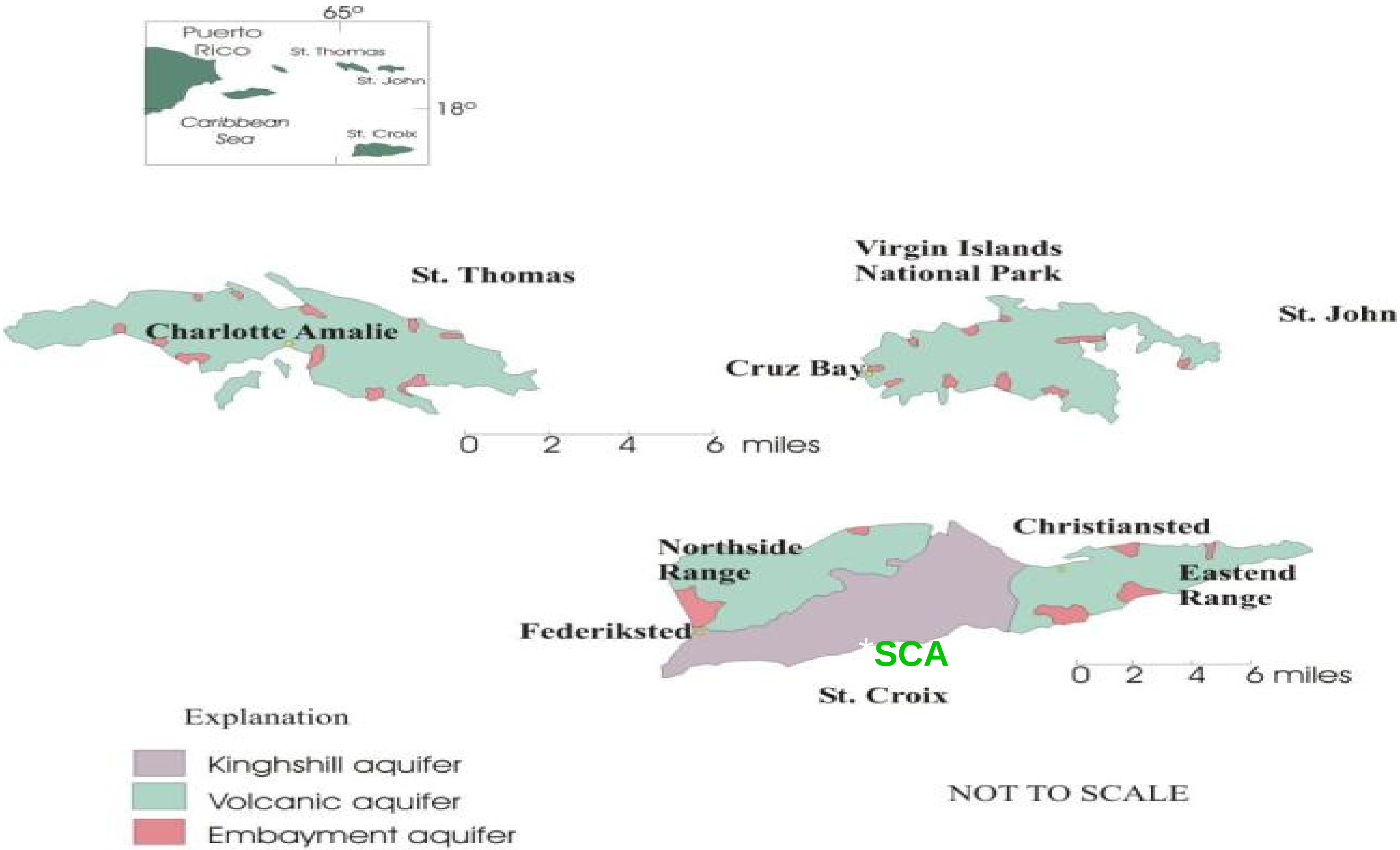
Integrated Solar and Wind Energy Powers Oil Recovery

Former St. Croix Alumina (SCA) site in

St. Croix, VI

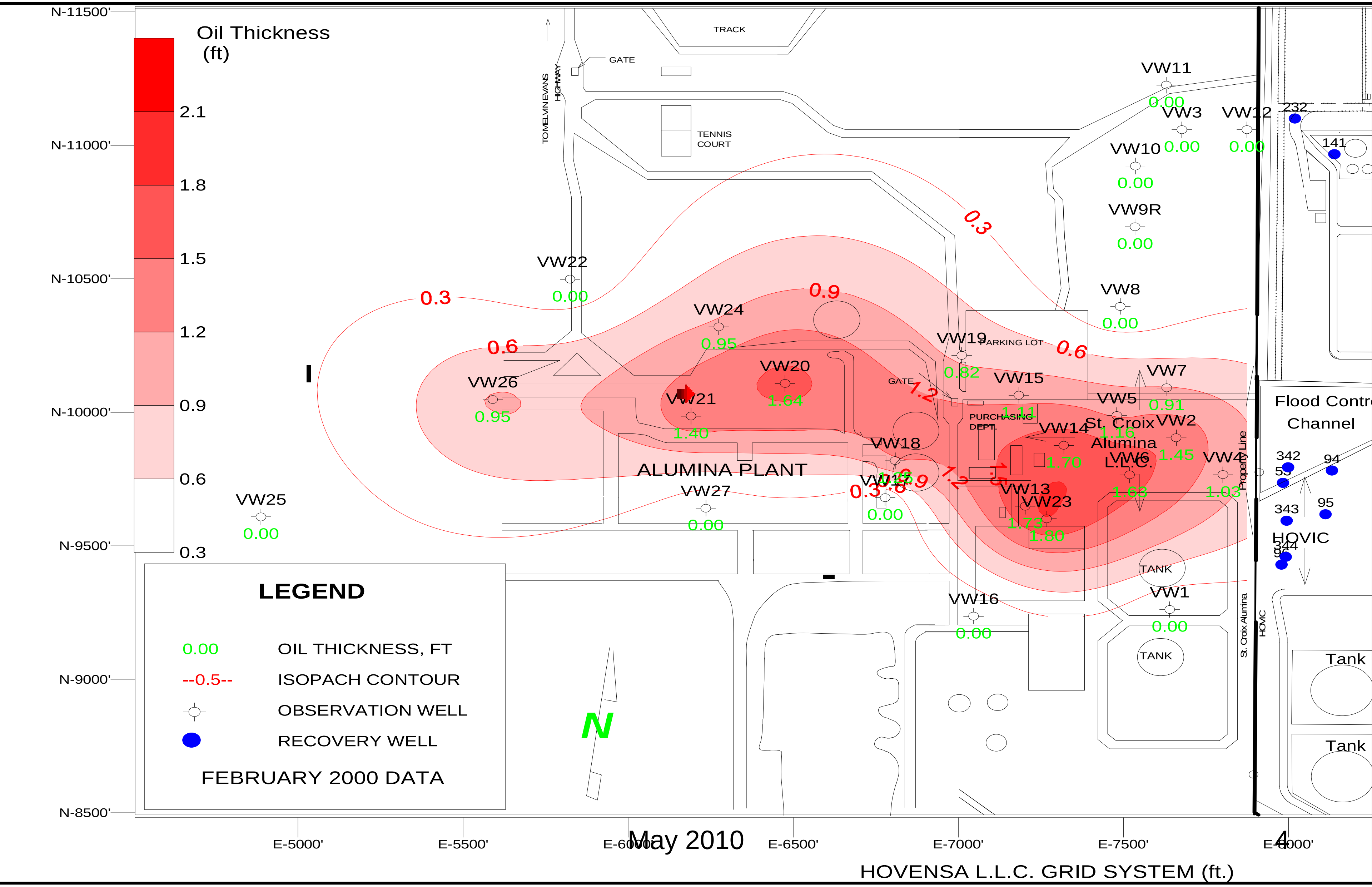
Site Location, US VI



Background

- SCA was a bauxite refinery which utilized the "Bayer Process" to produce alumina (aluminum oxide), an intermediate product in aluminum manufacturing. The facility was closed in 2002 and is slated for redevelopment.
- In 1994, EPA became aware of a subsurface oil plume at the SCA site, which was later shown to be caused by commingled petroleum products released at both SCA (formerly VIALCO) and the adjacent HOVIC (now HOVENSA) petroleum refinery.
- The contamination exists in the form of a light non-aqueous phase liquid (LNAPL) plume of petroleum (mostly diesel) floating on the groundwater in the Kingshill Aquifer and perched groundwater in unconsolidated sediments over the Kingshill.
- Groundwater is not utilized at the SCA facility; however, the Kingshill Aquifer is used upgradient of the facility and elsewhere on the island where it is less saline.

ST. CROIX ALUMINA RECOVERY GROUP



Initial Recovery System

- Under a 2001 RCRA Consent Order, oil recovery began in January 2002 through use of four wind-driven turbine compressors (WTCs) to drive compressed air operated, pneumatic total-fluid pumps in six recovery wells.

- The WTC power system was initially selected because electricity was not available at this closed site when the project began (the facility when operational had previously generated its own power).

- The WTC-powered system was estimated to cost approximately one third the cost to connect to the power grid. This provided an economic advantage to using alternative energy instead of additional construction to provide conventional power.

Wind-driven turbine compressors

- Each WTC is powered by a windmill with 4.33 foot blades that begin rotating at a wind speed of 4 mph.
- When wind speed exceeds 30 mph, the blades furl and turn out of the wind.
- The air compressor is located directly behind the windmill.
- The combined blade/compressor unit is on a hinged tower, and can be lowered to the ground for maintenance or protection in case of a hurricane.
- Each WTC is designed to generate approximately 45 psi of operating pressure (see photos).

Wind-driven turbine compressors

View of Wind Field at St. Croix Alumina

Power System

- The capital costs for the initial power system (installation of 4 WTCs and masts) totaled approximately $20,000), which does not include the cost of the fluid recovery gathering and compressed air distribution systems.

- Since then the power system has been expanded to include four wind-driven electric generators (WEGs) and photovoltaic (PV) panels, both used to power four electric submersible pumps.

- Electricity in the power grid on St. Croix is generated from fuel oil. Estimated cost to connect to the SCA recovery system to existing power grid was $100,000.

Solar Panels

- In 2004, solar panel arrays were installed to power electric submersible pumps which were installed in two recovery wells (to supplement the free product recovery via pneumatic pumps in six initial recovery wells).
- The initial solar system consisted of six free-standing, 55-W PV arrays installed in fixed-tilt position.
- In May 2007 two additional solar panel arrays were installed.

Wind Electric Generators (WEGs)

- In 2006, two Whisper 200 mast-mounted WEGs were installed to supplement the electrical power provided by solar panels for powering the two wells with submersible pumps (see photo).
- In May 2007, two additional WEGs were installed along with submersible pumps in two additional recovery wells (total of four wells now having electric submersible pumps).
- Each WEG provides 6.8 kWh per day in a 12 mph wind.

Wind Electric Generator

Whisper Wind Generator

- MODEL Whisper 200

The Whisper 200 is designed to operate in a site with low to medium speed averages of 8 mph, 3.6 m/s, and greater. The 200 provides 200+ kWh per month, 6.8 kWh per day, in a 12 mph average wind.

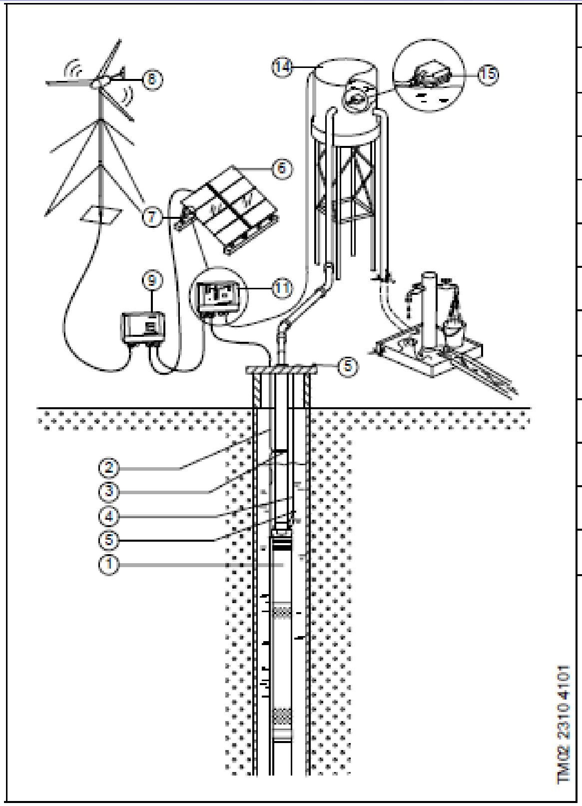
Solar Panels

Solar System
Controller Installation

Wind Electric/Solar Integration

- Each individual electric pump (total 4) is wired directly to 1 WEG and the solar panels.
- A control panel draws electricity from either the WEGs or solar panels, or a combination of both, based on the power needed by the pump at that instant to lift fluid from the well.
- It is an "on-demand" system. Power is supplied as Needed, as available. So at night the system operates on WEG power only. If there is no wind at night, then no fluid is pumped. So (all other things be equal) in general, you can expect maximum pumping rates and power consumption during day-light hours.
- There are no batteries being charged during the day, etc.

Schematic of Wind/Solar Integration



Pos.	Description
1.	SQF pump
2.	Submersible drop cable
3.	Cable clips
4.	Straining wire
5.	Wire clamps
6.	Solar panel(s)
7.	Support structure
8.	Wind generator
9.	Breaker box
11.	CU 200 control unit
14.	Water reservoir
15.	Level switch

Fig. 7. Combined pumping system with CU 200 and level switch.

Advantages of Direct Drive System

- Average instantaneous power demand per pump is estimated at 150 – 260 watts (depending on fluid levels and column of fluid being raised by the pump).

- This direct drive electric system (no batteries) has following advantages:
  - lower capital cost,
  - lower maintenance cost (due to no theft of batteries and need for regular inspection & replacement of batteries);
  - and no hazardous waste generated by battery disposal.

Capital Cost for WEG and Solar Power Equipment

- The WEGs cost $2,750 each. There are 4 installed, which totals $11,000.

- Each solar photovoltaic panel cost $597 each. There are now 24 Photovoltaic panels (in 8 arrays), which totals $14,328.

- 8 Power Controller arrays to merge wind and solar power and control submersible pumps cost $575 each, which totals $4600.

Recovery Pumps

- 4 wells have Grundfos electric submersible pumps that cost $1600 each. Total for 4 = $6400
- 7 wells have Pneumatic Pumps (compressed air) that cost $2000 each. Total for 7 = $14,000

Project Costs

- Total capital cost for alternative power equipment (WTCs, WEGs, Solar panels, and system integrator controllers) was approximately $50,000 .
- Total cost for 11 pumps was $20,400.
- Does not include costs for well drilling and completion, and installation of gathering system (flow lines, separators, tanks).
- Current capital cost for a similar wind/solar powered system and a recovery pump is estimated at $13,800 for each well.

Recovery Status

- For most recent six month period (ending December 31, 2009), the system recovered a daily average of 127 gallons of free product per day.
- Eleven active recovery wells (7 “total fluid” pumps and 4 “skimmer” pumps).
- Through December 31, 2009, a cumulative total of 347,676 gallons of free product has been recovered.
- As of December 31, 2009, the estimated in-place remaining free product is 832,000 gallons.

Fluid Handling

- The recovered fluids consisting of oil and commingled groundwater are transported by pressure from the well pump system, via above-ground, fiberglass lines to a separation tank, where the oil and groundwater are separated via gravity separation.

- The separated oil is then reclaimed at the adjacent HOVENSA petroleum refinery while the recovered groundwater (average of 25,488 gallons per day during six months ending December 31, 2009) is discharged for treatment in a permitted wastewater treatment system prior to being discharged to the Caribbean Sea.

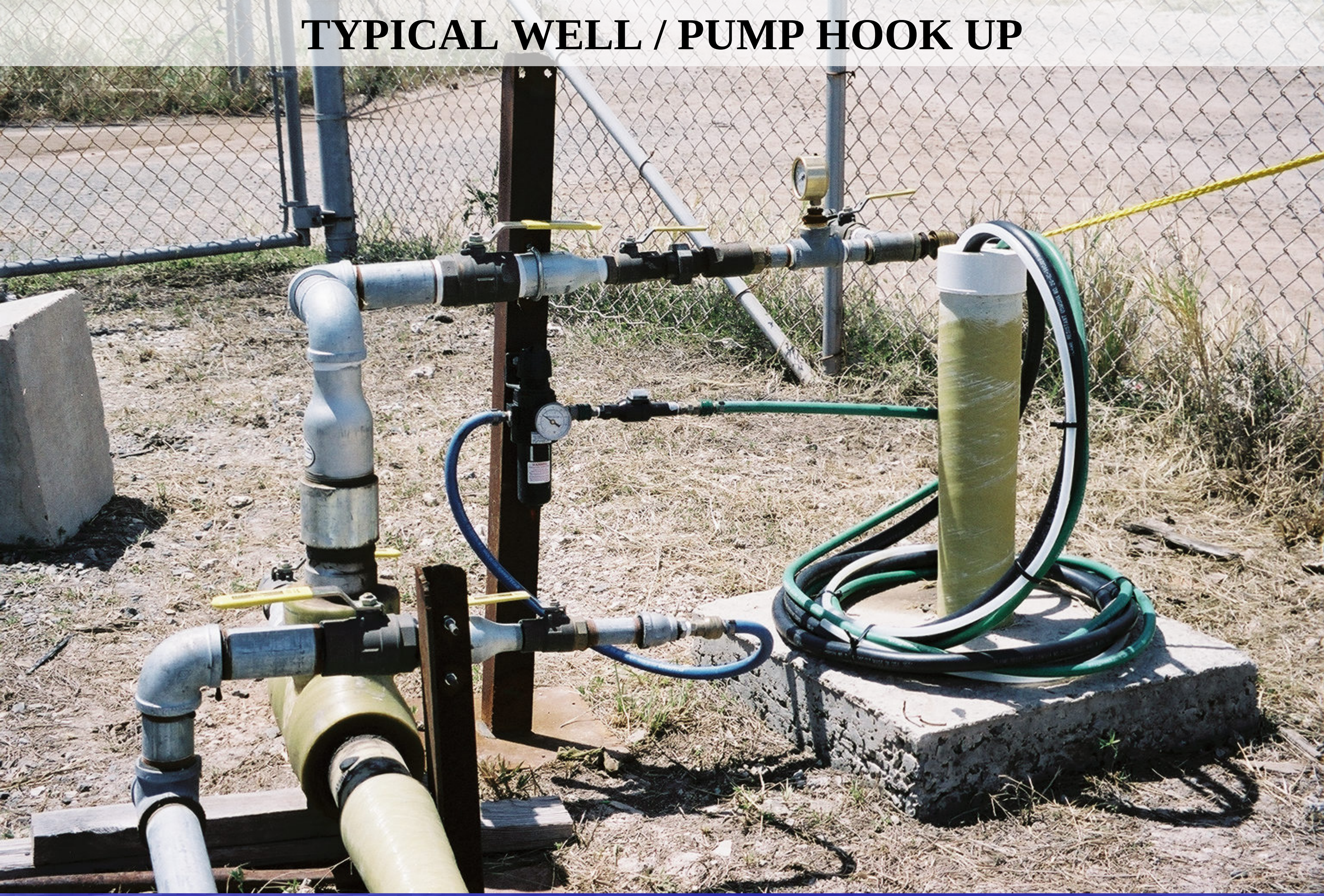
Benefits

- Environmental Benefits
  - Reduced emissions of greenhouse gasses (CO_2) and other air pollutants (SO_X, NO_X)
  - Reduced dependency on fossil fuels
  - Reduced waste generation
  - Reduced impact on local ecosystems and communities
- Economic Benefits
  - Reduced construction costs for remote sites where utility power is unavailable
  - Power system is portable and can be moved to other sites
  - Minimizes on-going power and hazardous waste disposal costs
  - Federal tax credits for renewable energy use

VIEW OF WIND FIELD FACING SOUTH

Fluid Gathering Line (Fiberglass) and Compressed Air Distribution Line (Steel) and Well Hook-up

TYPICAL WELL / PUMP HOOK UP



Points of Contact

- Project Operator for the St. Croix Alumina Respondents Group (former owners/operators of both the alumina facility and the adjacent petroleum refinery) is Hess Oil.

- EPA point of contact is Tim Gordon, RCRA Programs Branch, EPA Region 2, phone (212) 637-4167, gordon.timothy@epa.gov