



Reliable Solar Pumps Boost Gas Production at Upper Midwest Landfill . . . In Winter

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Class D landfill agency installs gas system in 2010

- Production disappoints
- Possible leachate migration
- High costs of expansion, power

Agency engages local Foth engineers to define issues, offer solutions, implement



Cedar Rapids - 42° North Latitude



First Steps

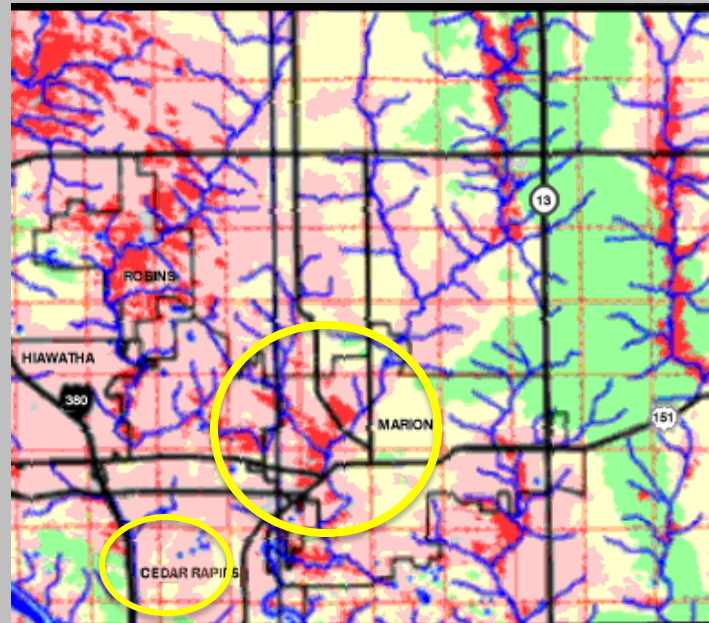
Foth prepares assessment & controlled-measures study



Lead engineer
Brian Harthun

Study postulates:

1. Less liquid in well could mean:
 - More gas production
 - Reduced impact to groundwater
2. Low-flow pumps might do the job



GROUNDWATER VULNERABILITY MAP

- Most vulnerable aquifers
- Vulnerable aquifers
- Less vulnerable aquifers
- Protected aquifers

Test Plan

4-month in-well test

- Landfill site #2, NE of city
- 3 wells, deeper than 50 ft.
- 30-acre closed cell

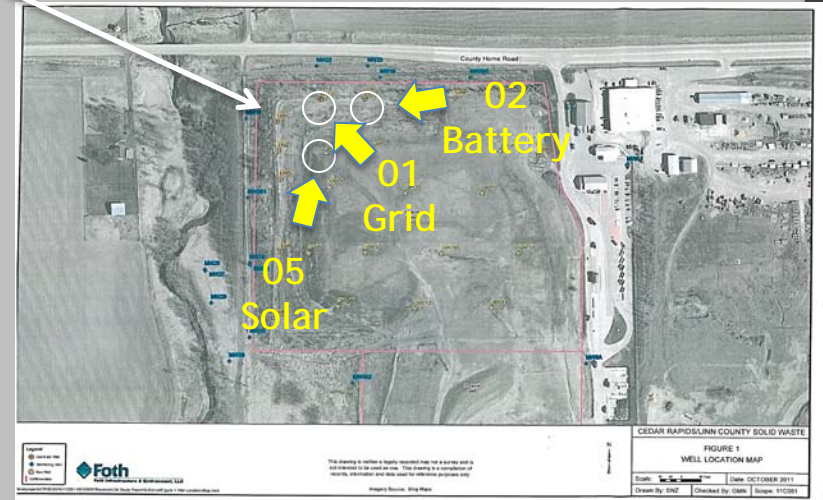
3 pump-power options

- Electric grid: GW-01
- Solar with batteries: GW-02
- Solar panel only: GW-05

Clockwise
from upper
left: Wells
GW-01, GW-02
GW-05



Linn County landfill



Test Comparisons

3 Apollo™ pumps installed

- Identical motors
- Linear-rod driver, piston action
- Low flow -- <2 gpm (7.6 lpm)
- Intakes at 1-3 feet above bottom
- Test begins Dec. 2011, winter



Apollo Model 101 with solar battery pack



1 power source for each pump

- Electric 220v AC to 24v DC (GW-01)
- Solar panel with 12v batteries (GW-02)
- Solar panel direct to motor (GW-05)

Wells Nearly Identical

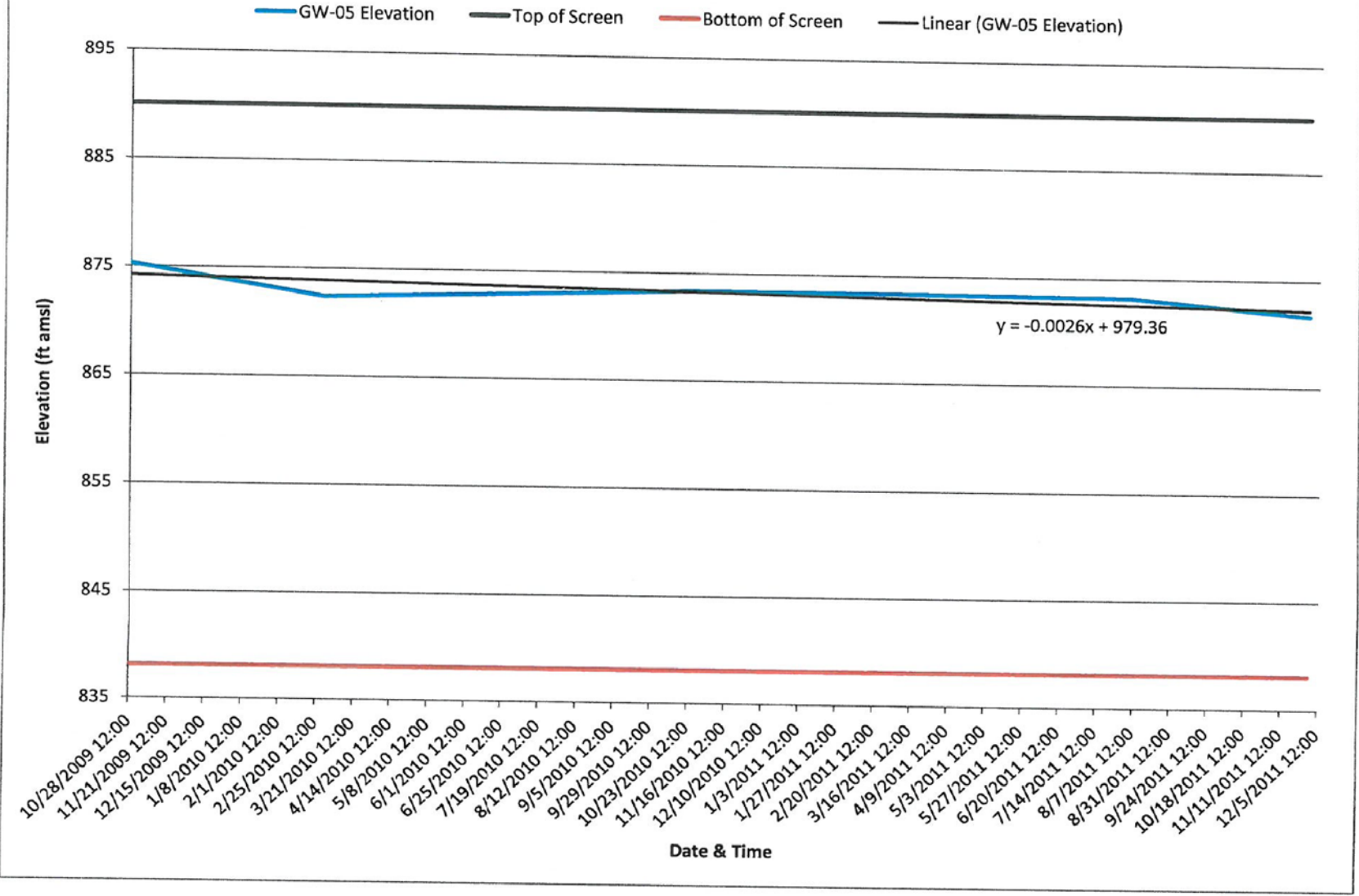
Gas Well	Initial Liquid Elevation (ft amsl)	Pump Intake (ft amsl)	Top of Screen (ft amsl)	Bottom of Screen (ft amsl)
GW-01	865.55	~850	886.35	840.35
GW-02	868.56	~849	888.21	843.21
GW-05	871.67 ⁽¹⁾	~849	890.07	838.07

(1) = Measured on 11/29/2011. Pump installed 12/21/2011. Initial depth to liquid not measured.

G. Nauman and B. Harthun,
Foth Infrastructure & Environment,
LLC, Client memorandum, 2012



Graph 3 - Liquid Elevations in GW-05 (Prior to Pumping)



Test Methods

Measurements

- Liquid levels Dec. 2011 thru March 2012
- Transducers installed 3/6/12; report every 15 minutes
- Methane & O₂ noted before & during operations
- Lantec GEM™ 2000 gas analyzer records variations
- 42° North latitude (= Toronto)
 - 65-76% cloudy days; 10-11 hrs./day sunlight



Test Findings - Power Sources

Results: All options viable

- All 3 sources, including solar, dewater wells -- reduce liquid to intake
- Low-flow pumping proves effective
- Ave. 24-hr. groundwater levels satisfactorily lowered and maintained; addresses migration



Linear-rod motor with open hood

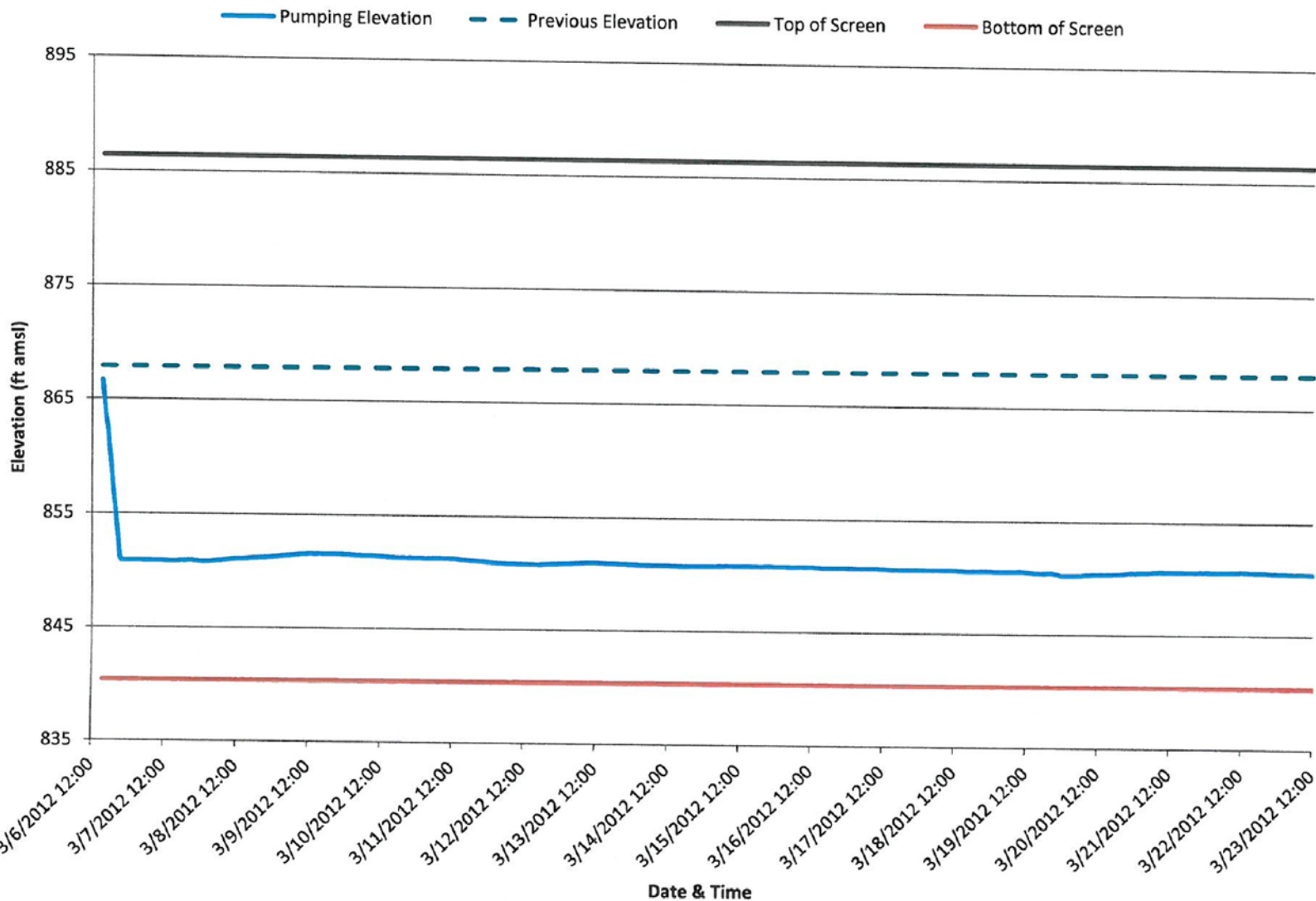
Solar Only Results

- Solar maintains low liquid levels over each 24-hour span
- On-off matches day/night
- 3-4 feet accumulates at night, and . . .
- . . . Morning pumping lowers to intake
- Consistent day to day
- No maintenance

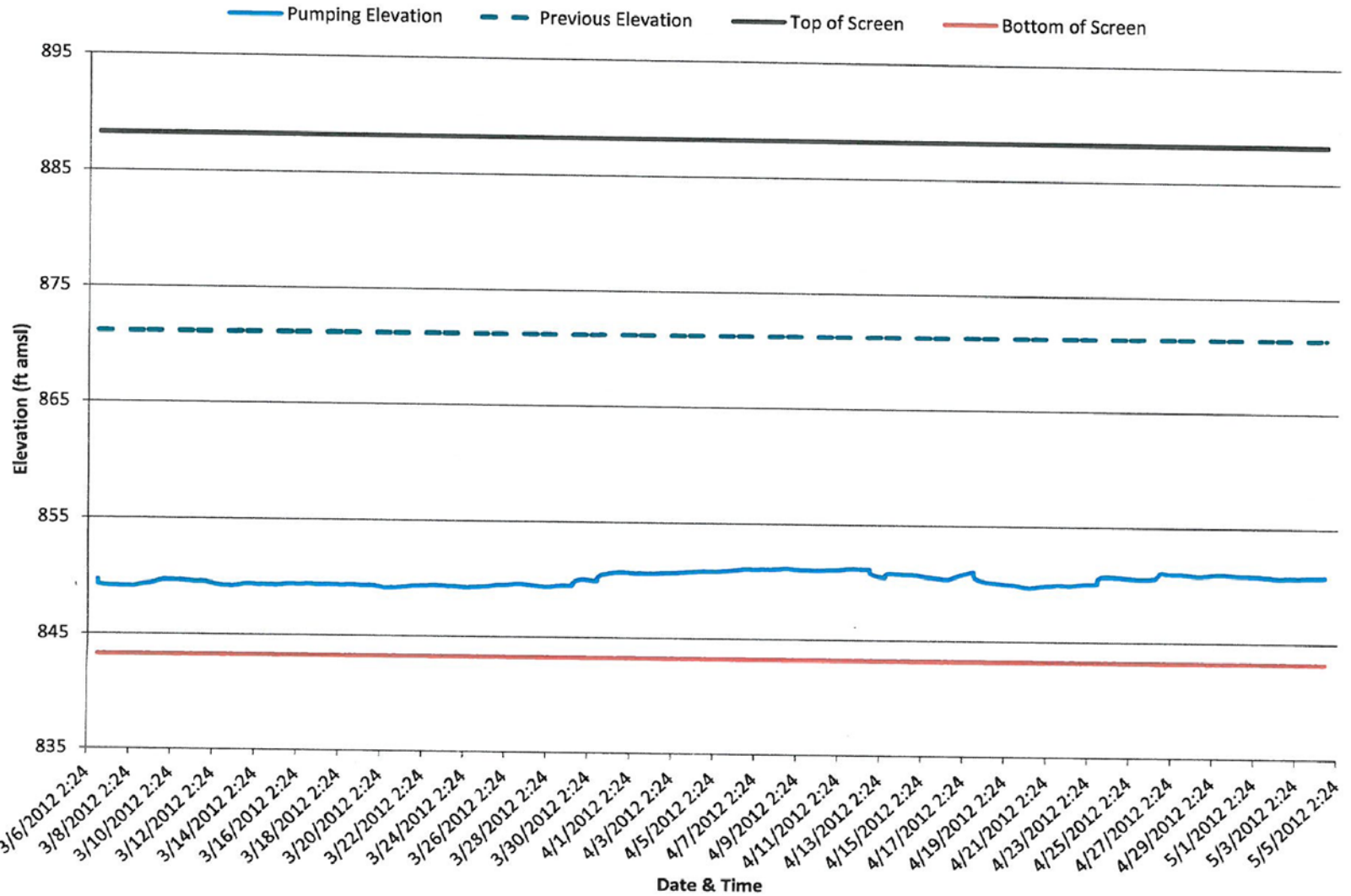


Site installed simple insulation below driver

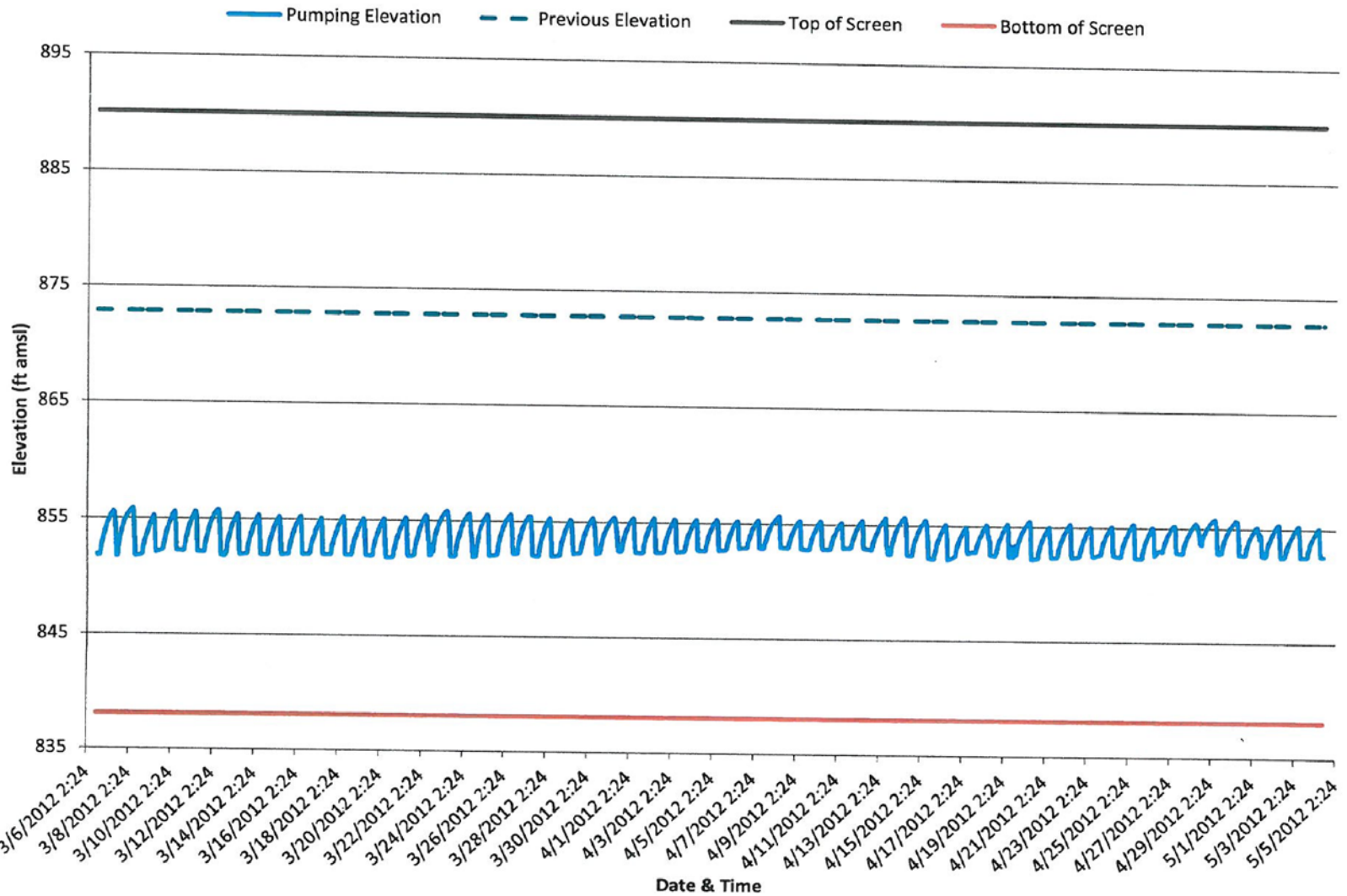
Graph 4 - Liquid Elevations in GW-01 (During Pumping)



Graph 5 - Liquid Elevations in GW-02 (During Pumping)



Graph 6 - Liquid Elevations in GW-05 (During Pumping)



Significantly More Gas

More screen = More gas

- All power sources dewatered 75-90%+ screen (15-18+ ft.) in each well
- Methane production increased 15%+ in electric & solar-battery wells . . .
- And 20%+ in solar-only
- Positive correlation: More screen exposure and higher methane flow



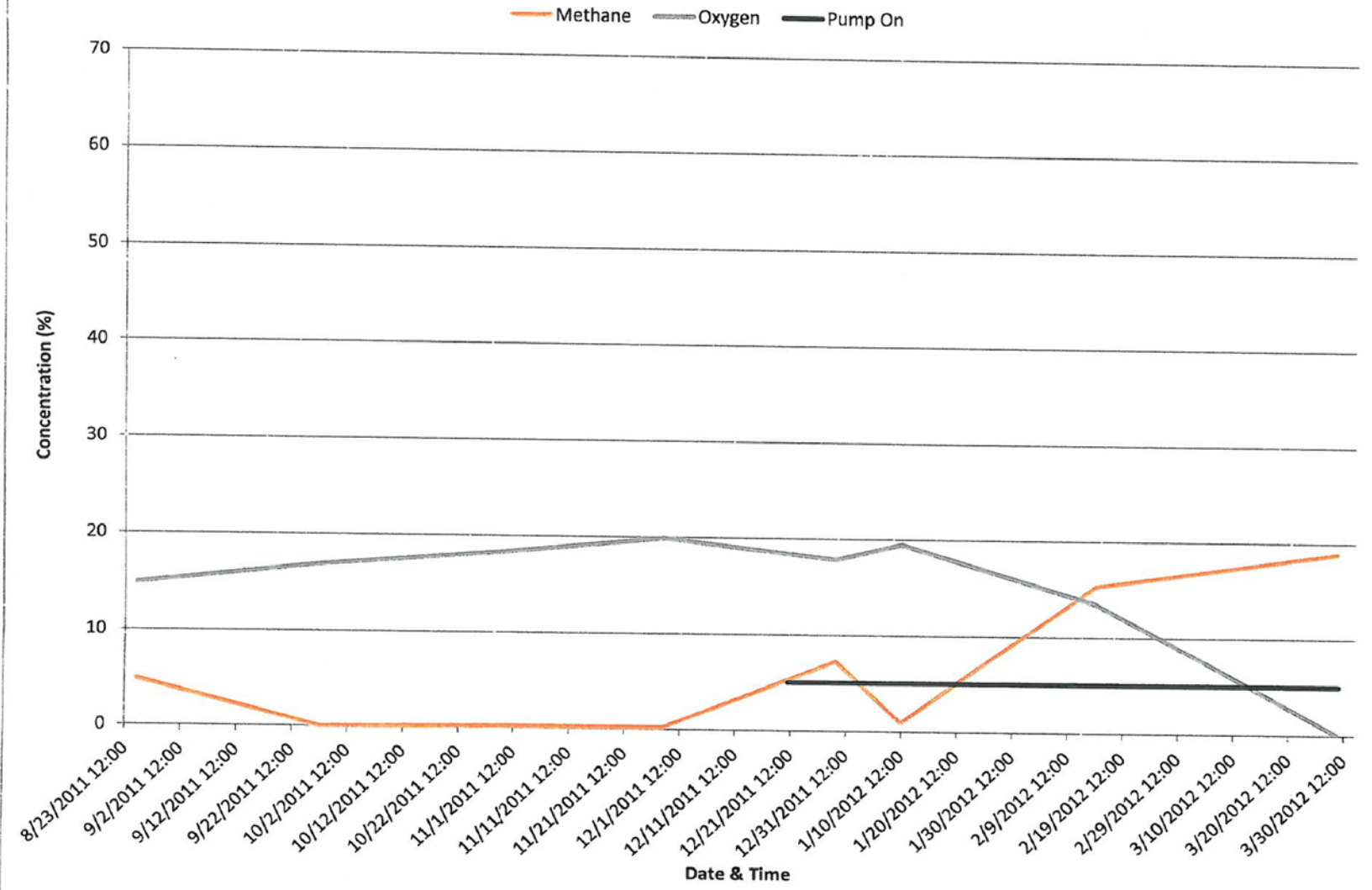
Screen Exposure to Methane Flow

Gas Well	Initial Liquid Elevation (ft amsl)	Average Liquid Elevation During Pumping (ft amsl)	Initial Length of Screen Exposed (feet)	Length of Screen Exposed During Pumping (feet)	Percent Of Additional Screen Exposed During Pumping	Percent Increase in Methane Flow
GW-01	865.55	850.96	20.80	36.42	75.0	15.9
GW-02	868.56	850.15	19.65	38.06	93.6	17.3
GW-05	871.67	853.65	18.40	35.39	92.3	20.2

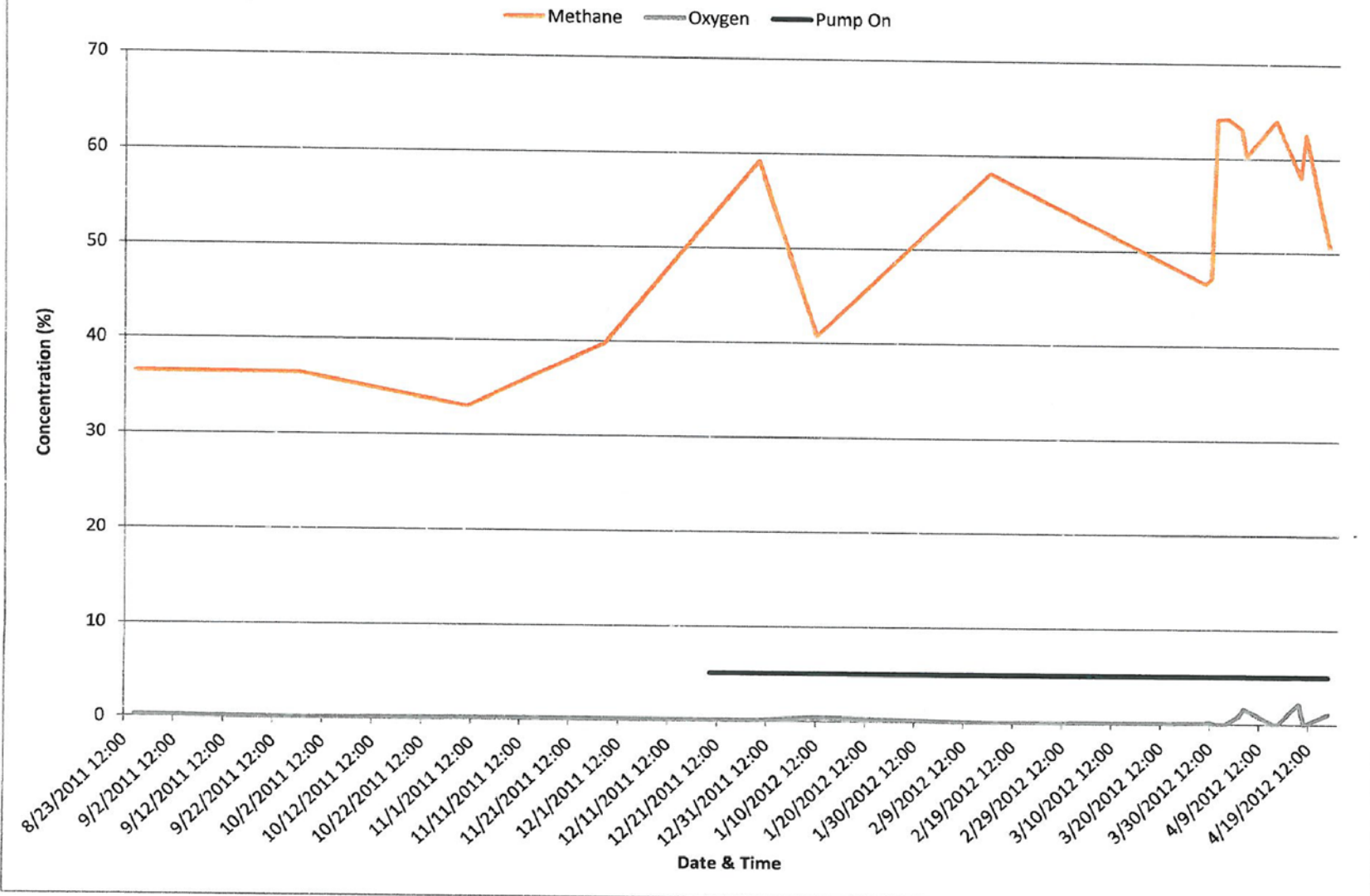
G. Nauman and B. Harthun, Foth Infrastructure & Environment, LLC, Client memorandum, 2012



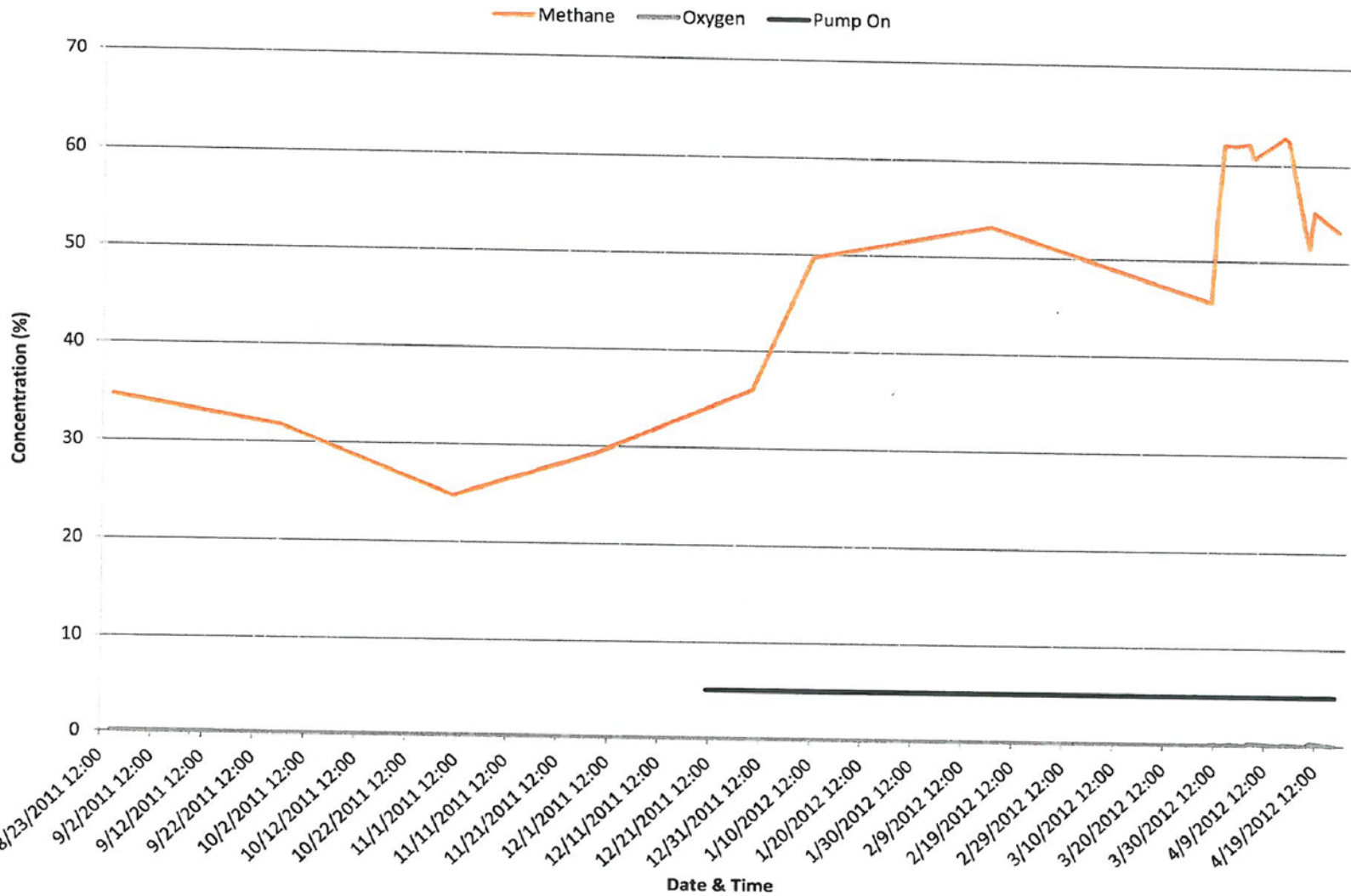
Graph 7 - Gas Concentrations at GW-01



Graph 8 - Gas Concentrations at GW-02



Graph 9 - Gas Concentrations at GW-05



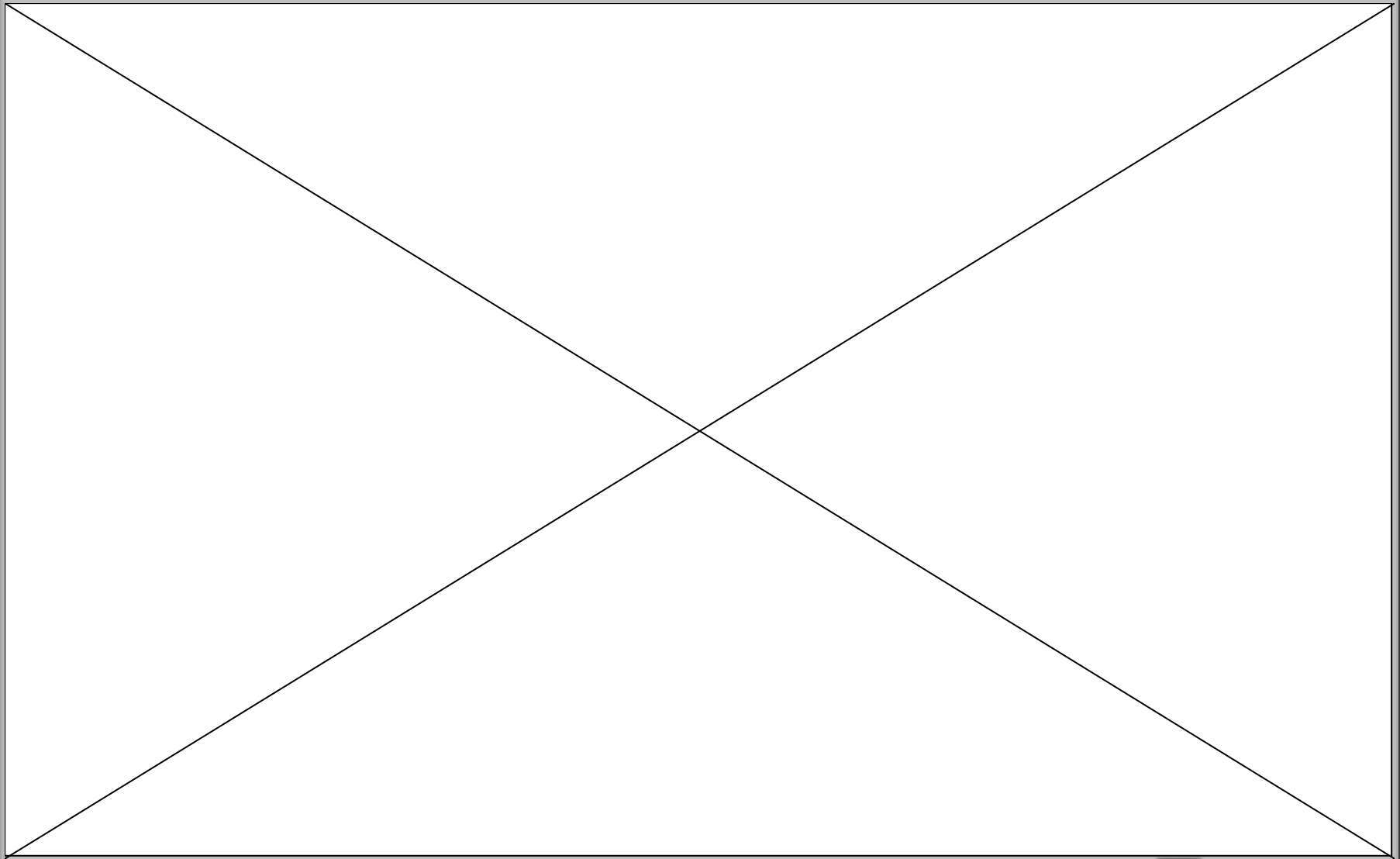
Specs and Action

More solar pumps installed

- Foth specs solar-only low-flow pumps for all site gas wells
- System expands: No costs for compressors, grid, batteries or new lines
- Pumps continue to operate satisfactorily: 2+ years, no or minimal maintenance



How Solar Pumps Work



Thank You



Mark Bertane

Pneumatic and Electric Pumps



Atlas Pneumatic Ext., Winter



Apollo Solar - Field Array



V-2 Pneumatic, Side Slope



Edge Pneumatic, Brownfield

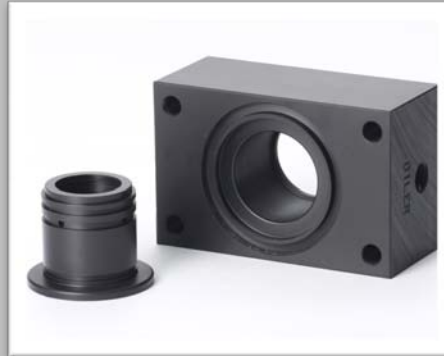


Anchor Electric, with Controller

Accessories



Solar Panel



Pop-Out Seal Cartridge



Rod Oiler



Flow Meter



Solar Charge Controller



Power Supply Converter



On-Off Timer



Pneumatic Timer