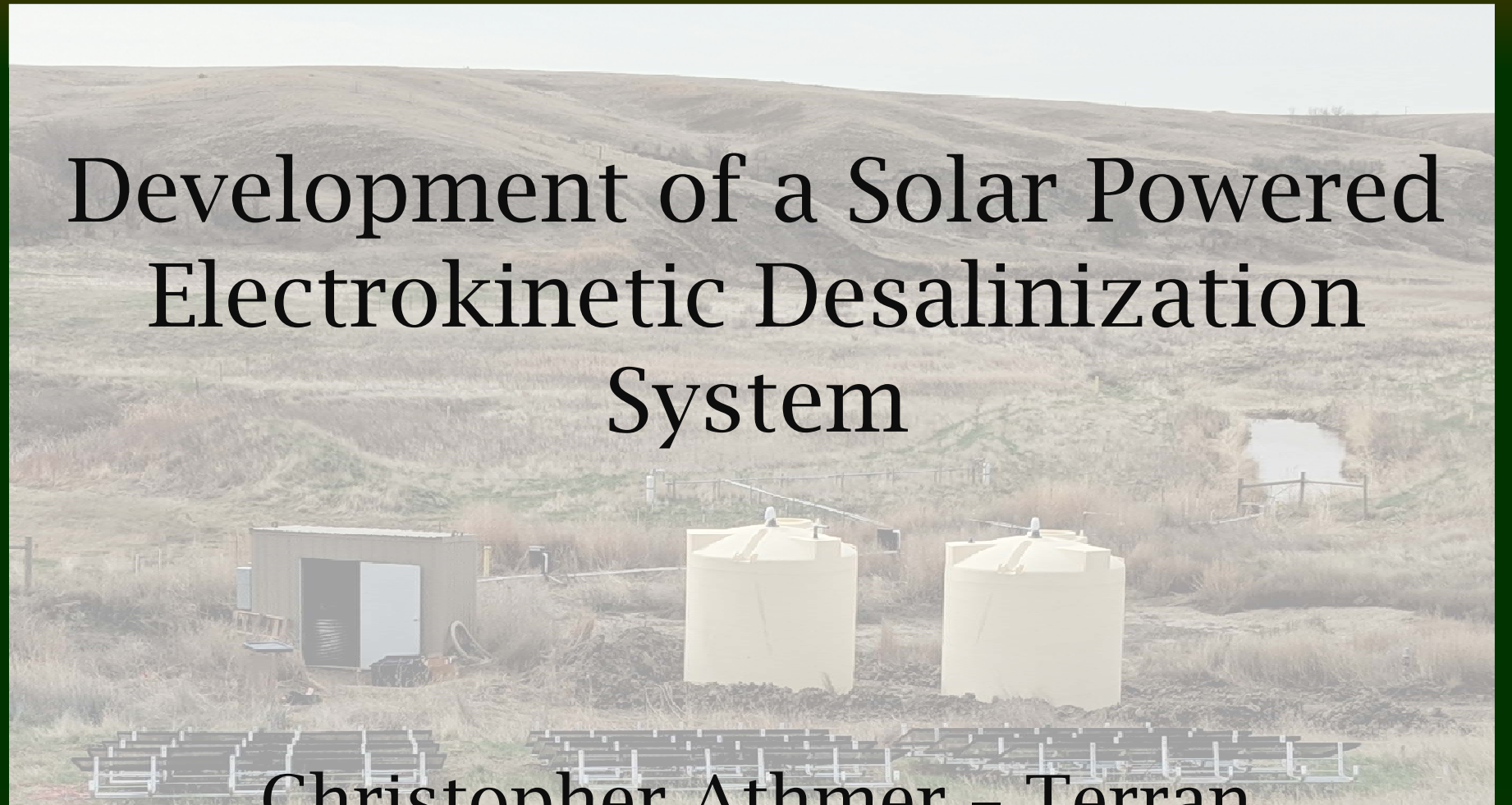
Development of a Solar Powered Electrokinetic Desalinization System



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Environmental Issues for Brine Spills

- Chloride and Sodium do not break down any further… **Must be removed or diluted**.
- Sodium exchanges with calcium in the soil leaving the land barren.
- Chloride percolates to the water table with precipitation.

Electrokinetic Remediation ?

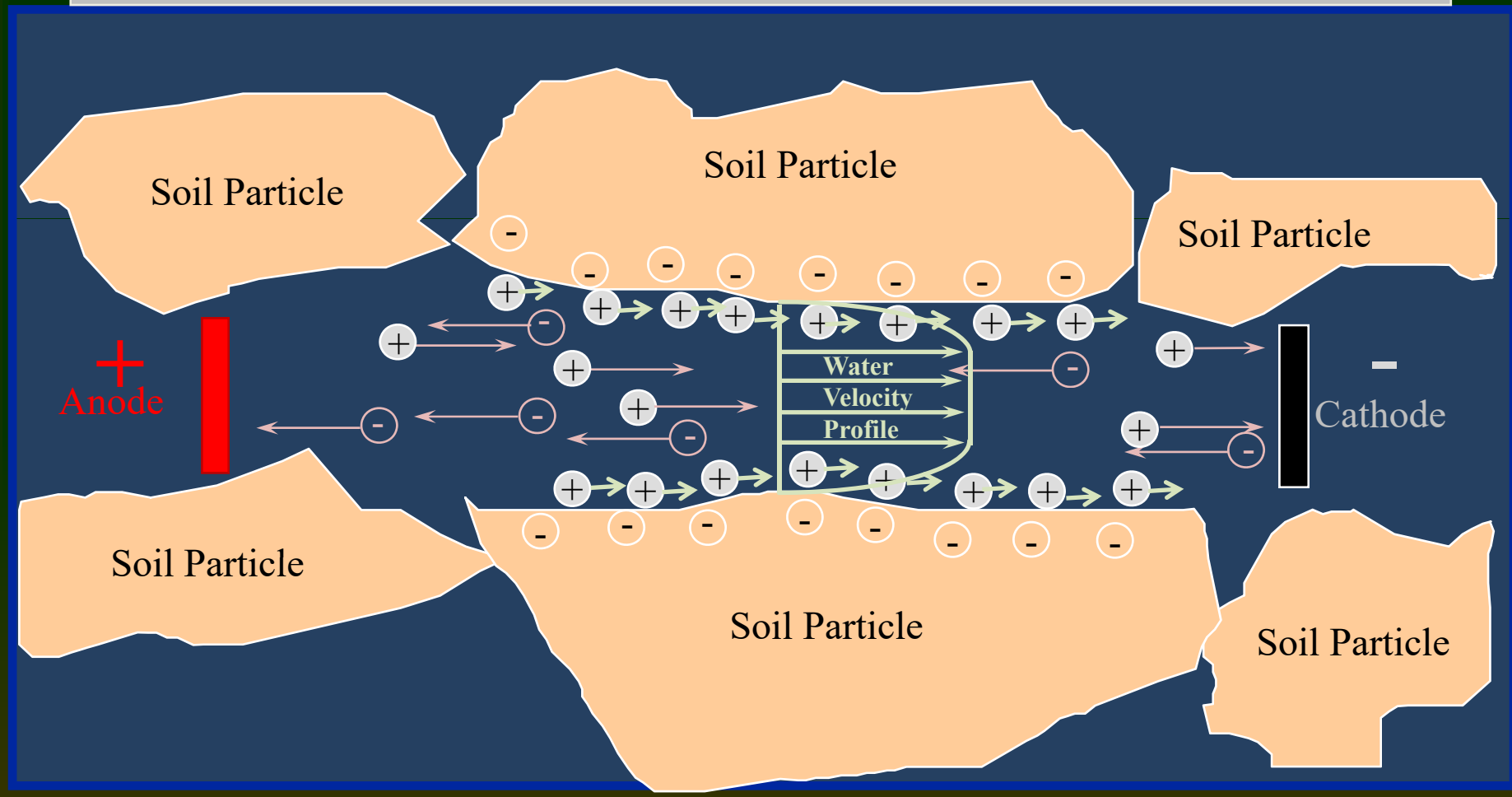
- Application of direct current (DC) electricity to the soil
- Polarized electrodes induce movement of pore water and ions contained in the pore water, even in low permeability soils
- Effective in saturated and unsaturated soils

Electrokinetics

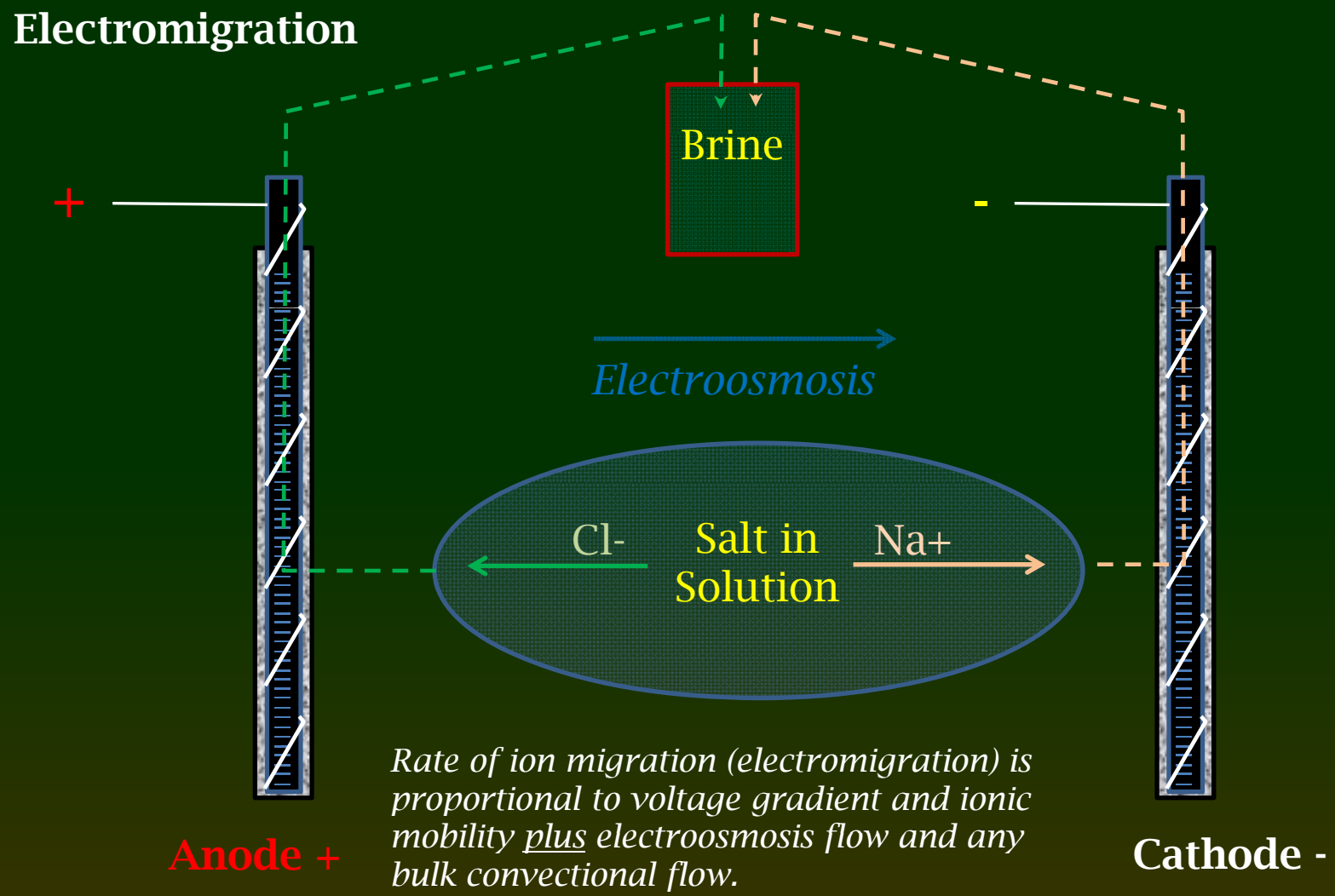
- Electroosmosis – Movement of pore water and contaminants toward the cathode
- Electromigration – Migration of ionic species toward respective electrodes (anions toward anode, cations toward cathode) by electrical attraction
- *Transport rates proportional to voltage gradient*

Principles of Electrokinetics

Electroosmosis = Water Transport from anode to cathode
Electromigration = Ion Transport to the opposite electrode

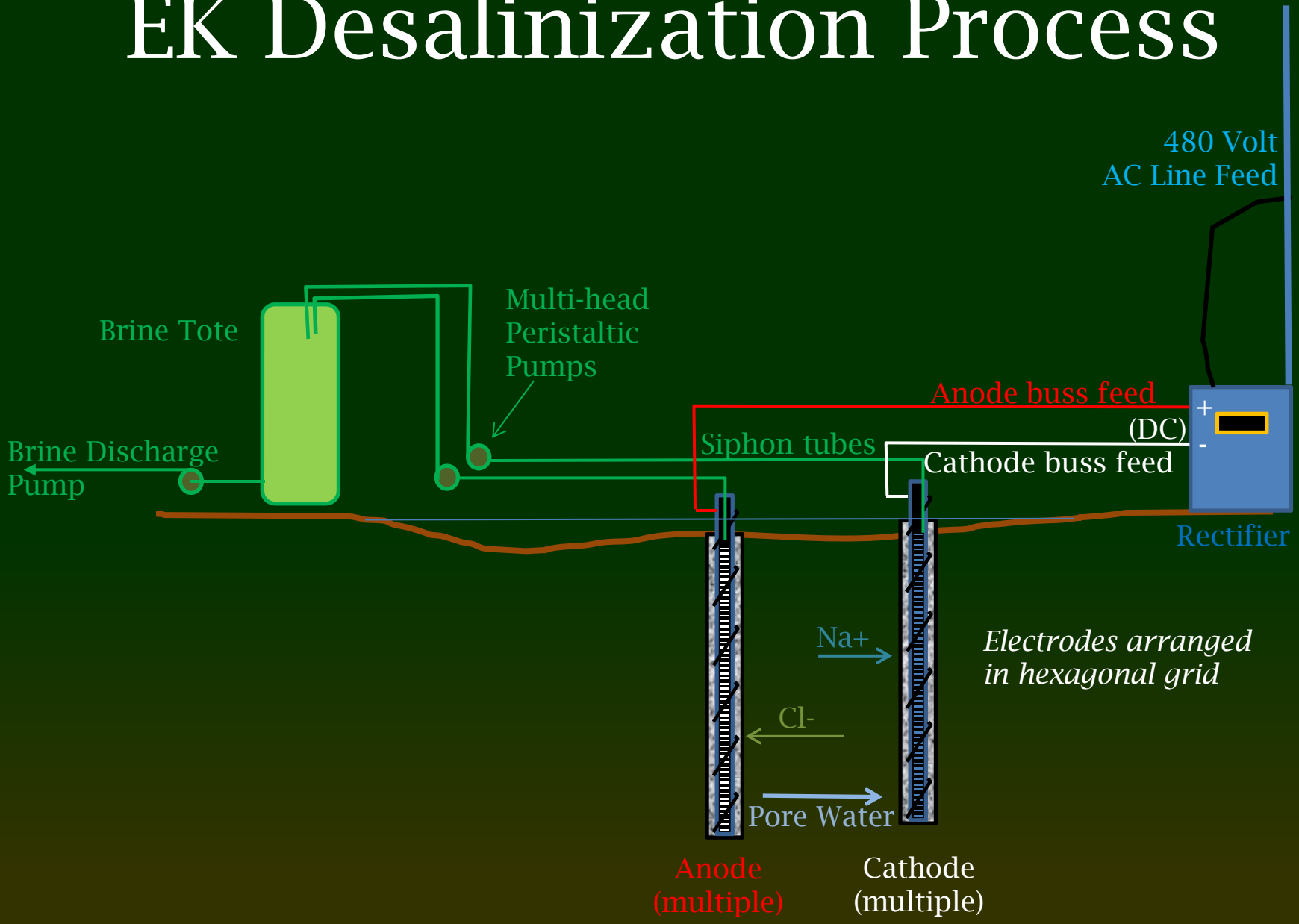


EK Desalinization Application



Rate of ion migration (electromigration) is proportional to voltage gradient and ionic mobility plus electroosmosis flow and any bulk convectional flow.

EK Desalinization Process



Power Requirements for Practical EK Systems

- Voltage = 24 – 48 volts
- Current = 100s of amps
- Constant or cyclic potentials
- Robust and reliable
- Low maintenance

Ideal application for solar power

Solar Power Has Potential

- Direct Current in cyclic mode should work well.
- No battery banks or voltage controllers.
- PV panels wired in parallel provide reliable low voltage, high current DC power.

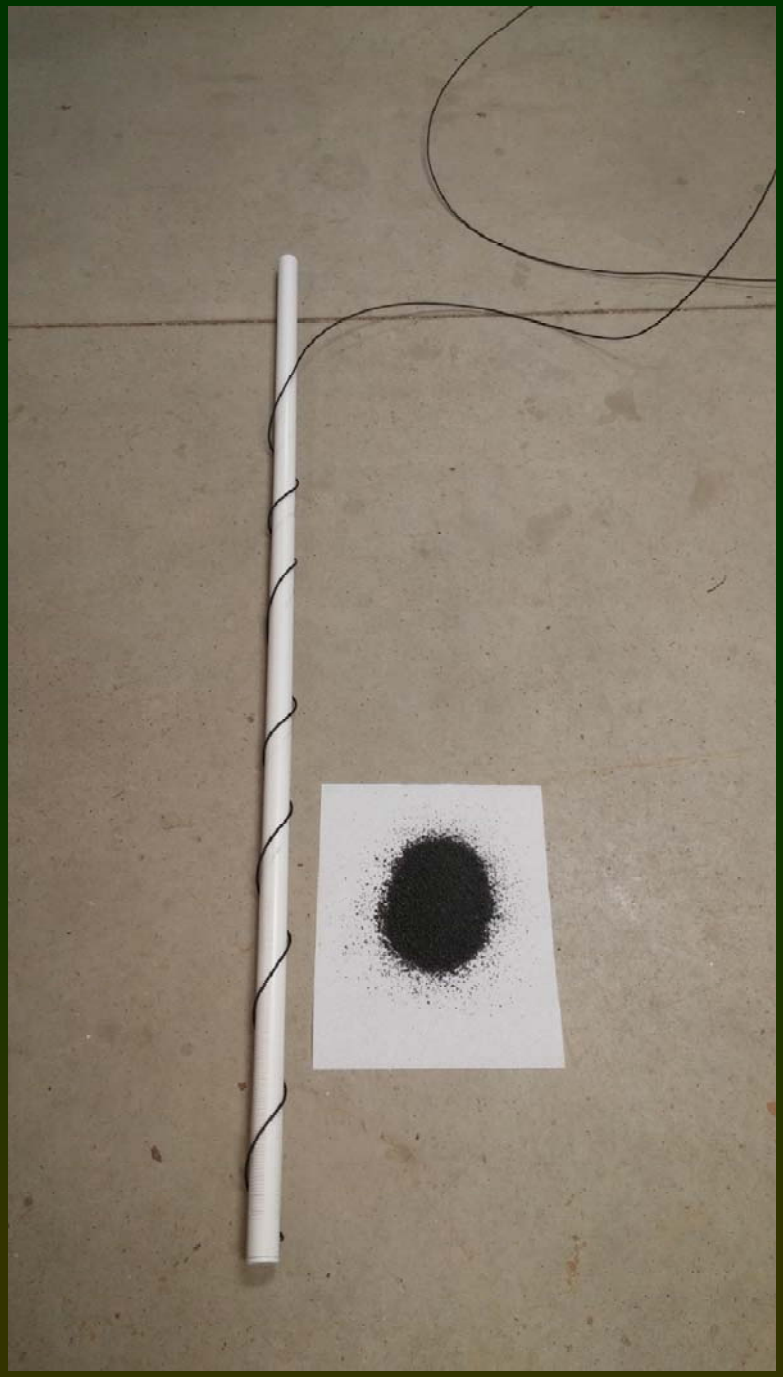
- *Received grant from NDIC to pilot a solar powered GW remediation which was installed spring 2019.*

Demonstration Site

- Brine spill contaminated vernal stream lowlands area.
- Soil and groundwater contamination.
- Groundwater at 6-10 feet.
- Stream bisects contaminated area.
- Previous GW collection system as treatment.

Basic Equipment

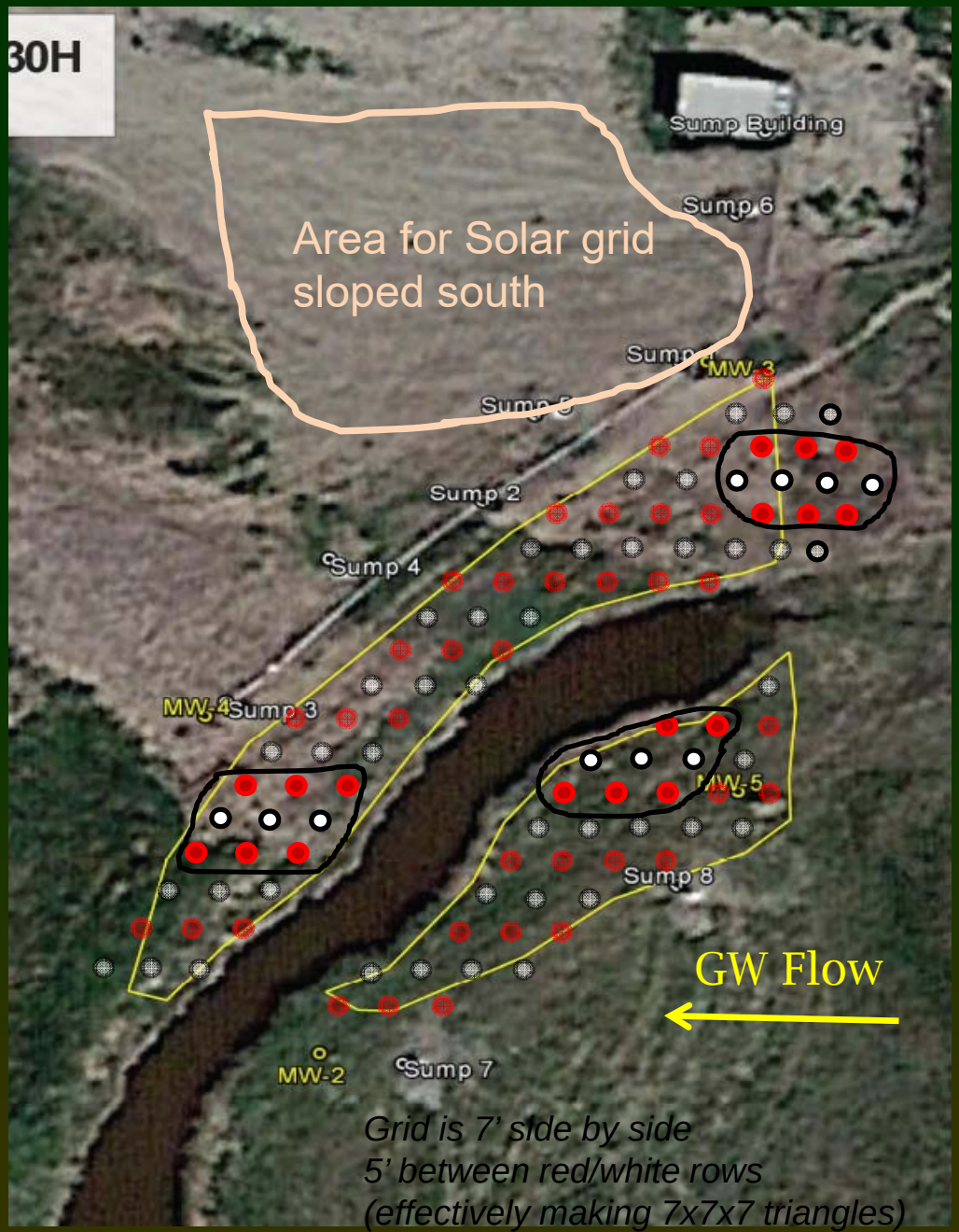
- PV panels
- 27 electrode/wells
- Multi-head peristaltic pumps
- Poly tubing (1/4” P.E.)
- Buss wire (350 aluminum)
- Lead wire (#10 copper PV wire)
- Data system with cellular



Electrode/Wells consist of 1” PVC well pipe with lower 5 feet screened spiral wound with dimensionally stable anode (DSA) wire.

Wells installed using Direct-Push.

Annulus backfilled with coke breeze (Loresco SWS Cathodic backfill).



Originally set up grid to treat whole area of contamination

Revised pilot layout to treat 3 more heavily impacted areas.

MW-3, MW-4 and MW-5 areas treated. Original overall grid was maintained to allow orderly expansion if warranted.

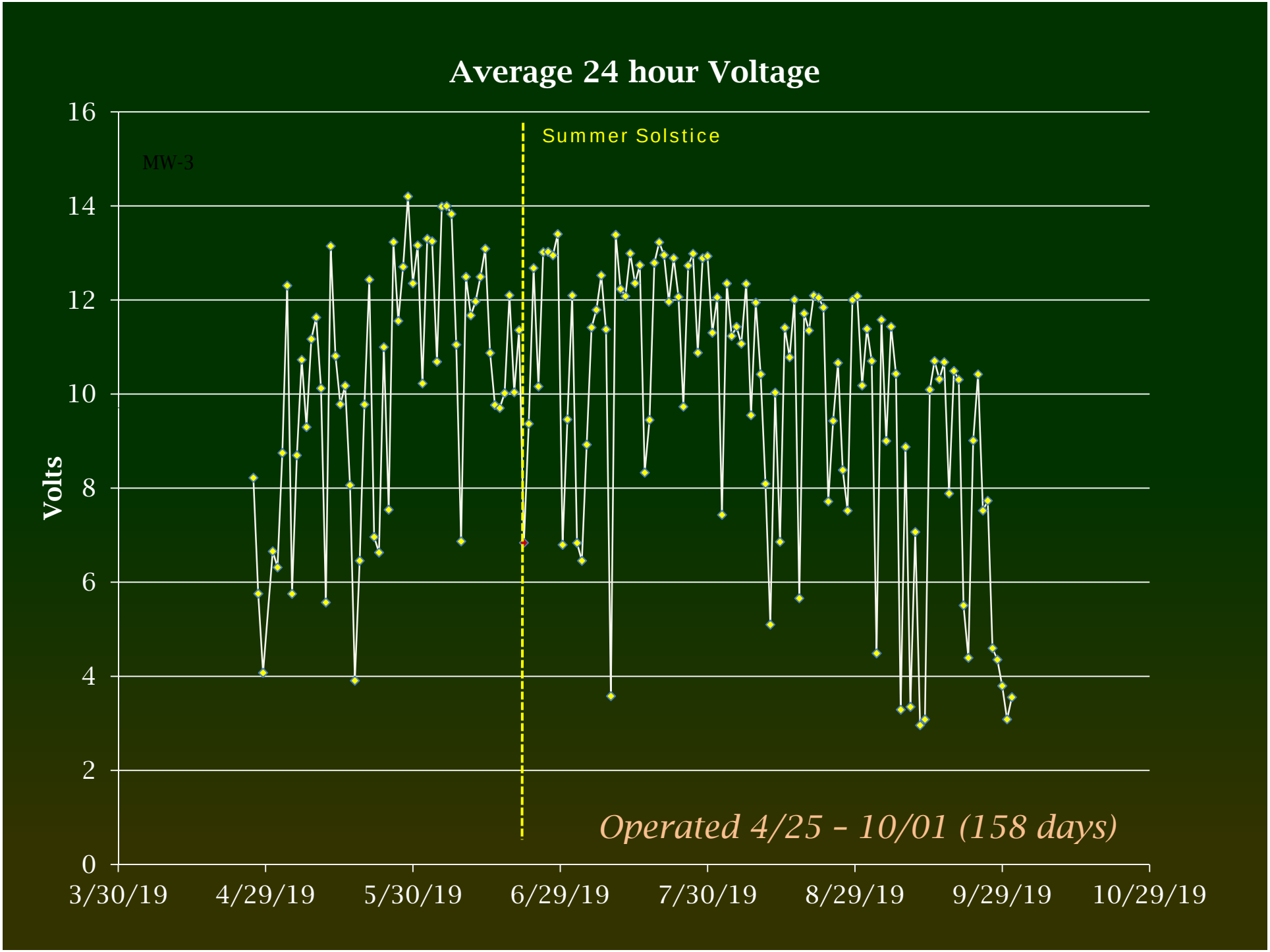
Each well grouping was powered by separate mini-grids or 8 to 12 PV panels, depending on overall site electrical conductance.

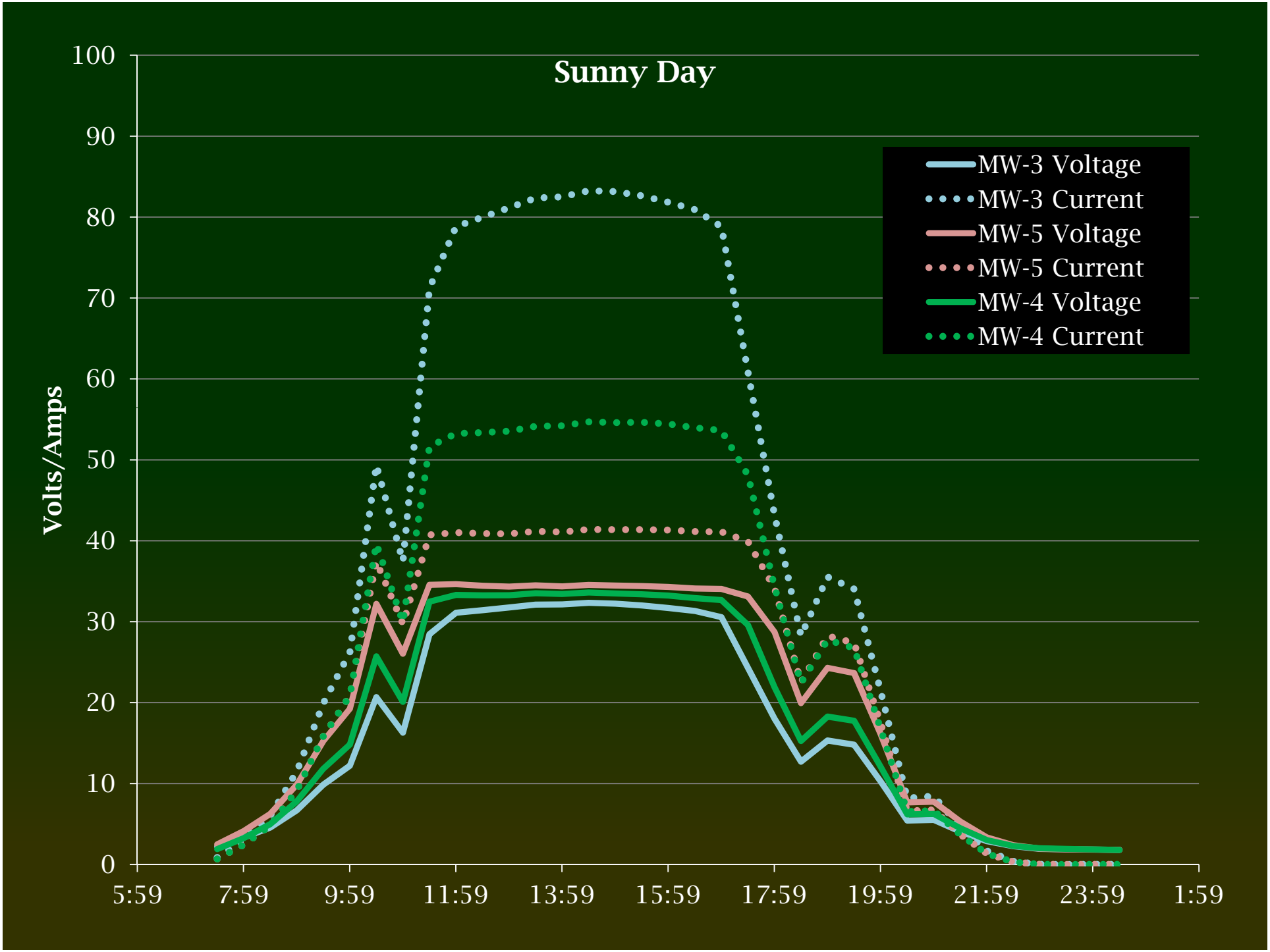
South-facing slope was ideal for PV panel grids.

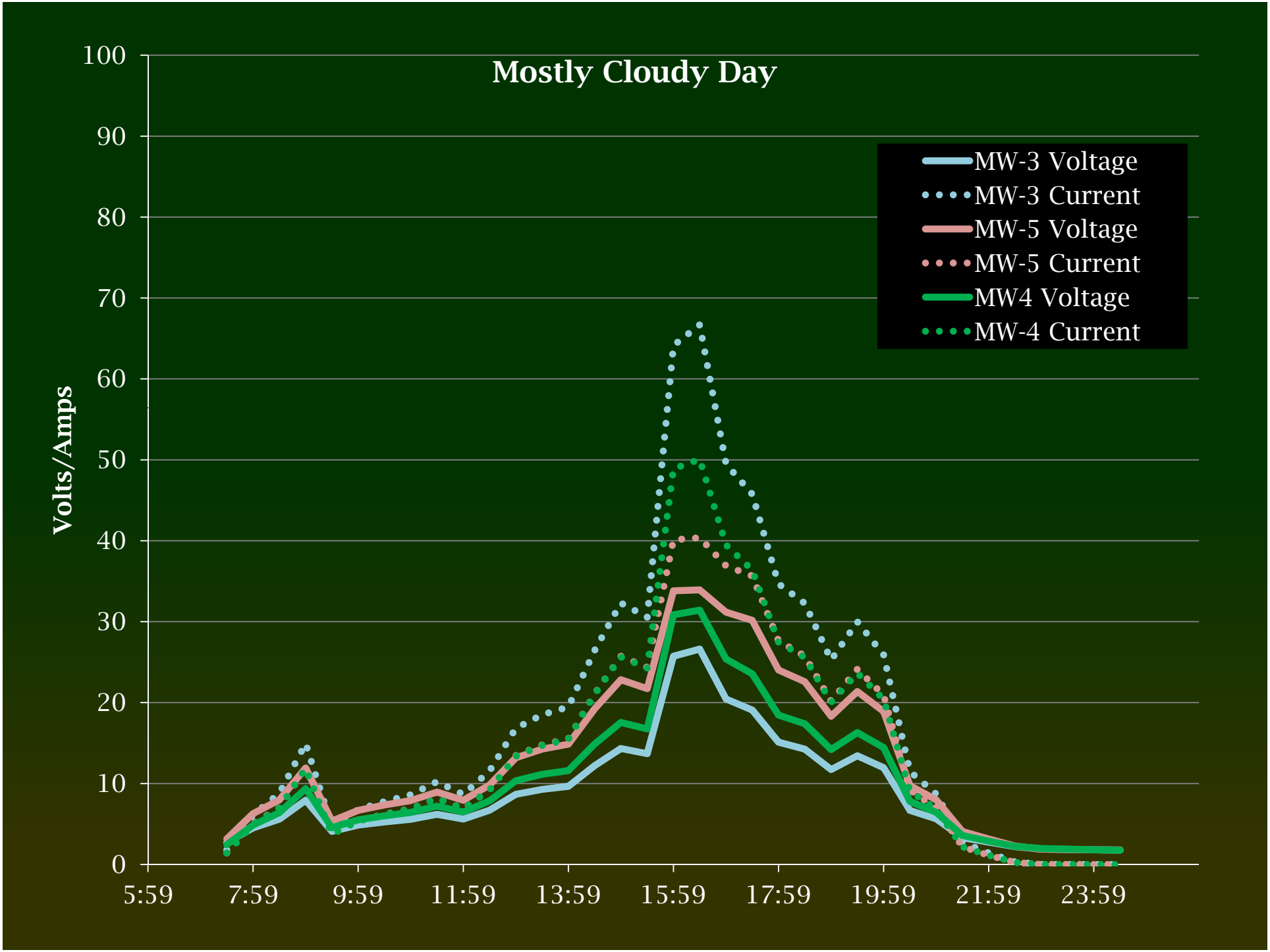
Grid of 295W Panels - 3 Bundles of 8 Panels

4 more panels have since been added to the right bank for MW-3 Sector

Data acquisition and control box with cellular communications


Average 24 hour Voltage
Summer Solstice
MW-3
Volts
16
14
12
10
8
6
4
2
0
3/30/19
4/29/19
5/30/19
6/29/19
7/30/19
8/29/19
9/29/19
10/29/19
Operated 4/25 – 10/01 (158 days)


Sunny Day
Volts/Amps
100
90
80
70
60
50
40
30
20
10
0
5:59
7:59
9:59
11:59
13:59
15:59
17:59
19:59
21:59
23:59
1:59
MW-3 Voltage
MW-3 Current
MW-5 Voltage
MW-5 Current
MW-4 Voltage
MW-4 Current


Mostly Cloudy Day
Volts/Amps
100
90
80
70
60
50
40
30
20
10
0
5:59
7:59
9:59
11:59
13:59
15:59
17:59
19:59
21:59
23:59
MW-3 Voltage
MW-3 Current
MW-5 Voltage
MW-5 Current
MW4 Voltage
MW-4 Current

Removed Water Quality

- Calcium = 70.4, 98.8
- Magnesium = <2.0, 26.2
- Potassium = 727, 415
- **Sodium = 11,200, 7,900**
- **Chloride = 3760, 6,250**
- Sulfate = 960, 1870
- Sp. Cond. = 71.2, 39.6 mmhos/cm
- pH = 13.19, 12.77

Extracted groundwater collection tanks 7/16/19. Units mg/l. Roughly 500 gallons removed

Issues/Lessons

- Voltage limitation at MW-3 cell
  - Added 4 more panels
- Pump flow rates inconsistent
  - Animal vandalism
  - Peristaltic pump tubing material
  - Connections get brittle
  - Will double flow next season

Conclusions

- Simple DC power source
- Voltage increments practical for EK systems
- Lower cost, but varies seasonally
- No need for line power
- Huge potential for remote sites
- Take into account seasonality issues