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CHARACHTERIZING MINING AFFECTED GROUNDWATER WITH CONTROLLED SOURCE - AUDIO FREQUENCY DOMAIN - MAGNETICS

Case Studies in Mining

Abstract

Traditional seepage diagnostic methods can be disruptive, inefficient and expensive

Innovative technology improves determining the presence and location of sub-surface seepage

CS-AFD-M is efficient and can cover large areas

Basic physics behind the CS-AFD-M method

Case study will be shared to show application in mine related seepage

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Controlled Source – Audio Frequency Domain - Magnetics

- Electrical conductivity of groundwater is used to complete an electric circuit
- Maxwell's Equations
  - Ampere's Law
  - Faraday's Law of Induction
- Biot-Savart Law

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CS-AFD-M Applied

- AC electric circuit established between two electrodes down wells
- Electric current follows paths of least resistance
- The electric current generates a magnetic field
- The magnetic field is measured from the surface of the ground
- This collected data is mapped and modeled

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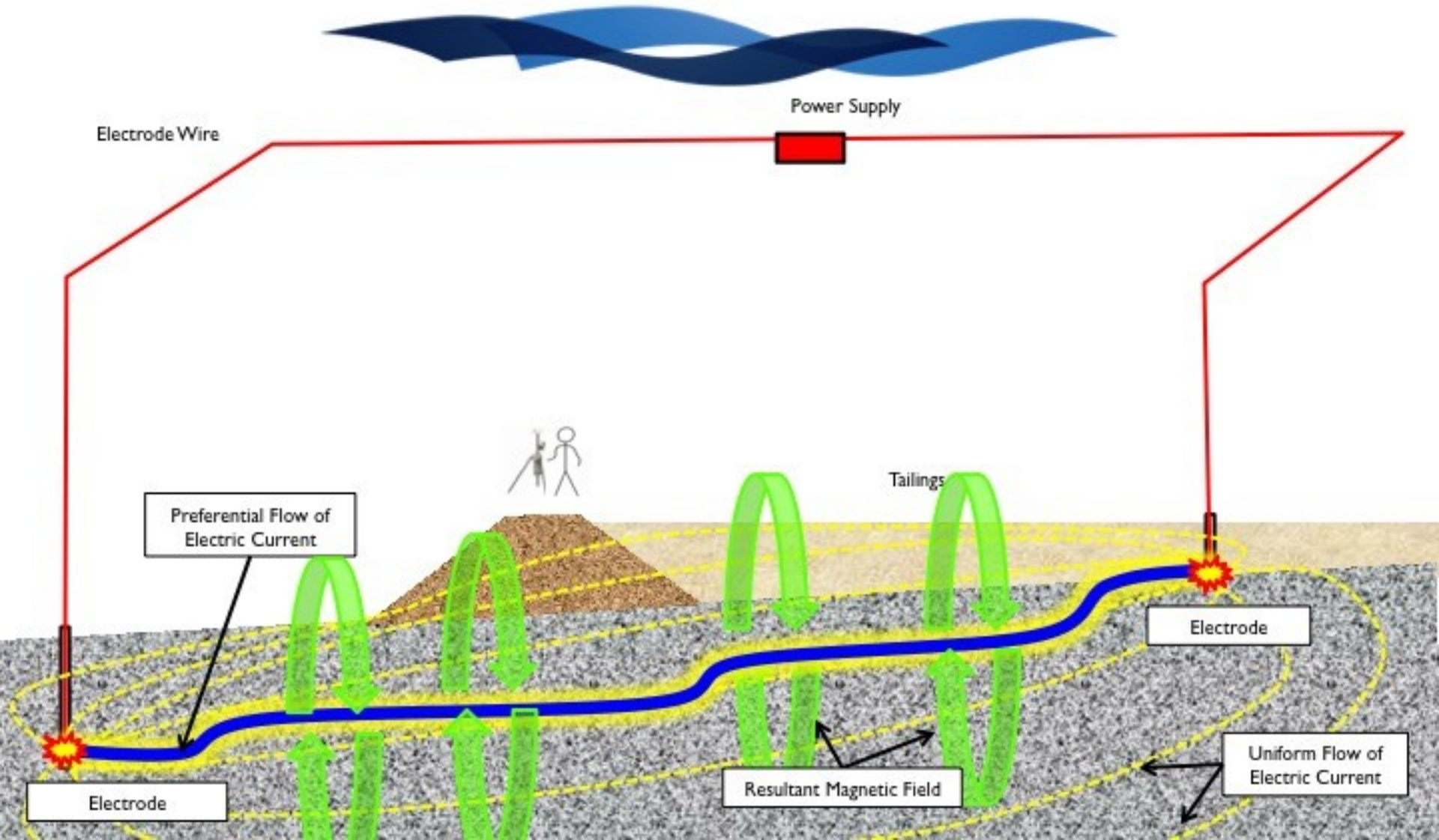
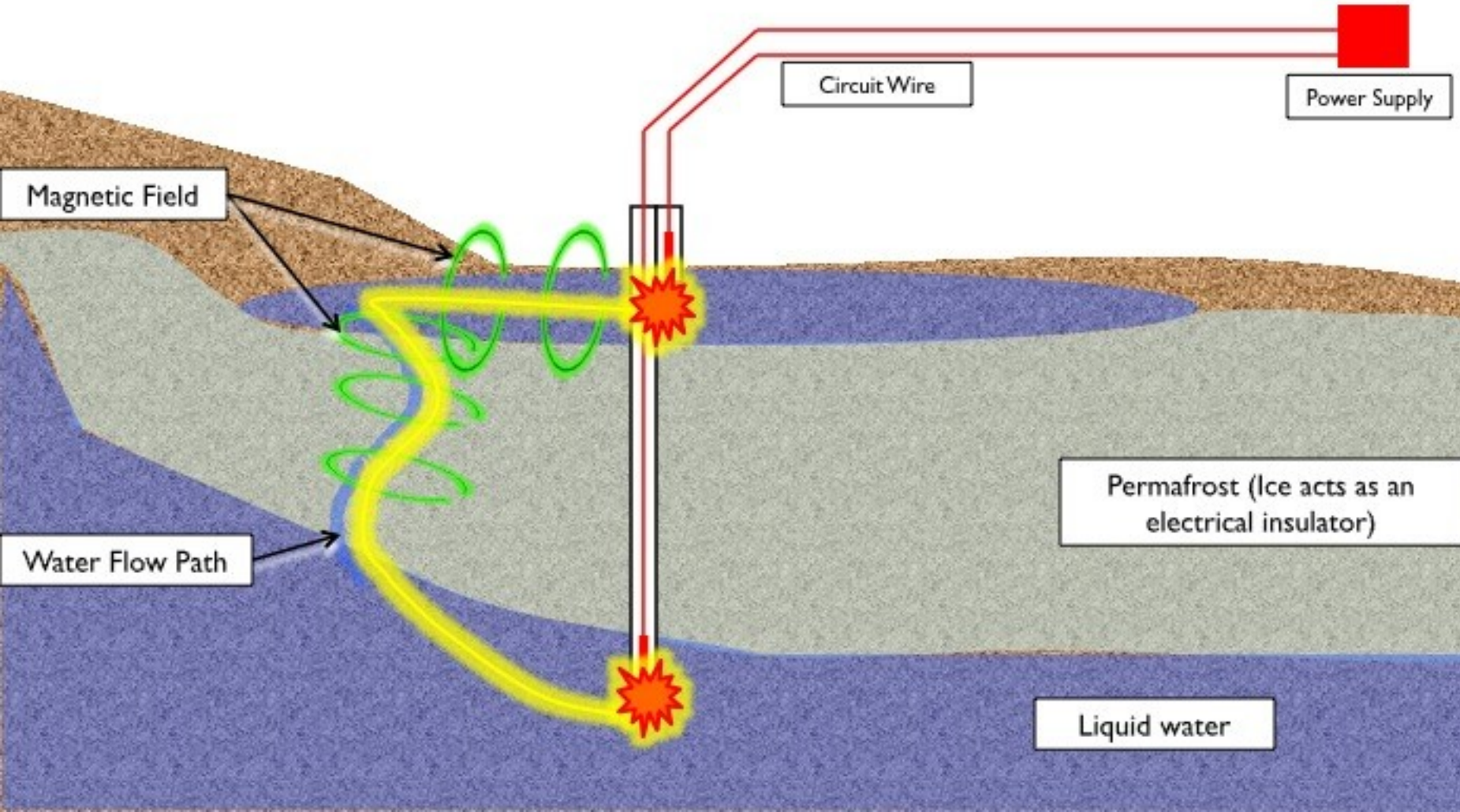
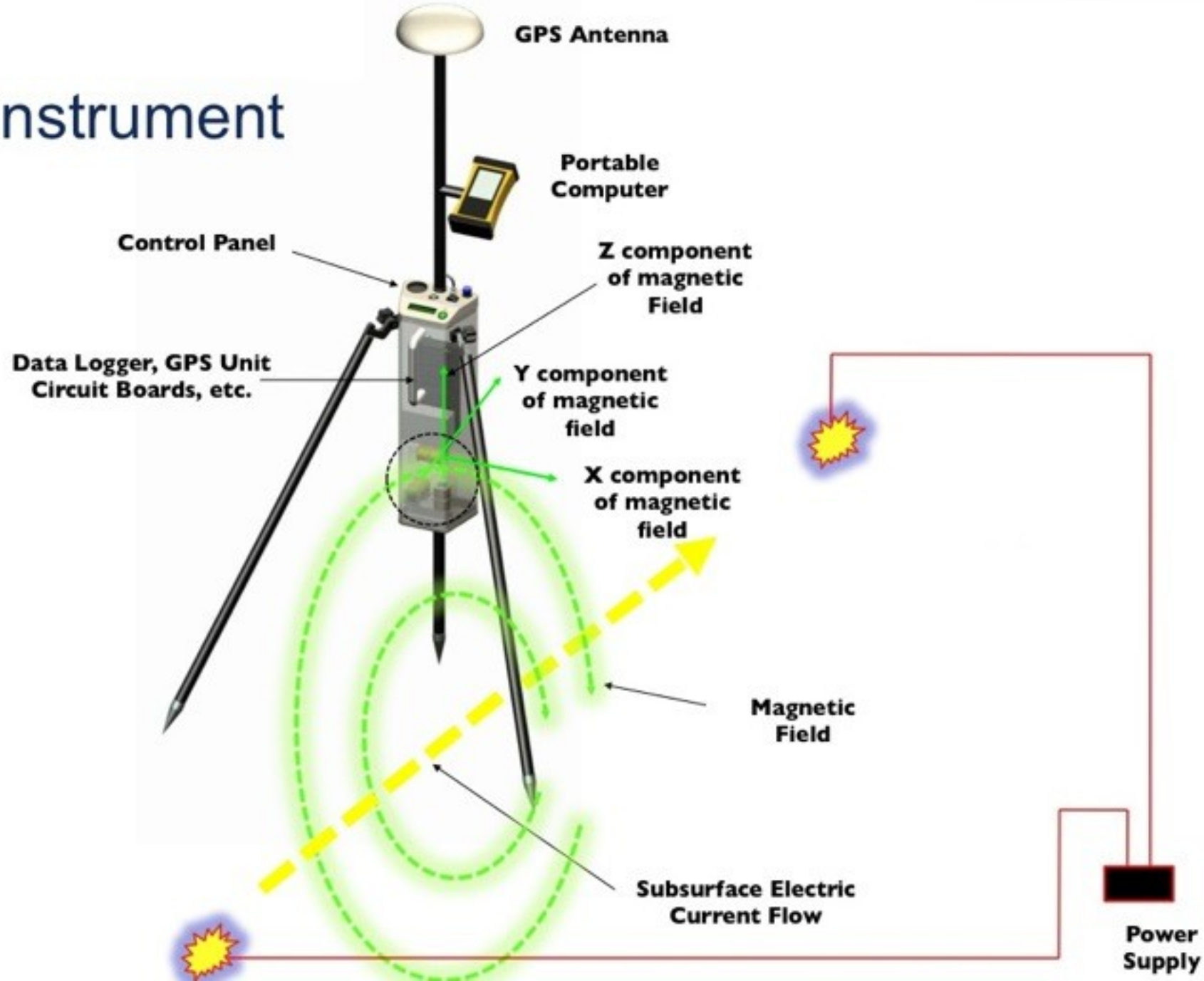
Horizontal Electrode Configuration



Vertical Dipole Configuration



Instrument


GPS Antenna
Portable Computer
Control Panel
Z component of magnetic Field
Data Logger, GPS Unit Circuit Boards, etc.
Y component of magnetic field
X component of magnetic field
Magnetic Field
Subsurface Electric Current Flow
Power Supply

CS-AFD-M Equipment

Field Operations

- Typical surveys last from one week to many weeks
- Typical crew size is 2-3 people
- Can be employed in most terrain and circumstances

Limitations

- Anthropogenic influences, particularly long metal conductors, can be problematic
- Electrodes must be in direct contact with the groundwater of interest
- Near surface flow paths can mask deeper flow paths
- Can't determine water quality, volume, velocity or direction of flow
- Unable to directly map non-conductive contaminants
- Must have contrast in electrical properties between groundwater and surrounding materials

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Case Studies

Mapping Mine Affected Water

Case Study – Tailings Dam

The Problem

Mine impacted water manifesting downstream of dam beyond the seepage containment facilities
(environmental and safety concerns)

Survey Objectives

Identify, map and characterize groundwater flow paths under, around or through embankment

Proposed Survey

- Area of investigation identified by red + marks
- Electrode and circuit wire lay outside of survey area to minimize magnetic interference
- Distance between electrodes in excess of 1.5 kilometers

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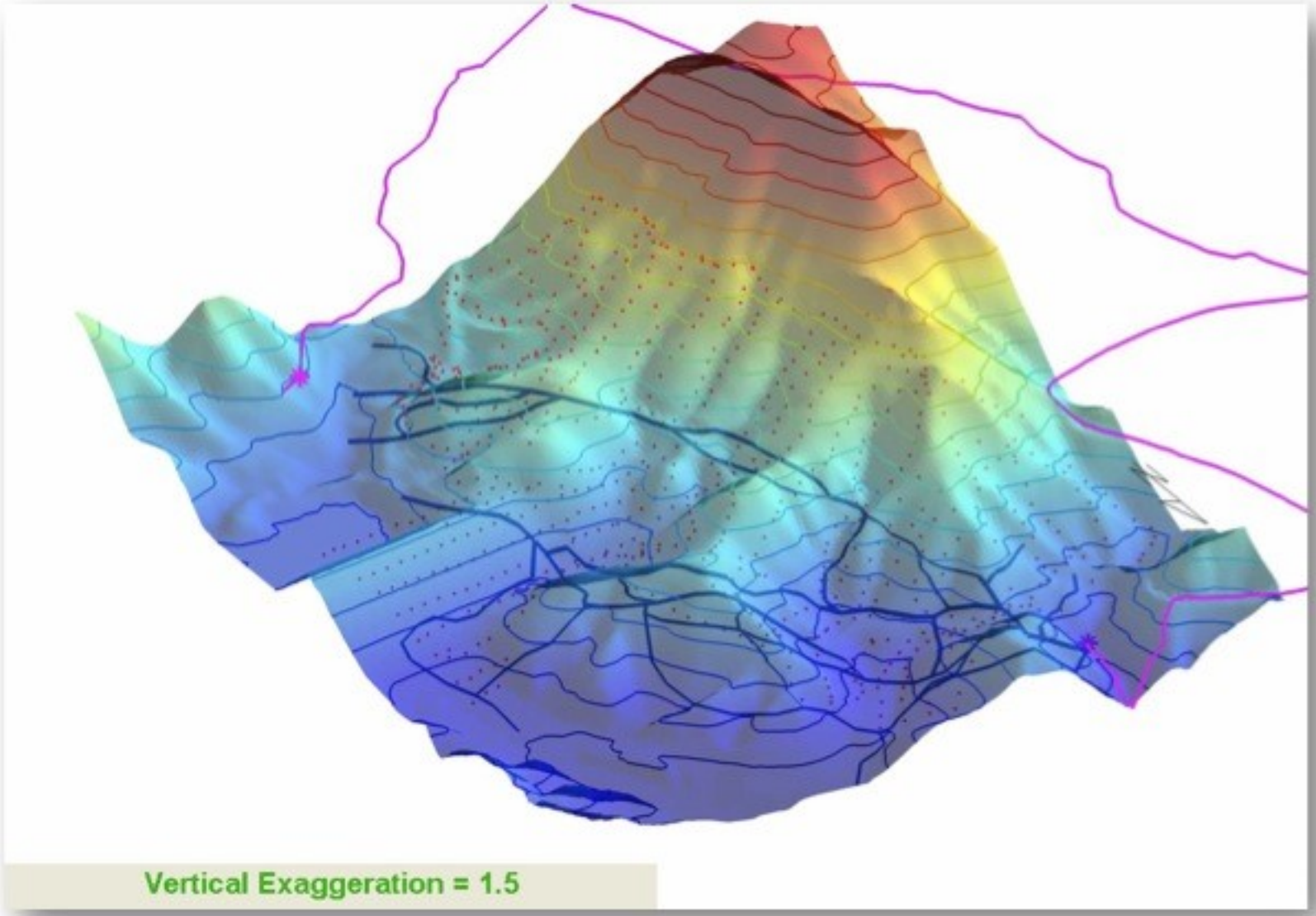
Observed Data

- Electrodes were placed in bore holes below the dam as well as directly in the tailings water
- Dark lines show preferential flow path of the electrical current
- Green contours show relative strength of the magnetic field

Modeling

- Red lines show the modeled magnetic field
- Darker blue lines show main channel of the Electric Current Flow (ECF)
- Light blue line shows secondary flow paths
- The width of the flow paths indicates the width of the anomalies in the subsurface
- Modeling allows us to determine depth of flow

3D Visualization



Value of Tailings Dam Investigation

- Targeted remediation efforts can now be employed rather than best guess
- Survey delineated how and where the tailings were connected to connected to the down gradient well
- They now have a baseline against which to compare remediation efforts as the tailings storage facility expands



Mine Impacted Water Investigation

The Problem

- ARD water (pH 2.5)
- Frustrating low-volume but persistent flow
- Challenge to getting final regulatory sign-off

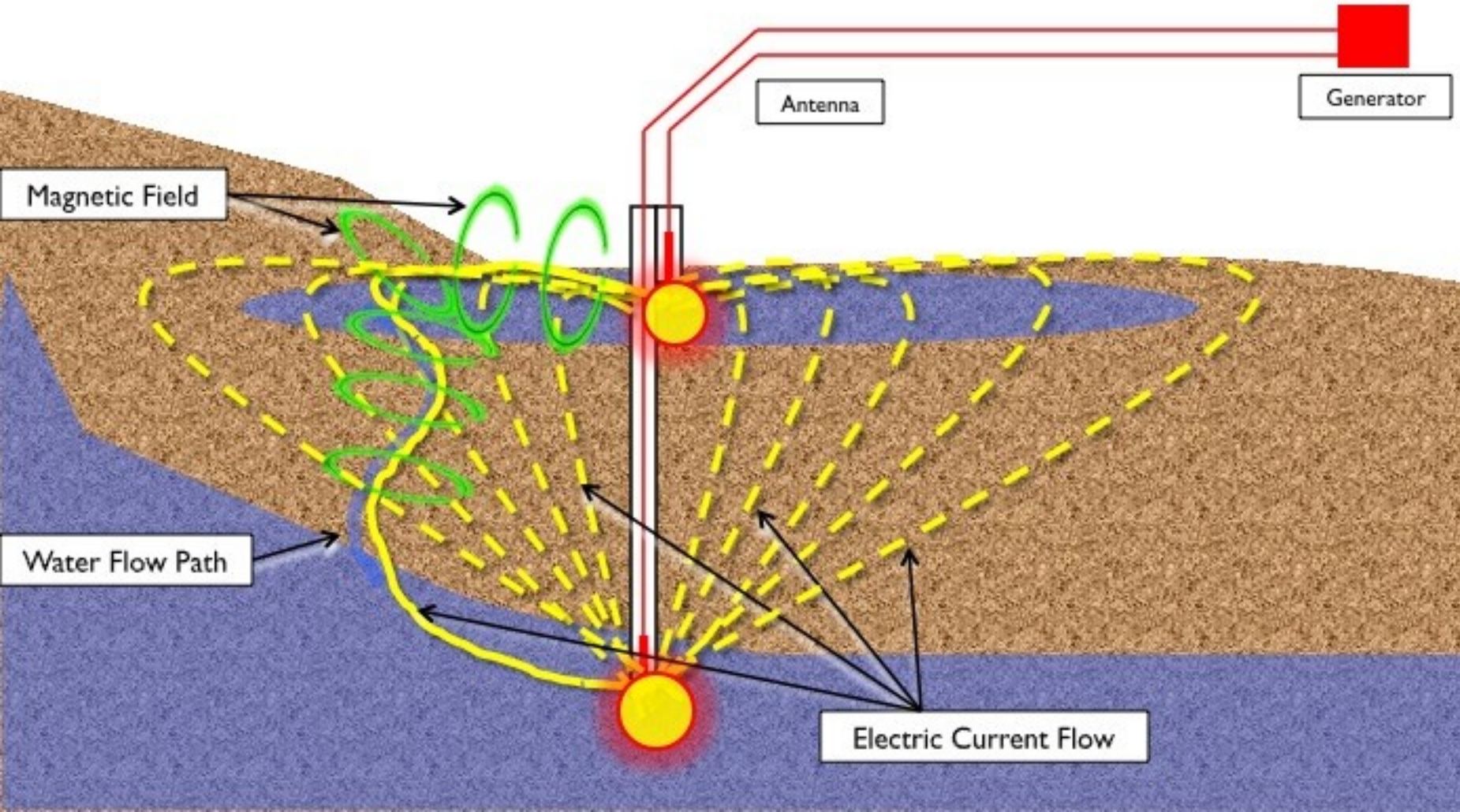
Survey Objectives

- Characterize source of water entering pit
- Is source lateral flow or upwelling into the pit?

Investigation Summary

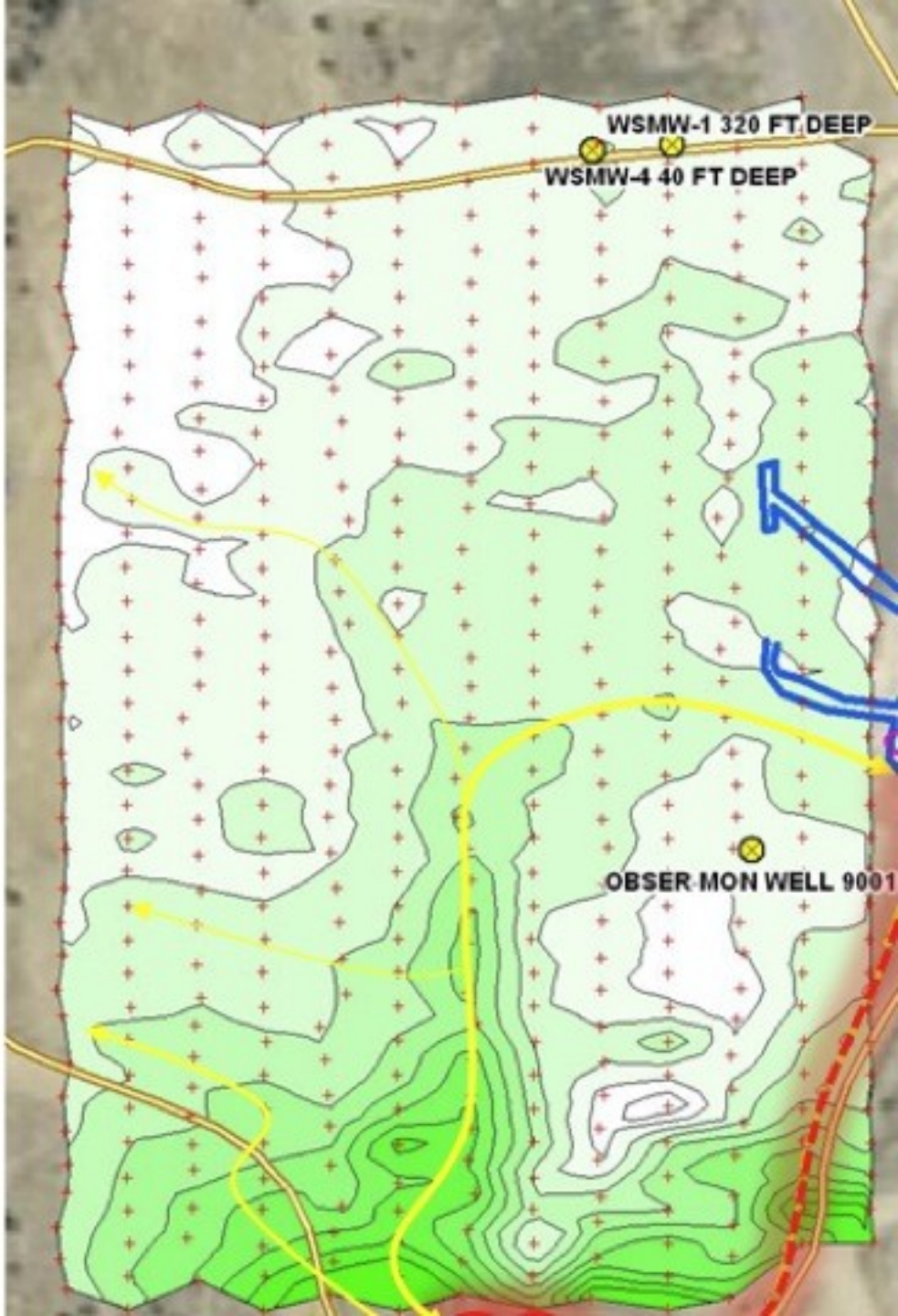
- Electrodes placed in the sump as well as down well
- Energized site from multiple perspectives
- Used both horizontal and vertical electrode configurations
- Investigation identified both near-surface lateral flow paths as well as flow paths flowing from depth up to the surface

Vertical Dipole Configuration



Mine Impacted Water Investigation

- Energized between near surface (10 feet below surface) and deep (410 feet below surface) using a vertical dipole configuration
- Yellow lines show main channel of the Electric Current Flow (ECF)
- Thin yellow lines show secondary flow paths



Value of Investigation

Both lateral (shallow) and vertical (deeper) flow of water affecting site

Identified prominent flow between near surface and depth

Client comparing Willowstick results with other known data (geologic, hydraulic, bore hole locations, etc..) to develop remediation plan

Thank You