RECLAMATION

Managing Water in the West

Geophysical Techniques to Monitor Embankment Cracking (Laboratory Scale)

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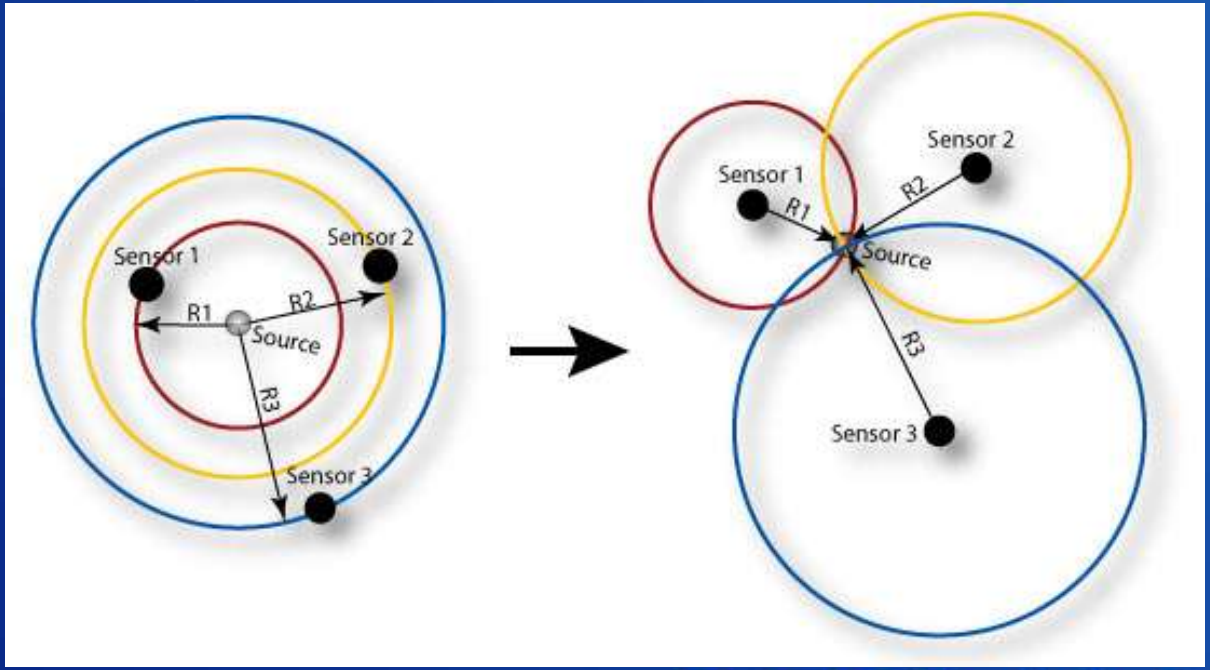
Introduction

- **Problem:**
  - **Internal Erosion (IE) represents one of the major hazards to earthen embankments**
  - **Current practices make it difficult to detect IE in its early stages**
    - **IE often not discovered until the emergency state**
  - **No means by which to determine a Factor of Safety against IE**
  - **IE can manifest after decades (or centuries!) of good performance**

- **Can geophysics aid in the early detection of IE?**
  - **Could provide continuous, remote monitoring**
  - **Could detect the onset or early progression of IE**
  - **Many different techniques to explore**

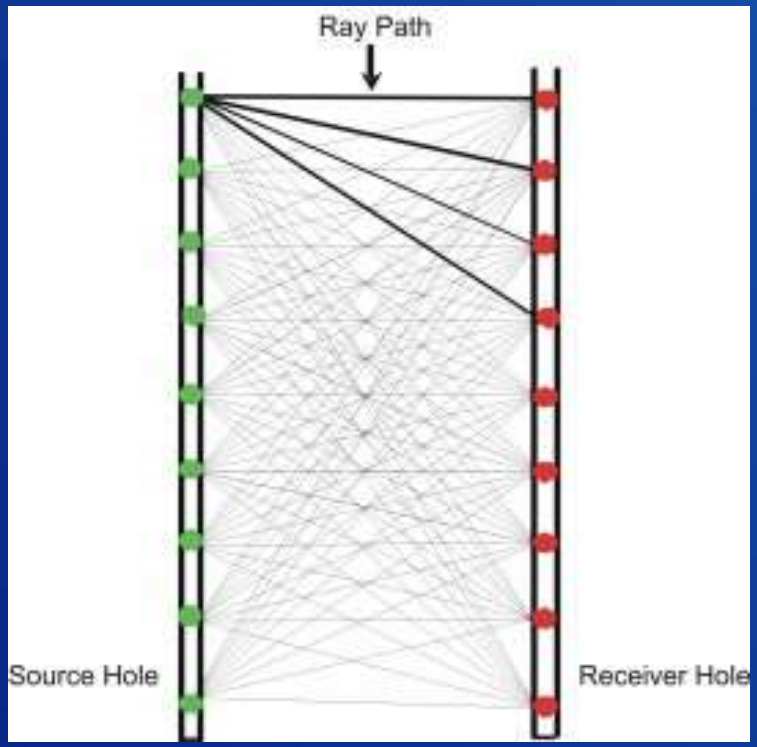
Potential Techniques

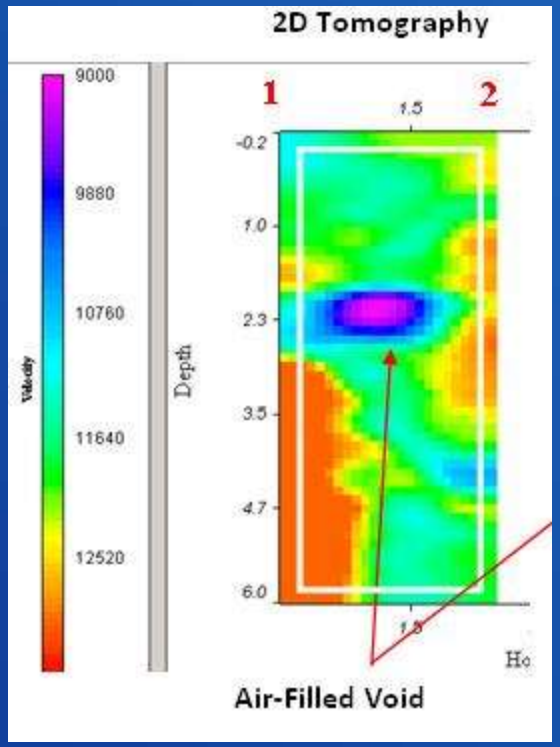
- **Passive Acoustic Emission (AE)**
  - **Passively "listening" for acoustic energy released during soil cracking, internal erosion, seepage, etc.**
  - **Can locate source via triangulation from several sensors**
  - **Other industries are able to extract information about the nature of the defect….geotech is not there yet!**



Potential Techniques

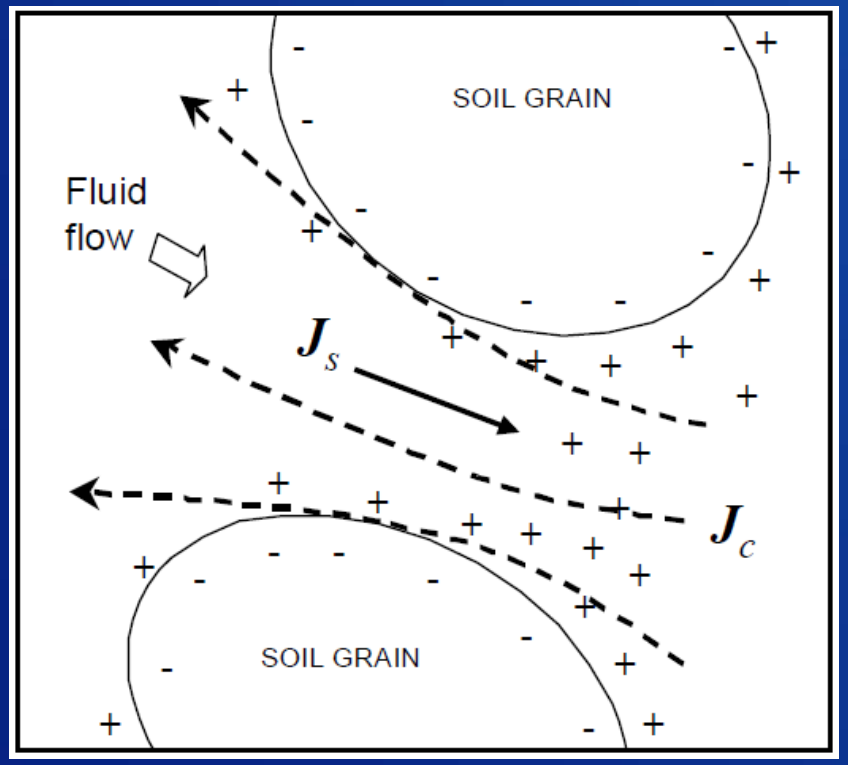
- **Cross-hole Sonic Tomography (CT)**
  - **P- and S-waves transmitted between boreholes (active)**
  - **Direct measurement of wave velocities → material properties**
  - **Can perform imaging similar to CAT scan medical technology**





Potential Techniques

- **Self Potential (SP)**
  - **Measure the surface expression of very small electric fields created by fluid flow through porous media (and other sources)**
  - **Raw voltage measurements can indicate flow/gradient pathways directly, or can be used to perform inverse modeling for flow and geotechnical properties**



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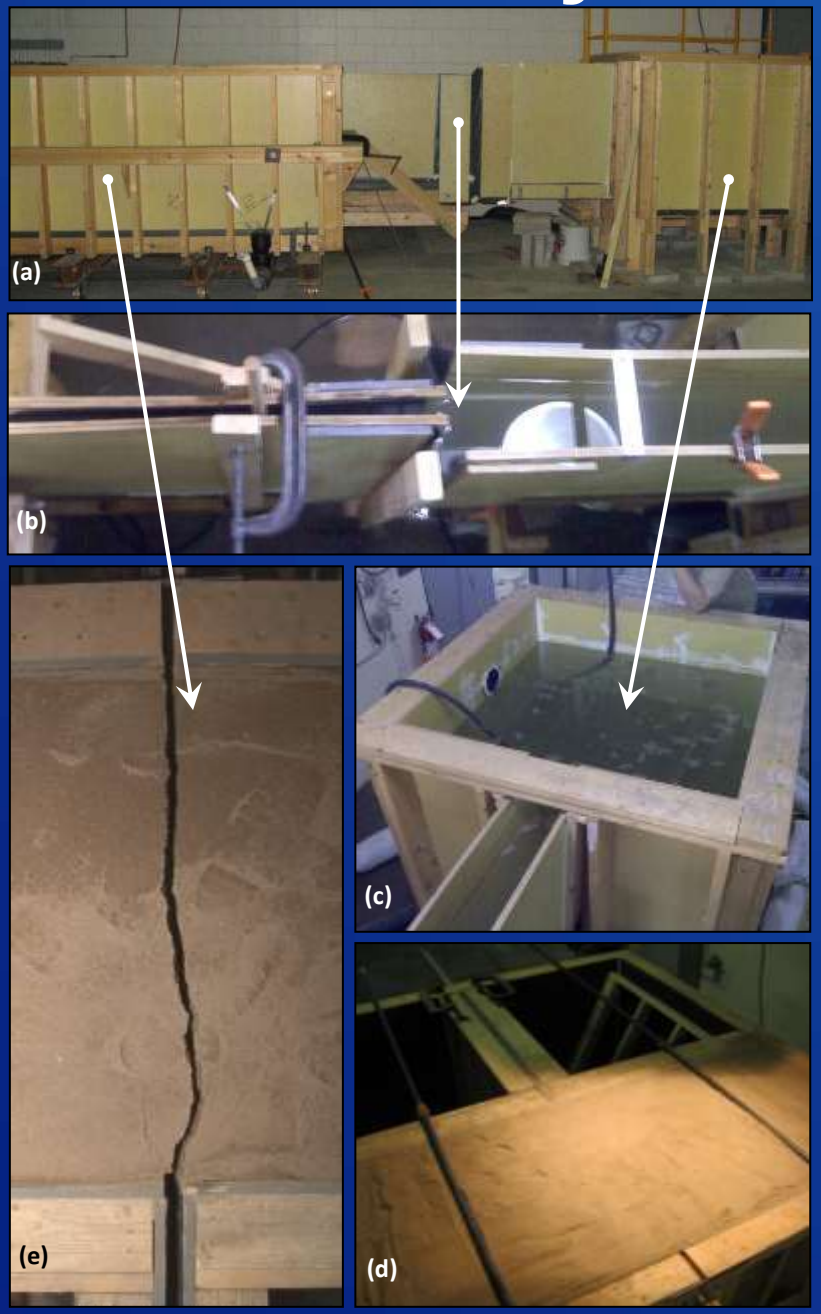
Laboratory Model – Soil Crack Box



- **Laboratory model created to study performance of granular filter materials:**
  - **Materials (filter and/or core) are compacted with box "closed" and then cracked by pivoting around a central axis using jacks**
  - **Constant head reservoir allows water to impinge on crack**
  - **Floor drains in the base of the model simulate filter drains, or can be closed to simulate an isolated filter or clogged drainage**
  - **Much more information available in Redlinger et al. ICSE-6 paper!**

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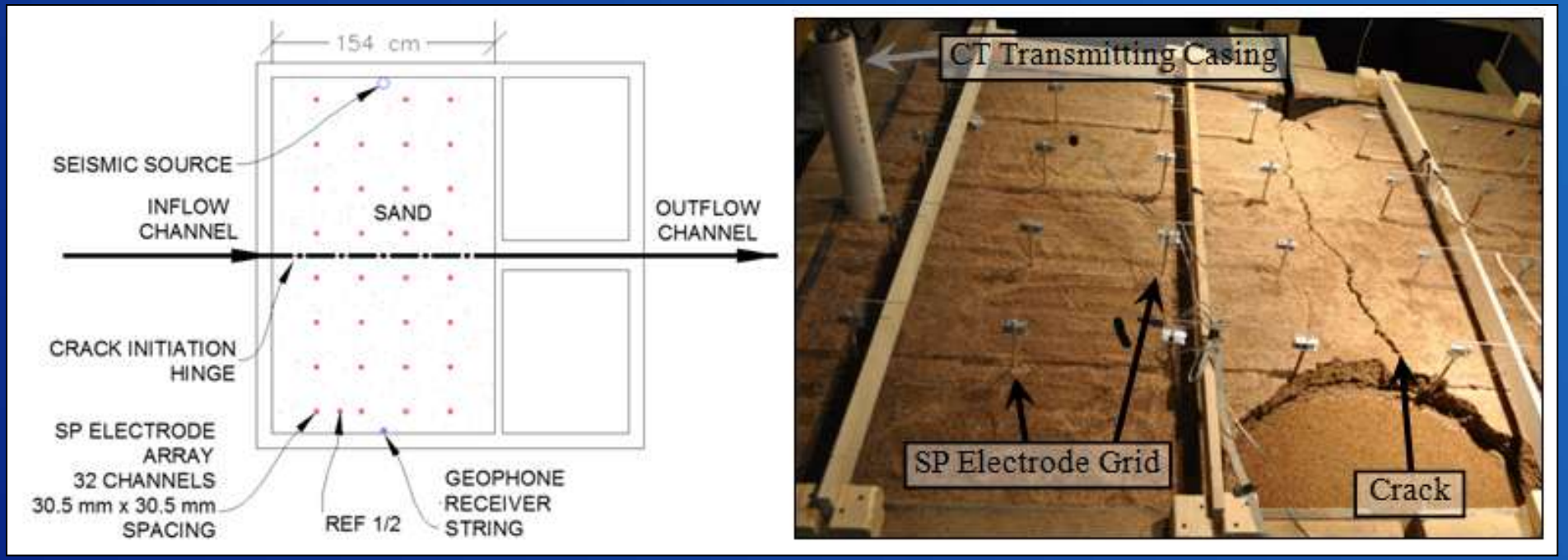
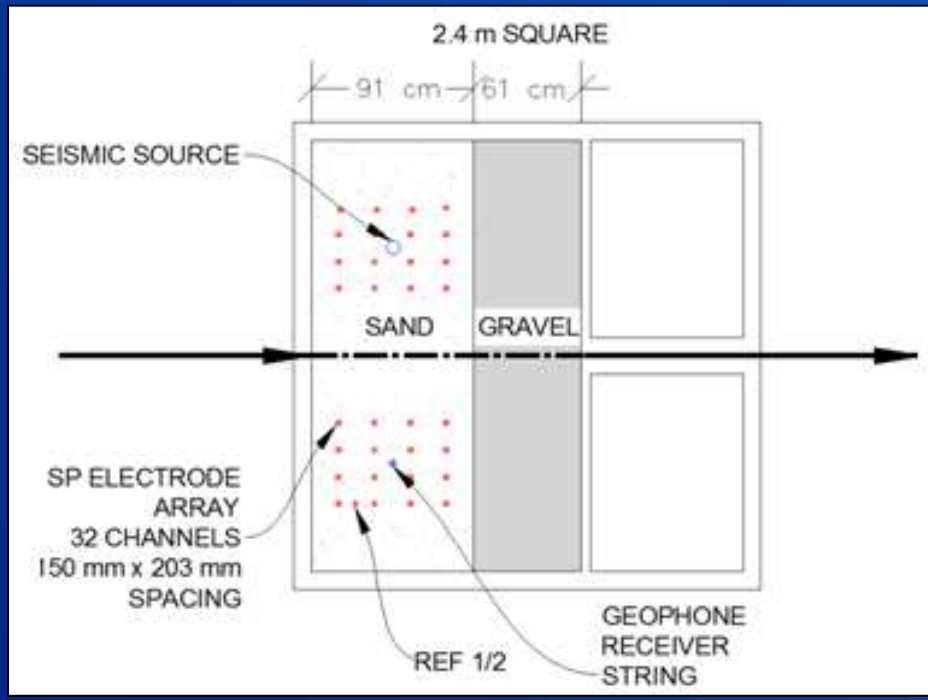
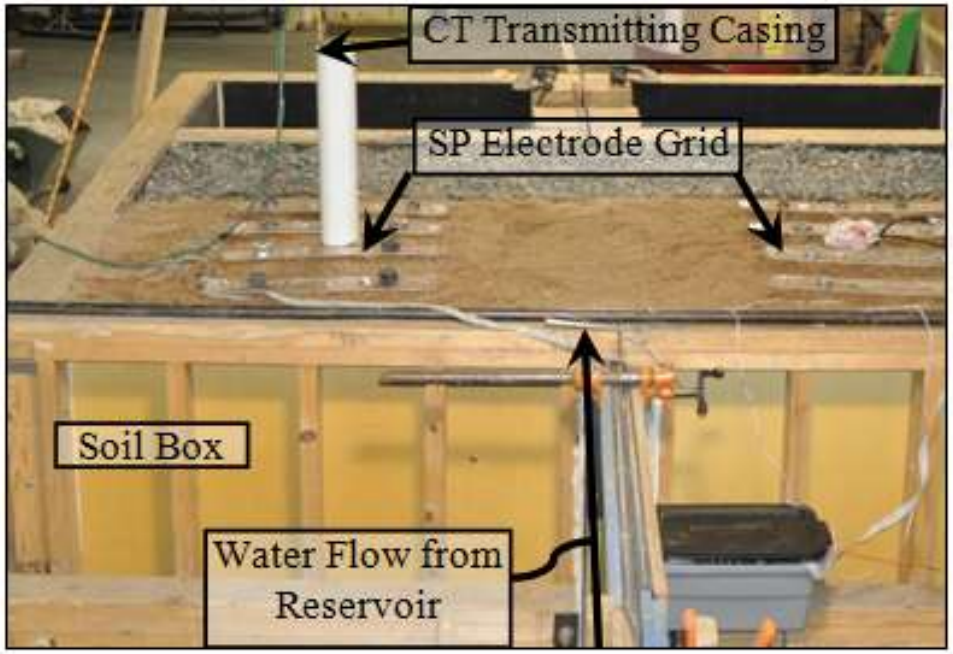
Instrumented Crack Box Tests



Test 1 (single stage filter)

Instrumented Crack Box Tests

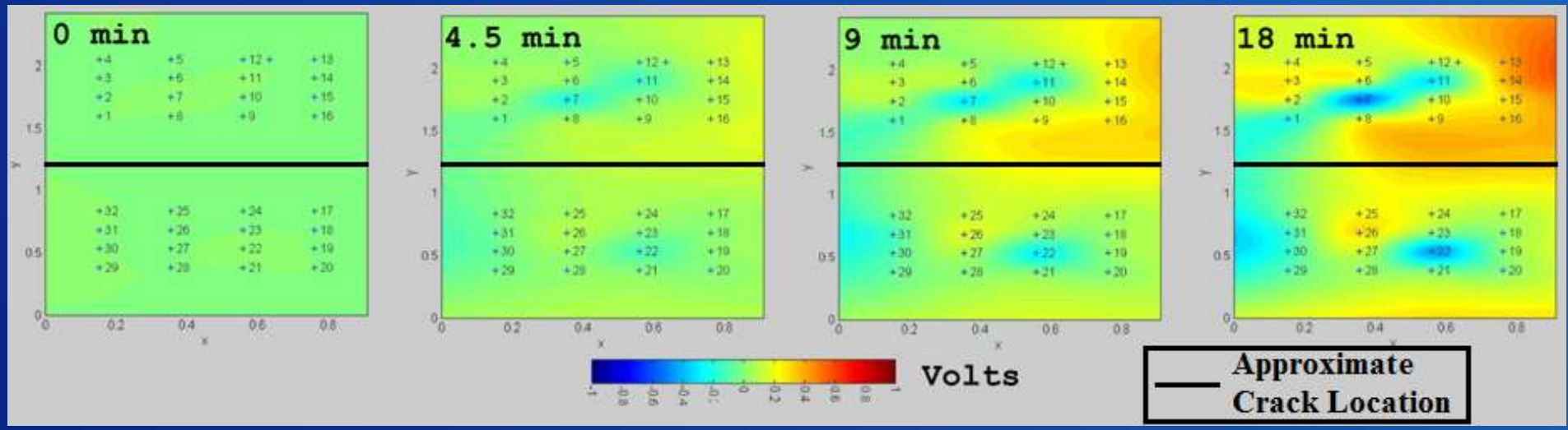




Test 2 (two-stage filter)

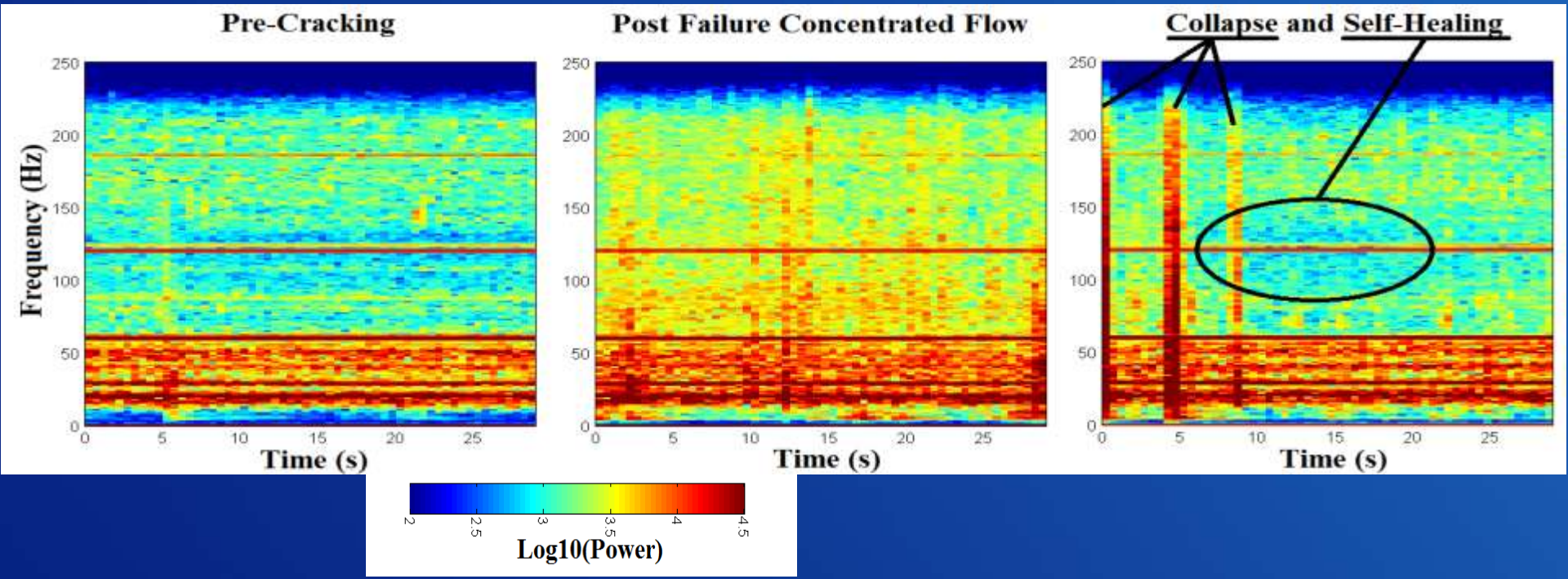
Preliminary Results

- **Self Potential allows you to track to seepage**
  - **Migration of water into filter zone**
  - **Downward flow of water towards drains**



Preliminary Results

- AE
  - Clear contrast between no flow and concentrated flow (uncontrolled seepage)
  - Collapse of filter material crack (i.e., filter healing) leads to reduction in flow



Conclusions

- **The geophysics methods investigated hold promise for early detection of cracking and IE**
  - **Signatures associated with cracking, self-healing, concentrated flow exist in the data and were well above the ambient noise in the challenging laboratory environment**

- **Time-lapse geophysics can show spatial and temporal changes in the subsurface of any embankment structure, at higher resolution (space and time) than traditional methods**
  - **More effective monitoring of several different failure modes**
  - **Very cheap and easy measurements, possible to install a widely distributed sensor network**

Acknowledgements & Questions

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WHERE DISCOVERIES BEGIN