Utility Technologies, LLC

Technology Solutions for Efficient Utilities

Underground Locating and Marking of Pipe, Cable, and Objects

OTCO
Deer Creek Training July 25, 2024

Mark Beatty, Principal Owner/CEO

What are we typically locating:

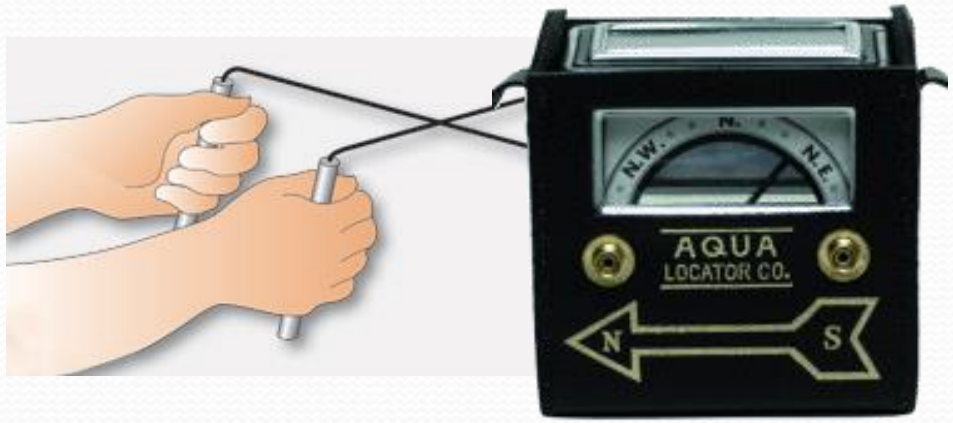
- Metal Pipe (Iron, Copper, lead, Steel)
- Non-Metallic Pipe (PVC, PE/HDPE, Concrete, A/C)
- Cable and Wire
  - Tracer Wire
  - Other Cables (not ours – Avoidance)
  - Live Electrical Wires (safety)
- Metal Objects (Valve, Curb, & Meter Boxes, Manholes)
- Leaks in water lines
- Pipe Flaws, Illegal taps, Lost assets, Abandoned Lines

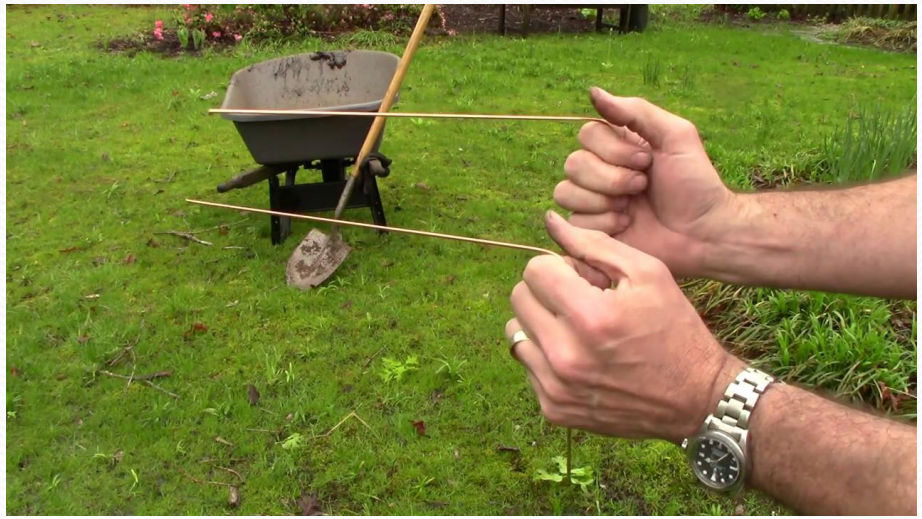
Underground Locating Methods

- Maps, Plans, GIS and GPS/GNSS
- Tile Probes, Shovels
- Witching (divining, dowsing)
- Metal Detectors
- Ferromagnetic Locators, magnetic locators, UAV
- Electronic Pipe & Cable Locators (Radio Frequency)
  - Metallic Pipe, Tracer wire, Marker balls, Sondes
- GPR - Ground Penetrating Radar
- Ultrasonic Detectors
- Leak Detectors, Correlators, Loggers, Gas Tracers
- Water Main Video Cameras & Diagnostics

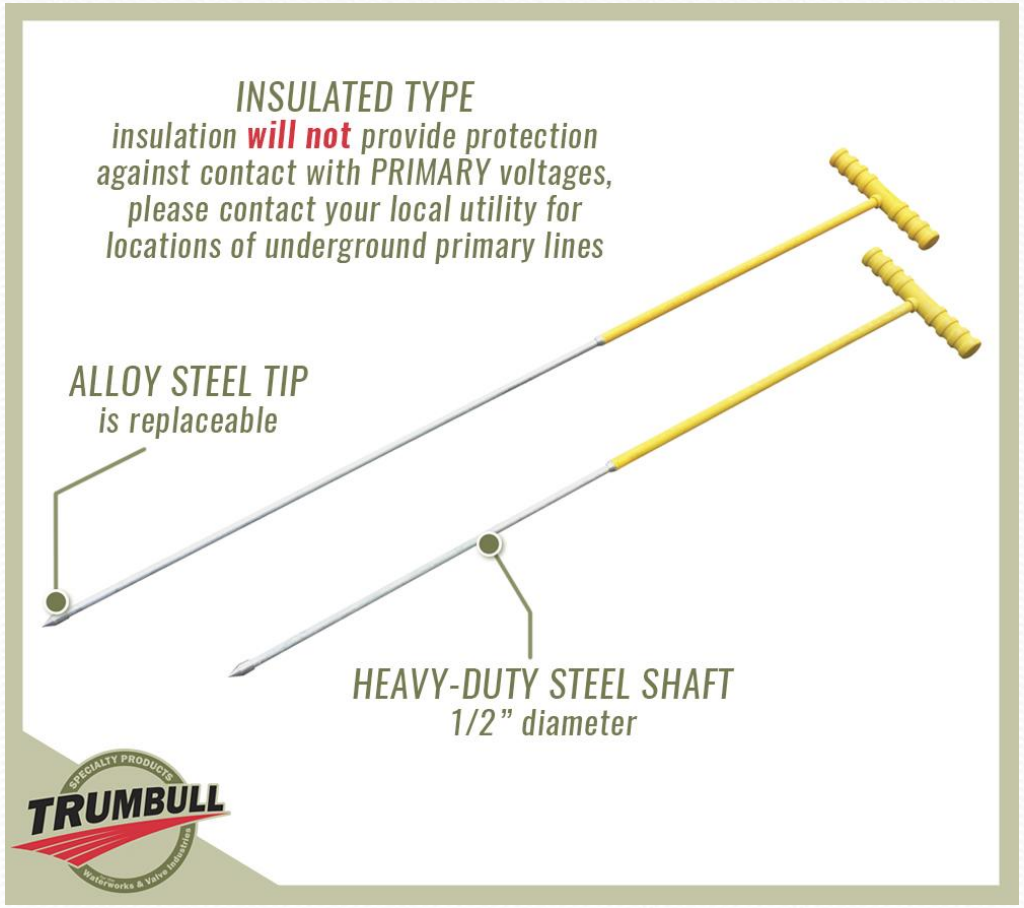
Ferromagnetic & Metal Detectors

- **Witching, Dousing**
  - Works sometime, but not reliable, not utility positive
- **Dip Needle**
  - Proven, but not positive I.D.





Soil Probe Rods



- Insulated and non-insulated
- Replaceable tips
- Sharp or rounded tips

Metal Locators

- Can detect all or many types of metal (tin, copper, nickel, brass, lead, aluminum, etc.)
- Some have filtering for specific uses or metals
- Inexpensive and Easy to use
- Limited depth & distance
- Some are Industry Specific Designs tuned to Utility assets
- Avoid Hobby (treasure) locators

Ferromagnetic Locators

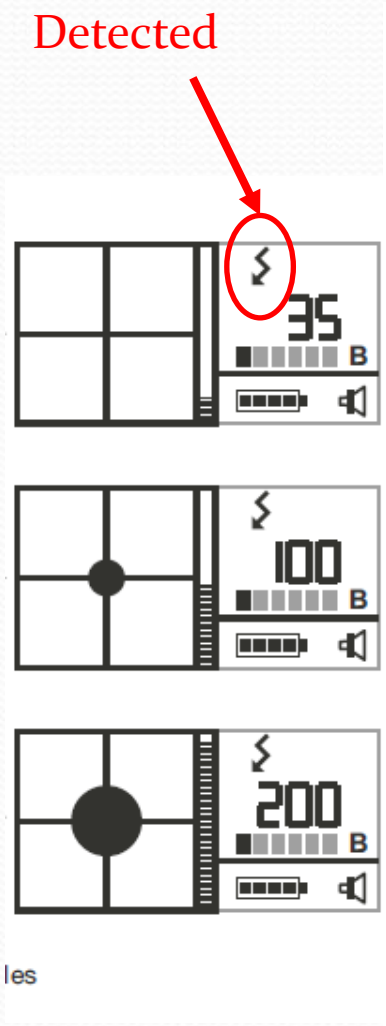
- Can locate Iron or Steel pipe
- Easy if no other utilities in area
- Will detect **ONLY Ferrous** metal objects or **Magnets**
- Small, lightweight
- More Expensive than Metal detectors
- Inexpensive compared to pipe locators
- Some Detect Power and Polarity
- More Selective than general “metal detectors”.

Ferromagnetic Locators

Optional Features:

- Polarity
- Live Power
- Reset, Calibrate,or “zero set”

Live Power Detected



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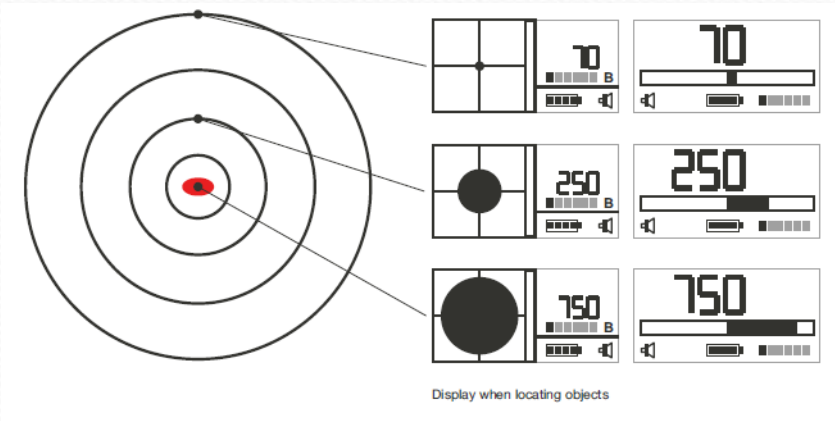
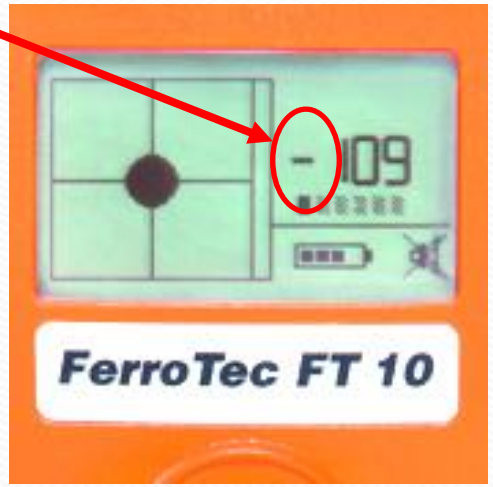
Polarity Indication



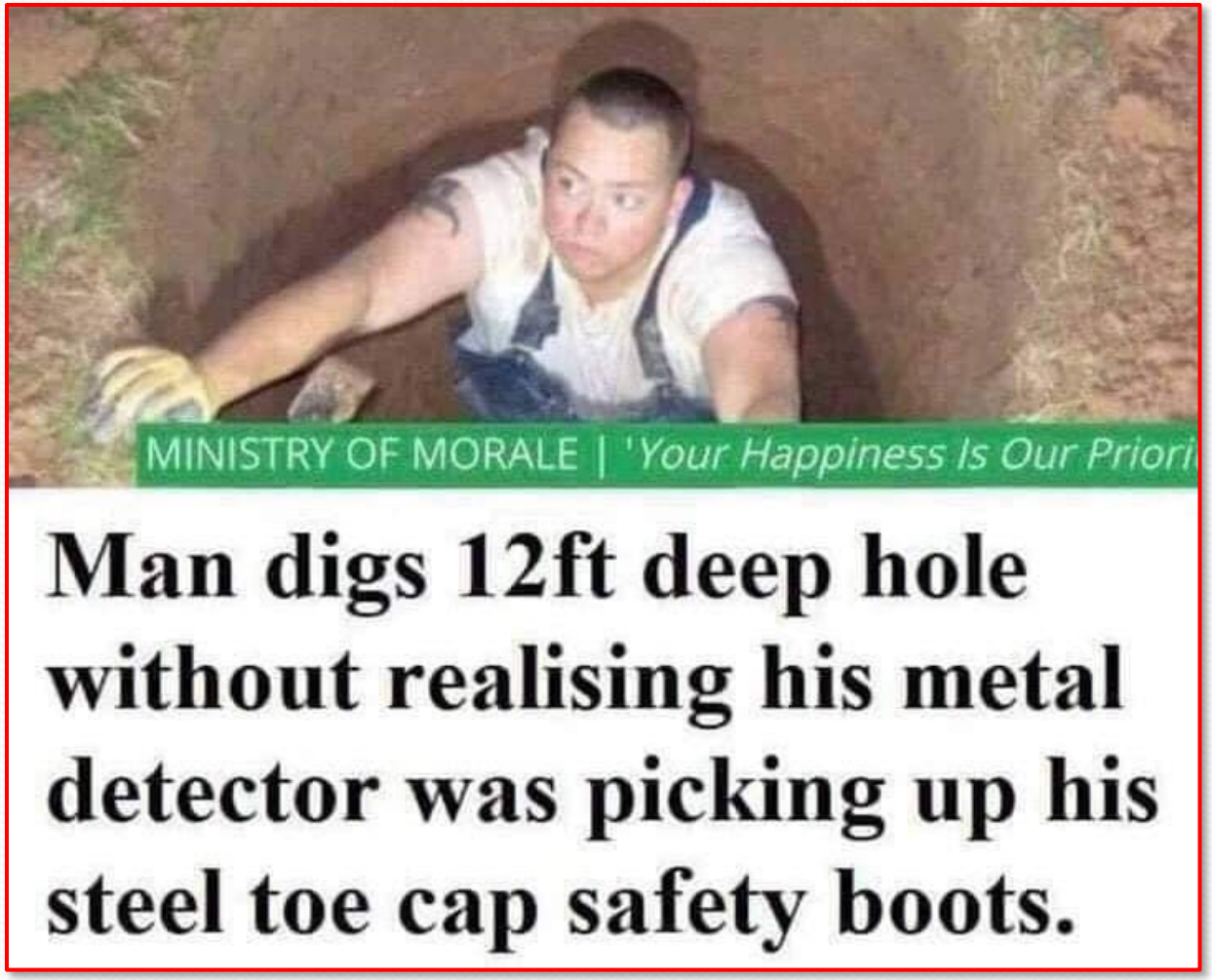


Ferromagnetic Locators

Magnetic Locator, Magnetometer

Metal Locating Tips:

- Steel Toe Shoes are detectable
- Precise location is directly under the stick or coil
- Depth can be estimated by tilting magnetic locators
- Magnetic locators can detect iron or steel pipe. (or magnets)

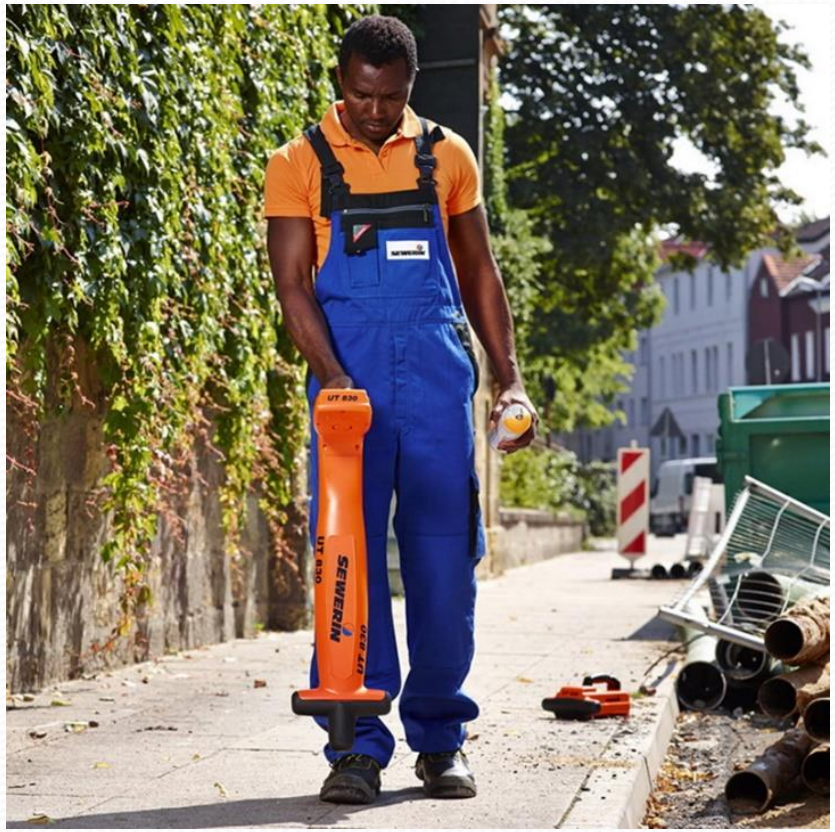


RF Pipe & Cable Locators

- Usually Two Parts
  - Transmitter
  - Receiver
- Transmits Alternating Current radio frequency signal.
- Works on metal pipe or Pipe with tracer wire.
- Some can also locate a Sonde in non-metallic pipe.

Pipe & Cable Locators

- **Passive Locating Signal**
  - AC current
  - Radio Frequencies
  - Receiver only
- **Active Locating Signal**
  - Transmitter and Matched Frequency Receiver
    - Direct Connection (preferred)
    - Signal Clamp
    - Induction



Pipe & Cable Locators

Question:

Does a Pipe Locator actually locate the underground pipe, tracer wire and cables?

Pipe & Cable Locators

Question:

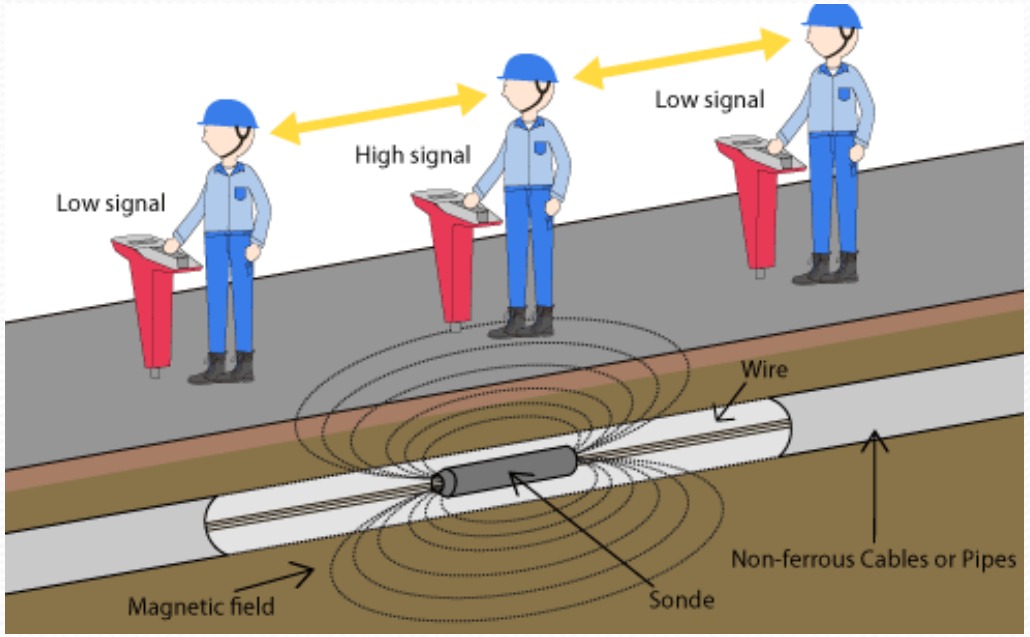
Does a Pipe Locator actually locate the underground pipe, tracer wire and cables?

Answer:
***No**. It only locates a signal we send through the pipe*

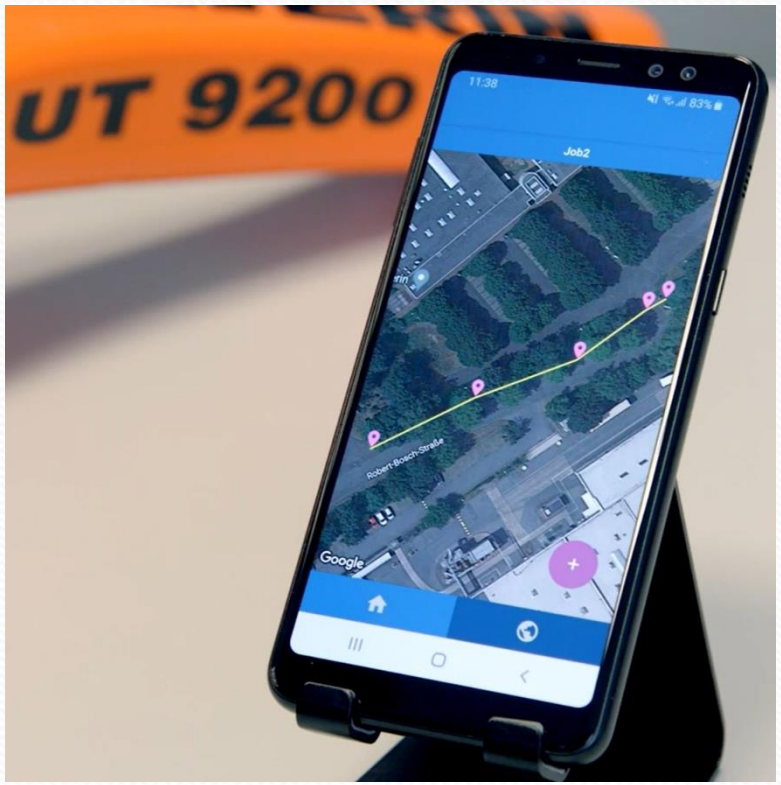
RF Pipe & Cable Locators

Singal Clamps

Sonde Transmitter



GIS Mapping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Locator Theory

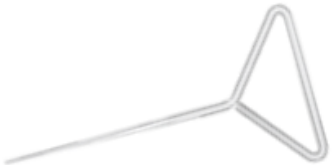
The Principles of Pipe & Cable Location

A Typical Locator consists of……

Receiver

Transmitter

Connection Leads

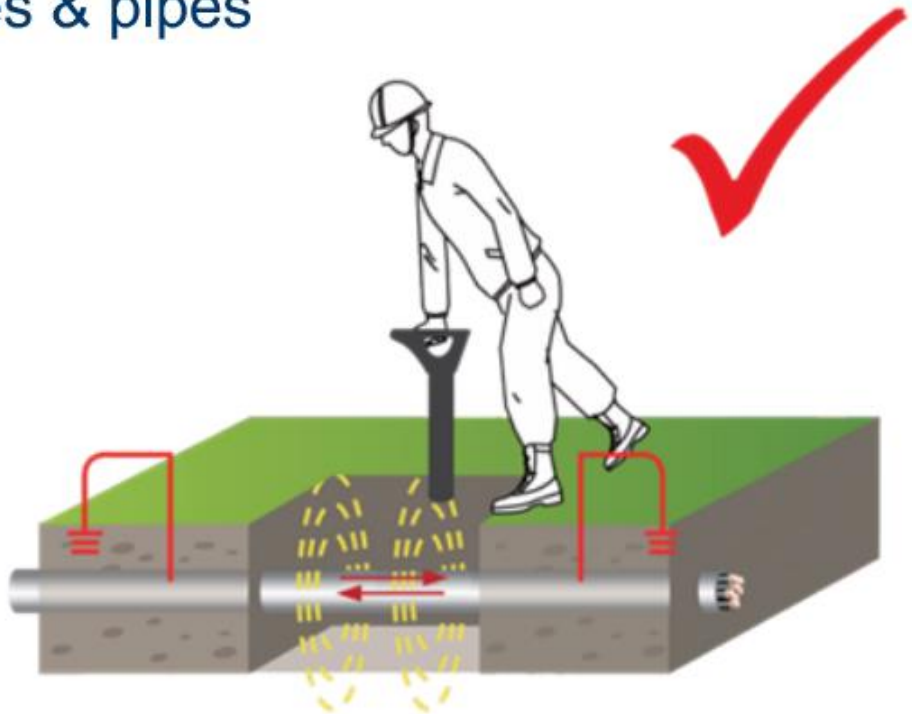


Ground Stake

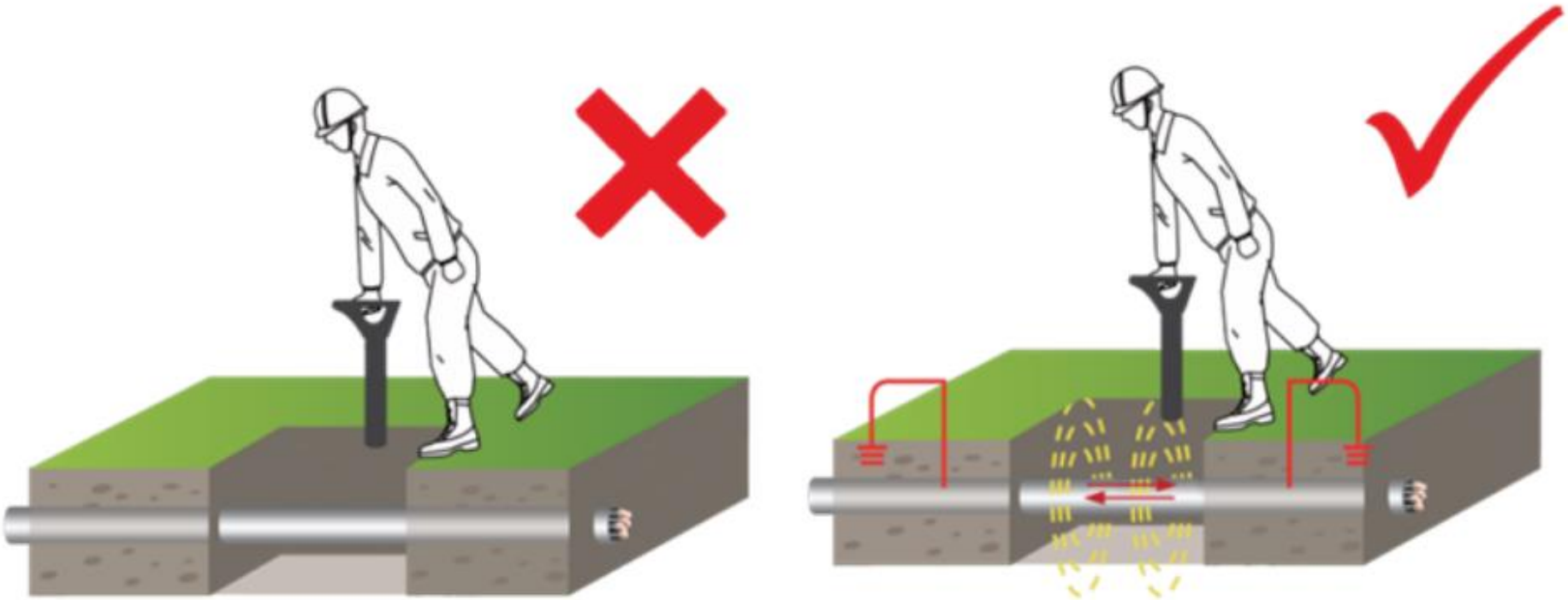
Signal Clamp

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

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

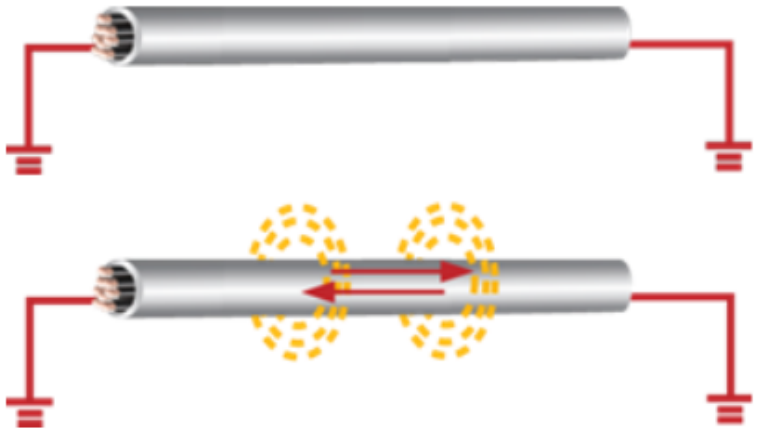


- if there is *NO AC CURRENT FLOWING*, there will be *NO LOCATING SIGNAL*.

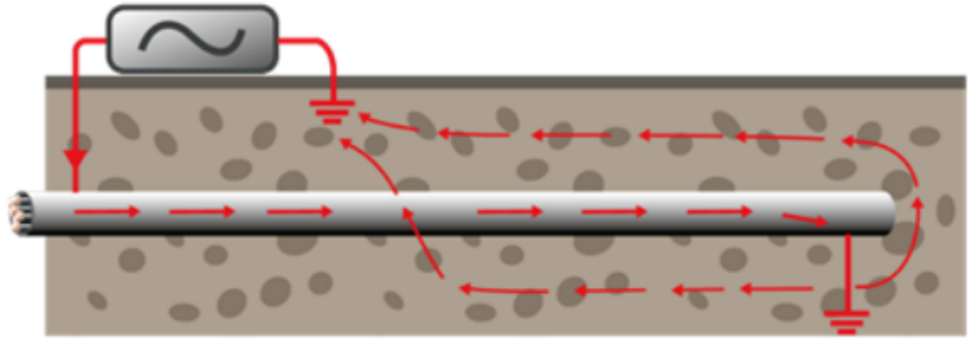


- Is produced by the flow of the alternating current *(AC)* which creates an electromagnetic field

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



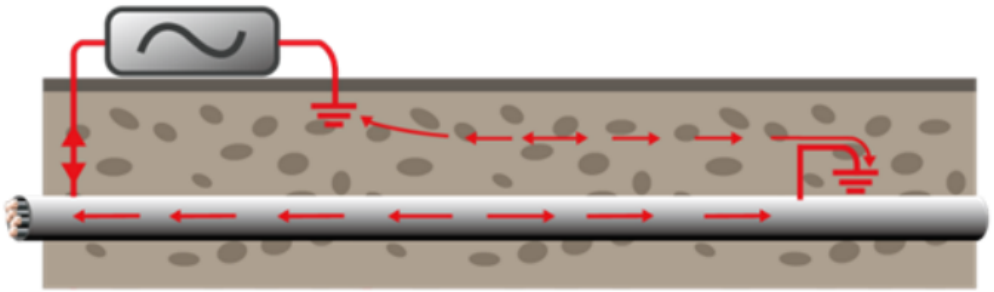
The Locating Signal……



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

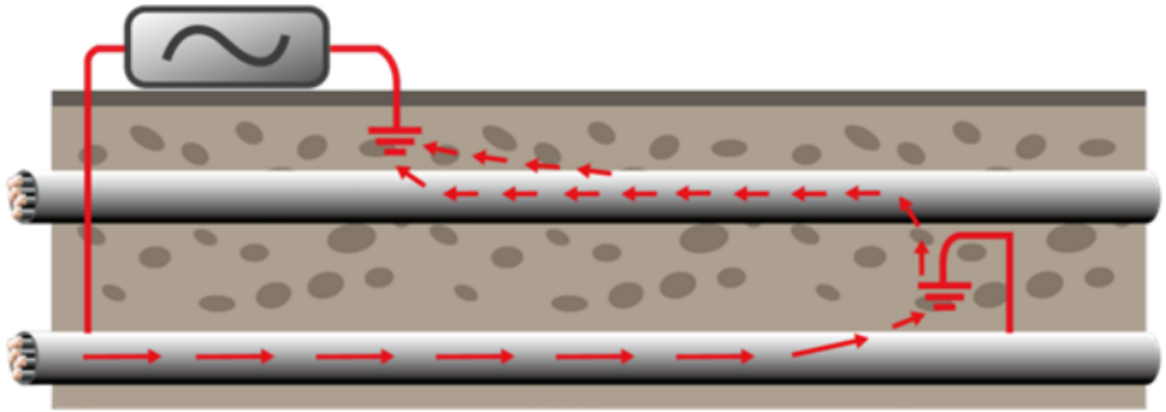
- The current typically uses the ground to complete the current. The earth stake is used to complete the circuit through the ground.

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.

The Locating Signal……



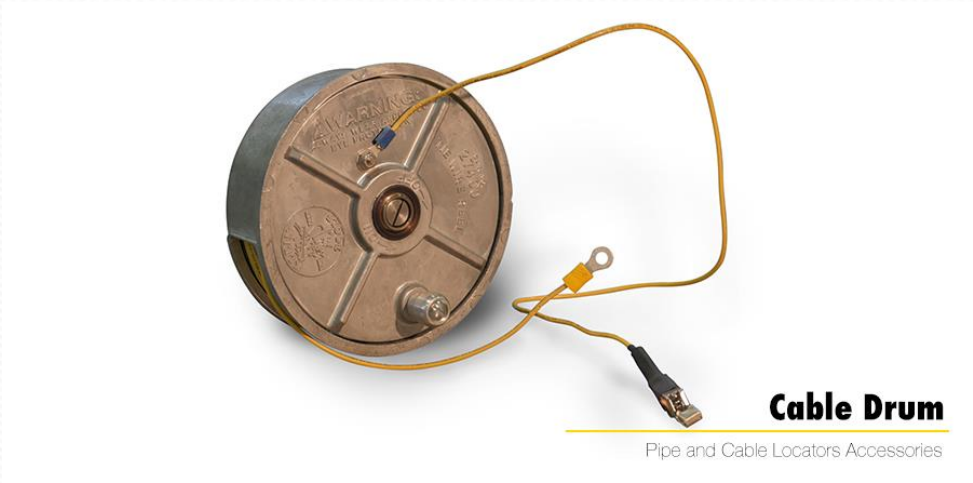
- Signals may use other pipes and cables to turn to the transmitter because they represent a lower resistance than the ground

Grounding

- Grounding (Earthing) is best done at 90 degrees from the pipe position.
- Grounding stake should be as far as possible from the pipe.
- If possible, do not cross other underground lines you don't want to locate
- Dry Soil or shallow dirt can create poor grounds (water around stake can help grounding)
- Alternate Grounding options: Sign posts, Fence posts of non-metallic fencing.
- A Cable Drum can be used as an alternative to grounding in fully paved areas or inside buildings

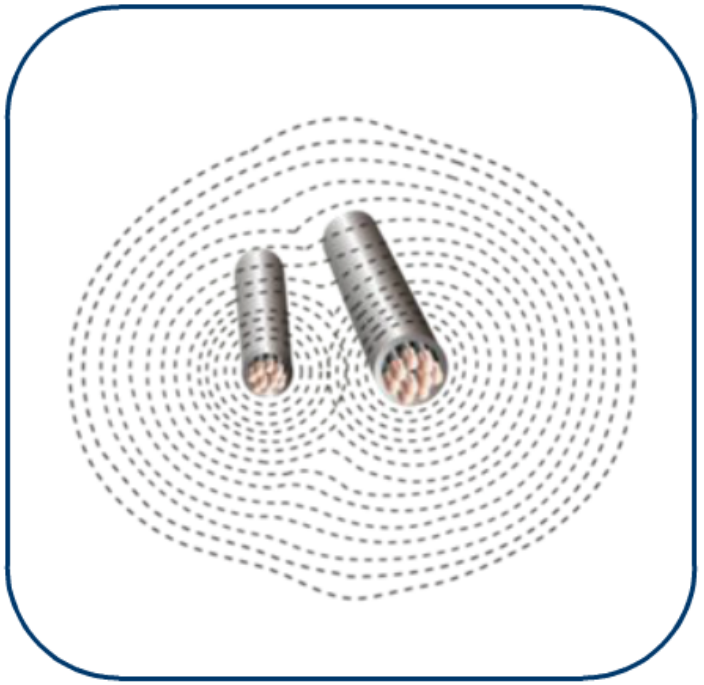
Cable Drums

Create your own completed circuit with a cable drum.



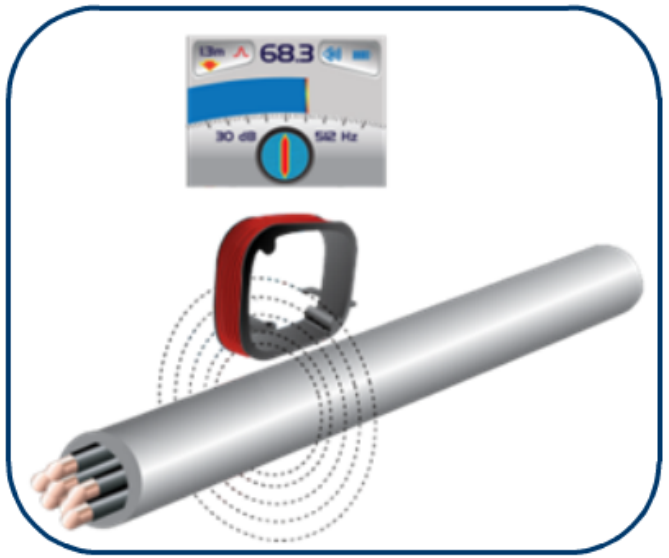
The Locating Signal……

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



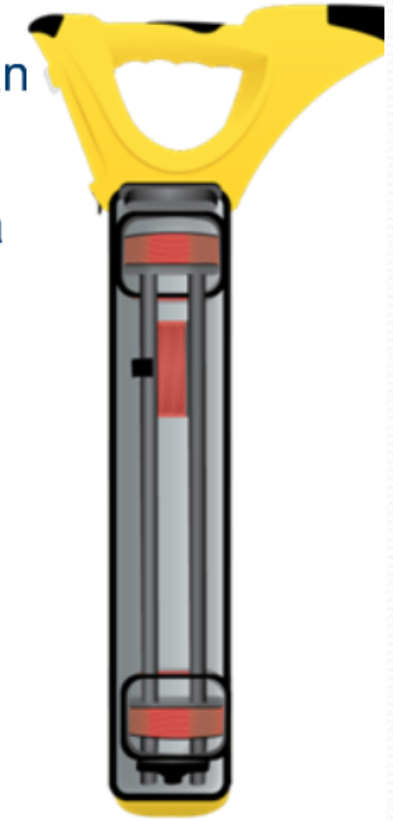
Detecting the Locating Signal……

- 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



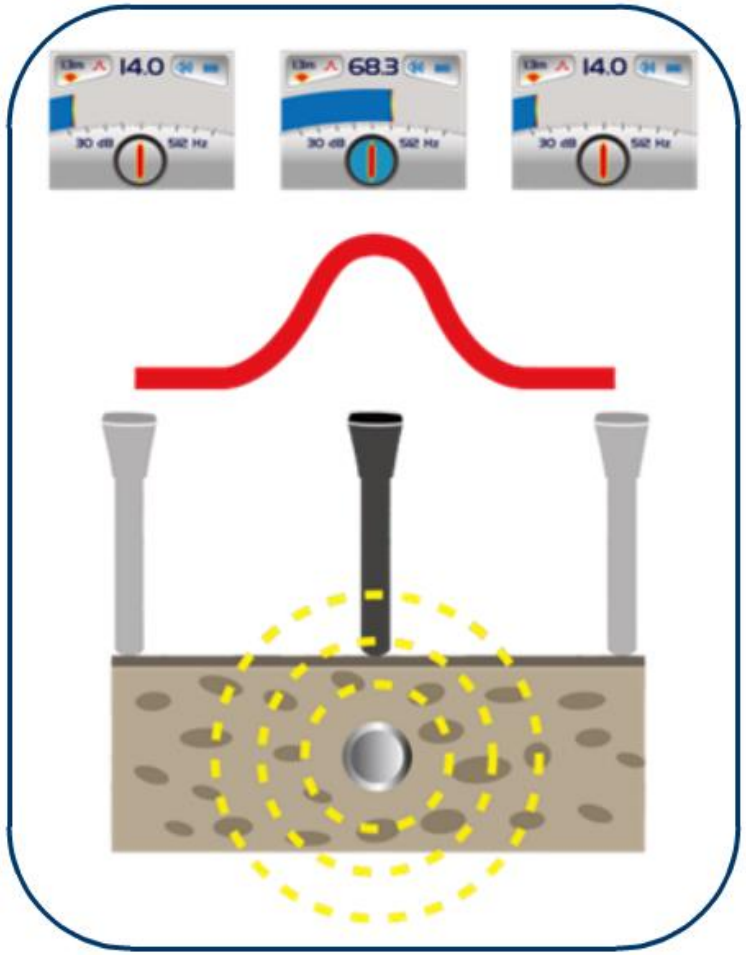
The Response to the Signal……

- 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



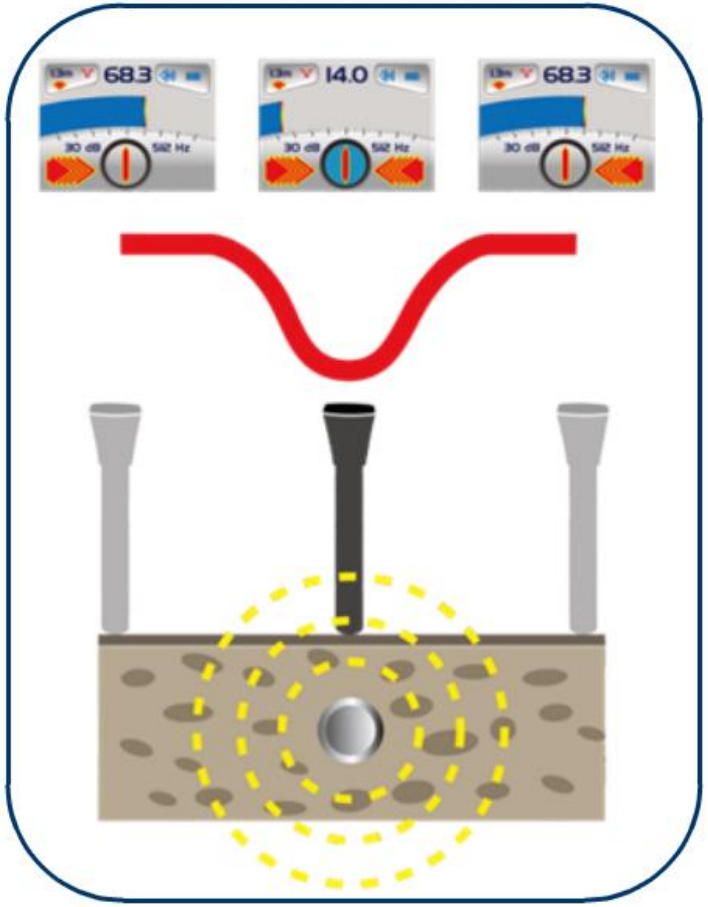
Modes……

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



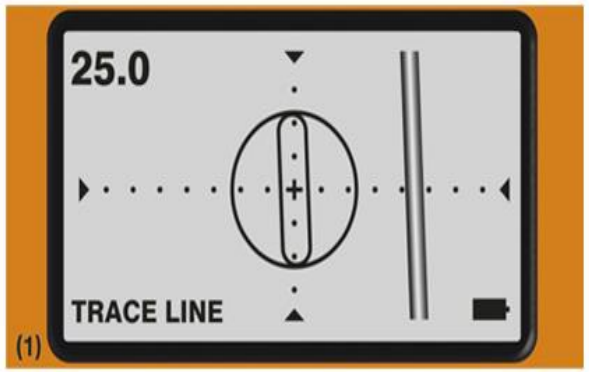
Modes……

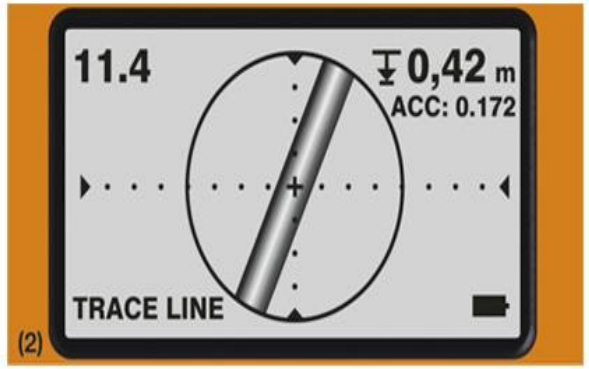
- "Null mode"
  - provides a minimum response over the line



Modes……

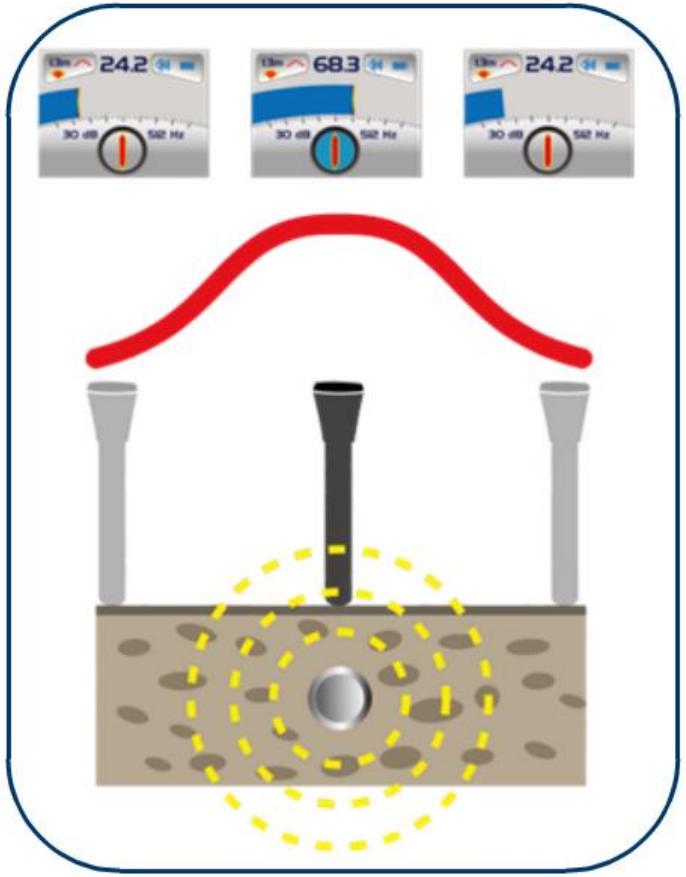
- "Compass LR"
  - Provides "direction" & "orientation" to the line

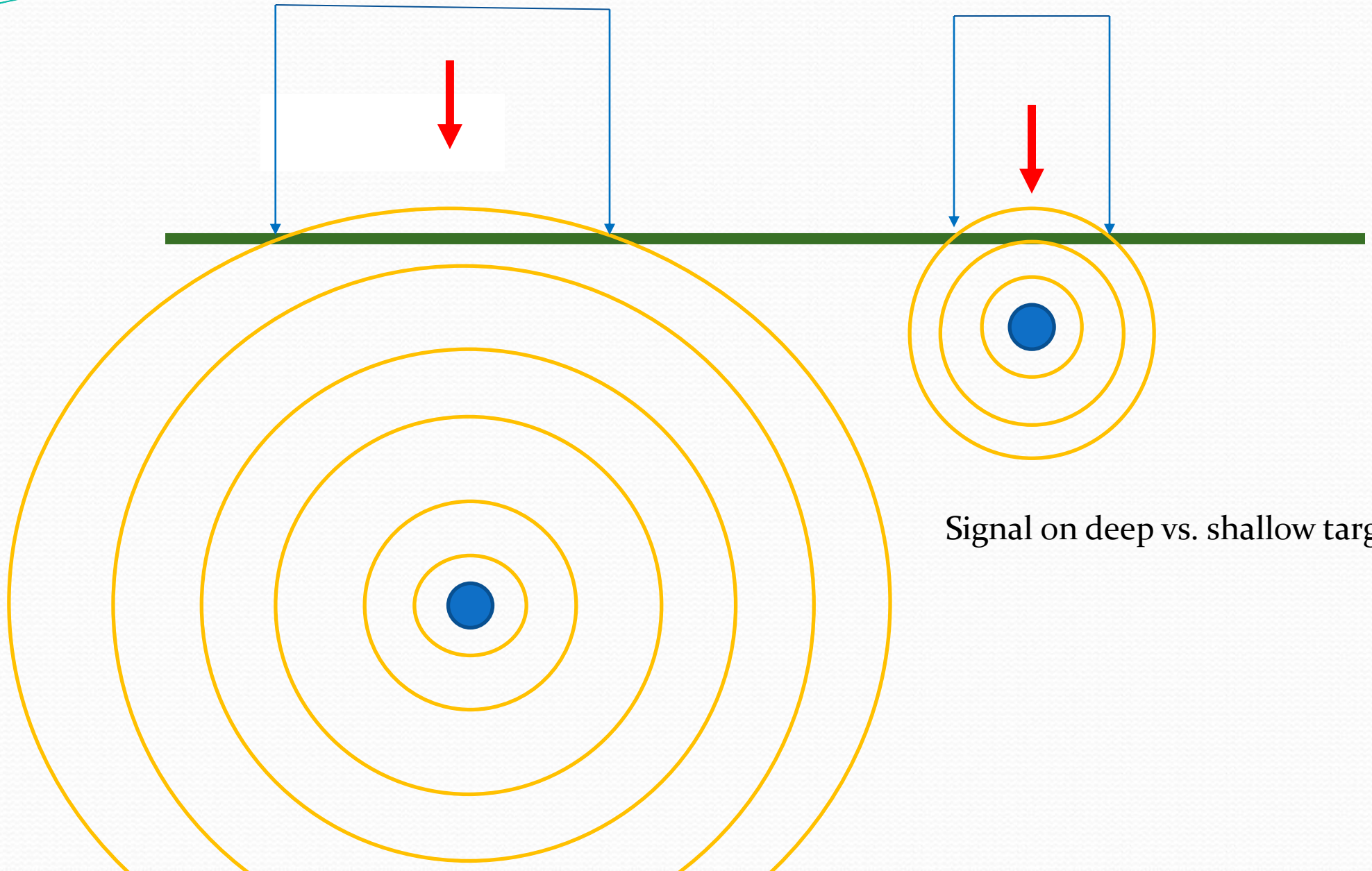




Modes……

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

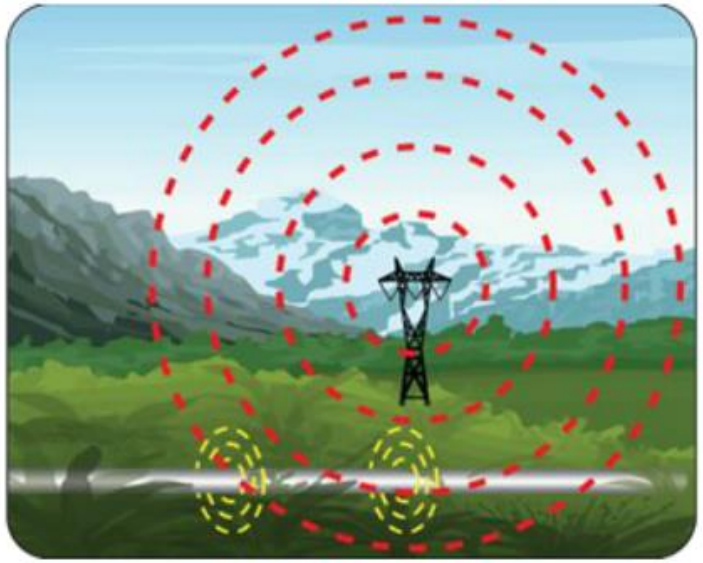




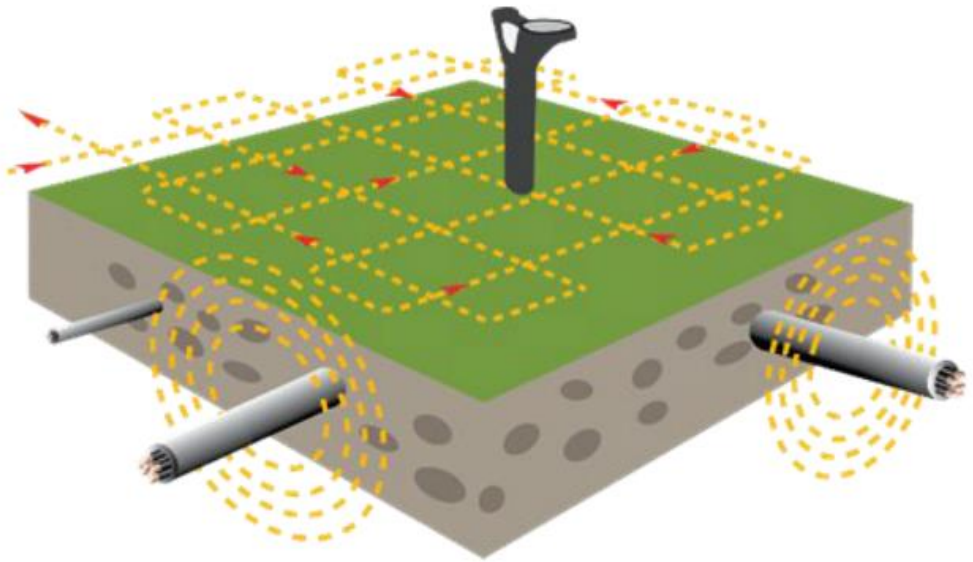
Signal on deep vs. shallow target

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.)



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.

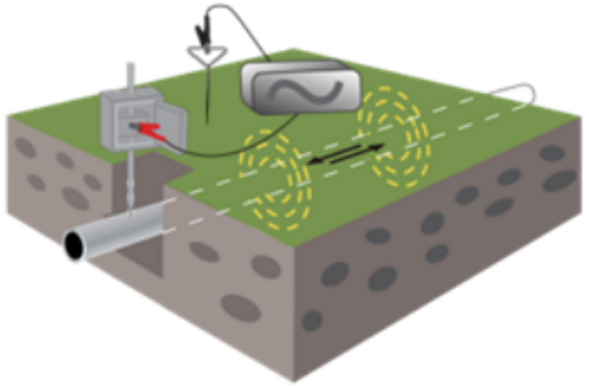
Active Signals……

Active signals are applied by a locator transmitter

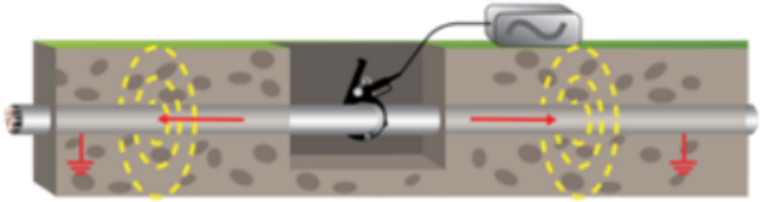
- transmitter have one or more dedicated frequencies
- the choice of frequency depends on the line being located, and the method the signal is applied

(Each manufacture offers slightly different frequencies)

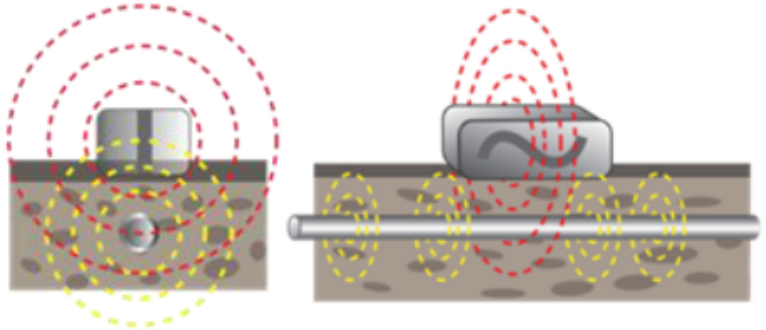
Active Signals……



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



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



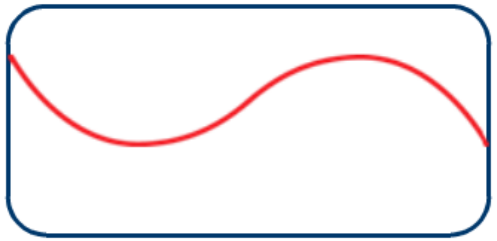
Induction –induces a signal into a cable or pipe, by placing the transmitter on the surface over the target line.

Passive verses Active Location……

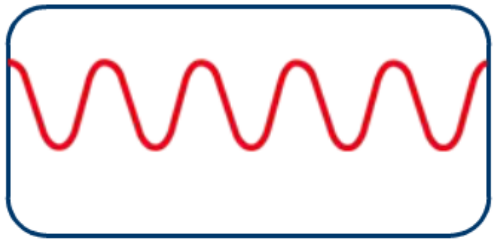
- Passive Location
  - Use to mark the location of unidentified buried lines before digging (Avoidance)
  - Do ***NOT*** use to identify or trace "specific" lines

- 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

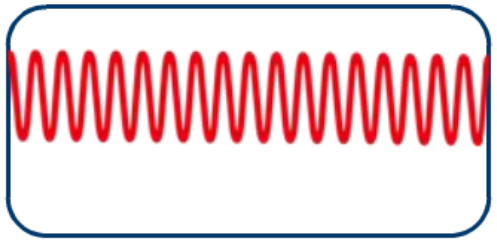
Active Signals Frequency……



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

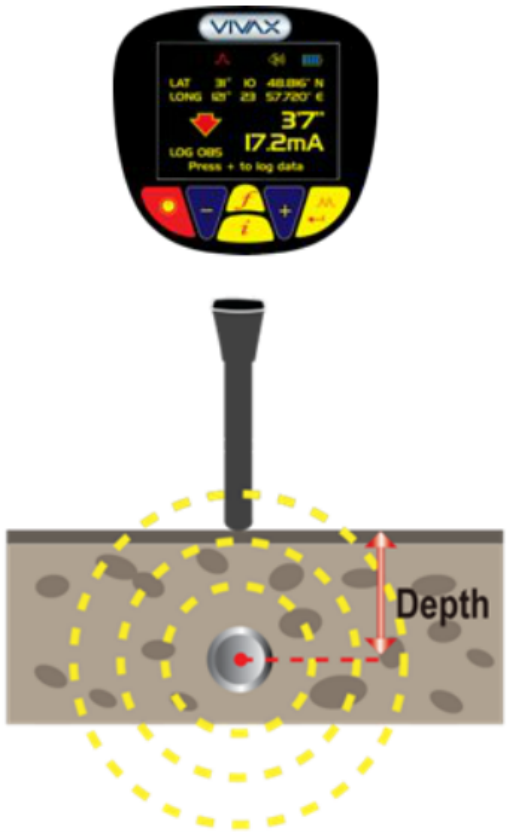


- Medium frequency (8 kHz –33 kHz)
  - Cables & pipes
  - Direct connection, clamp & induction
  - Reasonable distance



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

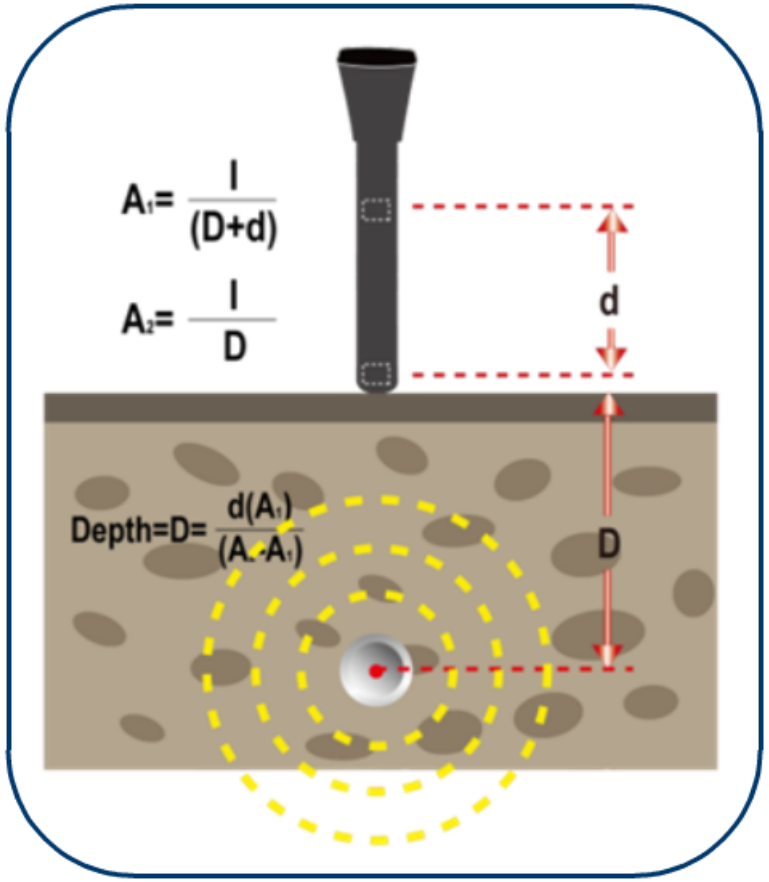
Measuring Depth……



- 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

Tracer wire may be in the bottom or the top of the ditch – Demand Consistency

Measuring Depth……



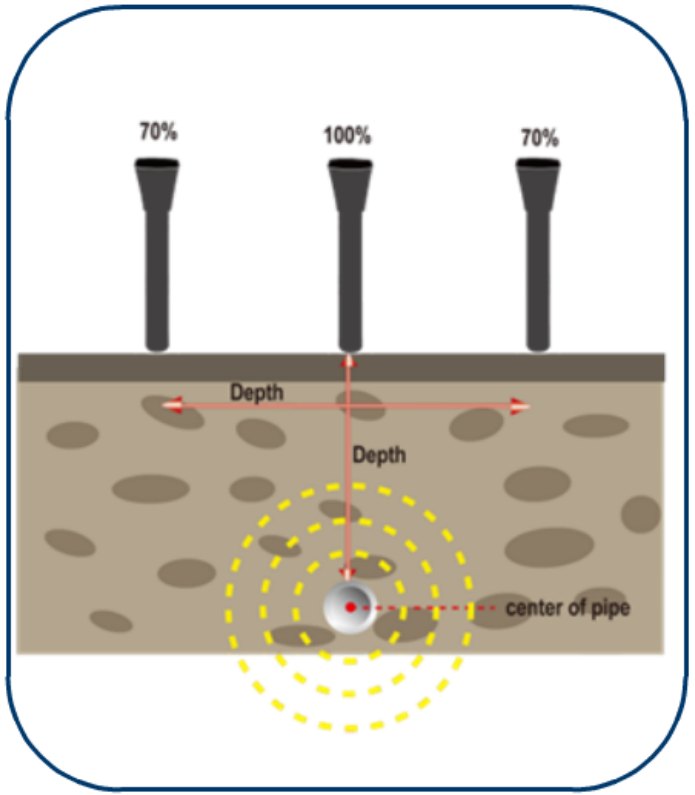
Pushbutton Depth

All locators with pushbutton depth work in a similar way

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

The nose of Locator should be touching the ground

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.

Offset Depth

- Automatic Offset Depth Calculation
- Manual or automatic Calculated angle

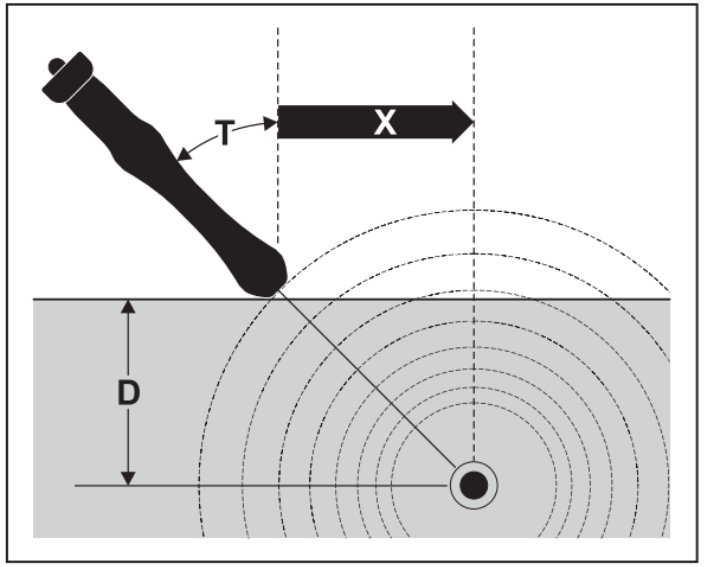
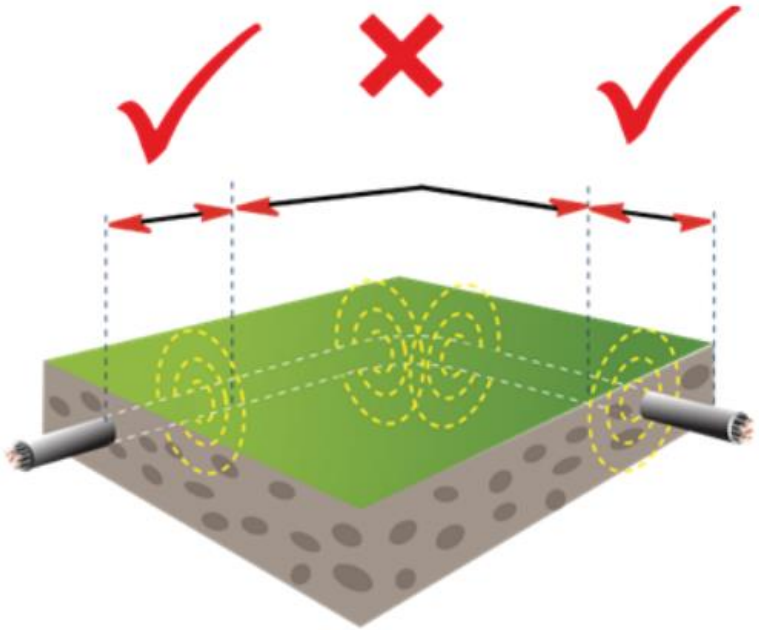


Fig. 18: Determining the offset depth
D depth
X distance receiver – location object
T tilt angle of the receiver

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

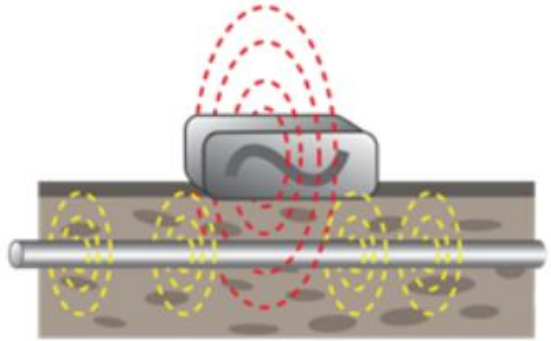


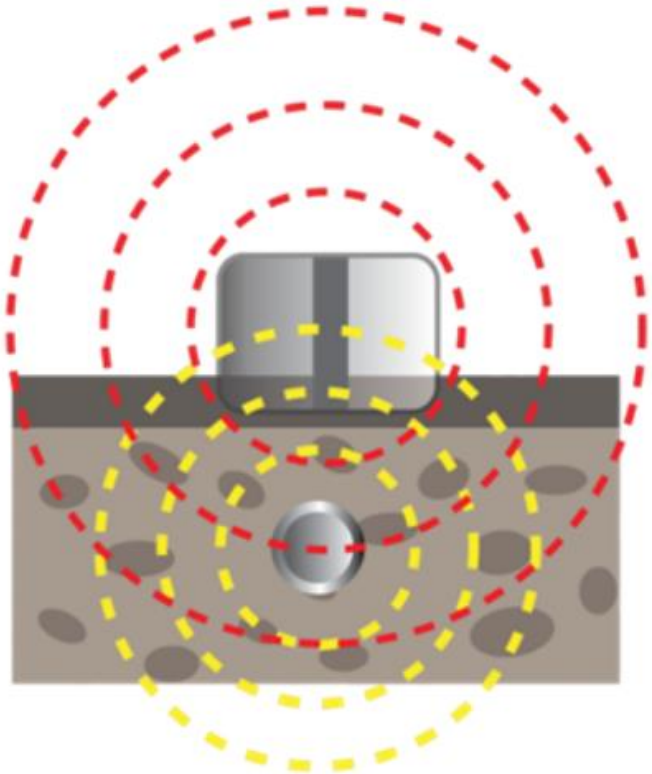
All of these factors can result in inaccurate depth & current readings

Applying the Transmitter Signal to the Line……

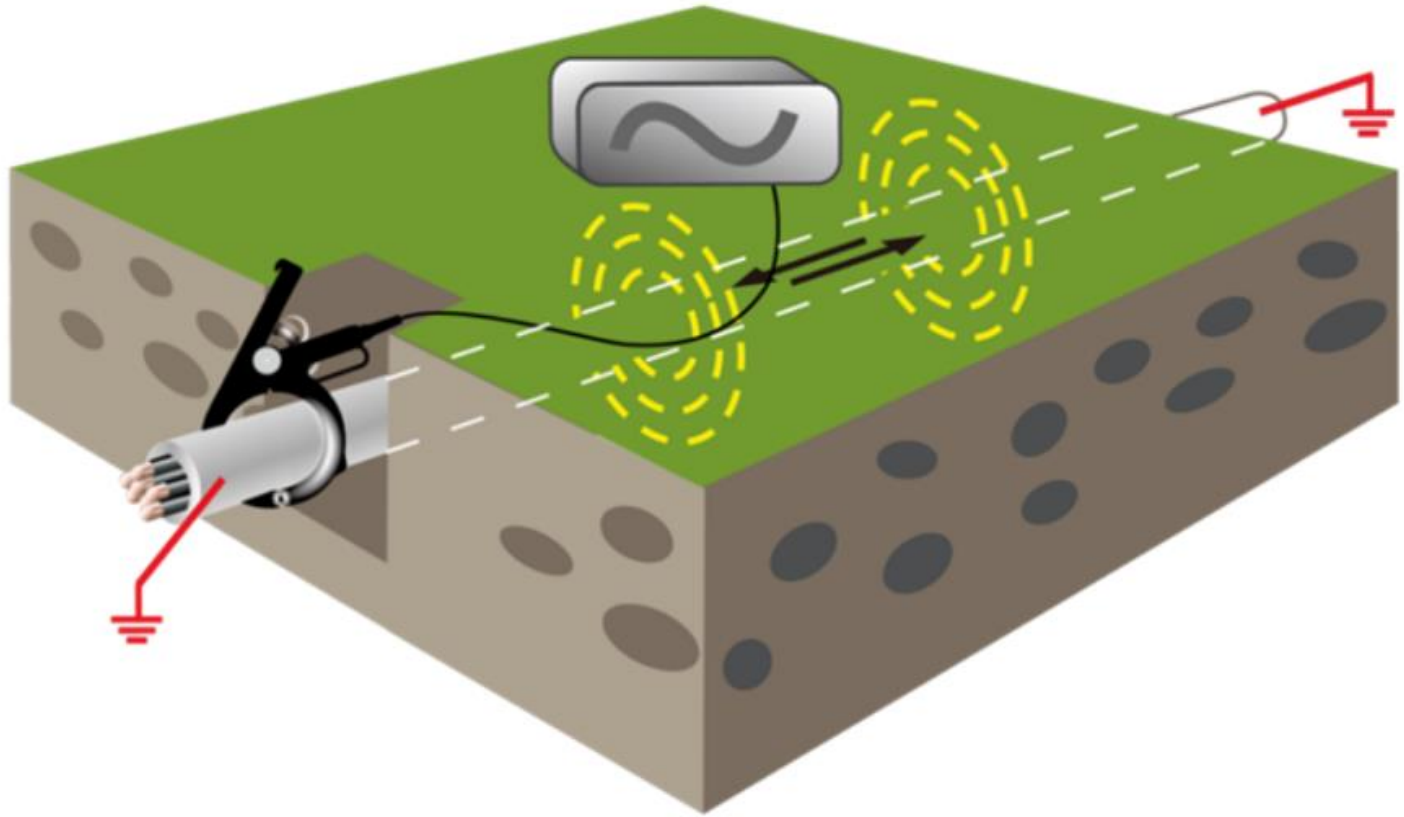
Induction

- 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





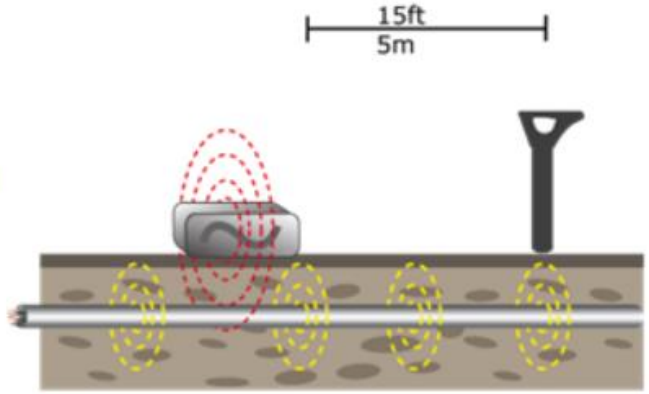
Using a Signal Clamp……

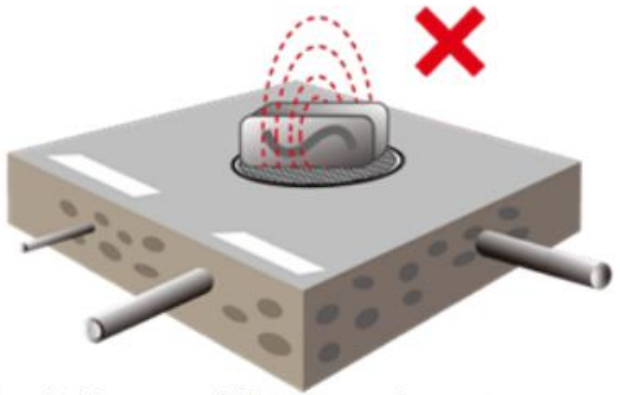


Applying the Transmitter Signal to the Line……

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

Pipe Locating Tips

- Start with the lowest frequency and power settings, and increase only as needed.
- Use Direct Connect primary, induction secondary.
- The other end of the pipe or cable must be grounded to have a locatable signal.
- Grounding fixes: cable drum, water, grounding switch, pre-grounded object, stick in ground, soil probe rod.
- Depth is typically accurate with direct connection only, not inductive.
- Depth and location are not accurate near sharp bends or near the transmitter.
- Does depth make sense? Look up for overhead electric.
- Depth can be integrated with GIS for 3D GIS mapping.

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)
  - Compass Direction / Signal Direction
  - Depth Reading
  - Bluetooth and/or internal GPS
  - Data Logging
  - Sonde Locating antenna
  - Sheath Fault (A-frame for wire faults)
  - Color display, heads up feedback

Locator Buying Tips

- Buy from someone local who can assess your needs based on your intended uses and pipe or tracer wire types.
- Buy from someone who knows your industry.
- READ the user manual – Learn Unique Features of your locator.
- Buy from a source who will provide hands on field training, or take a hands on course.
- Consider advanced features you may want in the future, and accessories available.

Plastic Pipe or duct Locating

- Tracer Wire
- Glass Fiber Tracer rods with copper core
- Sondes (Select frequencies)
- Sonde Integrated sewer camera heads

Plastic Pipe Locating

- Glass Fiber Tracer rods with copper core & tips
- Hub has a contact for the locator signal

Glass-fibre rod GFS

Plastic Pipe Locating

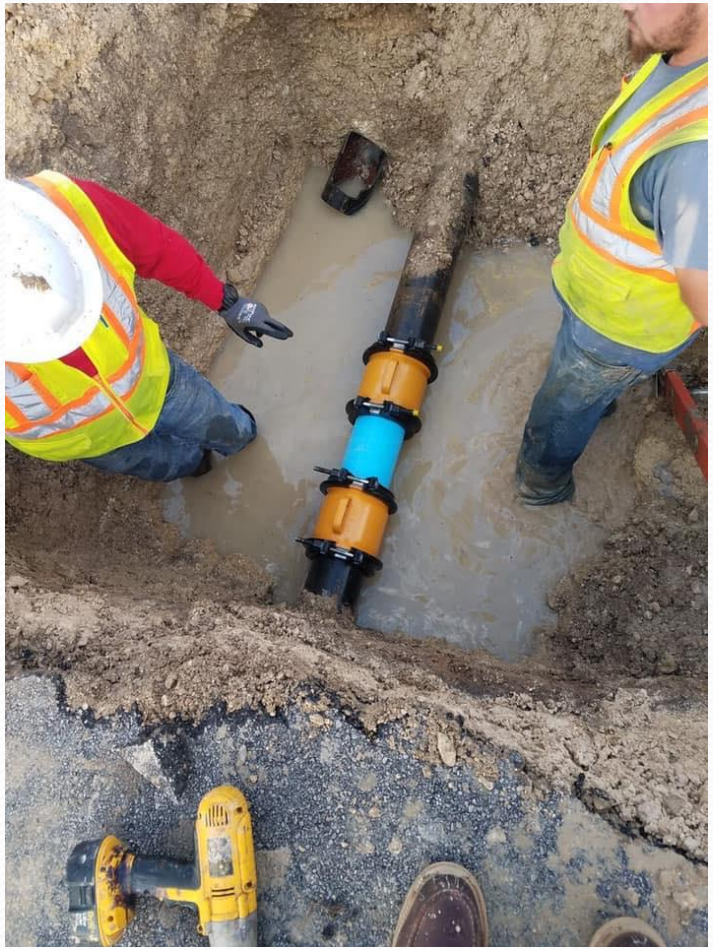
Glass Fiber push rod vs. fish tape

Signal Bleeds from bare conductor

Signal goes to end of trace rod with fiberglass coating

Maintaining a Traceable System

- Tracer Wire
- Do you have a Specification?
  - Wire
  - Connectors
  - Anodes
  - Test Stations
- Don’t repair metal pipe with plastic sections
- Do you have a policy and stock parts to repair your tracer wire?



Tracer Wire Facts

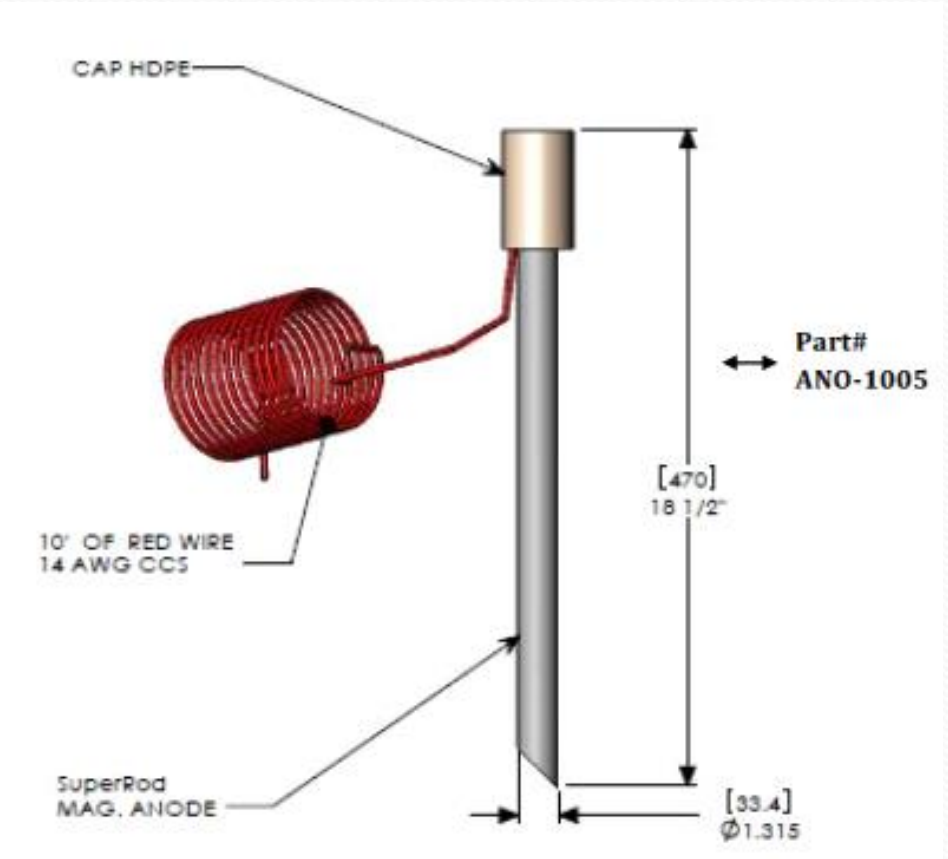
- THHN wire is NOT for underground use.
  - Break Strength
  - Corrosion resistance
  - Outer Casing Material
  - Long Term Failure
- Tracer Wire Specs.
  - Copper Clad Steel is Stronger
  - Tracer wire has HDPE or similar coating, 30 mil+
  - Boring or bursting wire should be stronger
  - APWA Color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

Tracer Wire Connectors and Test Ports

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

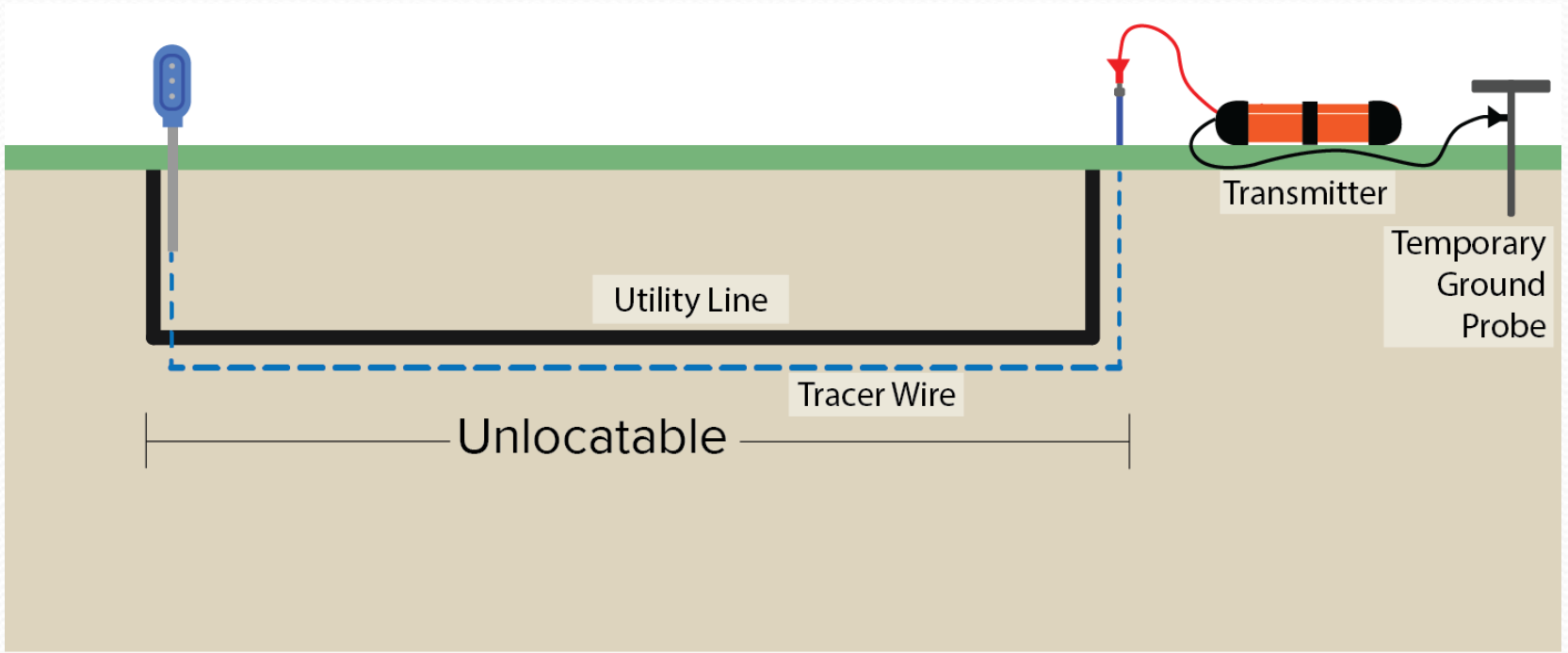
Tracer Wire Anodes

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



Tracer Wire Anodes

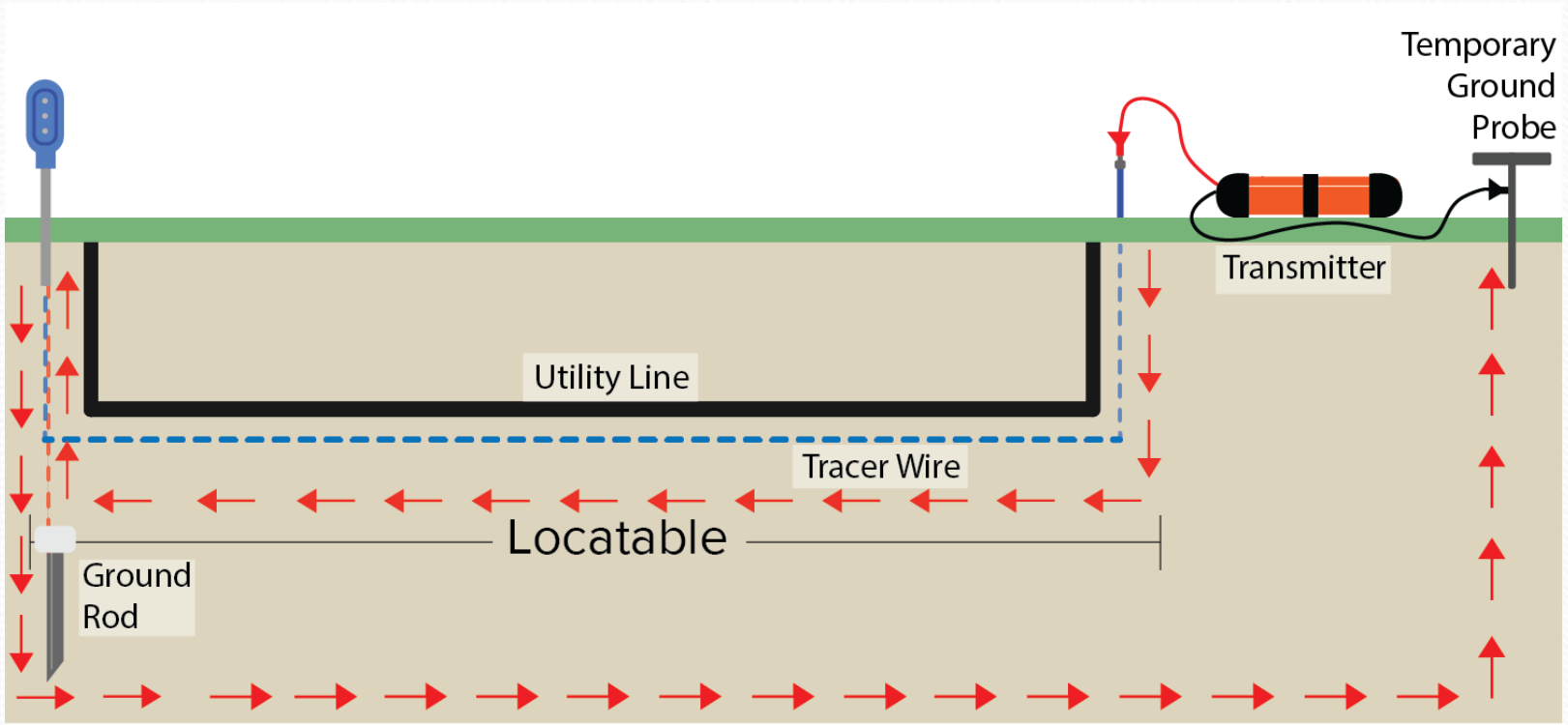
Incomplete Circuit



Tracer wire not properly grounded results in a missing signal and incomplete circuit.

Tracer Wire Anodes

Complete Circuit



Tracer wire properly grounded results in a complete circuit.

Tracer wire test stations

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

Tracer Wire Issues

Acoustic Plastic Pipe Locators

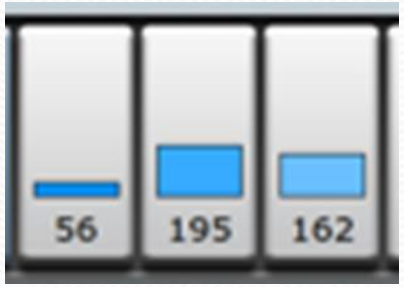
- Sound Generator
- Mechanical knocker
- Hydrant Stopper

Acoustic Plastic Pipe Locators

- Acoustic Listening Device with filters or
- Listening Device with Max Mode

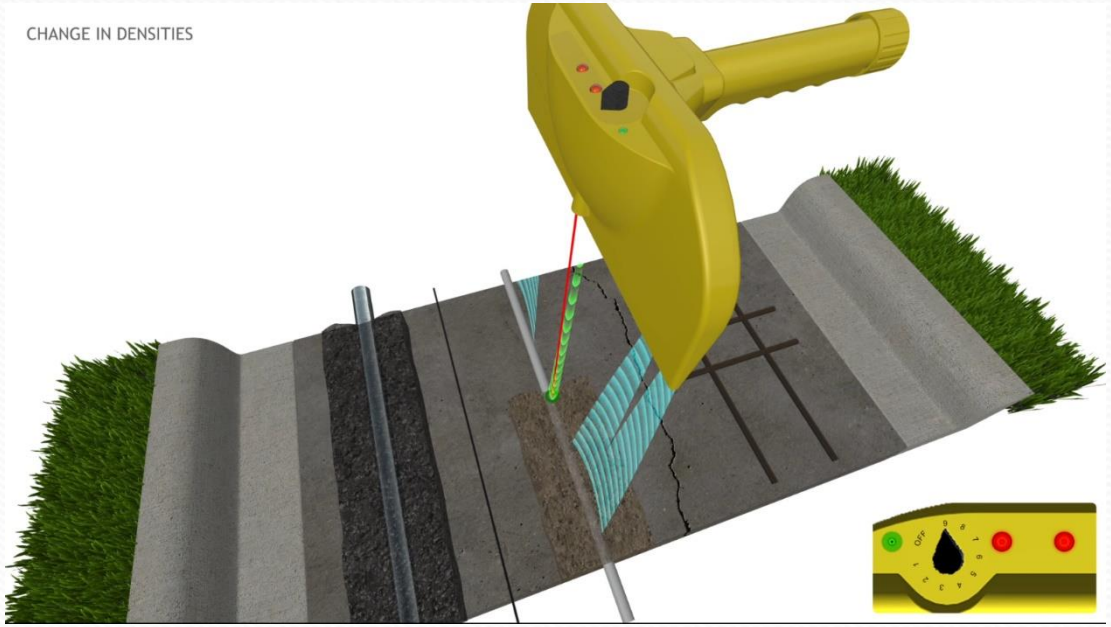
Acoustic Plastic Pipe Locators

- Listening Device Max Mode



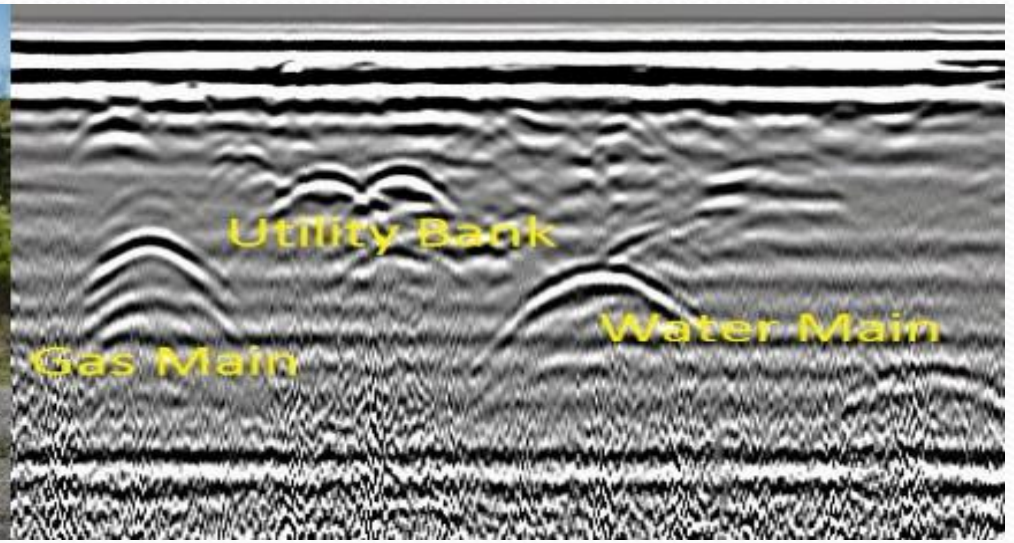
Ultrasonic Underground Locator

- All Materials Locator
- Works similar to stud-finder
- Doesn't discriminate between any material
- Finds any material with linear density.
- Best used after using other locatable items



Ground Penetrating Radar

- GPR Requires expertise, training, and experience (hire an expert)
- Locates many types of objects, metal and non-metal
- Requires expert to differentiate what gives a radar signature
- Doesn't work well in some types of soil or with rocks
- Doesn't work well on rough or unlevel ground
- Expensive to own

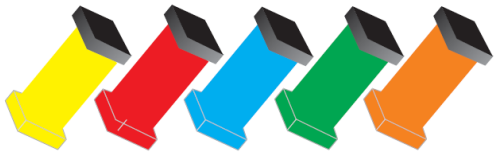


Marking Located Objects

- Temporary Markings
  - Paint, Flags, Whiskers
- Permanent Markings
  - Visual Surface Markings in soil or pavement
  - Detectable Tapes
  - Detectable Markers (metal, magnetic)
  - RFID Markers
- GIS Mapping and GIS corrections

Marking Located Objects

APWA Color Codes



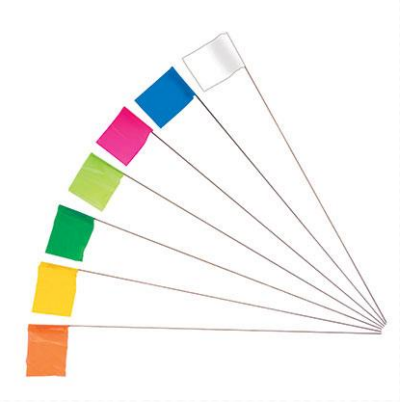
Marking Located Objects

Temporary Marking

- Marking Paint “Utility Graffiti”
- Water, Solvent, or Chalk based

Marking Located Objects

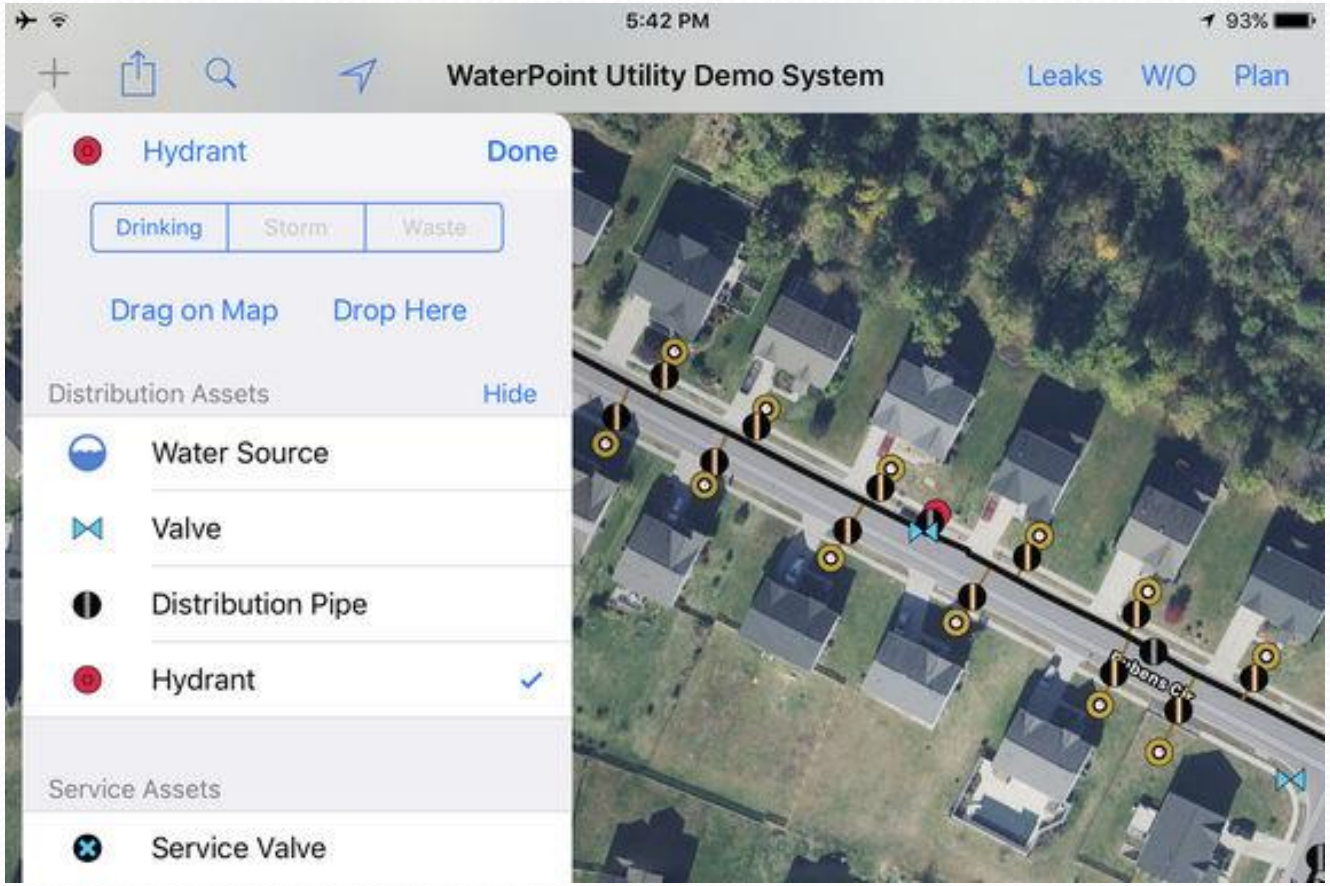
Flags and Whiskers



Marking Located Objects

Tips:

- GIS Locate while you have the lines temporary marked for 811 or other calls.
- Have GIS marking built into new construction contracts.
- Include GIS mapping as part of your construction inspection process.



Marking Located Objects

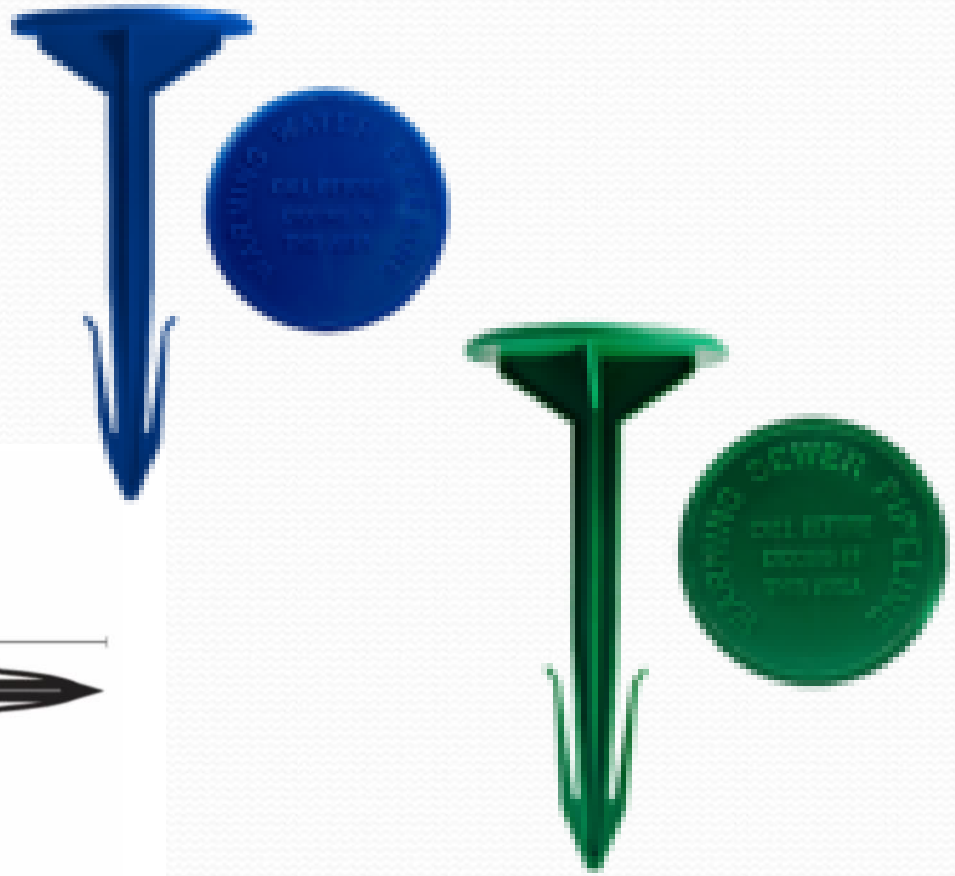
Permanent Markers

Detectable Markers

- Magnetic Markers
- Locatable Tapes
- 3M RFID Markers

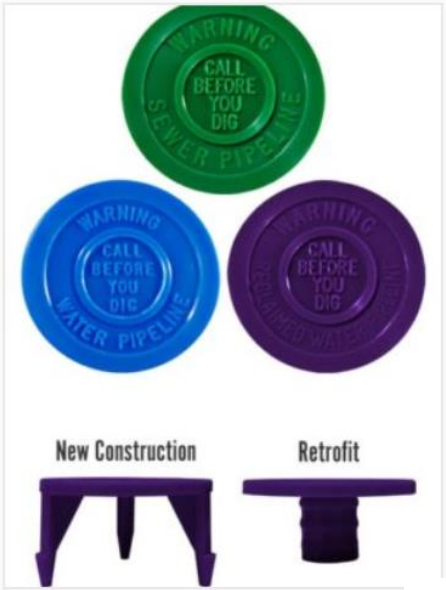
Marking Located Objects

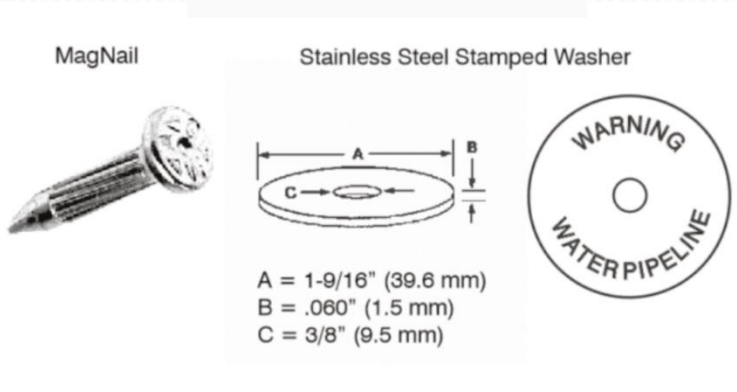
Permanent Surface Markers – Soil Markers



Marking Located Objects

Permanent Surface Markers – Pavement and Curb





Marking Located Objects

Permanent Surface

Post Markers and Signs

Utility Technologies, LLC

Technology Solutions for Efficient Utilities

Underground Locating and Marking of Pipe, Cable, and Objects

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