US EPA RECORDS CENTER REGION 5
431081

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE: April 23, 1992

SUBJECT: Saw Wee Kee Geophysical Investigation

FROM: J. Ursic, Geologist JRU
Technical Support Section

TO: Louise Fabinski, ATSDR

On Friday April 17, 1992 I conducted a cursory geophysical survey at the Saw Wee Kee Nature Preserve in Oswego, Illinois. The survey was conducted at the request of Louise Fabinski, the Agency for Toxic Substances Disease Registry (ATSDR) representative for USEPA Region 5. The purpose of the site visit was to meet with local residents and locate, if possible, general areas where drums were allegedly buried.

The park is located adjacent to the southeast bank of the Fox River approximately 2.5 miles west-southwest from downtown Oswego. The park occupies approximately 160 acres with several residences located northwest of the Preserve, and in the central portion of the Preserve. The area was used for strip-mining sand and gravel until the late 1930s. It was later reportedly used as an open dump until recently.

I arrived on site at approximately 9:35AM and calibrated the geophysical instrument to be used during the survey (an EM-31), shortly thereafter I was met by the following people.

Louise Fabinski, ATSDR
Frank Vaughan, Illinois Department of Public Health
Tom Baughman, Illinois Department of Public Health
Neil Hambly, Local resident
Ramona Capalby, " "
Wayne Capalby, " "
William Klages Jr., " "

A meeting was held at a local residence to gather information and maps concerning past operations at the site. Following the meeting, a reconnaissance of the area began guided by the local citizens previously mentioned. Weather during the survey was mild (low to mid 50°s) and overcast. Significant amounts of rain had occurred during the previous several days. The ground was wet and muddy.

The cursory geophysical survey was conducted with a Geonics EM-31 electromagnetic ground conductivity meter. A majority of the survey was conducted with the coils aligned in the vertical dipole

orientation (deepest detection mode), except when the coils were shifted to the horizontal dipole orientation (shallowest detection mode) to ascertain a relative depth to target.

Instrument response was measured using the in-phase or metal detection mode. Background readings were primarily in the upper 20 parts per thousand range, slightly higher than expected and probably due to wet ground conditions.

The cursory geophysical survey used no pre-determined grid location system to investigate the area. Local citizens helped reference areas of concern by using various landmarks found on-site. Instrument readings were not recorded at regular intervals for lack of an accurate identification system. However, areas having major off-scale in-phase readings were located and approximated on a map (see attachment).

The following is a record of the EM-31 traverses made on April 17 at the Saw Wee Kee site. Use the attached map for reference.

> Area A is located at an embankment and service road near the Preserve entrance where witnesses stated that some drums were recently removed. No drums were visible from the surface in the immediate area. Data interpreted from in-phase EM-31 readings indicated a very conductive zone (typically indicative of buried metallic entity[ies]) near the toe of the embankment. In addition, very conductive areas were also found on and above the embankment.
>
> Area B was noted as the "Boy Scout camping area". Metal debris and glass were scattered throughout the area. Several mounded gravel heaps were also noted in this area. Protruding from one mound was a 55 gallon drum which was partially covered with gravel. In-phase EM-31 readings on several of the mounds in this area were very conductive.
>
> Area C is the most extensive tract where high in-phase conductivities were concentrated. Surface debris such as plastic scrap and glass were scattered throughout this area. Several locations in area 3 have metal scrap evident at the surface.
>
> Area D is located adjacent to the river extending from the site entrance to several hundred feet past the boat launch area. In-phase EM-31 readings in this area were near background levels, with the exception of a few small isolated areas of high in-phase conductivity levels.
>
> Area E is noted as an area having buried railroad ties. In-phase EM-31 readings were at or near background levels in this area.

Area F had in-phase conductivity levels at or near background.

Area G is an alleged leachate seep. Quadrature phase mode (gross ground conductivity) readings were taken at this location to ascertain if the liquid was significantly conductive or non-conductive. No indications were observed with the EM-31 to establish that the liquid was significantly conductive or non-conductive. In-phase readings were taken at this location and at the top of the ridge and were at or near background levels. The ridge which exists above the alleged seep is bordered by a pond on the opposite side. It is my opinion that the level of the pond surface is higher than the level of the seep and a possible connection between the pond and seep is likely.

Area H is noted as the "bus turn-around". The site surveyed included an additional area immediately southwest of the turn-around. Generally, EM-31 readings at both areas were at or near background levels. Exceptions were noted near the edge of the road (southwestern edge) and near a tree near the turn-around. EM-31 readings near the edge of the road indicated a conductive object that appeared to be linear. It is my opinion that this linear object is a buried pipe, cable, utilities, etc. After I disclosed my opinion to the group, mention was made by Mr. Klages that an old railroad water pipeline may exist in this area. Mr. Klages stated that the line may exist from an old pump-house location near the river to the railroad tracks to the south. The anomaly near the tree was fairly limited in size and extent.

Area I, noted on the map as "1+ Acre Park Landfill/Dump Site", was not investigated. The local citizens who accompanied me did not offer the opportunity to survey this area. Therefore no determination can be made concerning the presence of absence of buried metallic materials.

The geophysical survey was concluded at approximately 12:30 PM.

During my traverses through the Preserve several ponds were observed. The ponds are probably a result of past mining activities. Some of the ponds have metal debris in or protruding from the water surface.

It is my opinion that several areas in the Preserve contain various amounts of buried metallic objects. Specific burial areas noted are: areas A, B, C and D. Area C seems to have the most intensive and extensive (several hundred thousand square feet) EM-31 anomalies of the Preserve. The region near area A also has significant but less extensive anomalies. In my opinion, both of

these areas (C & A) are predominantly metallic materials. Area B, as I stated before, has metallic materials limited to the mounds in the immediate area. Anomalies found in area D were less frequent and more typical of general landfilling operations, where metallic objects are usually indiscriminately scattered throughout the fill.

The amount of overburden which lies on top of the metal materials is fairly shallow, in most circumstances I estimate depths of approximately 1 to 5 feet. Actual depth to the bottom of the metal materials cannot be determined without further geophysical investigation.

Identifying specific pieces of buried metallic materials cannot be determined easily with the geophysical methods used during this investigation. Therefore, to state that these buried masses are drums cannot be assumed without further evidence. I can only state that a mass of metallic materials (ferrous and/or non-ferrous metal[s]) exist below the ground surface. However, some inference and connection could be associated with anomalies and areas where witnesses stated that drums were previously removed. The same assumption could also apply in those areas where anomalies and drum(s) still exist protruding from the overburden.

I have also attached, in addition to the location map, technical information regarding the EM-31.

Thank you for the opportunity to participate in this ASTDR project. If you have any questions, I can be contacted at 3-1526.

2 attachments

cc: Steve Ostrodka w/o attachments

THEORY

General Electromagnetic Theory

The electromagnetic method provides a means of measuring collectively the electrical conductivity of subsurface soil, rock and ground water (Benson et al. 1988). The conductivity value resulting from an electromagnetic instrument is a composite; it represents the combined effects of the thickness of soil or rock layers, their depths, and the specific conductivities of the materials (both natural and un-natural phenomena). The instrument reading represents a combination of these effects, extending from the surface to the depth range of the instrument (U.S. Environmental Protection Agency, 1987) The EM-31 has an inter-coil spacing of 3.66 meters, (12 feet) and is capable of an optimum depth of investigation range in the area of 3-4 meters (horizontal coplanar orientation, less in the vertical coplanar orientation - these terms will be explained later). The resulting values are influenced more by shallow materials than by deeper layers. Conductivity conditions from the ground surface to the instrument's normal depth range contribute the majority of the instrument's response. However, electromagnetic contributions from highly conductive materials lying at greater depths may have a significant effect on the reading (U.S. Environmental Protection Agency, 1987).

The basic principles of the EM-31 functions are as follows. A transmitter coil radiates an electromagnetic field which induces a temporary, time-varying, circulating electrical current "loops" into the ground (which is proportional to the volume of the current flowing within each loop). A (secondary) part of the magnetic field from each loop is intercepted by a receiver coil and results in an output voltage which is also linearly related to the terrain conductivity. Some of the electromagnetic field signals arrive via the air and some via the subsurface material. The field through the air is essentially constant for a given transmitter-to-receiver distance, but the field arriving from the subsurface materials depends on the subsurface electrical conductivity and other previously mentioned factors. If a conducting body is present in the subsurface material between the two coils, the total detected field is altered and the anomaly is noted (Koerner et al. 1982).

Electromagnetic instruments are calibrated to read subsurface conductivity in milli-mhos/meter. These units are related to resistivity units in the following manner: 1,000/(milli-mhos/meter) = 1 ohmmeter (U.S. Environmental Protection Agency 1987). Inphase electromagnetic values are derived from a ratio of the transmitted primary electromagnetic to the secondary related electromagnetic field. This value is noted in parts per thousand (ppt) of the primary electromagnetic field.

Most soil and rock minerals, when dry, have very low conductivity. However, conductivity is usually and overwhelmingly influenced by water content and by the

following (natural) soil/rock parameters:

- Porosity and permeability of the material.
- Extent to which the pore space is saturated.
- Concentration of dissolved electrolytes and colloids in the pore fluids.
- Temperature of the pore water.

Therefore, a specific conductivity value cannot be assigned to a particular material due to the interrelationships of soil/rock composition, structure, and pore fluids which are highly variable (Benson et al. 1988).

There are two components of the EM-31's induced magnetic field which are detectable and measured by the EM-31. The first is the quadrature-phase component which gives the ground conductivity measurements. These measurements are useful for locating natural changes in the earth and also cultural changes such as certain contaminant plumes. The second is the inphase component used primarily in the EM-31 for calibration purposes. Additionally, the inphase component is significantly more sensitive to large metallic objects and thus very useful when looking for buried metallic objects (Geonics Limited 1984).

Geological bodies (i.e. soils and rocks) are not perfect conductors (i.e. copper wire) in which current would flow inphase with the inducing field, nor are they pure inductances (i.e. glass), but have both inductance and resistance. The electromagnetic currents induced into a geologic medium by the EM-31, and also the associated "secondary" magnetic fields, will differ inphase from the primary field; thus the resultant at the EM-31's receiver will have components inphase and 90 degrees out of phase with the primary electromagnetic field.

Interpreting differences in the phase changes is how one portion of the data is analyzed. Inphase signals are sometimes also termed "real", the other component being described as "imaginary", quadrature or simply out-of-phase. Since magnetic fields propagate at the speed of light and not instantaneously, phase will change with distance from the transmitter. These shifts are trivial and are ignored in all normal surveys (Milsom 1989).

Dipole coil orientations (vertical and horizontal) can be used to obtain a general idea as to the depth of a conductive object. The horizontal coplanar orientation (vertical dipoles) is the most direct method of sending signals into the ground (deepest sensing mode [see Figure 1]). By turning the coils 90 degrees (along the same

coplanar axis) allows the dipole orientation to become horizontally aligned ([see Figure 2] note that this orientation is not to be confused with the 90 degree phase difference). When the instrument is in this position the transmitter and receiver coil orientation, with respect to the earth, causes the effective depth of penetration of the nstrument to be essentially halved. It should also be noted that in this configuration the current flow does not exhibit the circular symmetry as in the vertical dipole orientation (Geonics Limited 1984). Thus, under favorable conditions comparing the data from vertical and horizontal dipole orientations may provide a general idea to the depth of a layer or object.

Some general statements can be mentioned regarding contaminants capable of escaping into the soil and the ground water system. In many cases, these fluids contribute large amounts of electrolytes and colloids to both the unsaturated and saturated zones. In either case, the ground conductivity may be greatly affected, sometimes increasing by one or two orders of magnitude above background values. However, if natural variations in subsurface conductivity are very low, contaminant plumes of only 10 to 20 percent above background may be mapped (Benson et al. 1987).

In the case of spills involving heavy non-polar, organic fluids such as diesel oil, the normal soil moisture may be displaced, or a sizable pool of oil may develop at the water table. In these cases, subsurface quadrature- phase conductivities may decrease, sometimes causing a negative anomaly (Benson et al. 1987).

Regarding the detection of buried metallic objects, the inphase component (of the transmitted signal) has a resolution factor three to four times greater than the quadrature phase component. Typically, a single undamaged drum can be detected to a depth of 6 feet (in a uniform sandy soil) using the inphase mode. Usually, surface and near surface metal(s) will have a very strong influence on the instrument readings, while deeper buried metallic object(s) will result in proportionally smaller anomalies (if unaffected by near surface metal) based on the soil conductivity and several other factors which were mentioned previously.

Other factors to consider when using electromagnetic instruments is that they are calibrated by the manufacturer to measure the absolute conductivity over a section of earth; however, the earth is rarely both homogenous and isotropic. For example, in a layered earth, the signal measured is apparent conductivity due to varied thickness, depths and specific conductivities of each layer. The instrument reading is then the result of the cumulative contributions of all the layers from the surface to the depth range of the instrument. A strict solution for this function would require knowledge of the thicknesses of the layers and their respective conductivities. When one considers other complications such as scattered metal within a landfill, it is obvious that interpretation of the data is usually very generalized. Hence, a unique interpretation of subsurface conditions generally cannot be obtained from

electromagnetic sounding data alone; it must be supported by drilling data or other geologic, geophysical information (Benson et al. 1988).

BIBLIOGRAPHY

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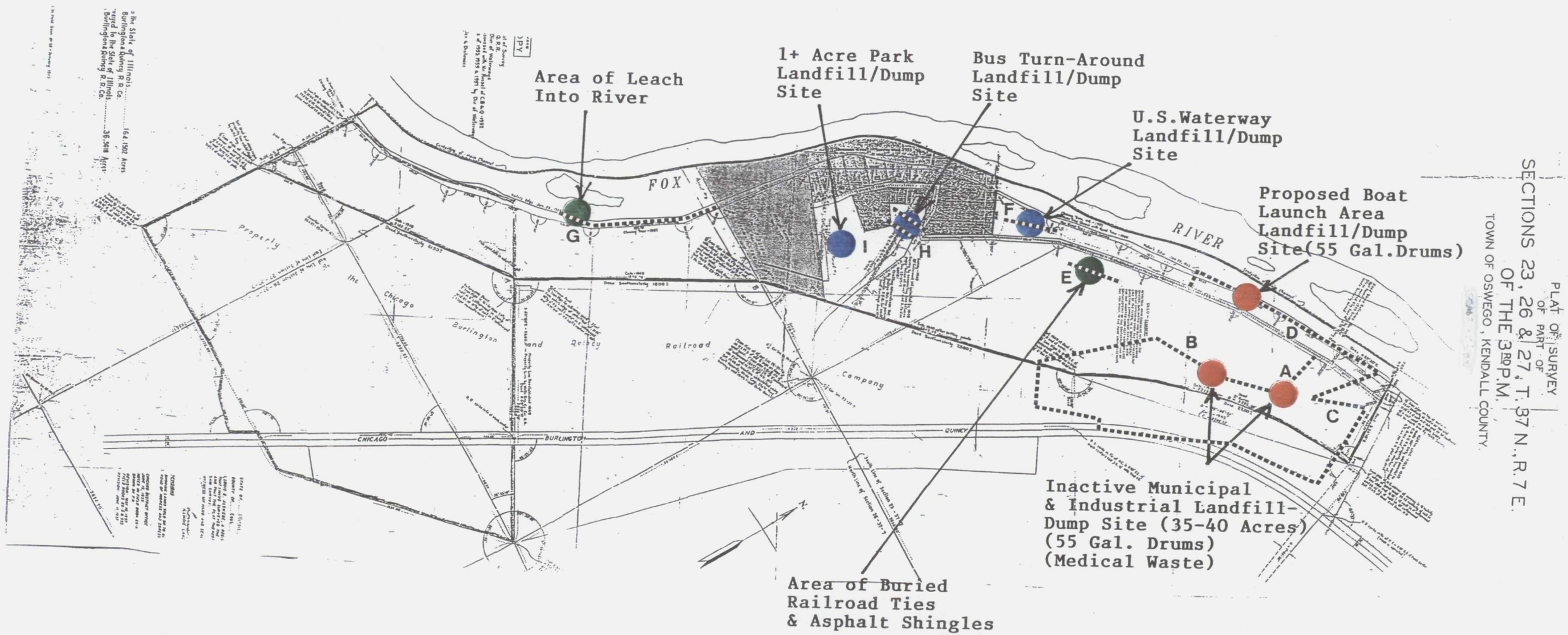
Koerner, R.M., Lord, A.E. Jr., Tayagi, S., Brugger, J.E., Use of NDT Methods to Detect Buried Containers in Saturated Silty Clay Soil, Drexel University, 1982.

Milsom, John, Field Geophysics, Halsted Press, 1989.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Office of Waste Programs Enforcement, 1987, A Compendium of Superfund Field Operations Methods.

SAW-WEE-KEE NATURE PRESERVE / PARK
OSWEGOLAND PARK DISTRICT

Base map provided by Wayne Capalby



Approximate traverses of EM-31 survey April 17, 1992

DIAGRAM ILLUSTRATING BASIC EM PRINCIPLE OF OPERATIONS
VERTICAL DIPOLE ORIENTATION
(MAXIMUM DEPTH OF INVESTIGATION)

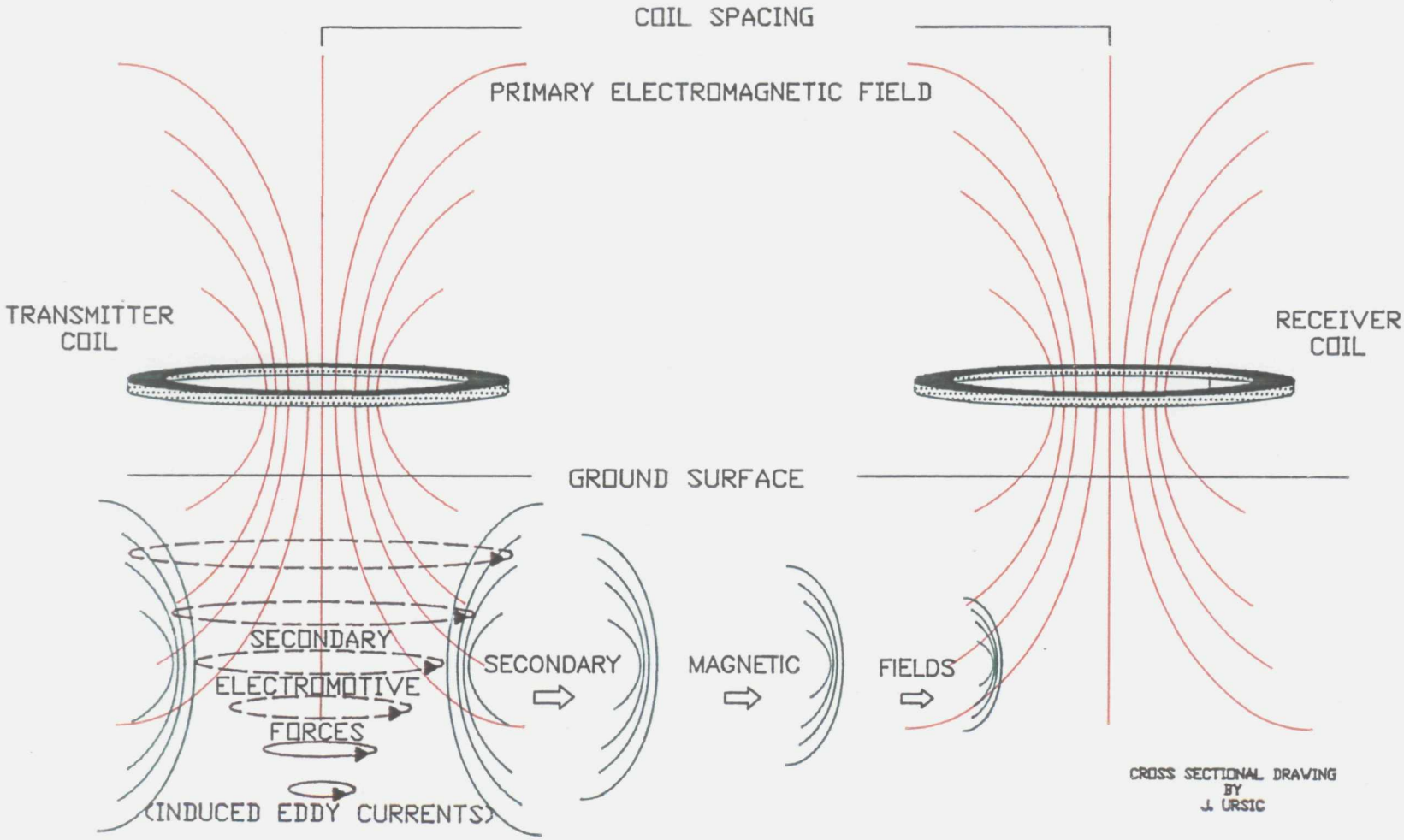


Figure 1

DIAGRAM ILLUSTRATING BASIC EM PRINCIPLE OF OPERATIONS
HORIZONTAL DIPOLE ORIENTATION
(SHALLOW DEPTH OF INVESTIGATION)

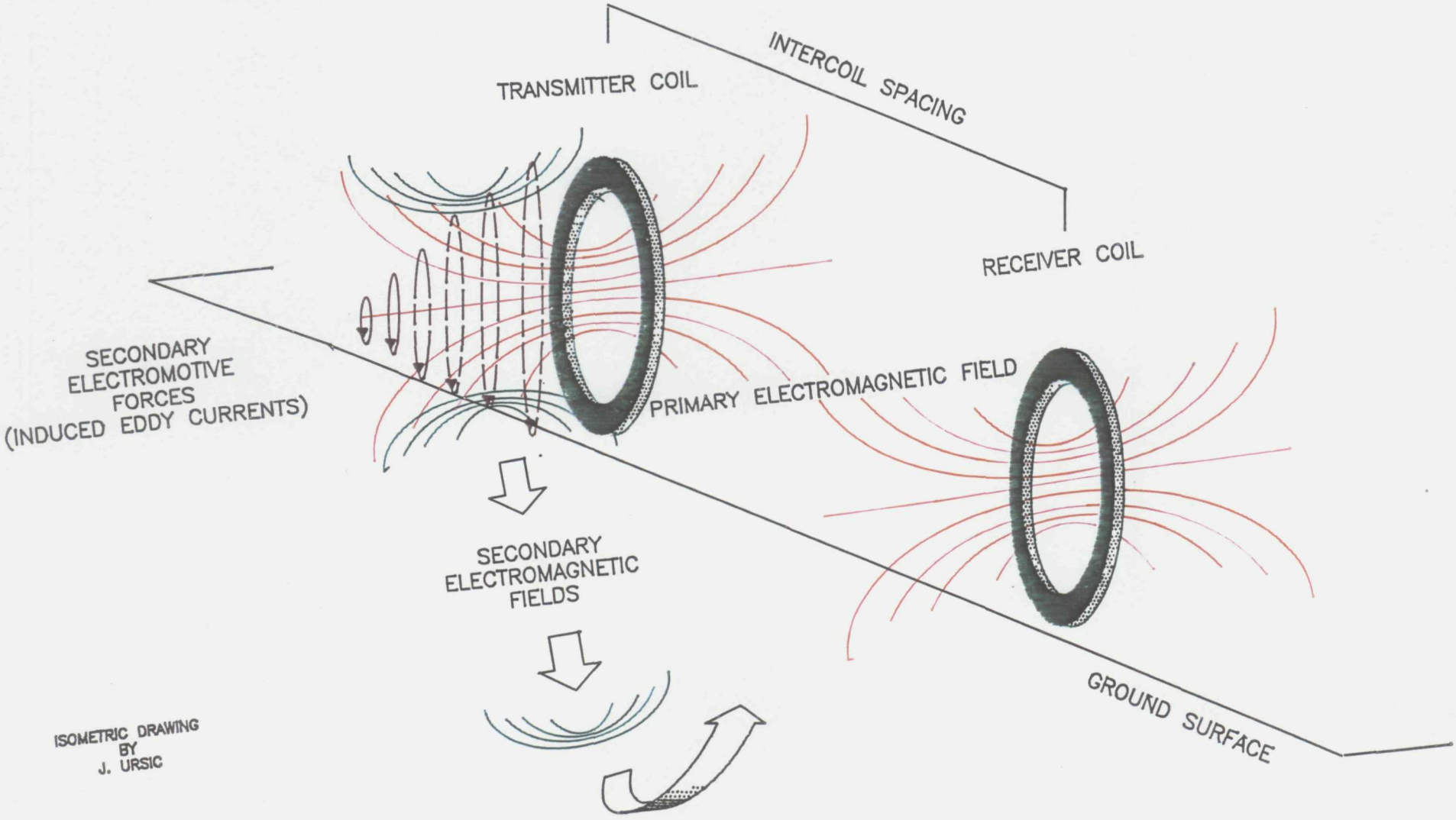


Figure 2