Utility Technologies, LLC

Technology Solutions for Efficient Utilities

Underground Pipe, Cable, and Leak Locating

Mark Beatty, Principal Owner/CEO

Underground Leak Locating

- Terminology
  - Leak Detector
  - Leak Locator
  - Leak Correlator
  - Leak Logger
  - Leak Mapping

Underground Leak Locating

- Leak Locator – Detects and locates a leak based on leak noise

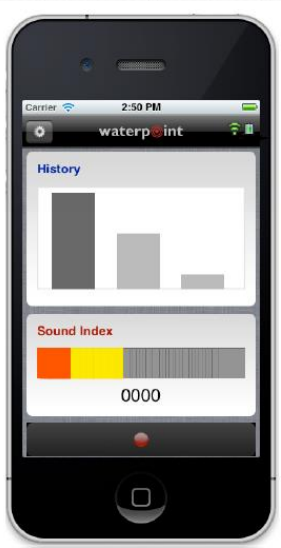
Underground Leak Locating

- Leak Locator – Features to look for
  - Digital or Analog
  - Sound processing & filtering
    - Frequency ranges & limits
    - Loud sound limitation
  - Sensors & Adapters (contact, ground)
  - Wired or wireless
  - Software /Firmware upgradable
  - Export or Database interface

Underground Leak Locating

WaterPoint PLD

- Accelerometer Leak Sensor
- Wireless
- Magnetic base
- Software is an IOS app
  - Updatable software
  - Runs on iPod, iPhone, or iPad
  - Simple to use
  - Filters non-leak frequencies
  - Can interface with GIS mapping



case

Underground Leak Locating

Sewerin Aquatest T10

- Test Rod based device
- Electro-accoustice
- Wireless or Wired Headset
- Band Filters
- Touchpad on/off
- Probe or tripod use

Underground Leak Locating

Sewerin AquaPhon A200

- High Feature Sound Processor
  - View frequency graphs and filters
  - Save/replay recordings
- Completely wireless
- Multiple Sensors
  - Touch microphone & Probes
  - Tripod ground mic
  - Wind protected ground mic

Underground Leak Locating

- Leak Locator – Features to look for
  - Digital or Analog
  - Sound processing & filtering
    - Frequency ranges & limits
    - Loud sound limitation
  - Sensors & Adapters (contact, ground)
  - Wired or wireless
  - Software /Firmware upgradable
  - Saving, Export, or Database interface

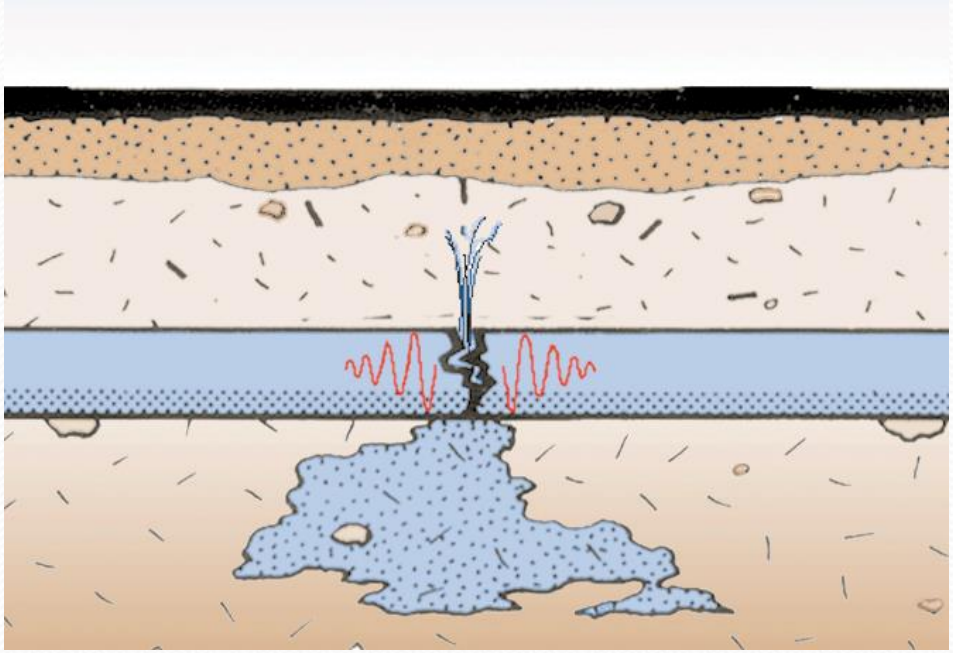
Underground Leak Locating

- Leak Noise Correlator – Detects and locates a leak based the time delay of leak noise reaching two or more sensors.
- Three Things needed for Calculation
  - Pipe Diameter(s)
  - Pipe Material(s)
  - Distance between Sensors

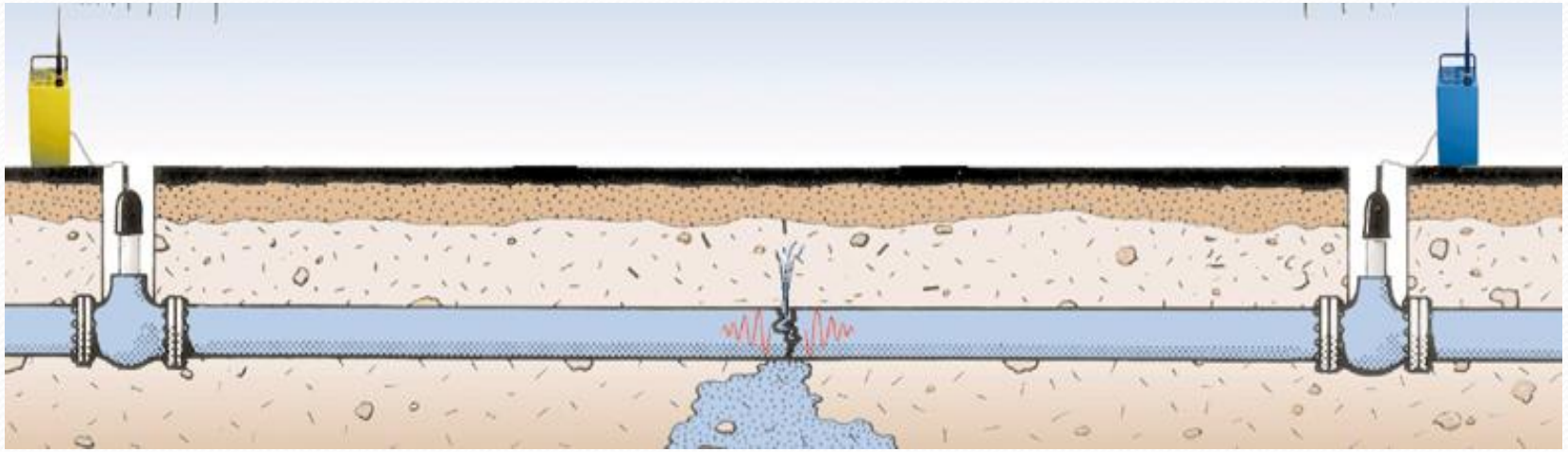
$$(f \star g)(t) \stackrel{\text{def}}{=} \int_{-\infty}^{\infty} f^*(\tau)\ g(t+\tau)\, d\tau,$$

Principals of Correlation Technology

- Vibration energy (sound) is emitted when a leak occurs.
- The leak sound travels away from the leak site through the fluid.



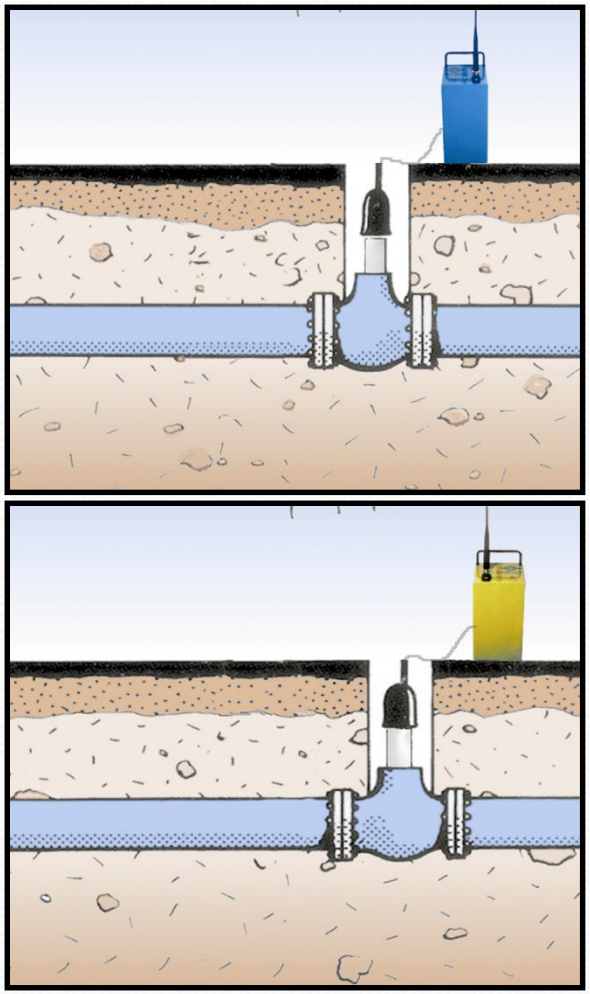
Principals of Correlation Technology (cont'd.)



Acoustic vibrations are sensed in two ways:

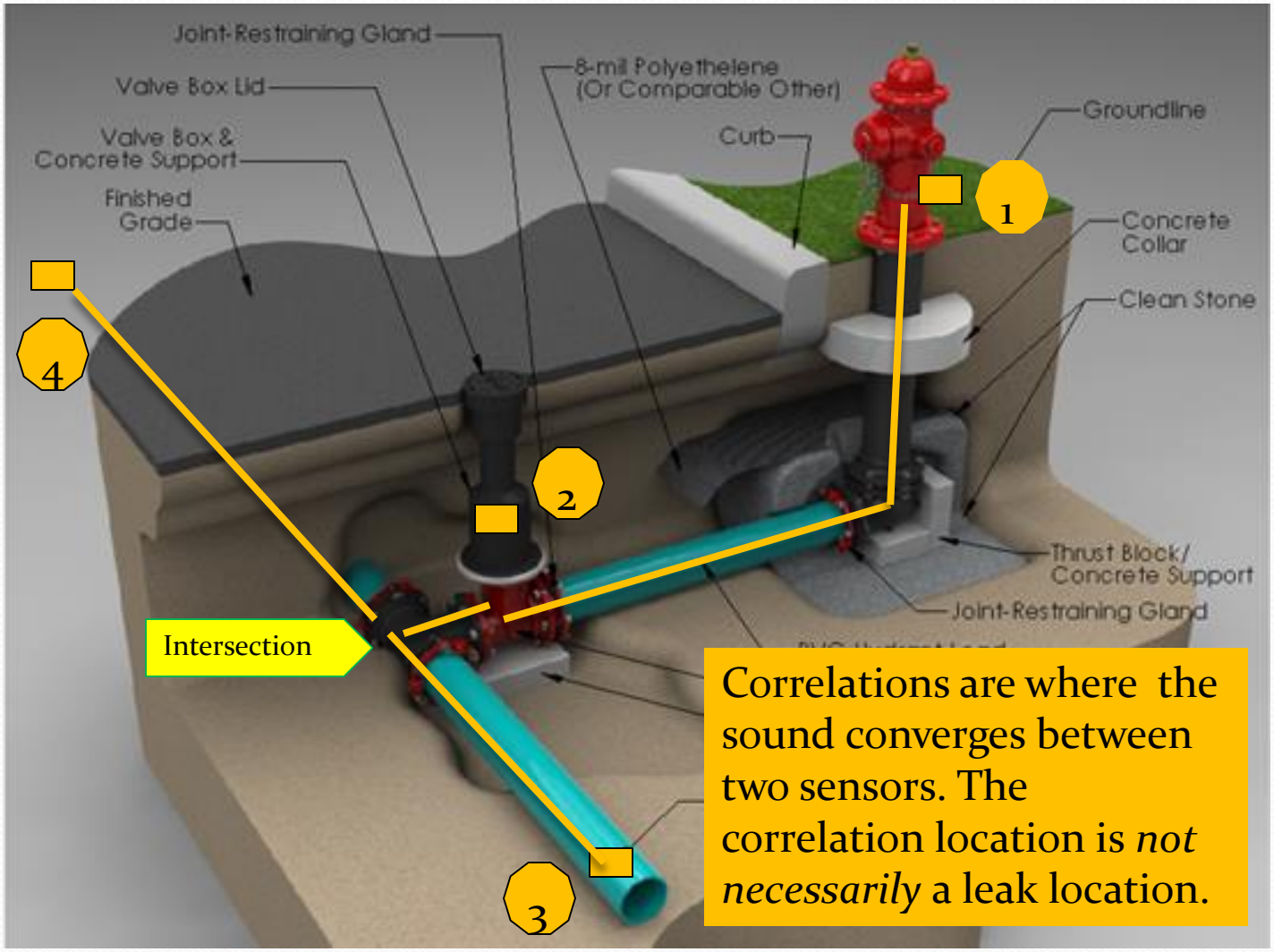
- Outside of pipe using *accelerometers*; and
- Within the flow using *hydrophones*.

Principals of Correlation Technology



- As the sound travels in either direction through the pipe, it will arrive at each sensor at a given time. Vibration energy (sound) is emitted when a leak occurs.
- The difference between the arrival time at sensor #1 and the arrival time at sensor #2 is referred to as the *time delay*.
- The time delay is computed using a signal processing technique called ***correlation***.

Correlating Pipe Intersections



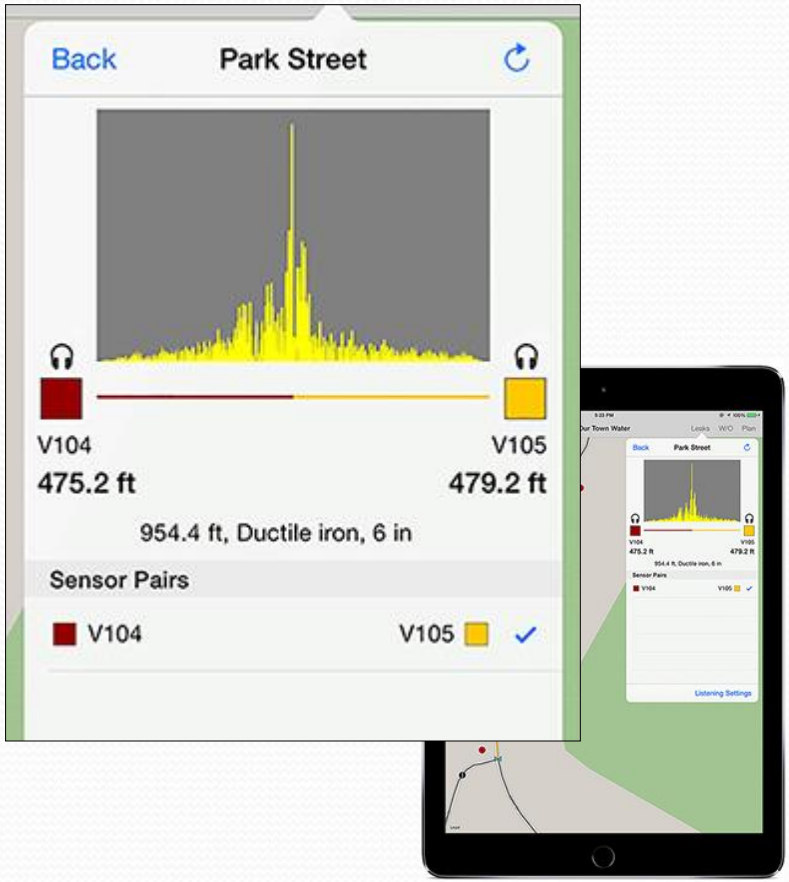
Underground Leak Locating

- 64 Seconds LNC

Underground Leak Locating

64 Seconds LNC

- Leak Noise Correlator
- Wireless communications
- Use 2-4 Sensors
- Delayed Depolyment - Logging
- Software is an iPad App
- Can use Existing GIS data:
  - Locations & lengths
  - Pipe Sizes & Materials
  - Enter data via GPS
  - Can save data to GIS locations



Underground Leak Locating

Sewerin Secorr 08

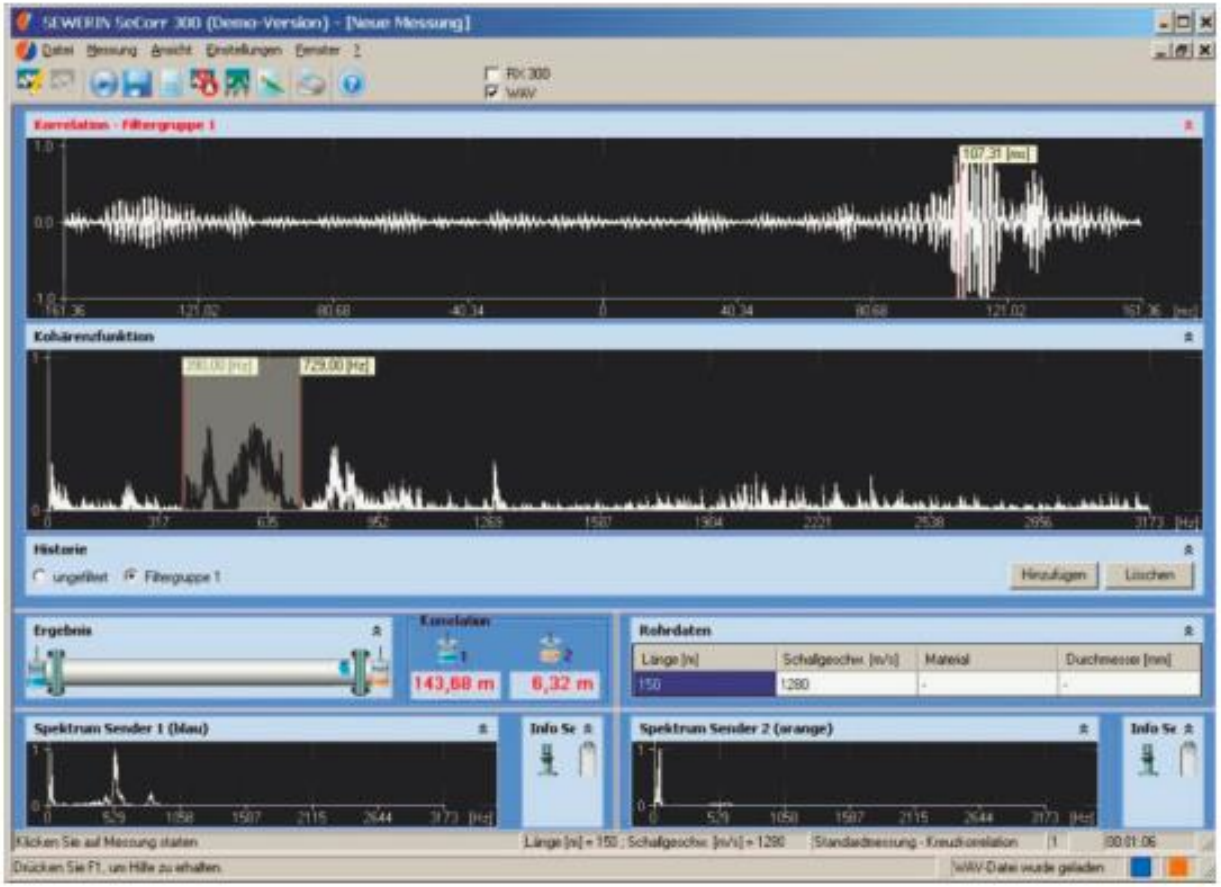
- Main Processor – Enter up to 3 sections of pipe
- 2 Analog Sensors communicate via Radio Signal
- Quick instant radio communication
- Enter Pipe data into Processor
- Pauses for temporary sound
- Easy to run multiple analysis
- Data not saved

Underground Leak Locating

Sewerin Secorr 300

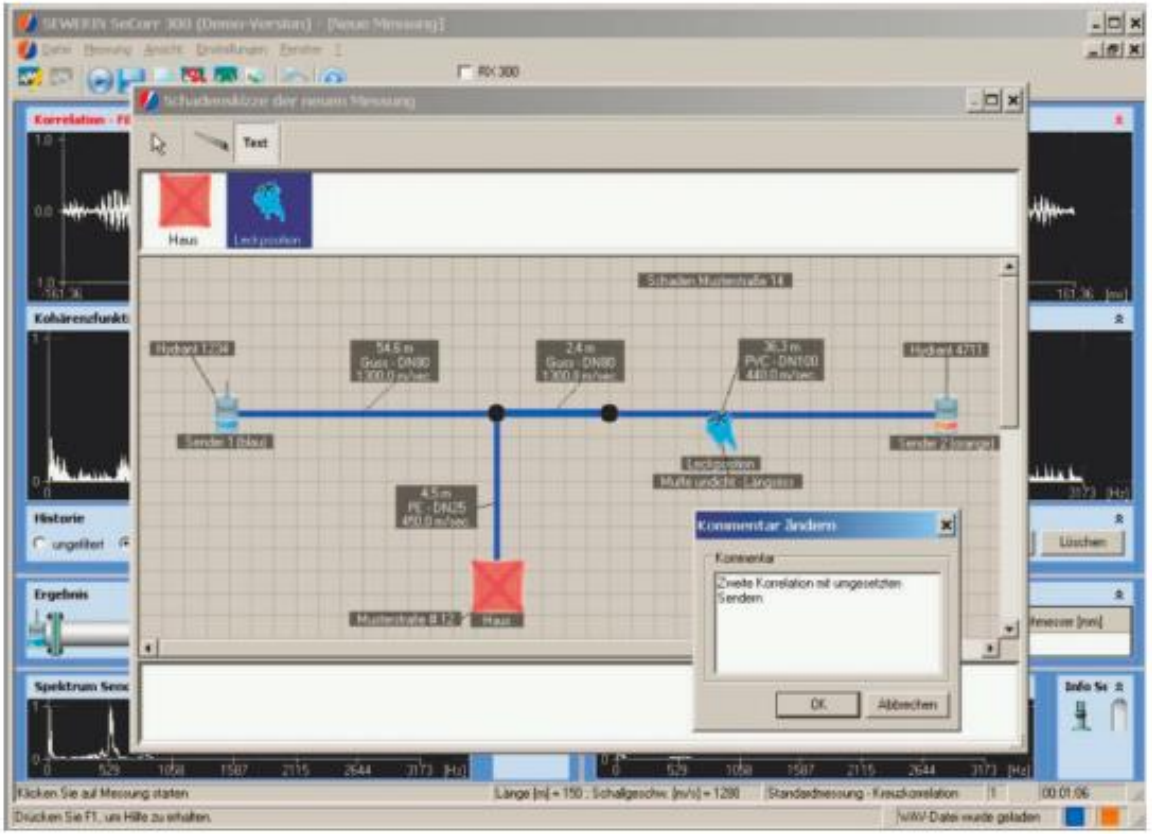
- Main Processor – Digital Sound Processing
- 2 Sensors communicate via Digital Radio Signal
- Long Range – up to 1000 meters (3300')
- PC Based high end software analysis
- Data saves to PC Database
- Sophisticated sound analysis
- Leak Situation Diagramming

Underground Leak Locating



Correlation result after filtering

Underground Leak Locating



Sample fault sketch

Underground Leak Locating

- Leak Loggers
  - Log leak sounds unattended at preset time or times
  - May also be correlators
  - Overnight leak detection advantages
    - Less background noise from use or traffic
    - Higher Pressures at night
  - Permanent Logging
    - Develop history of sound to find new leaks
    - Proactive leak detection plan – finds leaks early
  - Temporary Leak Logging
    - Leak Surveys with fewer loggers

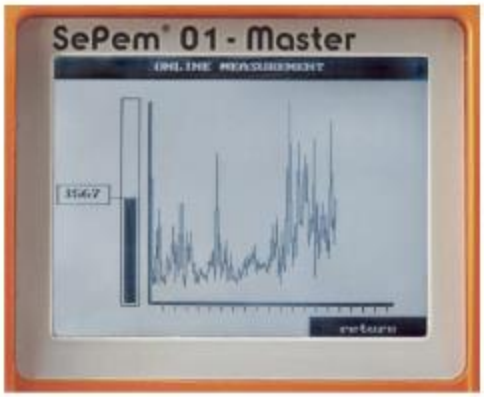
Underground Leak Locating

- Leak Loggers
  - WaterPoint LNC
    - Can be left for a single timed leak recording up to 24 hour delay.
    - Can also Correlate the any leaks found
  - SePem01 Radio Loggers
    - Drive-by or Walk-by Radio Solution
    - Radio loggers installed in valve boxes
    - Up to 400 loggers managed per Master Reader
    - Can be deployed Permanently to find leaks as they start and develop

Underground Leak Locating

- SePem 08

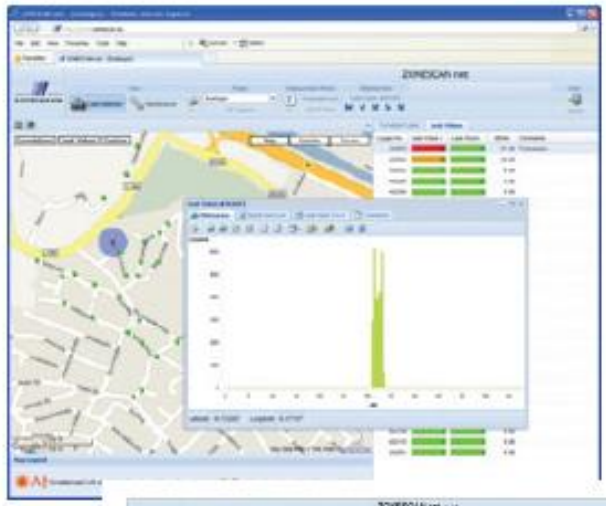
This table lists the data from each ***SePem® 01*** in succession as the vehicle passes the measuring points.

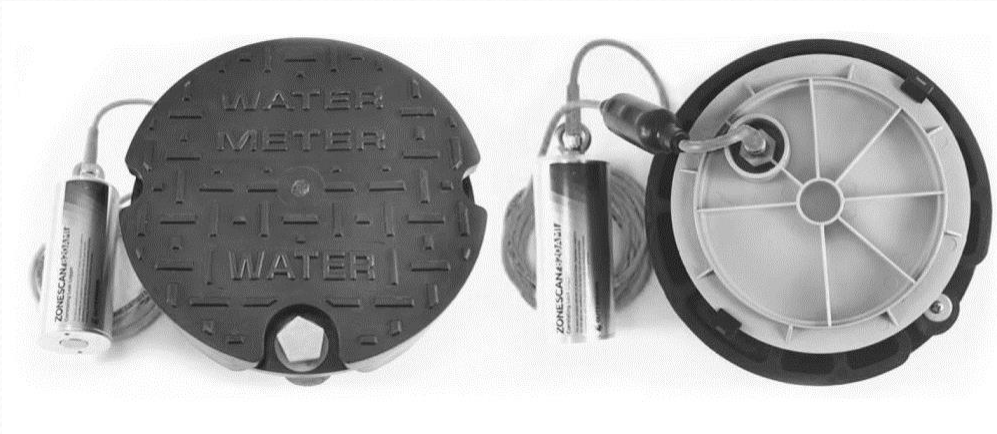


Online measure-ment, as illustrated here, allows you to determine prior to installation if a "zero measure-ment" might even be possible during the day.

Underground Leak Locating

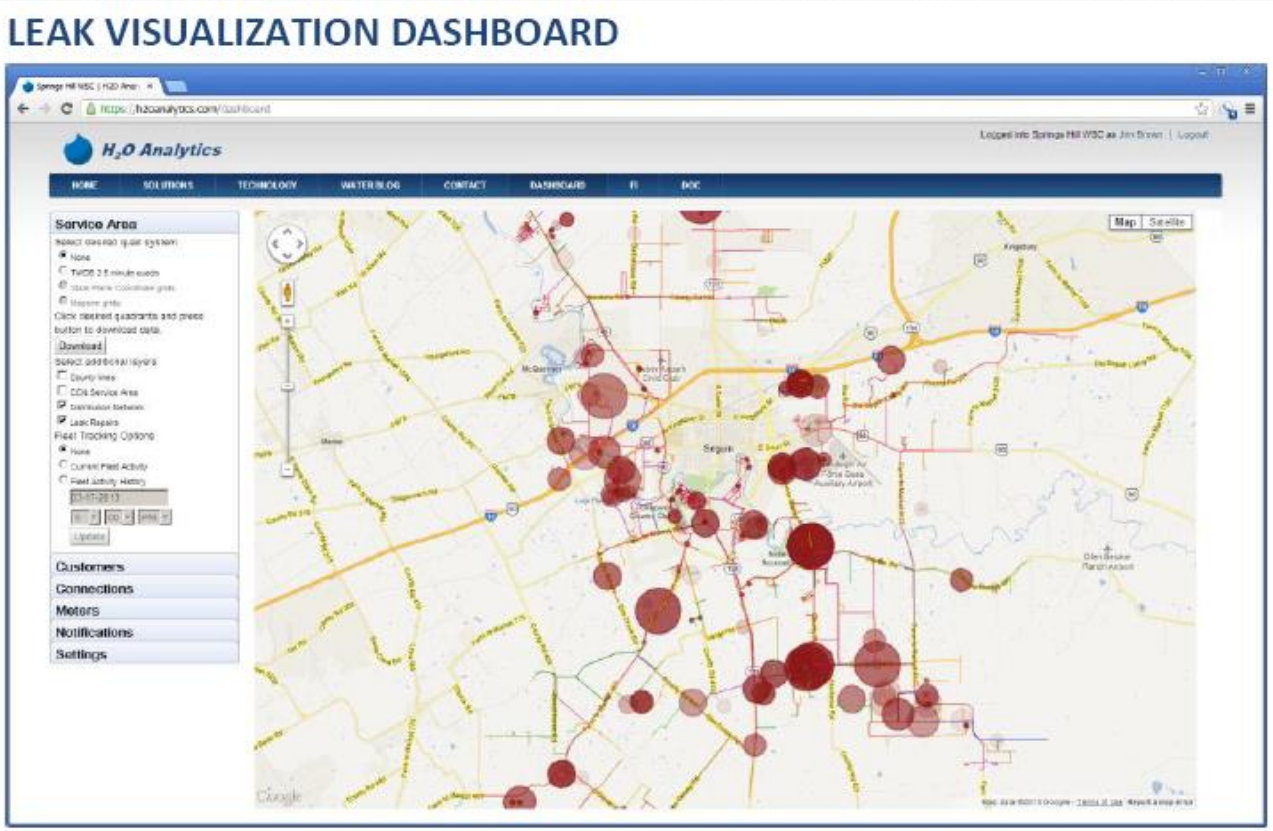
- Aclara Star Network ZoneScan
  - Correlating Leak Loggers
  - Permanent or Moveable
  - AMI Fixed Network





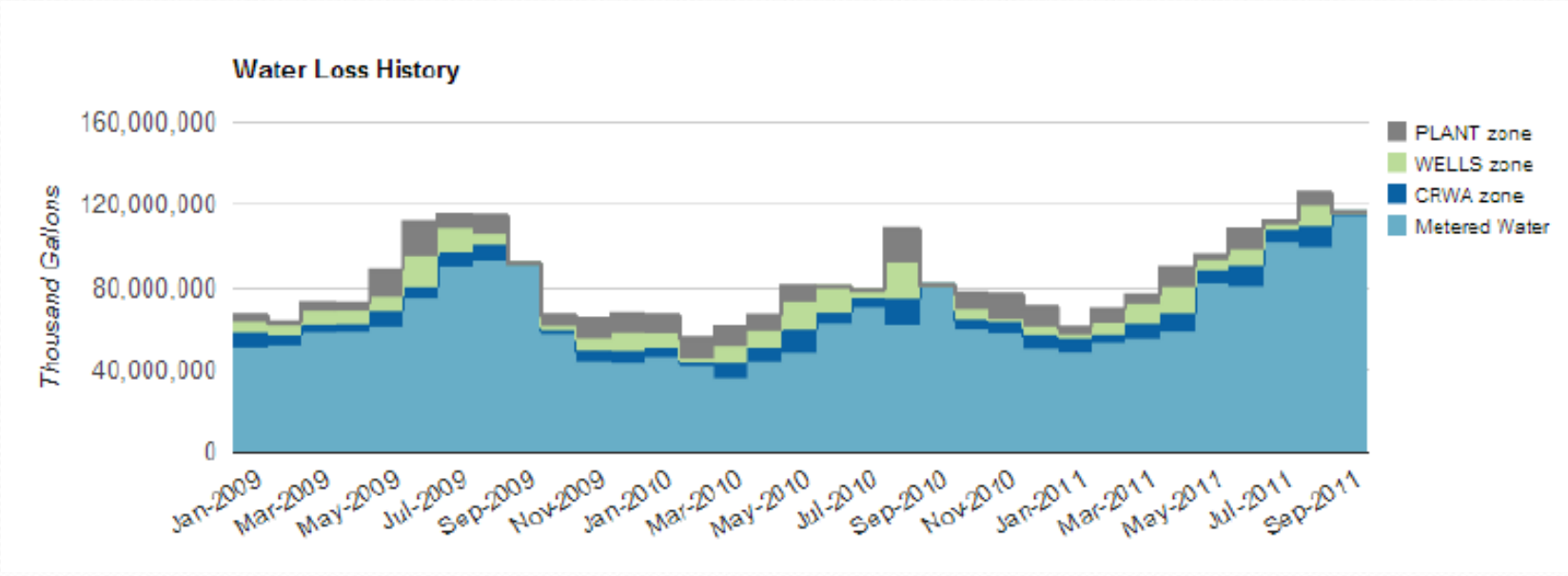
Underground Leak Mapping

- H2OAnalytics – Leak History Mapping



Underground Leak Mapping

- H2OAnalytics – Zone Analysis



Leak Detection Summary

- Best to use a combination of leak detection, leak locating, leak logging, and leak mapping tools.
- Integrate Water Loss Management with Metering, SCADA, and GIS.
- Most Leak detection depends on knowing where your pipes and underground assets are located.
- Preventing leaks can depend on knowing accurate underground pipe locations.

Underground Locating Methods

- Visible Assets at ground level
- Maps, Plans, GIS and GPS/GNSS
- Tile Probes, Shovels
- Witching (divining, dowsing)
- GPR - Ground Penetrating Radar
- Ferromagnetic Locators, magnetic locators
- Electronic Pipe & Cable Locators (Radio Frequency)
  - Tracer wire, Marker balls, Sondes
- Leak Detectors
- Sonic and Ultrasonic Methods

Ferromagnetic Locators

- Can locate Iron or Steel pipe
- Easy if no other utilities in area
- Will detect other **Ferrous** metal objects or **Magnets**
- Small, lightweight
- Inexpensive compared to pipe locators
- The difference between “metal detectors”.

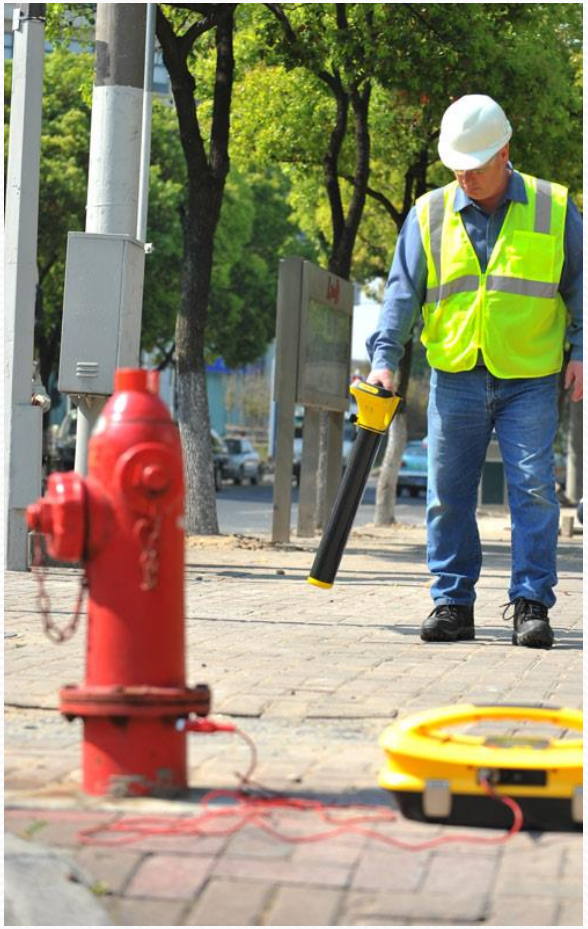
Ferromagnetic Locators

Metal Locators

- Can detect all types of metal (tin, copper, nickel, brass, etc.)
- Some have filtering
- Inexpensive

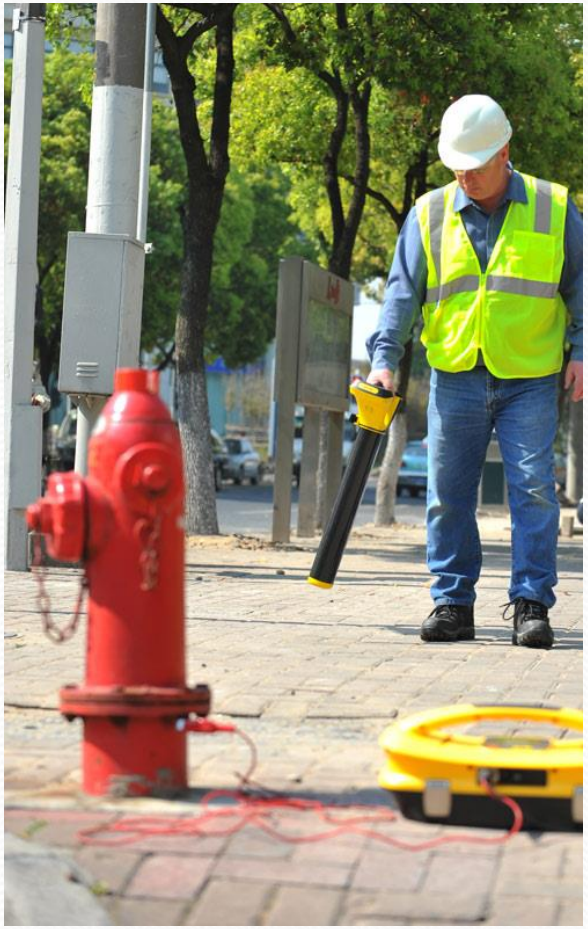
RF Pipe & Cable Locators

- Usually Two Parts
  - Transmitter
  - Receiver
- Transmits AC radio frequency signal
- Works on metal pipe or Pipe with tracer wire
- Can locate a Sonde in non-metallic pipe



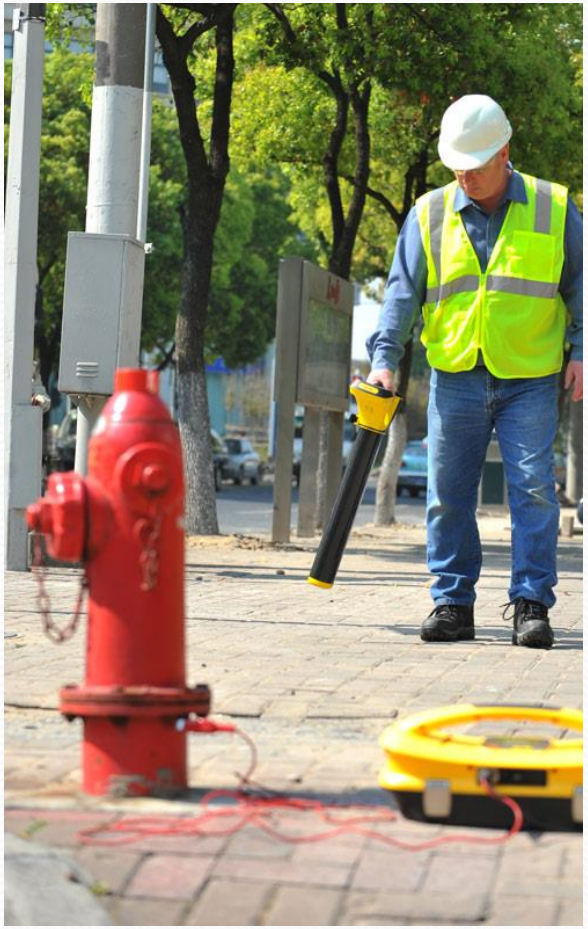
Pipe & Cable Locators

- Passive Locating Signal
  - AC current
  - Radio Frequencies
- Active Locating Signal
  - Direct Connection
  - Signal Clamp
  - Induction



Pipe & Cable Locators

- Does a Pipe Locator actually locate the underground pipe and cables?



RF Pipe & Cable Locators

Sondes

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Locator Theory

The Principles of Pipe & Cable Location

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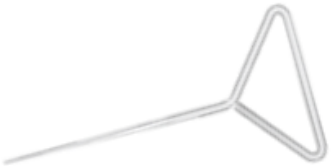
A Typical Locator consists of……

Receiver

Transmitter

Connection Leads



Ground Stake

Signal Clamp

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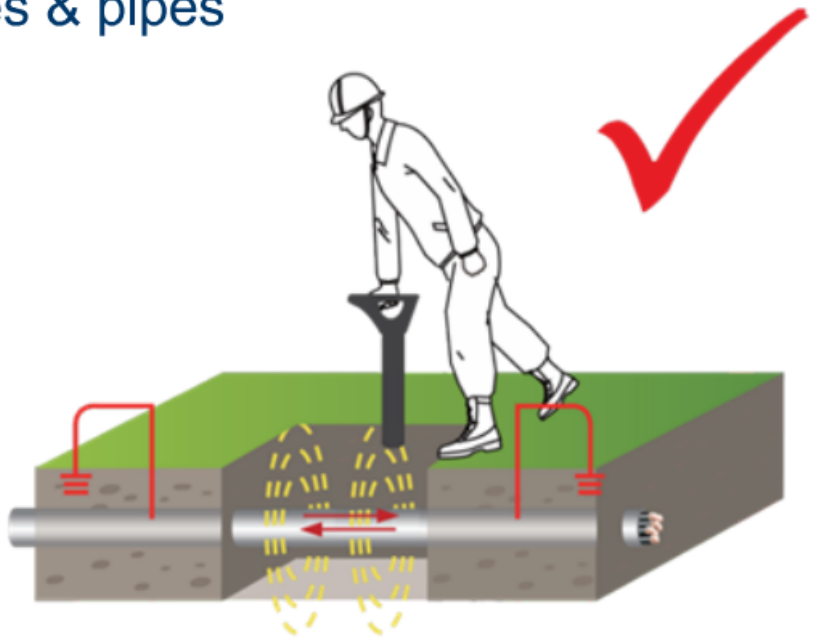
Locators do ***NOT*** locate buried cables or pipes

Locators ***DETECT*** electromagnetic ***SIGNALS*** radiating from metallic cables & pipes



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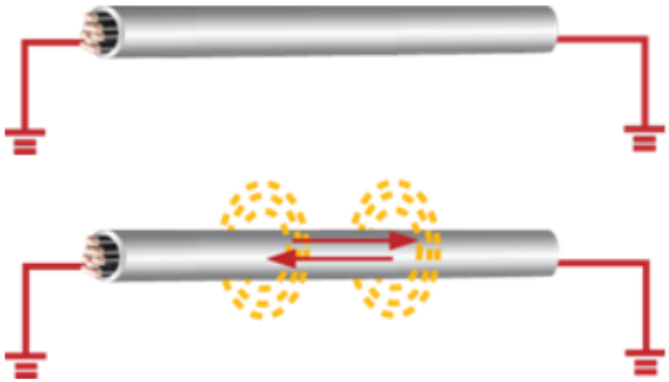
The Locating Signal……

- Is produced by the flow of the alternating current *(AC)* which creates an electromagnetic field

- This electromagnetic field *radiates from* the line and is known as the signal



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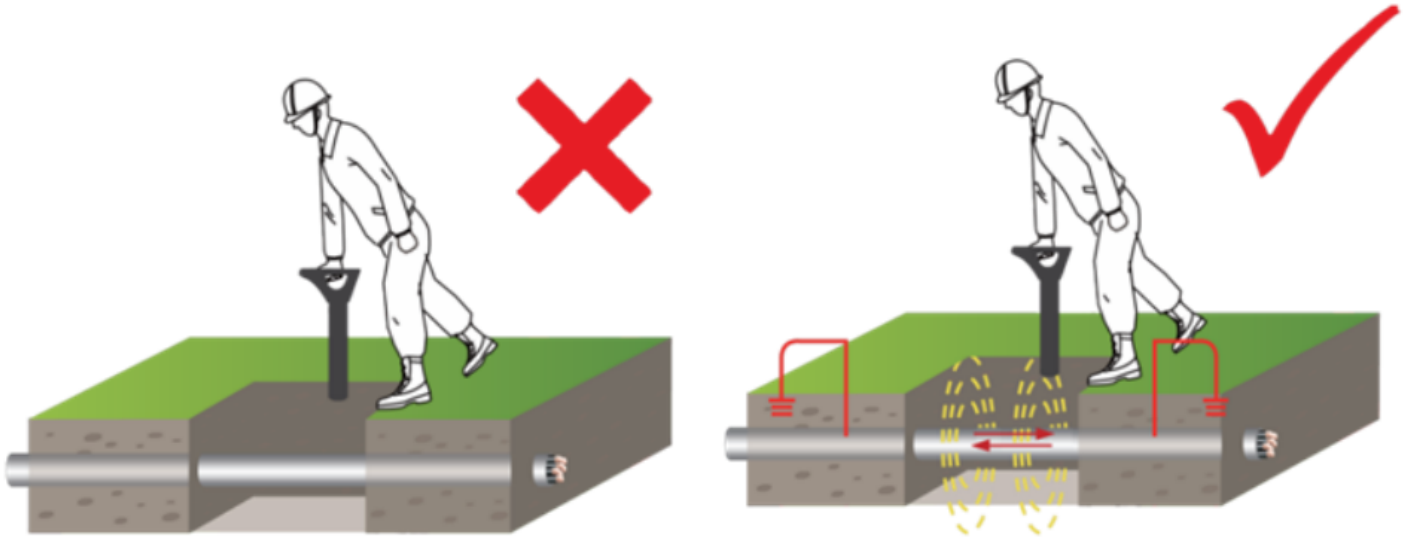
The Locating Signal……

- if there is *NO AC CURRENT FLOWING*, there will be *NO LOCATING SIGNAL*.



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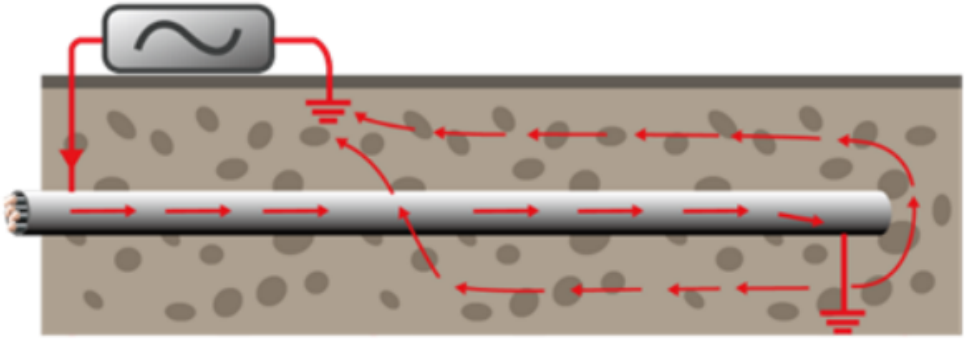
The Locating Signal……



- Signals are created by the current flowing from the transmitter which travel along the conductor (line/cable/pipe) and back to the transmitter.

- The current typically uses the ground to complete the current. The earth stake is used to complete the circuit through the ground.

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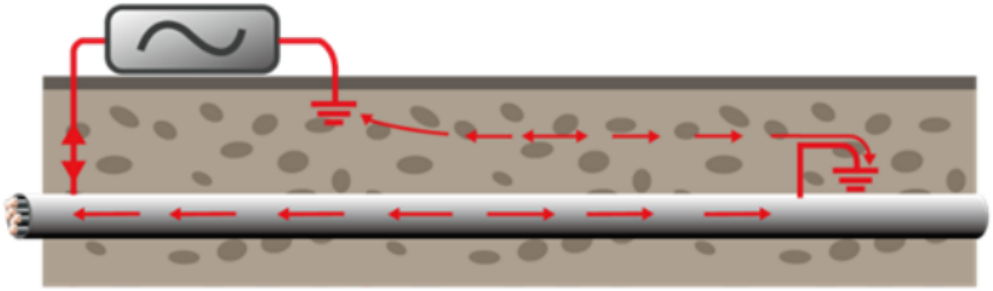
The Locating Signal……



- We think of the signal traveling from the transmitter and back to the earth stake. In fact the signal is continually changing direction, flowing back and forth.
- The rate at which it changes is called frequency, so for instance, 50Hz means the signal changes direction 50 times per second, 8000Hz (or 8 kHz) means 8000 times per second. (The "k" denotes 1000)
- The frequency is chosen depending on the application.

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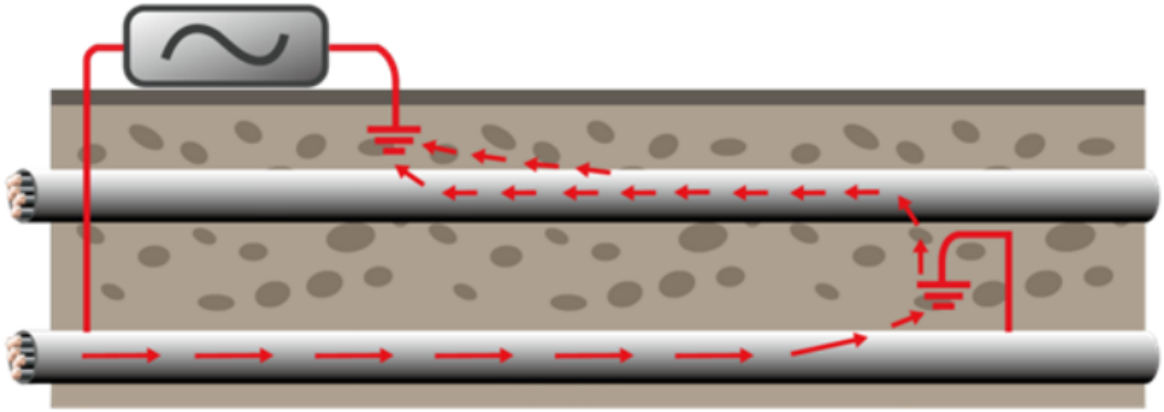
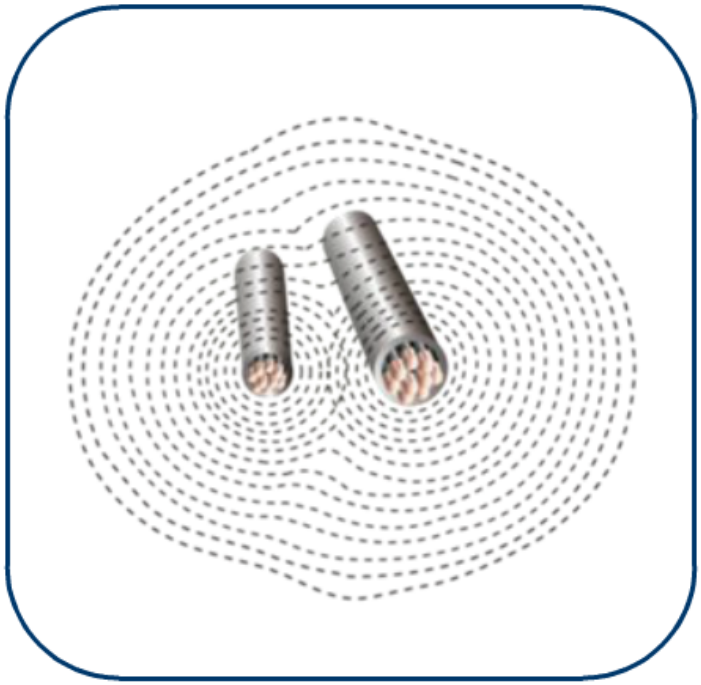
The Locating Signal……



- Signals may use other pipes and cables to turn to the transmitter because they represent a lower resistance than the ground

The Locating Signal……

- Because of these "return" currents the *ELECTROMAGNETIC FIELDS* surrounding the line can be *DISTORTED* by return currents on other metallic lines



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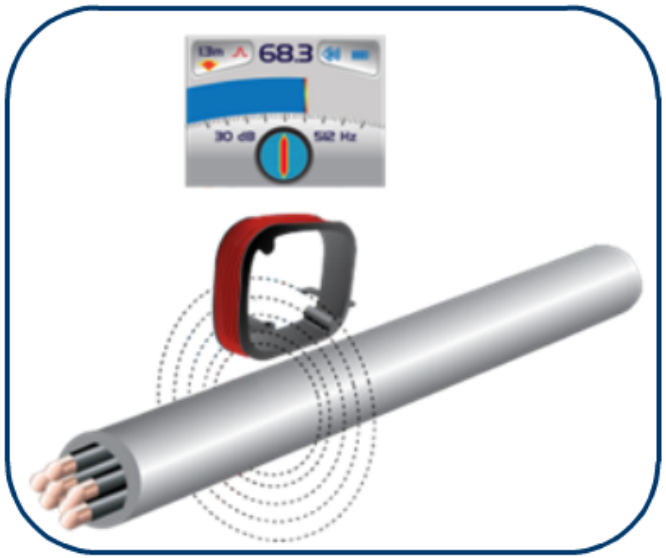
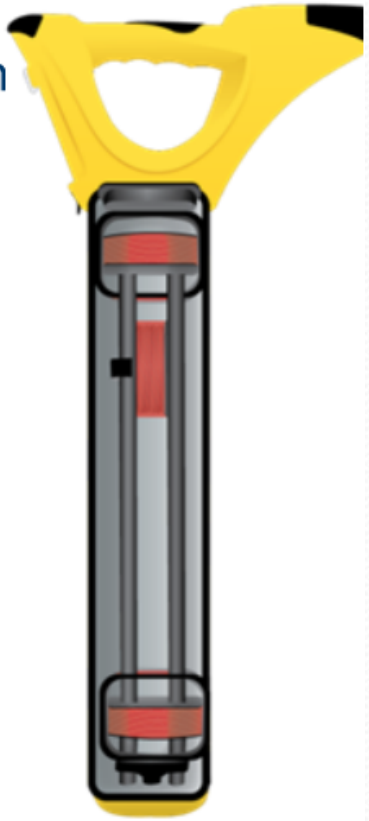
Detecting the Locating Signal……

- The locator receiver contains sensors that detect the electromagnetic field (the signal)
- These sensors are known as "antennas"
- The signal induces a "response" in the antennas by electromagnetic induction



The Response to the Signal……

- There are several antennas in a locator, these can be used in different combinations.
- Each combinations (known as modes) provides a different types of response.
- The three main types of response for general locating are "Peak", "Null" and "Compass/LR" indication.
- Two additional modes are often used for specific applications
  - "Broad Peak" (useful when locating very deep lines- operates like peak mode)
  - "Sonde" Mode (for locating Sondes or CCTV inspection cameras –see Sonde section



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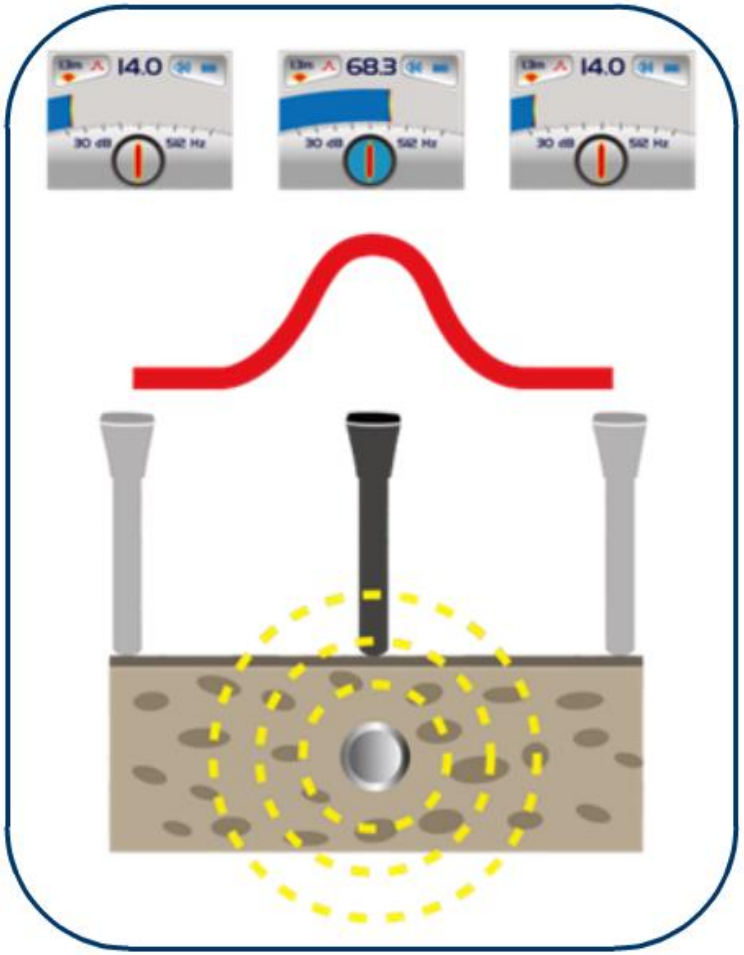
Modes……

- "Peak" mode
  - provides a maximum response over the line



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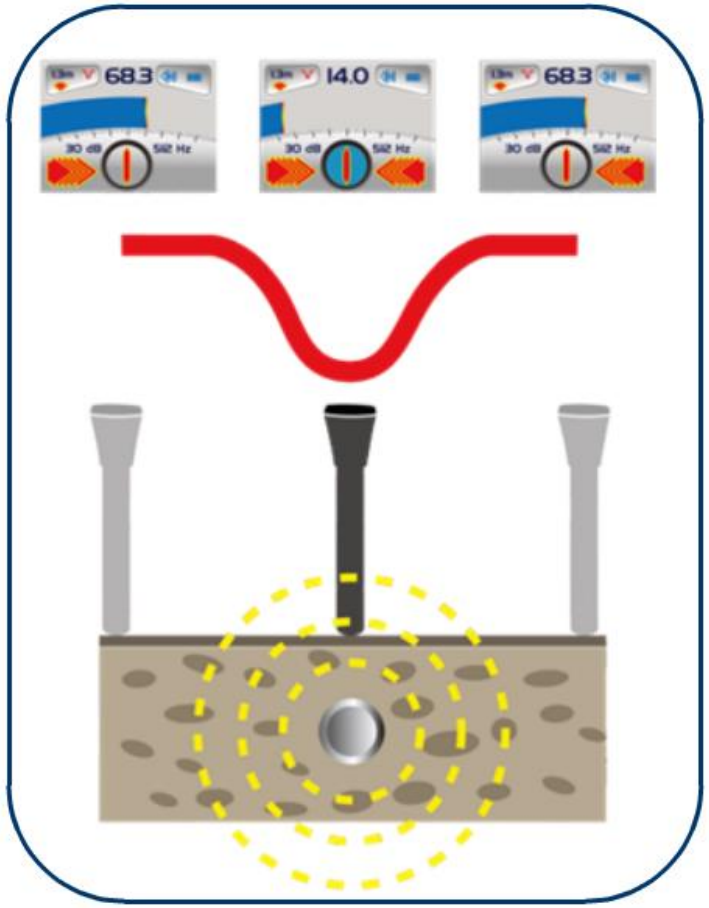
Modes……

- "Null mode"
  - provides a minimum response over the line



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Modes……

- "Compass LR"
  - Provides "direction" & "orientation" to the line

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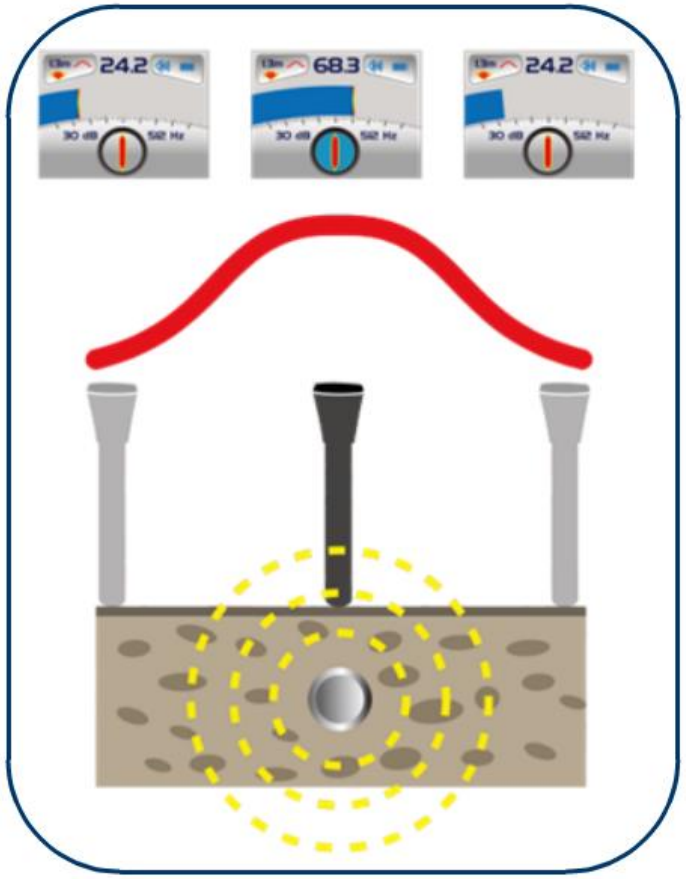
Modes……

- Broad Peak
  - Provides increased sensitivity locating for deep pipes
  - But response is broader, so more difficult to pinpoint



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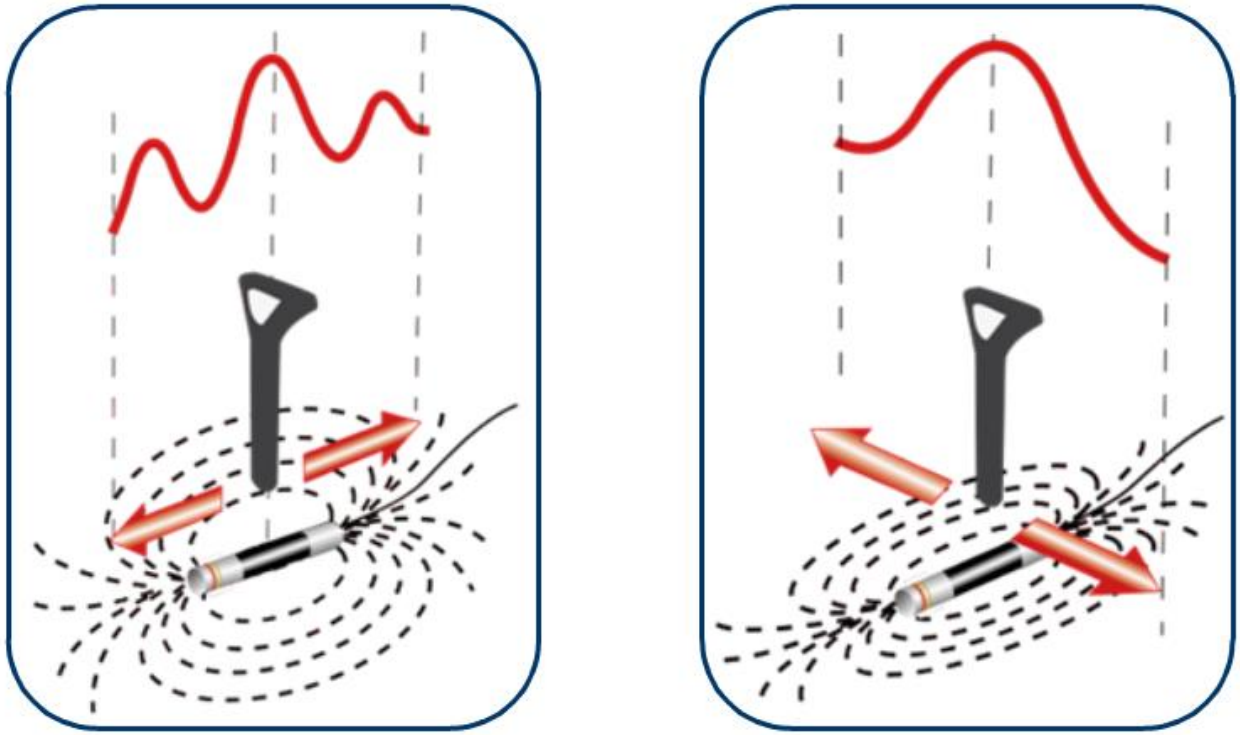
Modes……

- Sonde
  - A way to locate small "self contained" transmitter (used in non metallic pipes & some cast iron pipes)



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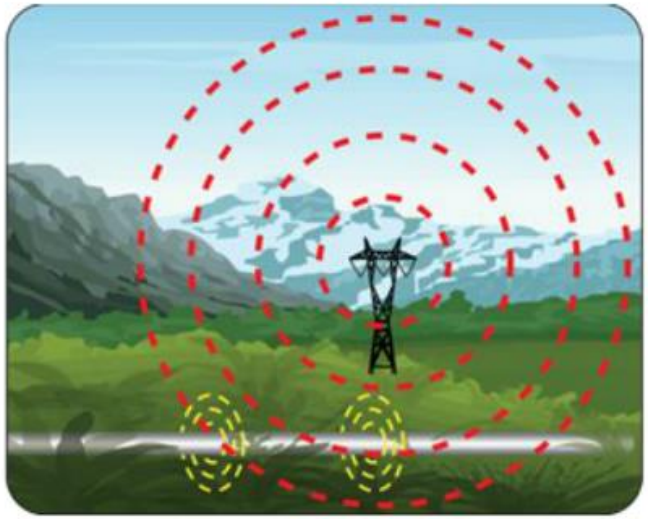
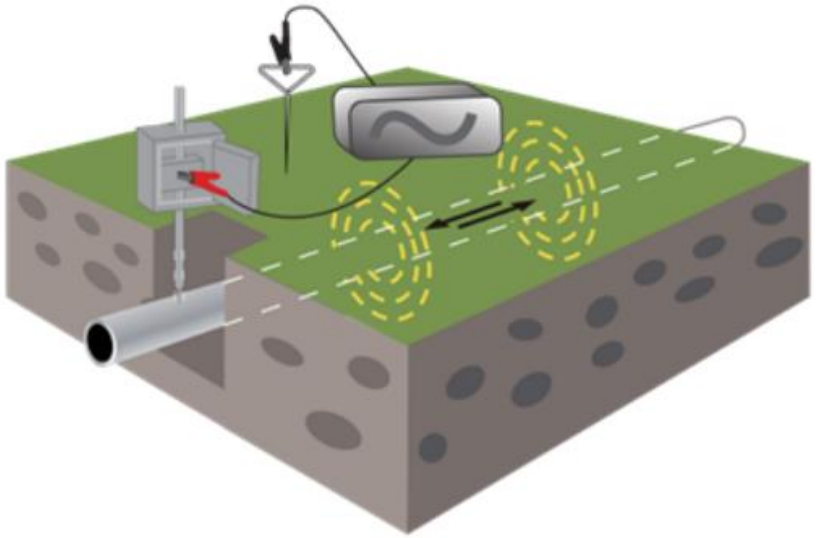
Signals used for locating can originate from a transmitter (active locating), or a variety of other sources (passive locating)





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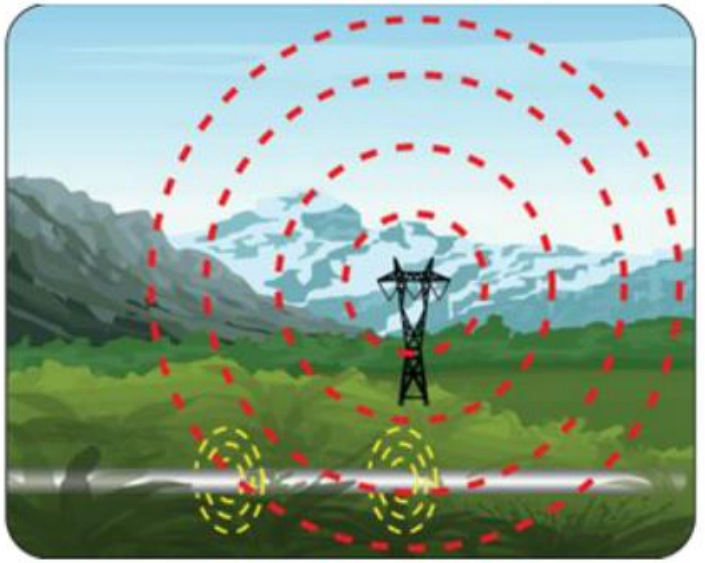
Passive Signals……

- Power
  - power transmission & distribution networks (50/60Hz & related harmonics)
- Radio
  - radio transmissions (15 kHz – 27 kHz & related harmonics)
- Application specific
  - signals from specific applications (CATV, Cathodic protection etc.)



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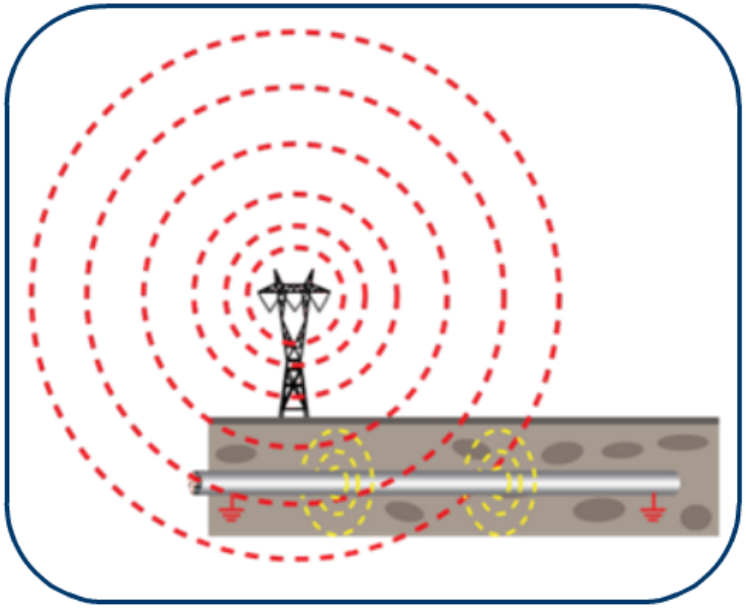
Passive Signals Sources……



Radio Signals

- Mainly generated by high power, low frequency (LF) communication transmitter.
- Buried cables and pipes act as antennas that re-radiate the signal.
- Radio signals are best re-radiated if the line is grounded at both ends.

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Active Signals……

Active signals are applied by a locator transmitter

- transmitter have one or more dedicated frequencies
- the choice of frequency depends on the line being located, and the method the signal is applied

(Each manufacture offers slightly different frequencies)

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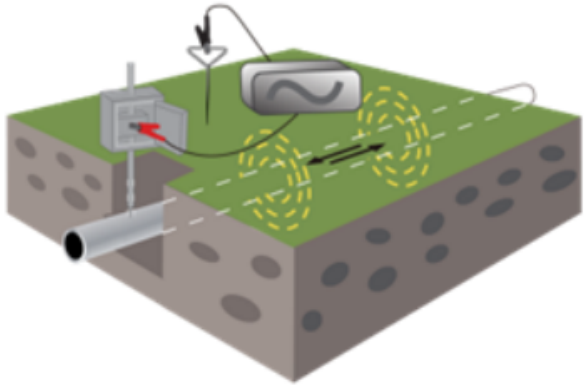
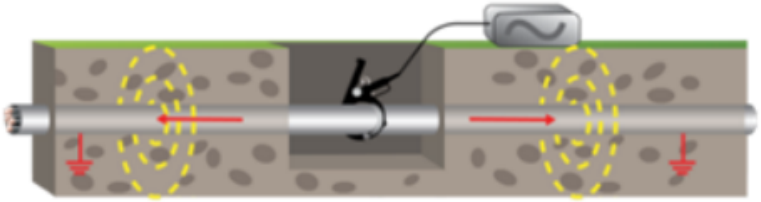
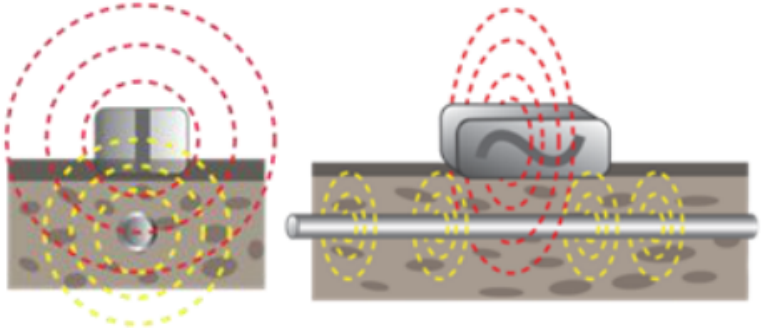
Active Signals……



Direct connection –one cable to the target line, the other to ground.



Clamp –induces a signal into a cable, without making a direct connection.



Induction –induces a signal into a cable or pipe, by placing the transmitter on the surface over the target line.

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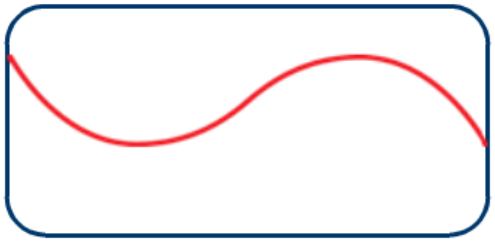
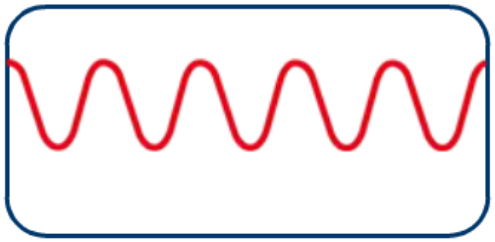
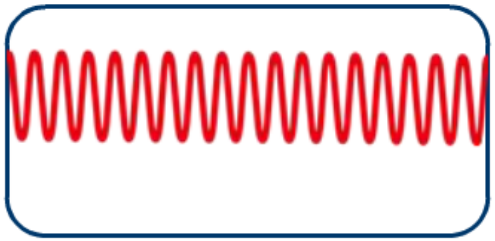
Active Signals Frequency……



- Low frequency (100Hz –1 kHz)
  - Cables
  - Direct connection
  - Long distance
  - Low distortion



- Medium frequency (8 kHz –33 kHz)
  - Cables & pipes
  - Direct connection, clamp & induction
  - Reasonable distance



- High frequency (65 kHz –200 kHz)
  - Induction
  - Short distance
  - High distortion

VIVAX METROTECH

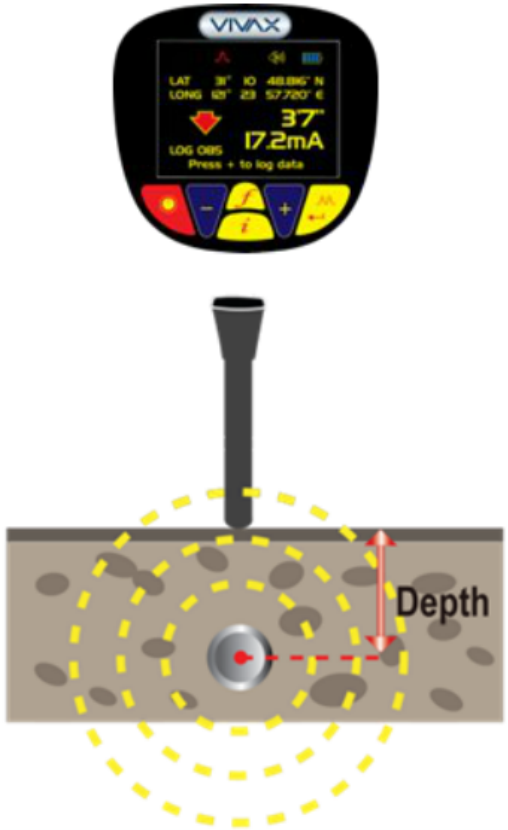
Passive verses Active Location……

- Passive Location
  - Use to mark the location of unidentified buried lines before digging (Avoidance)
  - Do ***NOT*** use to identify or trace "specific" lines

- Active Location
  - Use to trace, identify & pinpoint a buried line
  - Use to measure the depth of the buried line
  - Use to measure the signal current on the buried line

VIVAX METROTECH

Measuring Depth……



- Depth & signal current can also be measured using a locator
- Depth is measured to the center of the signal –in the case of a large pipe this is considerably different to the top of the pipe
- Some locators provide "continuous" depth –this is only accurate when directly over the line

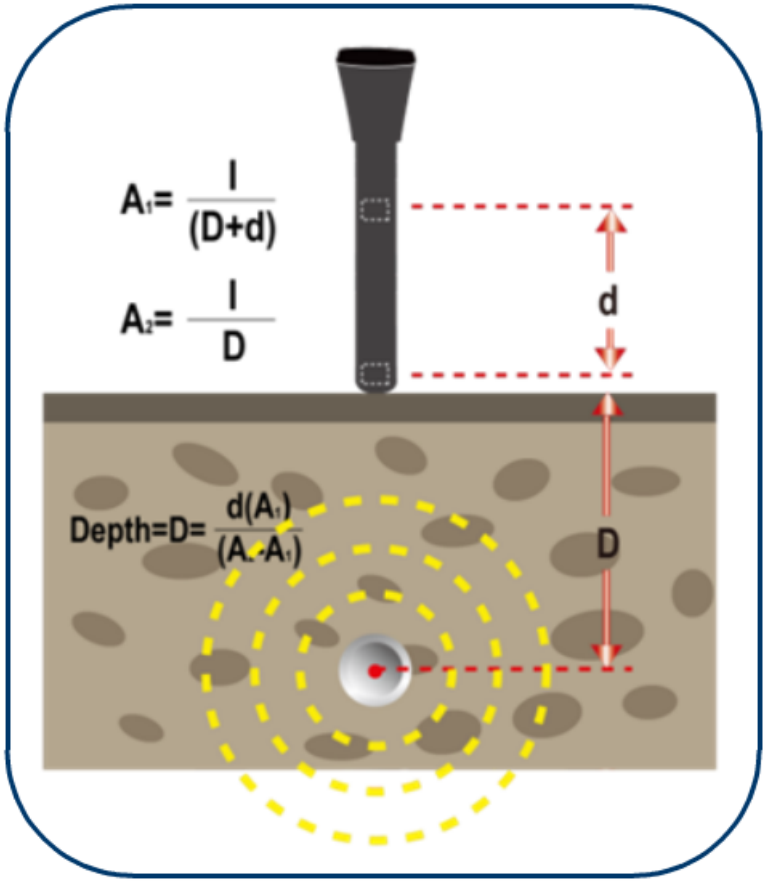
VIVAX METROTECH

Measuring Depth……

1. Pushbutton Depth
2. Triangulation Depth –70% rule
3. Triangulation Depth –50% rule

VIVAX METROTECH

Measuring Depth……



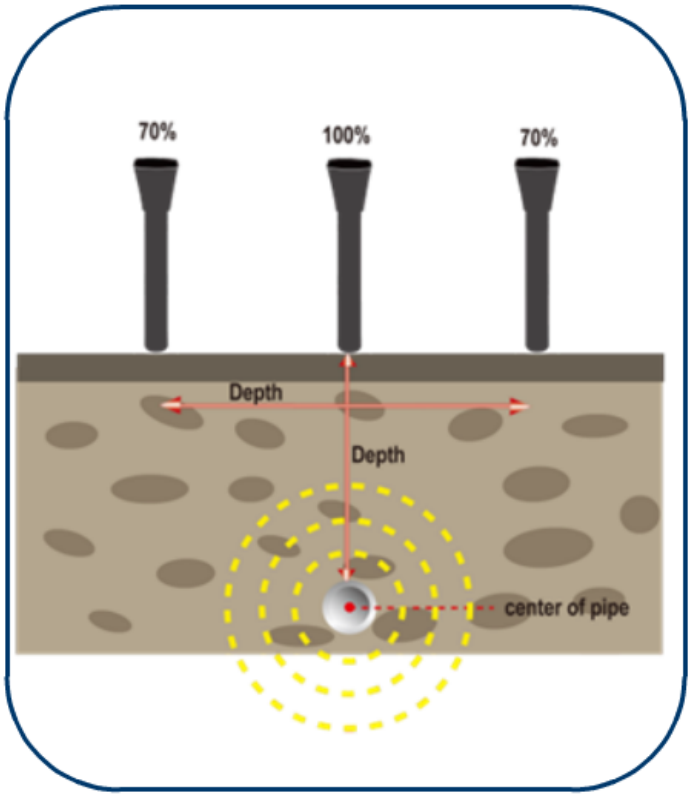
Pushbutton Depth

All locators with pushbutton depth work in a similar way

- Position the locator over the cable using the "Peak" mode
- Press the depth button

VIVAX METROTECH

Measuring Depth……



Triangulation Depth –70% rule

- Use "Peak" mode (two antenna)
- Locate cable, set gain to 100%
- Without changing the gain setting move locator to one side until the gain reduces to 70% and mark the position.
- Return to the cable, ensure gain returns to 100%.
- Without changing the gain setting move locator to the other side until the gain reduces to 70% and mark the position.
- The depth is equal to the distance between the two points you marked.

VIVAX
METROTECH

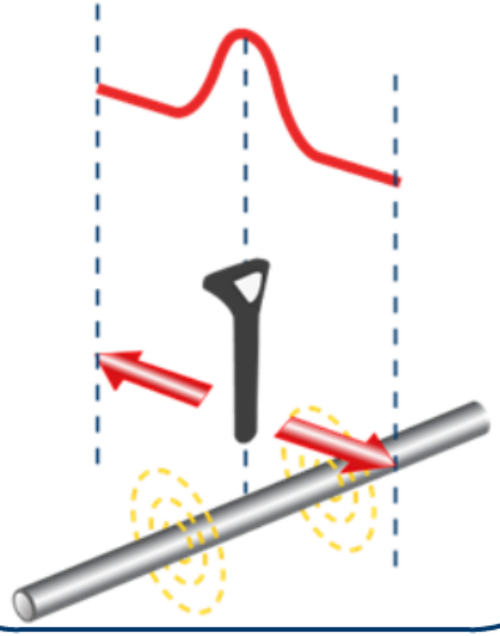
Using A Locator

The Principles of Cable & Pipe Location

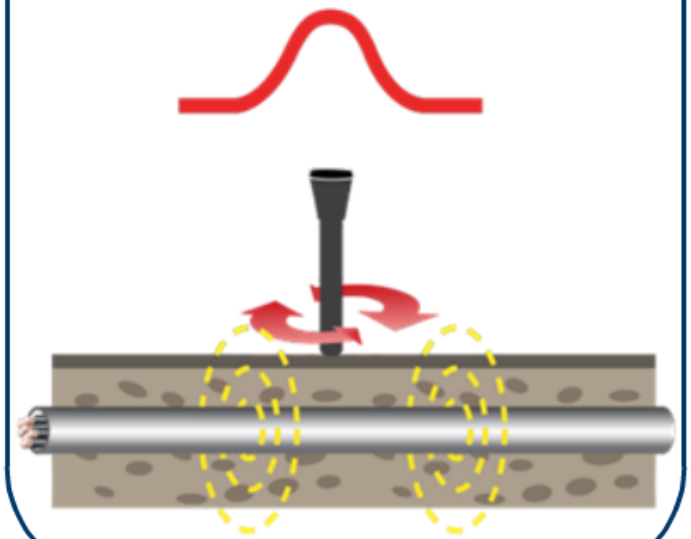
VIVAX METROTECH

Using the Receiver……

Move the receiver forwards and backwards across the line in a smooth action



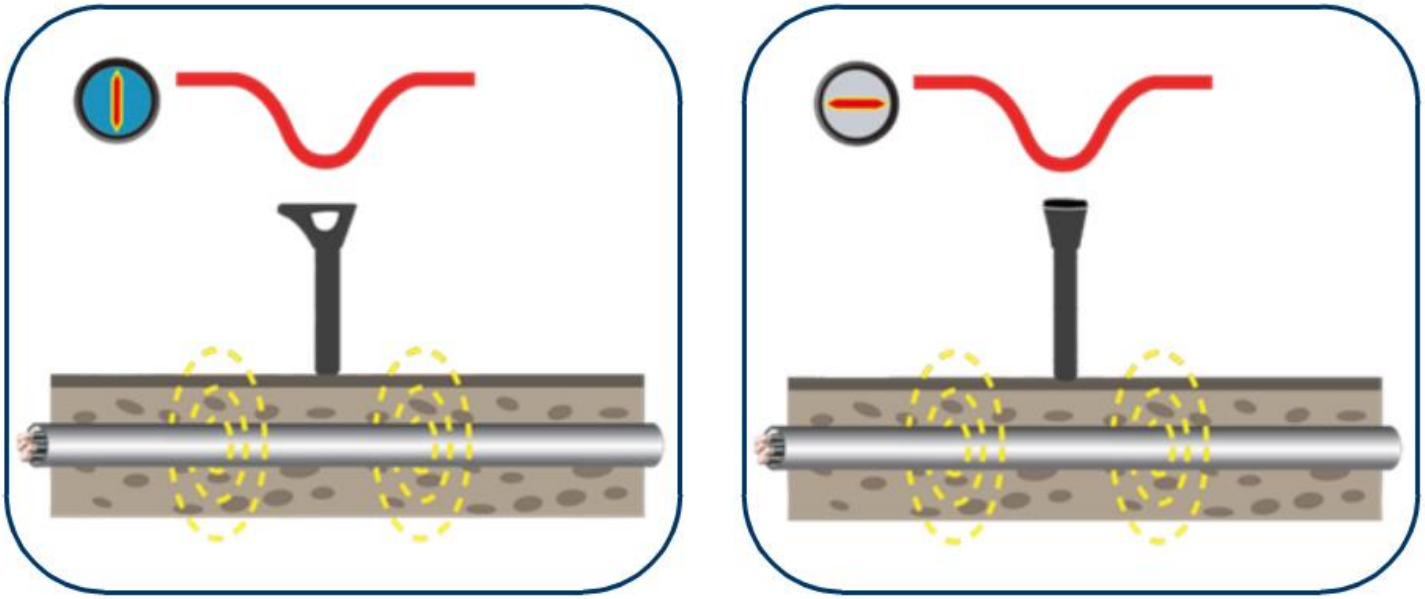
Rotate the receiver to establish the direction of the line



VIVAX METROTECH

Using the Receiver……

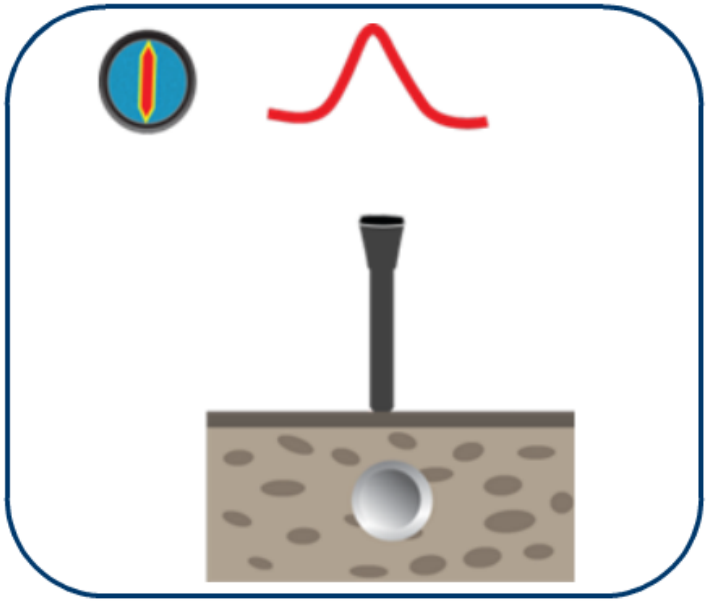
- The "Null" mode –will *NOT* indicate the direction of the line using the null signal strength alone. The left/right arrows and compass help to orient the locator to the line



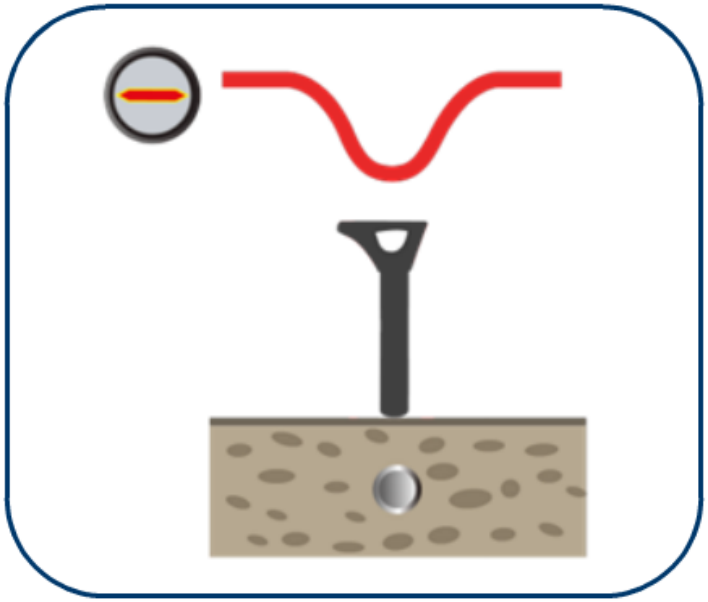
VIVAX METROTECH

Using the Receiver……

- The "Compass LR" mode –will indicate the direction of the line, the left/right arrows & compass help you orient the locator to the line



Peak signal when over the line



Null signal when at 90^{o} to the line

VIVAX METROTECH

Using the Receiver……

Select the locating mode:

- "Peak" mode
  - Best for tracing and pinpoint the line in congested areas
- "Null" mode
  - Best for following a line if tracing for some distance (swap to "Peak" mode to pinpoint)
- "Compass LR" mode
  - Similar use as "Null" mode (swap to "Peak" mode to pinpoint)

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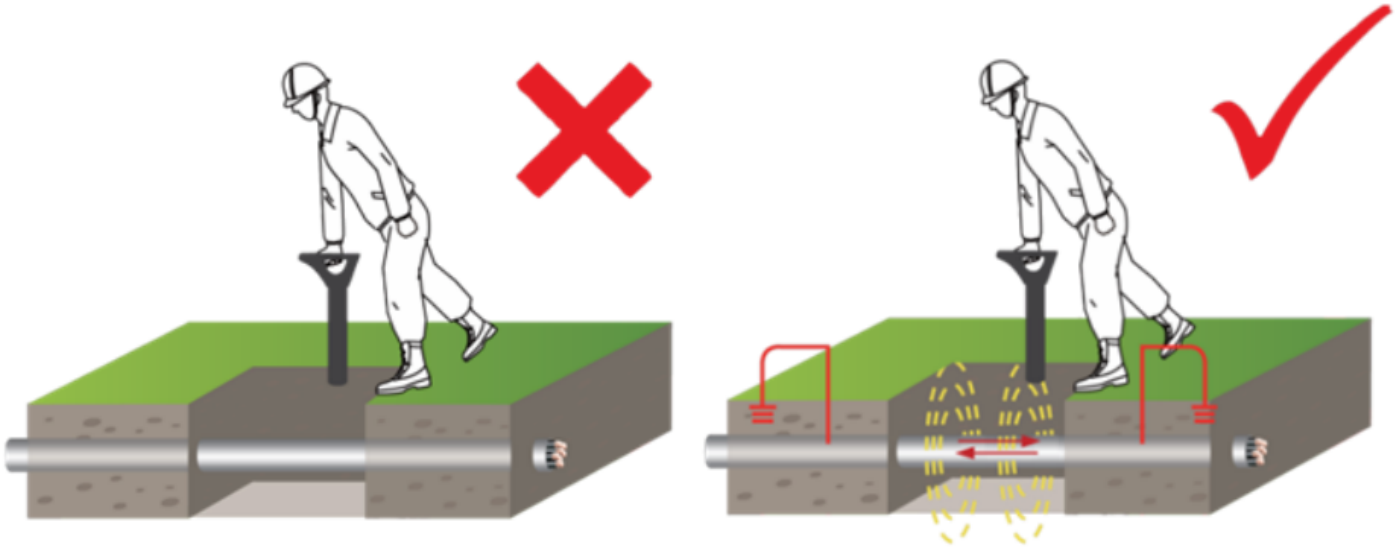
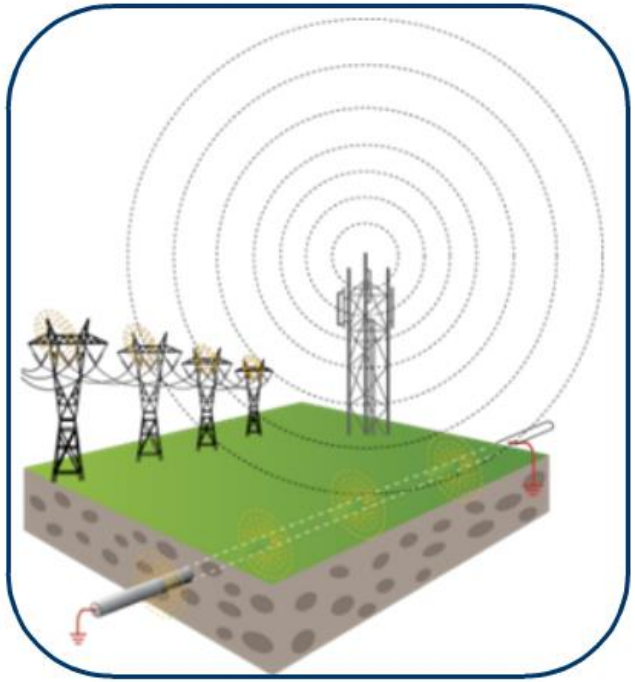
METROTECH

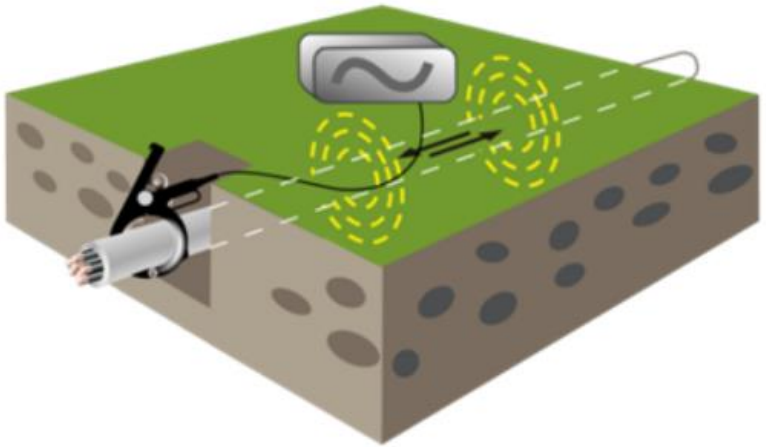
To locate a line an electric current must be flowing



VIVAX
METROTECH

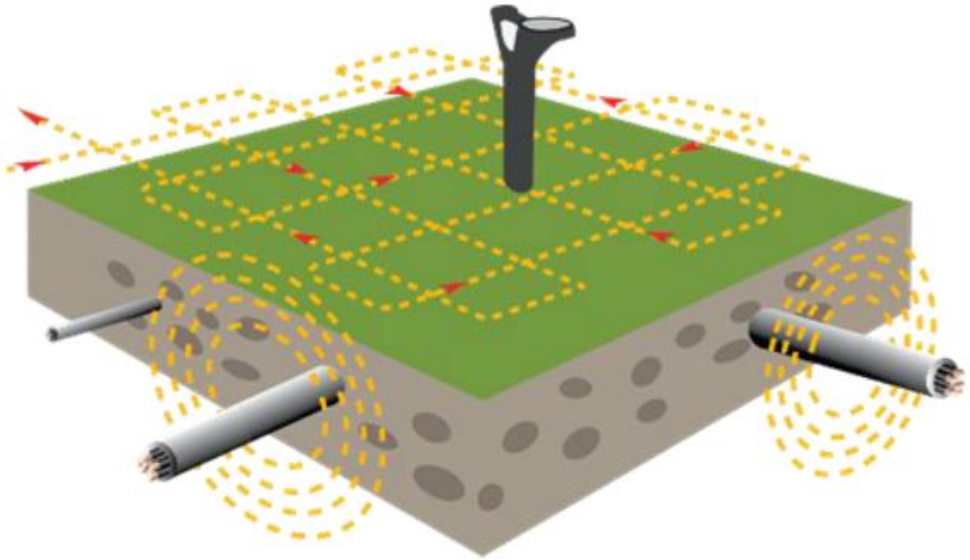
This electric current may originate from other sources (Passive Locating) or from the transmitter (Active Locating)





VIVAX METROTECH

Passive Locating……



- Passive locating is generally used to AVOID rather than identify buried lines.
- Using only the receiver, sweep the area in the search pattern shown.
- Sweep in "Power" mode, then "Radio" mode.

VIVAX METROTECH

Applying the Transmitter Signal to the Line……

There are three (3) methods of applying an active signal to a line:

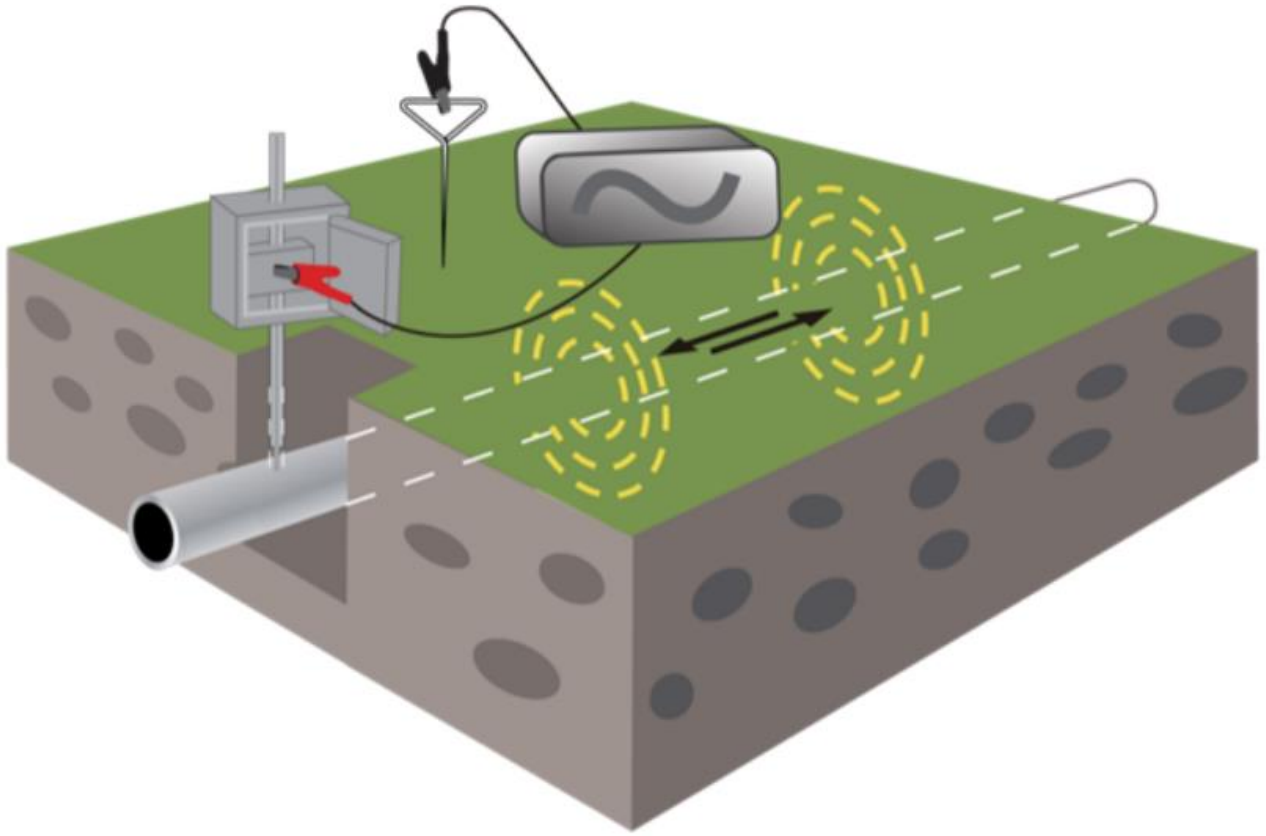
1. Direct connection (preferred)

2. Using a signal clamp

3. Induction

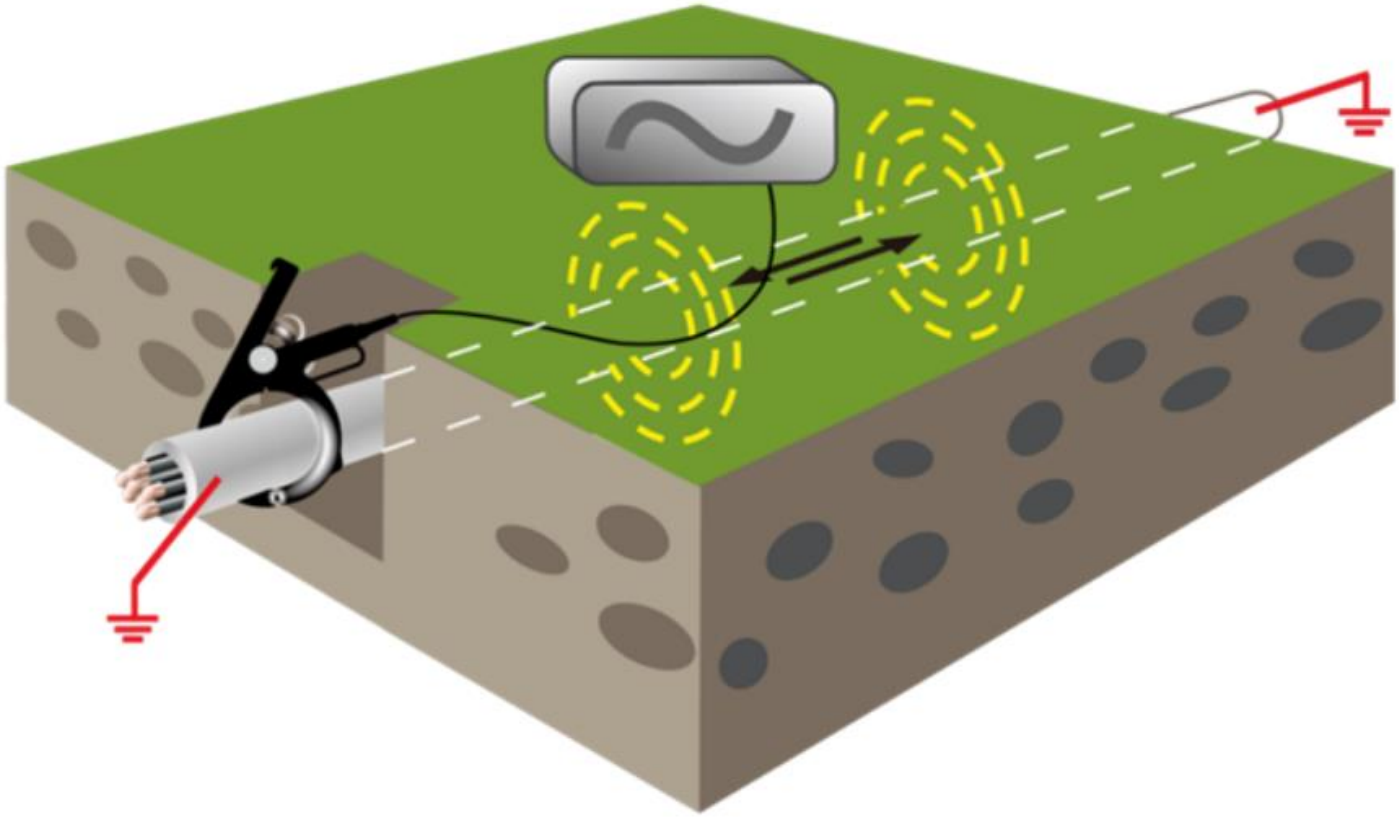
VIVAX METROTECH

Direct Connection……



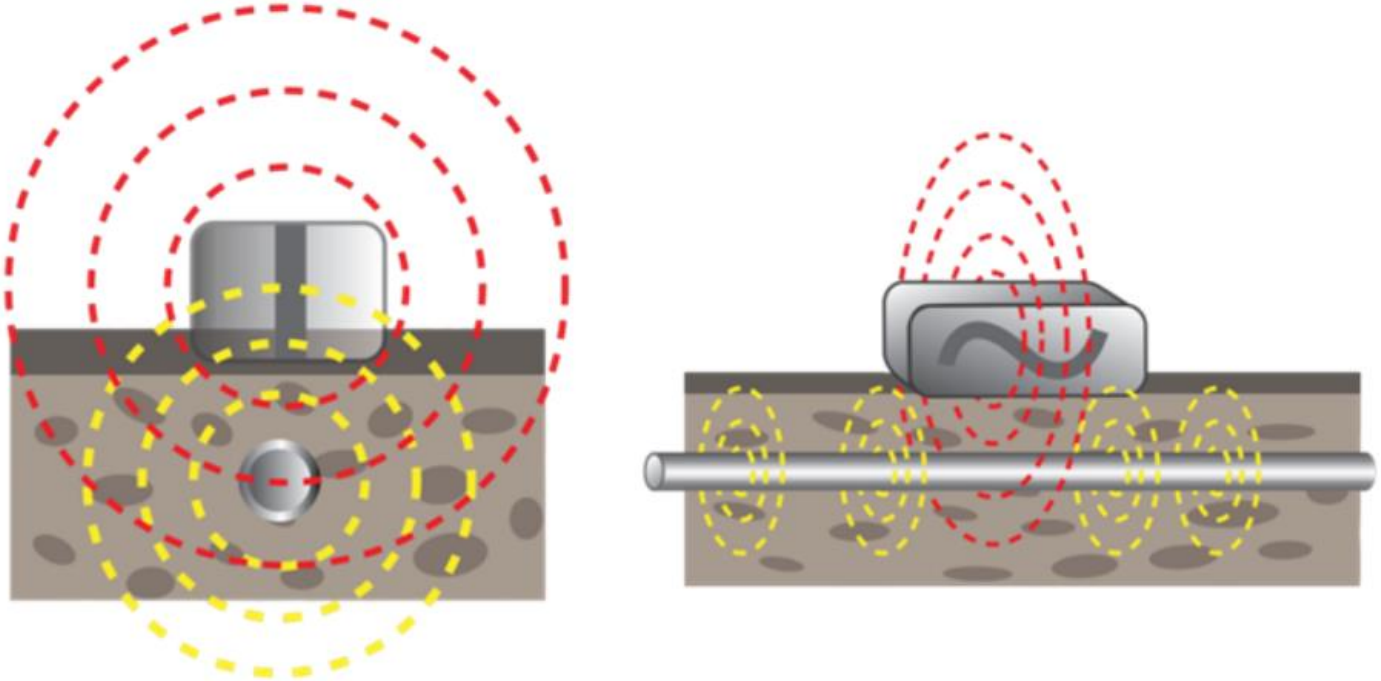
VIVAX METROTECH

Using a Signal Clamp……



VIVAX METROTECH

Induction Mode……

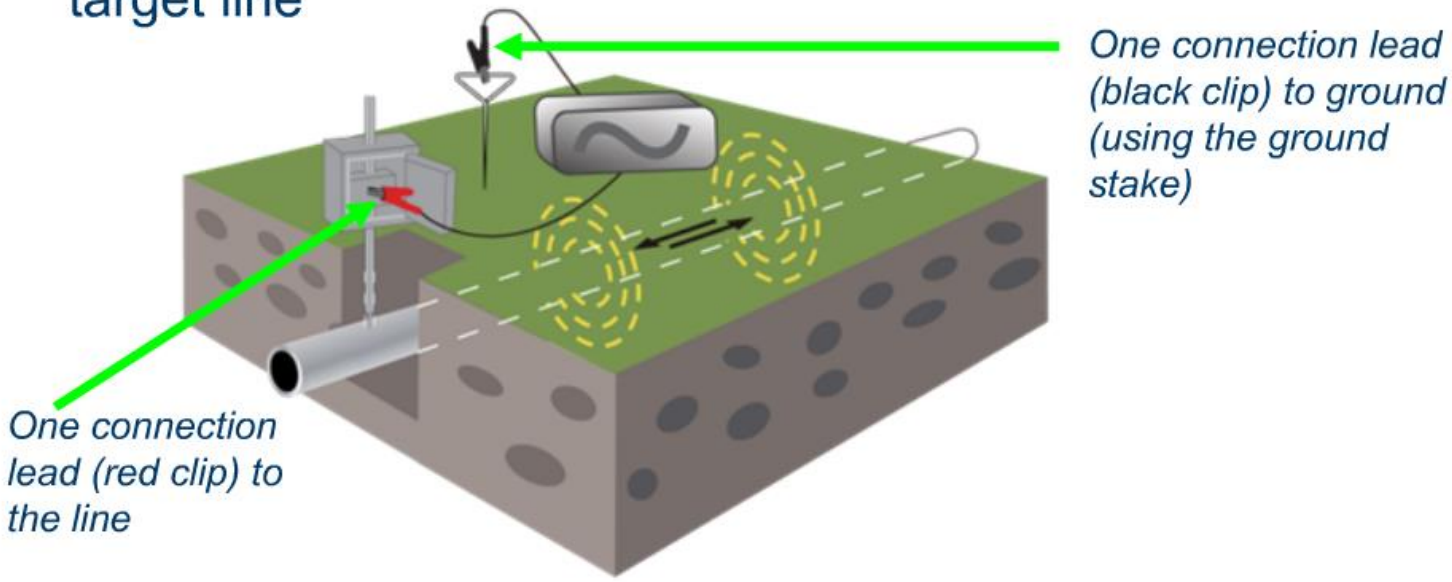


VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Direct connection

- Direct connection is suitable when there is safe to the target line

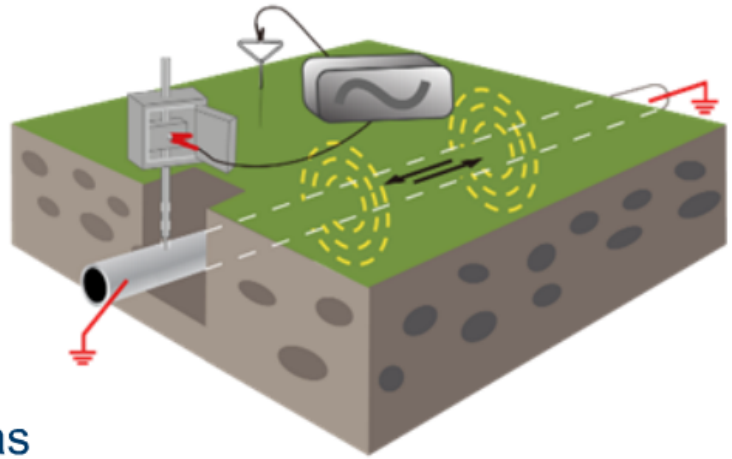


VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Direct connection

- Plug the connection lead into transmitter
- Remove any rust or paint to ensure a good electrical connection
- Place the ground stake in the ground at 90^0 to the cable and as far away as practical



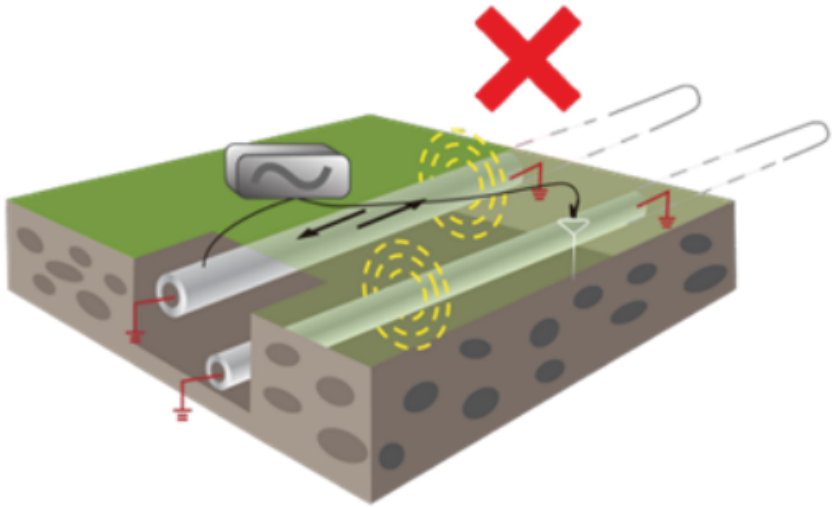
Remember you want good electrical contact to make the current flow

VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Direct connection

- When positioning the ground stake –to minimize coupling to other lines
  - Do ***NOT*** place it close to other lines
  - Do ***NOT*** place it the other side of adjacent lines
  - Do ***NOT*** place it close to metallic fences or barriers



VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Direct Connection

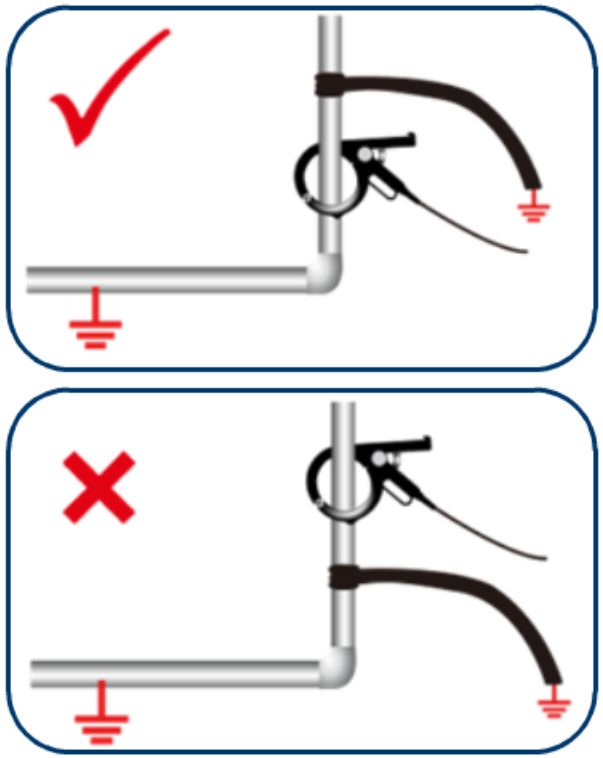
- Use the minimum output power needed to successfully locate the target line
  - Excess power may increase the risk of coupling to other lines.
  - This can make locating more difficult, and increases the risk of mis-locating.
  - More power reduces battery life.
  - The transmitter display will confirm how much current is being applied to the line indicating a good or bad connection.
  - A change in speaker tone also confirms a good or bad connection.
  - If the display shows no current or there is no change of speaker tone check the connection to the target line.

VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Using a Signal Clamp

- Use when you cannot connect to a conductor, or insulated sheath or for cable identification
- Place the clamp around the line
- Connect below the grounding point (to ensure the signal has a signal path between near and far ground points)
- A transmitter ground connection is not required when using the clamp (target line must be grounded at each end)



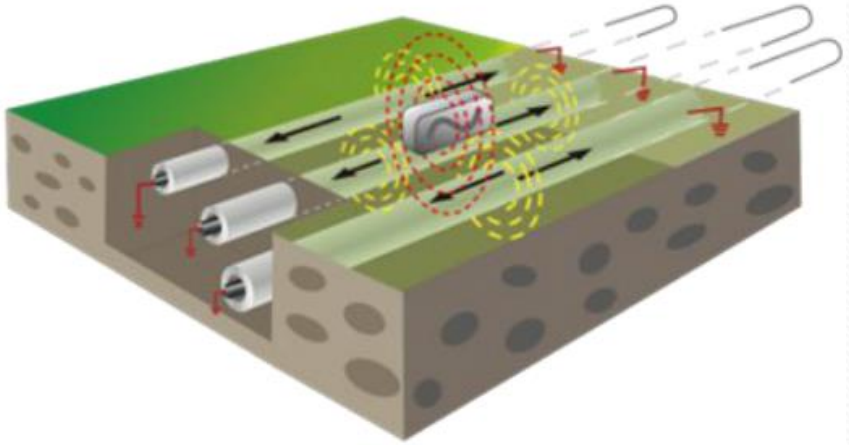
Clamps are designed for specific frequencies only (typically 8 kHz –83 kHz)

VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Induction

- Allows signal to be applied to a line without access to the line
- The applied signal is generally less than the other connection methods (as the signal has to travel through ground to reach the line)
- It may couple to other metallic lines & structures adjacent to target line

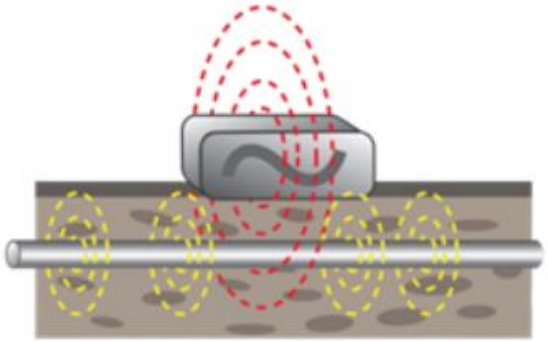


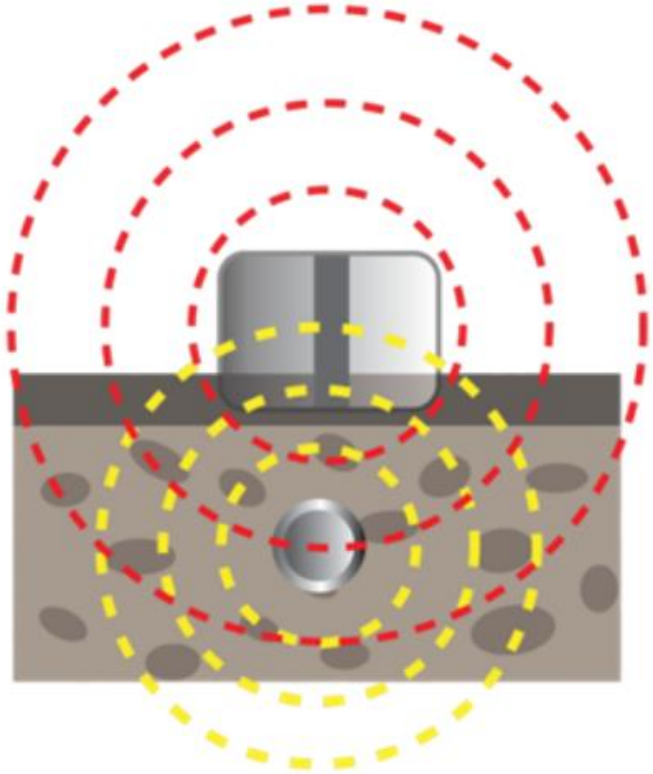
VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Induction

- Place the transmitter over and in line with the target line at a known point (close to, but not on an access point such as a manhole, handhold or pedestal)
- Ensure the transmitter is oriented correctly



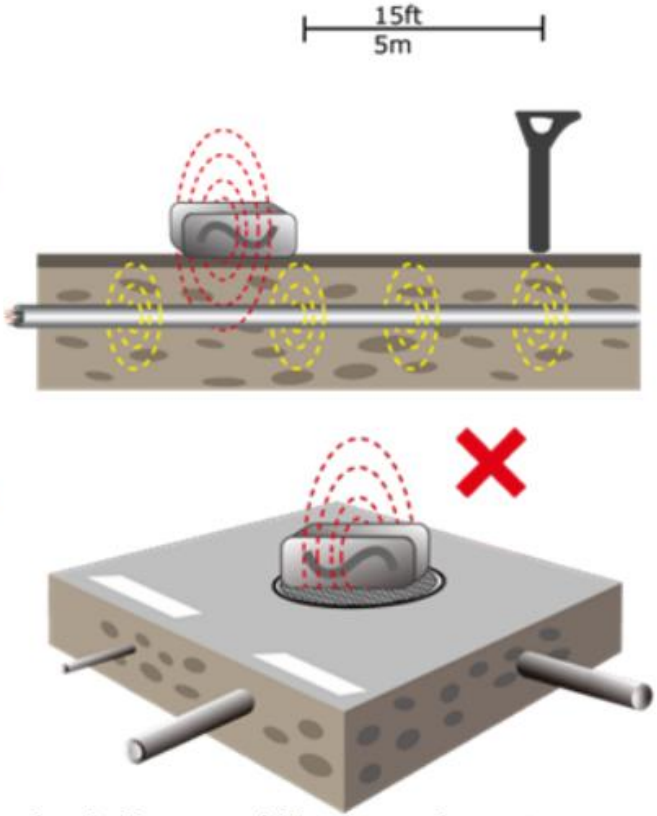


VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Induction

- Never locate within 15ft (5m) of the transmitter (the signal from the transmitter has an airborne element which you will locate)
- Never place on top of a manhole cover or metal plate (the signal will not penetrate to the line and may in fact damage the transmitter)

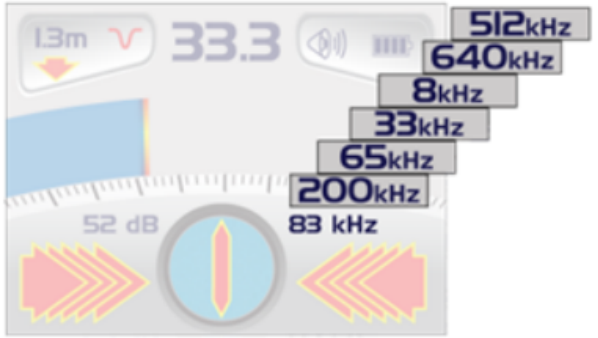


The accuracy of depth readings may be influenced if taken close to a transmitter on induction

VIVAX METROTECH

Applying the Transmitter Signal to the Line……

Frequency

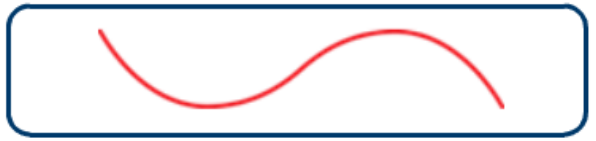


- Most transmitters can transmit several different frequencies
- Different manufacturers use different frequencies
- The best frequency for the job will vary depending on the way the signal is applied (direct connection, signal clamp, induction)
- The distance from the transmitter
- The type of line being located

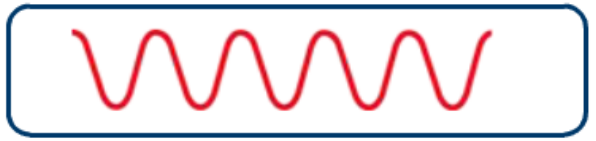
VIVAX METROTECH

Applying the Transmitter Signal to the Line……

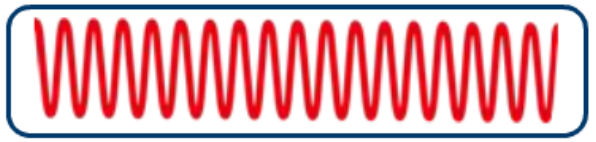
Frequency Summary



- Low Frequency
  - goes the farthest on cables, insulated pipe and cable identification
  - using direct connection



- Medium Frequency
  - good all round locating frequencies using any method of applying the signal

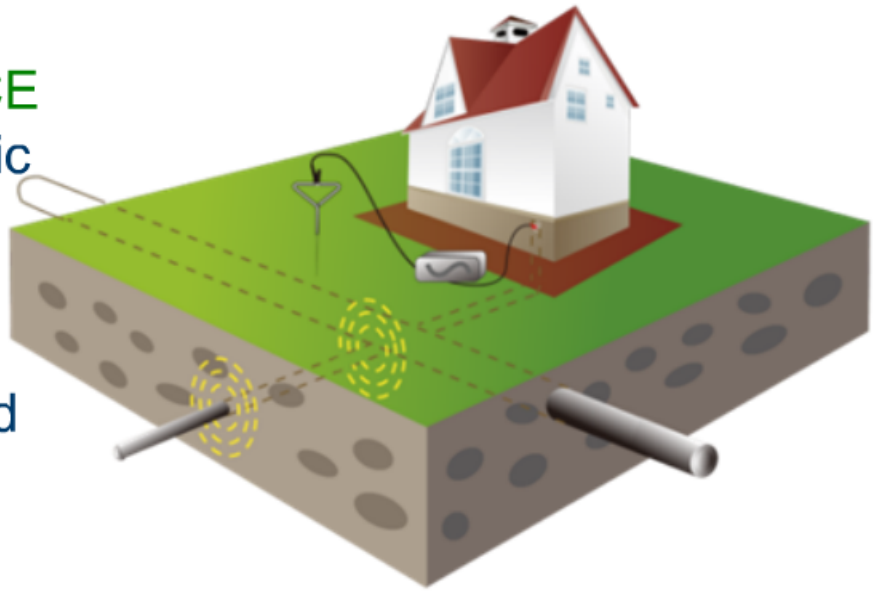


- High Frequency
  - good for induction, short distance & badly grounded lines

VIVAX METROTECH

Active Locating……

- Active location is generally used to TRACE and PINPOINT a specific buried line.
- Active location always require a transmitter and receiver.

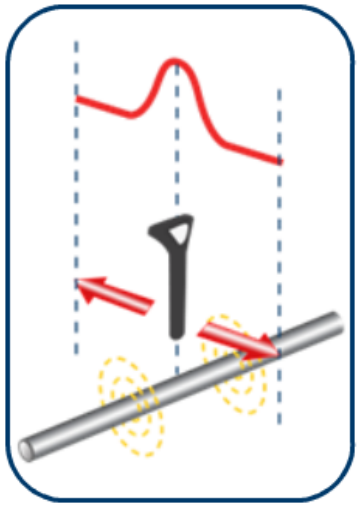


TRACING is following the path of the buried line from, or to, the transmitter.

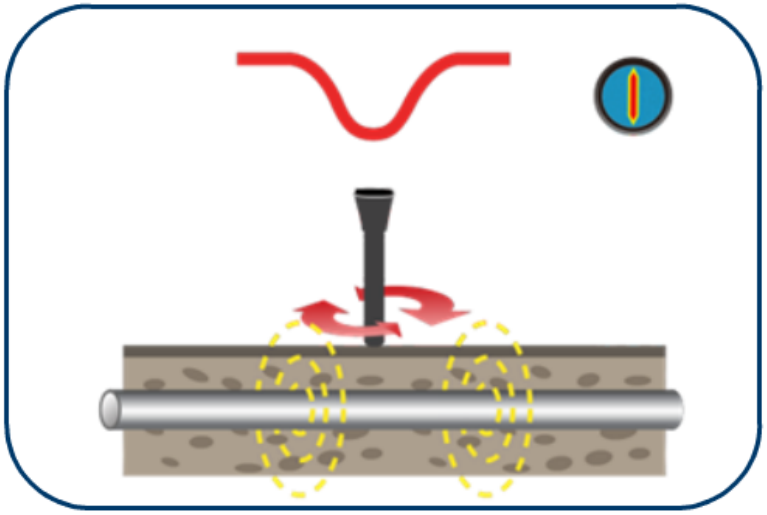
VIVAX METROTECH

Active Locating……

To pinpoint and establish the position and direction of the line:



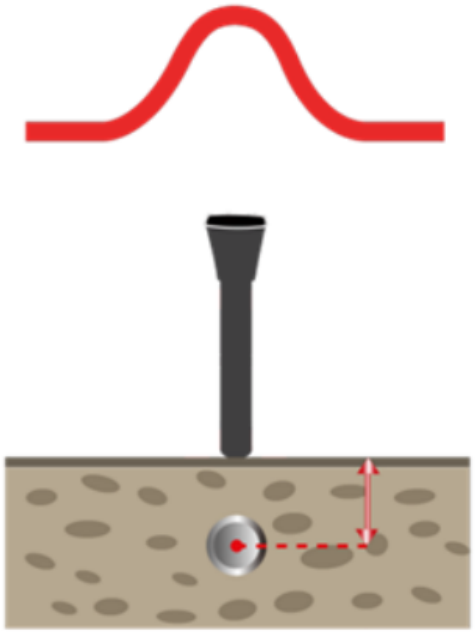
Precisely locate the peak signal



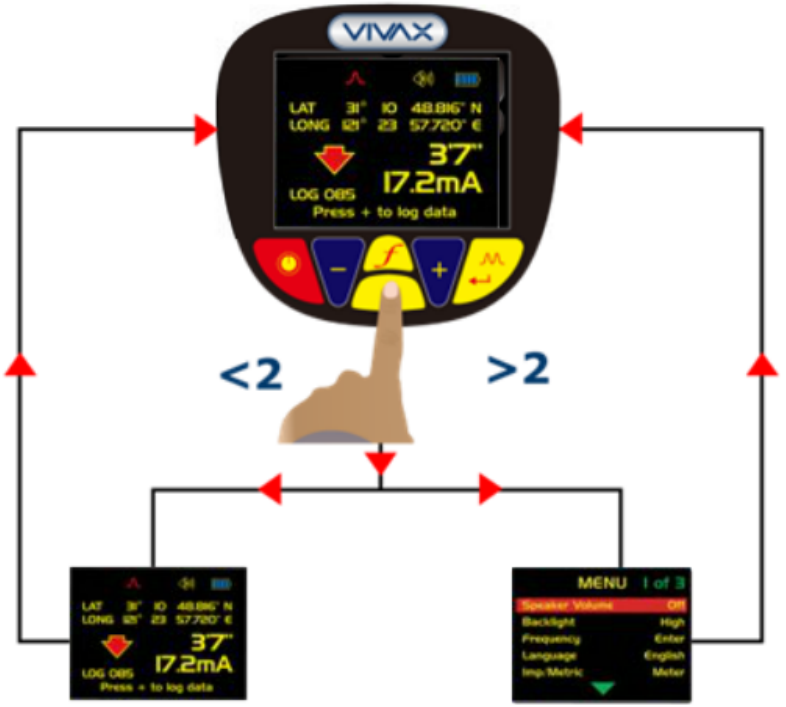
Rotate the receiver until the maximum signal

VIVAX METROTECH

Measuring Depth & Current……



To take a depth & current measurement, first pinpoint the line



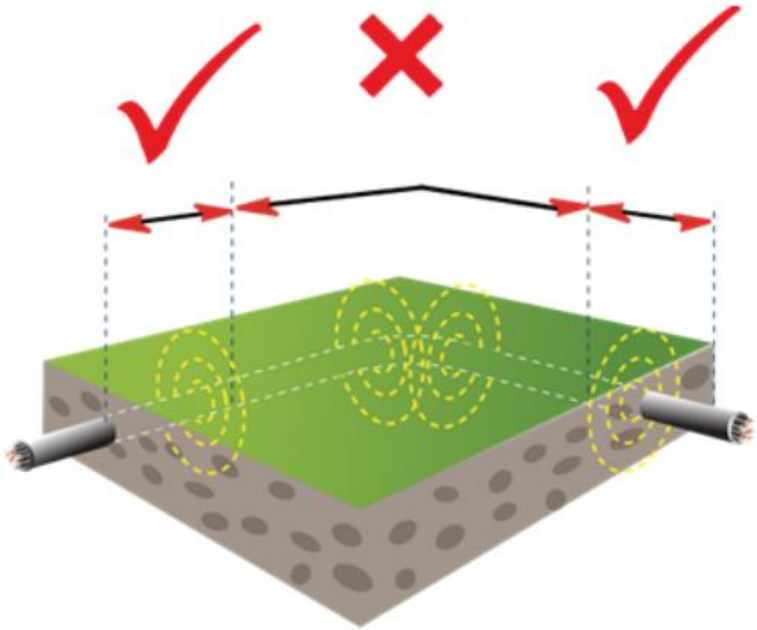
Momentarily press & release the "i" button and depth & current will be displayed

VIVAX METROTECH

Measuring Depth & Current……

Do *NOT* rely on depth & current measurements made if…

- Close to bends in the line
- Close to "Tee's" in the line
- Close to the transmitter
- Where the line is changing depth
- Where the field distortion has been identified



All of these factors can result in inaccurate depth & current readings

VIVAX METROTECH

Distorted Fields……

The magnetic field (the signal) radiating from buried lines can be distorted by the presence of adjacent metallic conductors or other signals.
This is caused by:

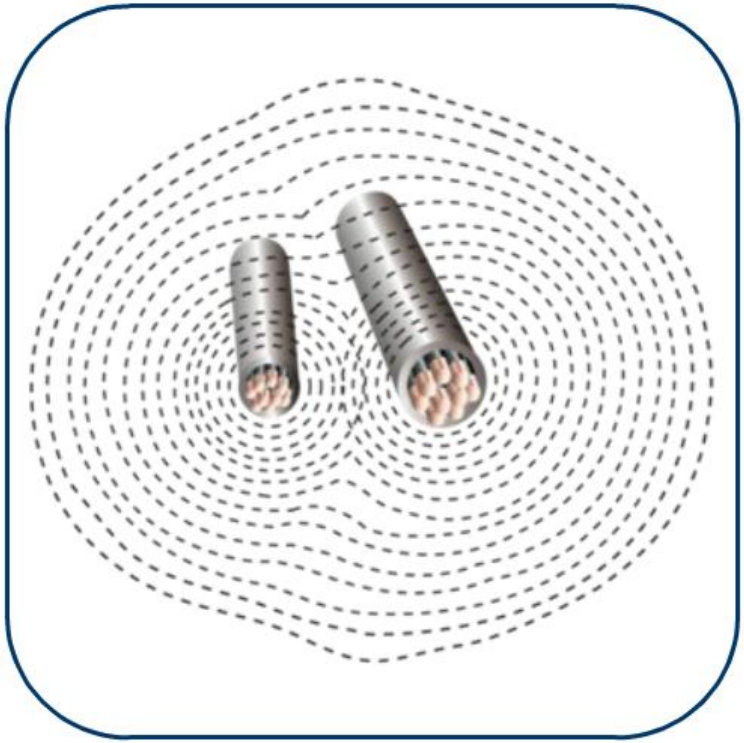
- Signals induced from the target line to other lines
- Commonly bonded structures
- Badly positioned ground (at the transmitter)

The result is that the locator detects signals from more than one course

VIVAX METROTECH

Distorted Fields……

A typical distorted field…

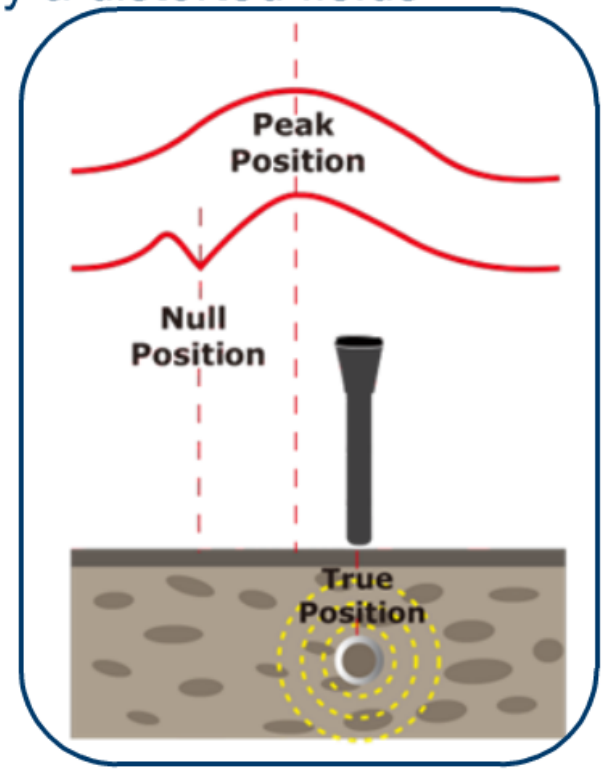


Identifying a Distorted Fields…..

Using "Peak" & "Null" modes to identify a distorted fields

- On a clean undistorted field the "Peak" and "Null" locate response will match
- If distortion is present, the peak and null locate response will no longer match.

Typically, the greater the distortion, the further apart these locate responses will be.



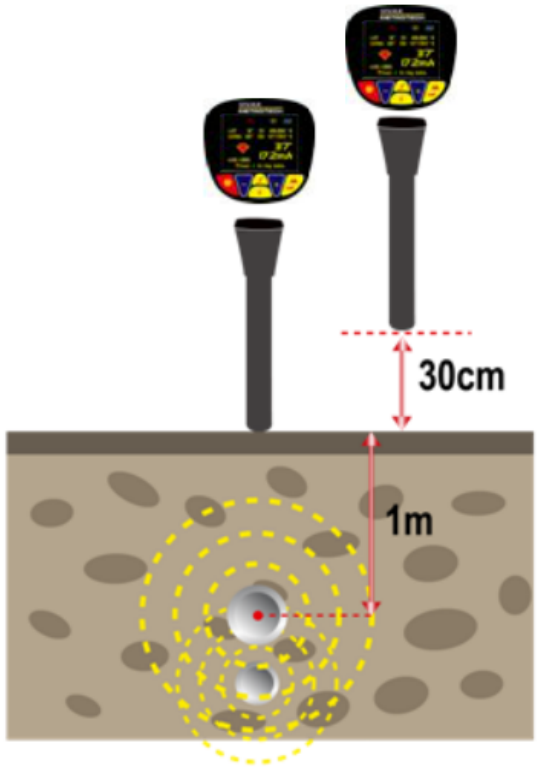
VIVAX METROTECH

Identifying a Distorted Fields…..

Using Depth Measurement to identify a vertical distorted field

- Locate the line & measure depth with the locator resting on the ground
- Lift the receiver off the ground by a known distance (say) 1ft (30cm)
- Take another depth reading

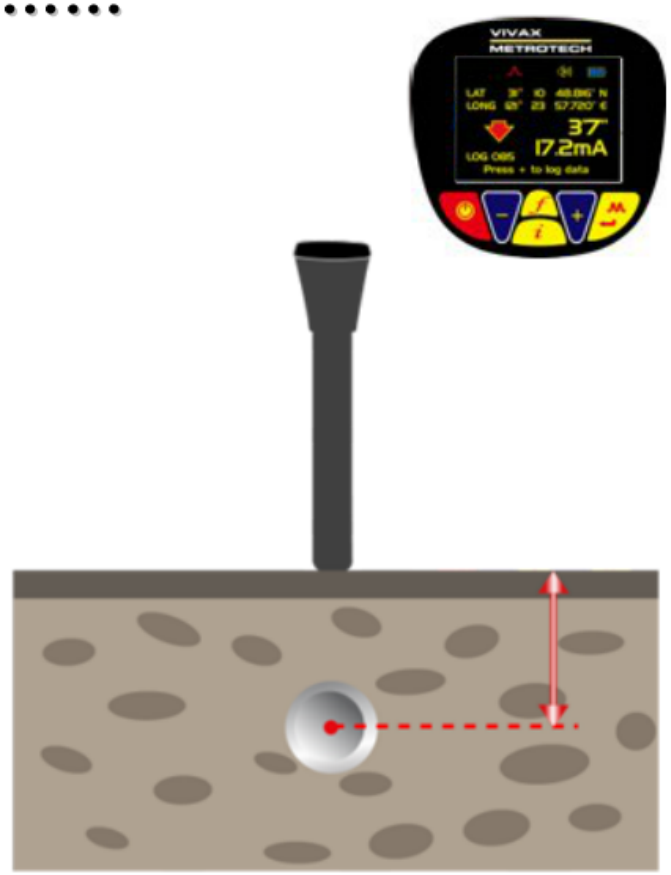
The depth reading should have increase by the distance you raised the receiver – *if significantly different* – the field is distorted



VIVAX METROTECH

Using Signal Current to help Identify the Target Line……

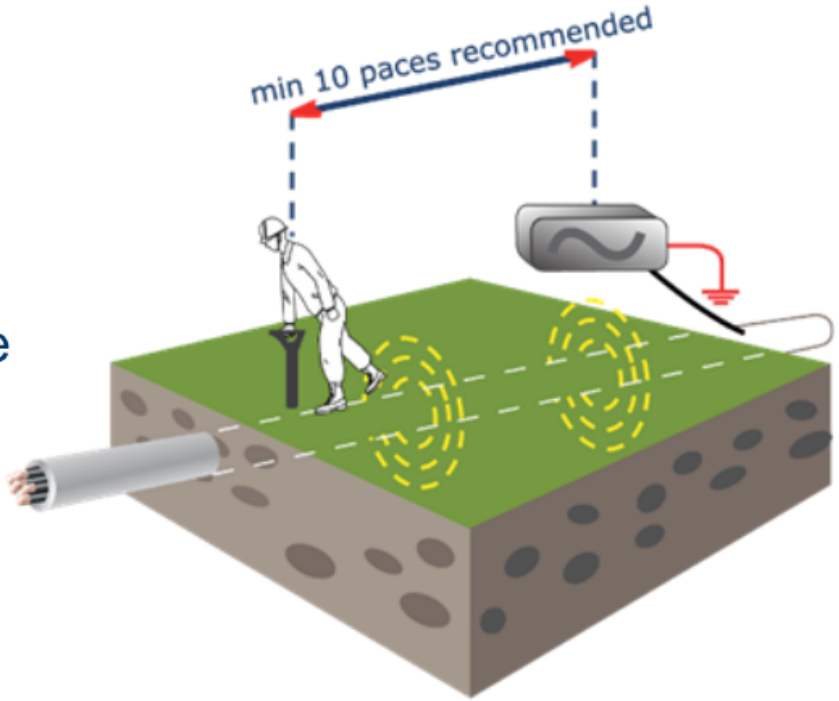
- Current readings are not influenced by depth
- Current readings should not be higher than the current being transmitted



VIVAX METROTECH

Using Signal Current to help Identify the Target Line……

- Current readings will reduce gradually unless
  - There is a "Tee" in the line
  - A large fault in the insulation



Or you are locating the wrong line

VIVAX METROTECH

Safety

Locators are precision well engineered tools, however the environment we locate in is not perfect.

- Always be aware of the influence of distorted fields
- Always take account of visual clues (manholes, pedestals etc.)
- Always use "as built plans" if available

- NEVER use digging machinery over marked out pipes or cables
- Do NOT give "depth" information unless authorized by your company
- Follow all Federal, State, and company rules and regulations particularly as regards safety

- Dispose of Batteries in line with Federal, State or company regulations
- Never submit batteries to extreme heat or fire.

CALL BEFORE YOU DIG - ALWAYS DIG CAREFULLY

Pipe & Cable Locators

- Features to look for:
  - Single or multiple frequency, and ranges
  - Dual Channel/Frequency
  - Transmitter Output Power (1, 5, 10, 12 watt)
  - Remote Power Adjustment, Auto Gain
  - Modes (Active, Passive, Null, Signal Clamp, etc.
  - Compass LR Direction / Signal Direction
  - Depth Reading
  - Bluetooth and/or internal GPS
  - Data Logging
  - Sonde Locating
  - Sheath Fault
  - Color display, heads up feedback

Acoustic Pipe Locators

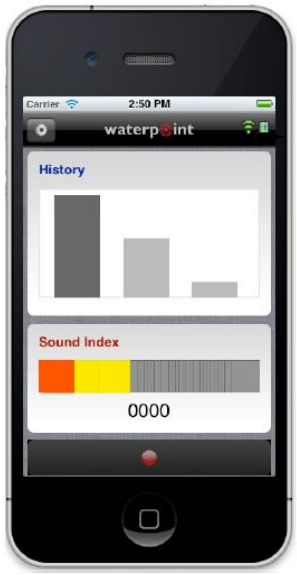
- Heitman Pipetool P50/P100 (RD 500)
  - StansOnde Accoustic Valve Kit
  - Pipetool Accoustic Receiver
- Sewerin CombiPhon
  - Accoustic Generator
  - Mechancial Knocker
  - Hydrant Stopper
  - Accoustic Locator

Acoustic Plastic Pipe Locators

- H50/H100 PVC Pipe Locators
- TransOnde induces sound to pipe.
- Sound locator zeros in on pipe location

Leak Locators

- PLD Leak Locator
- Can find pipe with Sound
- Leaks or artificial leaks
- Find Peak perpendicular to the pipe



case

Ultrasonic Locator

- All Materials Locator
- Works similar to stud-finder
- Doesn't discriminate between any material
- Finds any material with linear density.

Maintaining a Traceable System

- Tracer Wire
- Do you have a Specification?
  - Wire
  - Connectors
  - Anodes
  - Test Stations
- Do you have a policy and stock to repair?

Sample Tracer Wire Spec

- Minnesota Rural Water specification
- Email PDF or link on request

Tracer Wire Facts

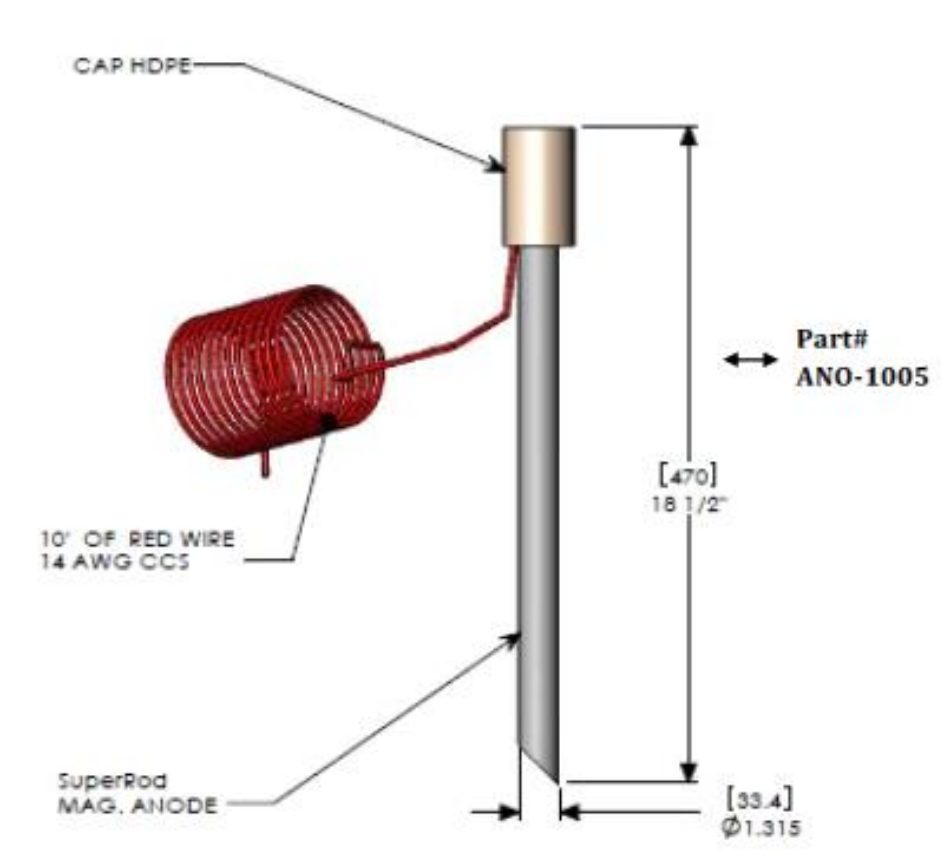
- THHN wire is NOT for underground use.
  - Break Strength
  - Corrosion resistance
  - Outer Casing Material
  - Long Term Failure
- Tracer Wire Specs.
  - Copper Clad Steel is Stronger
  - Tracer wire has HDPE or similar coating, 30 mil+
  - Boring or bursting wire should be stronger
  - APWA Color coded coating

Tracer Wire Connectors

- 2 and 3 way connectors
- Waterproof/direct bury
- Silicone gel filled
- Required at all connections, splices, and repairs

Tracer Wire Anodes

- Should be installed at all underground dead ends
- Red wire is a ground to test stations
- Enhances signal distance.



Tracer wire test stations

- Test Stations at or above ground level
- Wall or hydrant mount
- Ground level mount
- APWA Color Coding

Detectable Warning Tapes

- Generally installed above PVC pipe underground
- Not brought to surface
- Works by induction locating
- Acts as dig warning
- No determination of utility type
- Non-detectable is good with tracer wire

APWA Color Coding

- Tracer Wire Coating
- Test Stations
- Connectors (preferred)
- Detectable and non-detectable Tapes
- Utility Warning Posts

Utility Technologies, LLC

Technology Solutions for Efficient Utilities

Underground Pipe, Cable, and Leak Locating

Thank you!

Mark Beatty, Principal Owner/CEO