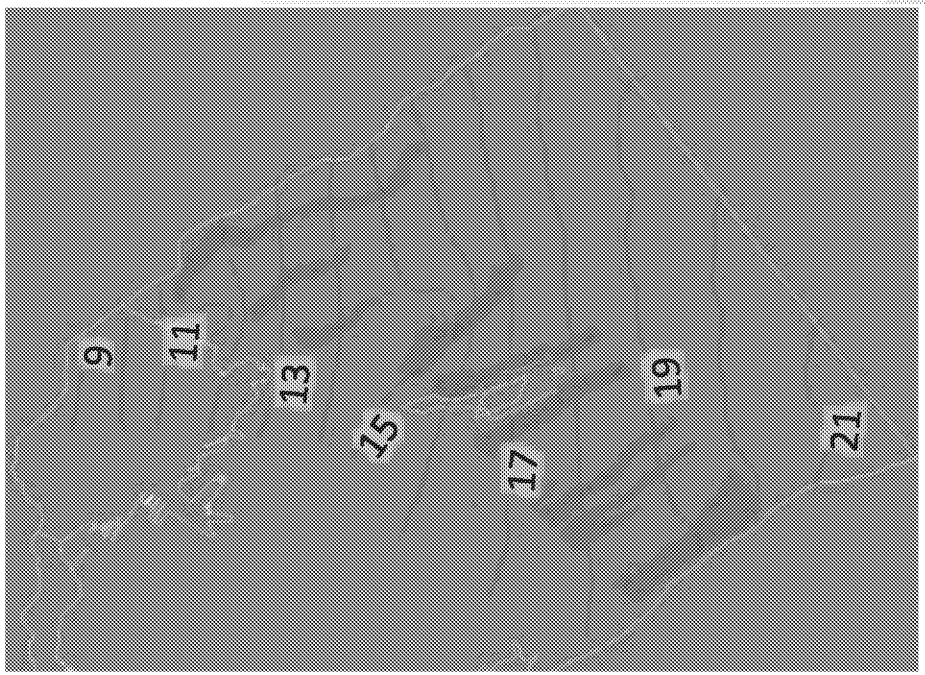
Assumptions

- Red Hill Shaft is not pumping for over 3 years
- Halawa Shaft is continuously pumping at 16 MGD for 3 years
- Saprolite material properties same as basalt
- These assumptions exceed criteria for reasonable worst-case analyses

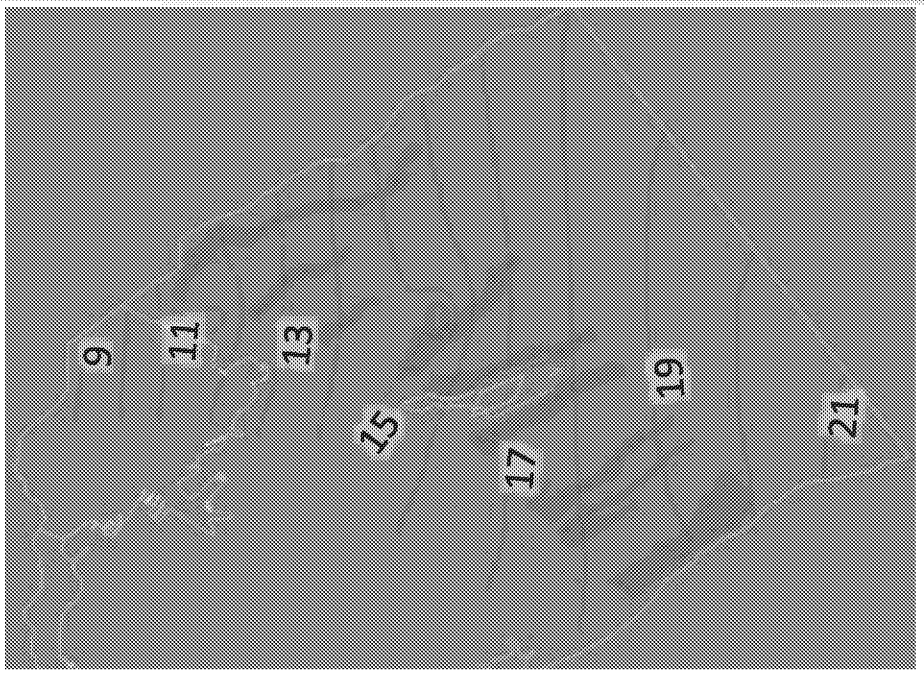
Key Observations

- Predictions are highly sensitive to saprolite properties being same as basalt
- Water from beneath the Red Hill Storage Facility moves in the SW direction then turns towards Halawa Shaft before entering caprock and traveling towards Pearl Harbor
- Halawa Shaft does not capture water from the water table beneath Red Hill Storage Facility
- Insensitive to calibration but sensitive to conclusion = Type IV

SAPROLITE PROPERTIES SAME AS BASALT
RED HILL SHAFT OFF – WATER LEVELS



Layer 2



Layer 3

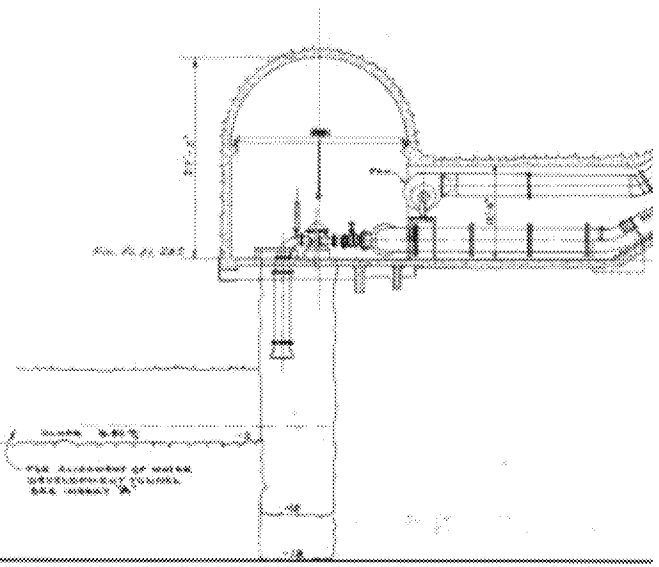
Key Observations

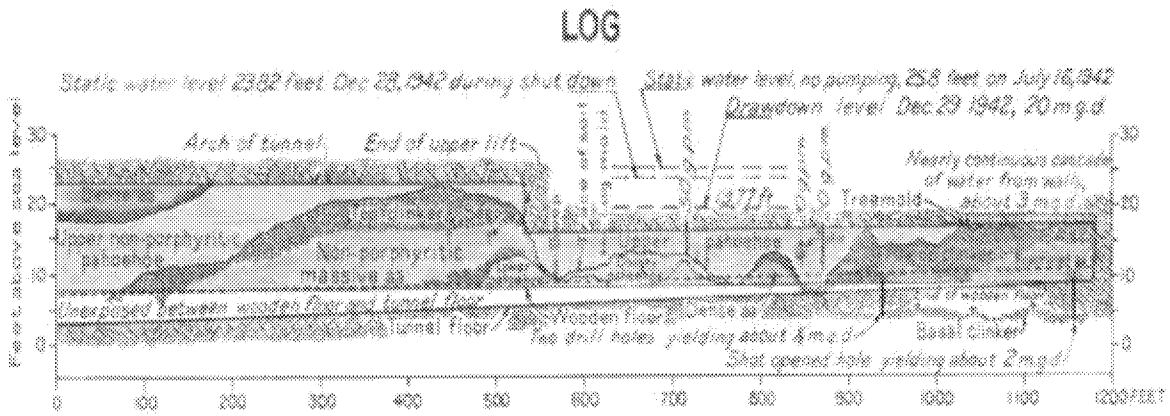
- Water levels are similar in layer 2 and layer 3

SENSITIVITY – INCORPORATE HĀLAWA SHAFT AND RED HILL SHAFT AS-BUILTS INTO MODEL

SENSITIVITY TO SHAFT ELEVATION

Base	Changed
Halawa Shaft Elevation, -18 ft/d	-2 ft msl (as-built shows -2 to +2.6 ft msl)
Red Hill Shaft Elevation, -10 ft msl	+3 ft msl (as-built shows +3 to +10 ft msl)





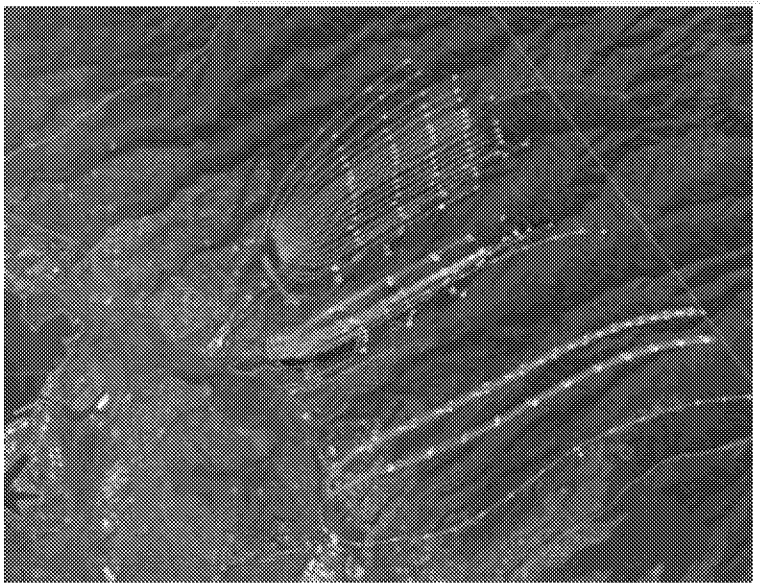
SENSITIVITY TO SHAFT ELEVATION SIMULATION STATISTICS SUMMARY

			Pearl Harbor Spring at Kalauao Flux (MGD)			Kalauao Spring Flux (MGD)		
	ME (ft)	RMS (ft)	2006	2015	2017	2006	2015	2017
Original: Halawa shaft at -18 ft msl Red Hill shaft at -10 ft msl	-0.25	1.20	10.9	10.0	11.6	0.12	0.11	0.12
Sensitivity Analysis: Halawa shaft at -2 ft msl Red Hill shaft at +3 ft msl	-0.17	1.21	10.8	9.3	11.2	0.12	0.10	0.12

Key observations

- Calibration statistics are insensitive to shaft elevations

SENSITIVITY TO SHAFT ELEVATION RED HILL SHAFT ON



Base Case

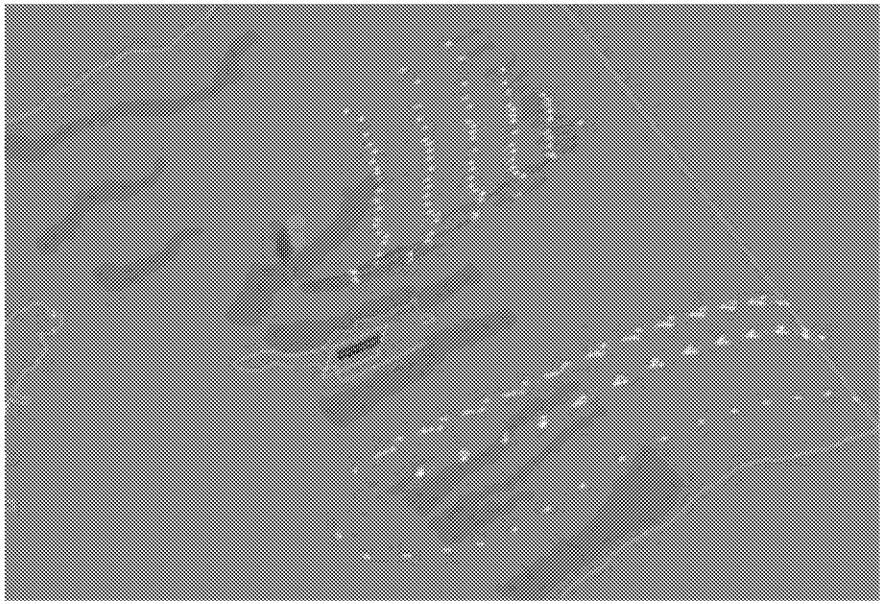
Halawa Shaft at -2 ft msl
Red Hill Shaft at +3 ft msl

Key Observations

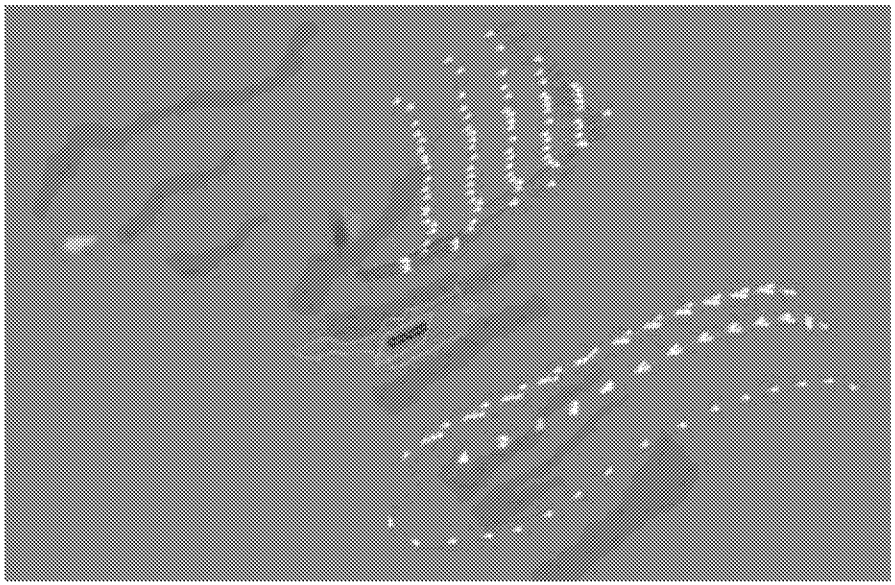
- Predictions are insensitive to shaft elevations

Arrows are 1-year time interval markers
Pathline colors, Layer 1, Layer 2, Layer 3, Layer 4, Layer 5

SENSITIVITY TO SHAFT ELEVATION
RED HILL SHAFT OFF



Base Case



Halawa Shaft at -2 ft msl
Red Hill Shaft at +3 ft msl

Arrows are 1-year time interval markers
Pathline colors, Layer 1, Layer 2, Layer 3, Layer 4, Layer 5

Key Observations

- Predictions are insensitive to shaft elevations
- Sensitivity Type = I

SENSITIVITY TO RIND OF LOW KH CAPROCK

OTHER DISCUSSION ITEMS

- **Synoptic water level study status**

NEXT GWFM WORKING GROUP MEETING

- June 7, 2018: in-person, all-day meeting