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# The Detection of Magnetic Fields Caused by Groundwater

Duane G. Chadwick

Larry Jensen

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**THE DETECTION OF MAGNETIC FIELDS  
CAUSED BY GROUNDWATER  
and the correlation of such fields  
with water dowsing**

**by**

**Duane G. Chadwick  
and  
Larry Jensen**

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**Utah Water Research Laboratory  
College of Engineering  
Utah State University  
Logan, Utah**

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## **ABSTRACT**

Perturbations on the earth's magnetic field may coincide with the existence of groundwater. Theoretical calculations are made showing how and to what extent this effect may exist. The suggestion is also made that water dowsers may get a dowsing reaction as a result of entering a change in magnetic gradient. Tests were conducted to determine the statistical significance of dowsing reactions obtained by separate individuals dowsing in a common test area. Approximately 150 people participated in the experiment over a period of one year. Chi-square tests showed considerable statistical significance. Virtually all people tested experienced dowsing reactions though most of them had never dowsed before. There is some evidence of correlation between magnetic gradient changes and dowsing reactions.

## **ACKNOWLEDGMENTS**

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Appreciation is also expressed to the over 150 people who participated gratuitously in dowsing tests in behalf of the project.

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# **THE DETECTION OF MAGNETIC FIELDS**

## **CAUSED BY GROUNDWATER**

**and the correlation of such fields  
with water dowsing**

### **Introduction**

Since the beginning of civilization, the abundance or scarcity of fresh water has had much to do with the welfare of the inhabitants of the world. As the water supply becomes less abundant, efficient means of locating the groundwater reserves become more important.

In reviewing the state-of-the-art regarding the locating of wells, the age-old question of water dowsing arises. Certainly if the method worked, nothing could be much more efficient or require less equipment. Dowsing by dictionary definition, means "water divining" or use of a divining rod to find water. A U.S. Geological Survey Bulletin (1965) suggests that dowsing may have had its beginning in biblical times when Moses took a rod and struck a rock and water gushed forth (Numbers 20:9-11). Regardless of the origin of dowsing; skepticism is still widespread regarding it, but so are there numerous stories which claim remarkable dowsing feats.

Few people could have approached the subject of dowsing with more skepticism than the principal investigator of this project. Having been challenged about the subject on occasions, some preliminary thinking was finally engaged in, in an effort to see if there were some scientific basis for the dowsing reaction. At the outset of this preview of the dowsing phenomena, a dowsing experiment was conducted. The results of the experiment were sufficiently interesting that serious thinking has taken place in an attempt to connect the observed human response to physical phenomena existing in the earth, thereby giving credence to some rather impressive circumstantial evidence that has been observed.

In searching for a scientific principle upon which a dowser response can be based, several interesting facts can be noted: (1) Several ways exist in which the presence of groundwater can cause a perturbation in the earth's magnetic field. The nature of these perturbations are discussed and the magnitudes calculated in the body of the report. (2) The dowsing devices, as observed, are all held by the hands in such a way that they could be considered unstable mechanical amplifiers. (3) Slight hand motion could cause a readily observable mechanical output. If the body, muscles, nervous system, etc. can be shown to be sufficiently influenced electrically by magnetic field perturbations, then at least one cause for the existence of the dowsing reaction can be shown to exist. (4) An electrical conductor cutting a magnetic field generates a voltage which may produce subsequent current flow. In the case for dowsing, the body serves as the electrical conductor and as it moves through the earth's field small electric potentials are generated. The chief question remains: Is the magnetically induced potential sufficiently large to cause an unconscious hand motion sufficiently large to cause the dowsing reaction?

In an effort to answer this question, calculations were made to determine the expected size of the magnetic field perturbations. Also, numerous dowsing tests were made. The nature of these tests, the test results, and an evaluation of the meaning of the results are presented in this report. Before discussing these in more detail, however, some general information pertaining to the historical background of dowsing is presented.

## Historical background

Exemplifying the existence of controversy and disagreement that surrounds the topic of water dowsing, even within the dowsing community, are the various claims of its origin. Tromp (1949) estimates that the divining rod is some 7000 years old. The first authenticated account of the use of the forked stick for dowsing is contained in a book written by Agricola (1556 AD). The account describes the use of the device for locating precious metals around a mining area in Bohemia. His book contains illustrations of men using the forked stick, clearly depicting the same type of device used today. There were many other documents written somewhat earlier which make mention of divining devices; however, no mention is made of their use for dowsing.

The divining rod became a subject of considerable controversy near the end of the 16th century. Many writers mentioned it during that period. In 1659, the dowsing practice was proclaimed as Satanic magic and denounced by the Church of England. At that time, Jesuit Father Gaspard Scott published a book stating that dowsing was controlled by the devil. The resulting impact of his book is not clearly documented, but, its wide distribution is credited with some of the increased popularity of dowsing in the European countries. Interestingly, the same man later revised his ideas and advanced the theory that movement of the rod was not the work of the devil but was simply unconscious muscular reaction resulting from some stimuli. The theory has persisted over the years and is presently supported by many dowsers.

From Europe, the use of the divining rod was carried to other parts of the world by explorers and colonists. Not all cultures were receptive to the practice, however, and in those areas dowsing was never adopted. Even the Asians, who firmly believed in astrology, considered water dowsing an amusing superstition and would have nothing to do with the practice.

Although some use was made of divining rods in the very early history of this country, no significant recognition of the practice was acknowledged until about 1775 when it became identified with witch hunts. Since that time, numerous newspaper accounts, magazine articles, and books have been written on the subject. Since the commencement of this project, mention of water dowsing has been noted to frequently occur in the nontechnical literature, television, cartoons, etc. The general current popularity of the subject plus the convincing oft repeated stories of testators leads one to conclude that dowsing may yet be around for a long time to come.

Since one of the objectives of this research was to try and determine if there was a scientific basis for dowsing, it was somewhat distressing to learn that the divining rod has been used for many purposes other than just locating water. It has

been used in criminal investigations, locating oil, answering yes-no type questions and in other seemingly unrelated areas. The variety and extent of this aspect of dowsing is beyond the scope of the present study and no attempt will be made to challenge or establish the validity of such claims.

## Dowsing techniques

A "standard" method for dowsing for water, or water witching, as such, does not exist. There are many techniques for obtaining dowsing reactions. Most of the dowsers have their own recommendations for optimizing dowsing results. Many of the recommendations are in direct opposition. For example, instructions are given by some to keep arm muscles strained while others state specifically that a person must keep his arms completely relaxed to obtain successful results. Directions are given to obtain maximum skin conductivity with the metal rod while others suggest that good results are obtainable only from an insulated or nonconductive device. One insists on copper wire; another says it is immaterial. The list of seemingly opposing viewpoints is long, with each experienced dowser favoring an especially developed technique of his own.

## Dowsing devices

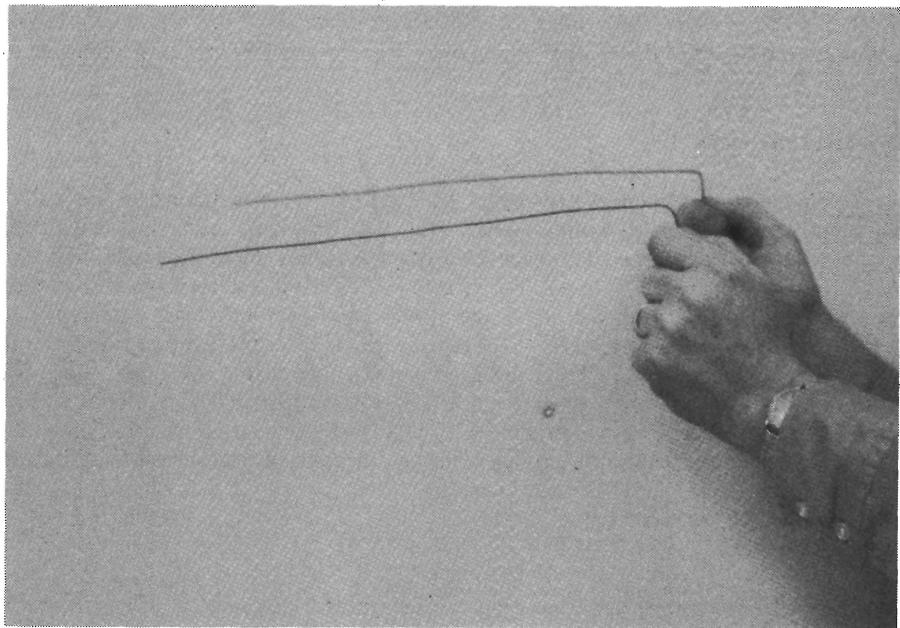
Equally as interesting to consider as the various dowsing techniques, are the numerous devices used in the practice. No one device has obtained universal acceptance. The traditional dowsing device first described in the literature is the forked stick made from peach, willow, hazel, or witch hazel. Other devices are fabricated from both conducting and nonconducting materials such as: metal wire, wood, plastic, etc. The materials are fabricated into various shapes depending on the preference of the dowser. No matter what kind of material is used, or what its shape may be, when the device dips, turns, twists, or otherwise changes shape, the dowser may indicate that a reaction has occurred.

The dowsing device most commonly used in the tests conducted on this project was made from wire clothes hangers. The wire was cut to approximately 18 inches in overall length, then bent into an "L" shape. Two such wires were held in a manner shown in Figure 1. Variations of this particular configuration were sometimes used.

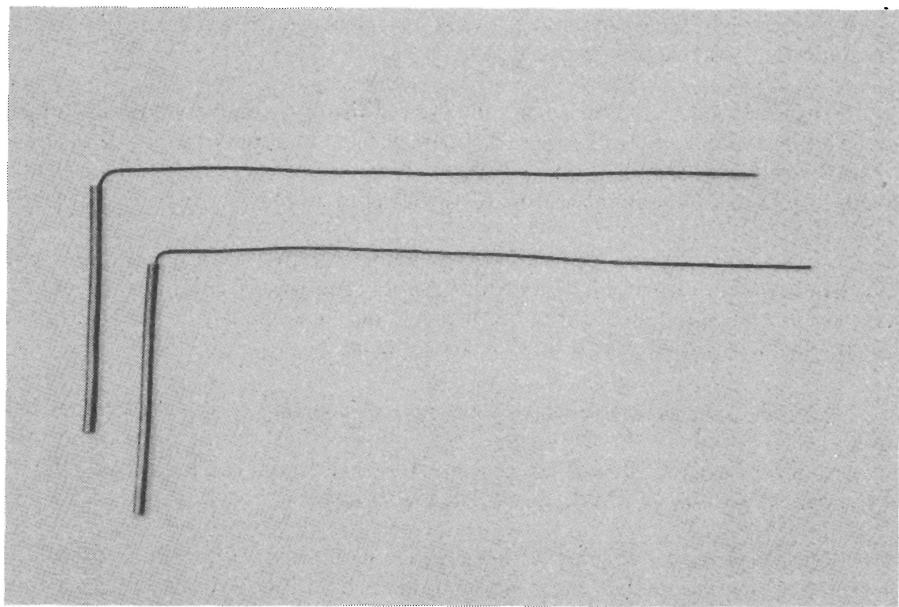
Copper brazing rods bent into an "L" shape and dowsing rods having copper tube handles were also tried. The idea of the handles was that they would tend to make the turning friction constant and it would not be a function of the tightness of the grip or the moisture present on the hands, Figure 2.

Another dowsing device which was used considerably was the "flying V" held as shown in Figure 3. This configuration is regarded by some as superior to other dowsing devices since it allegedly gives a directional response, i.e., it swings to the left or the right depending on the "polarity" of the stimulus.

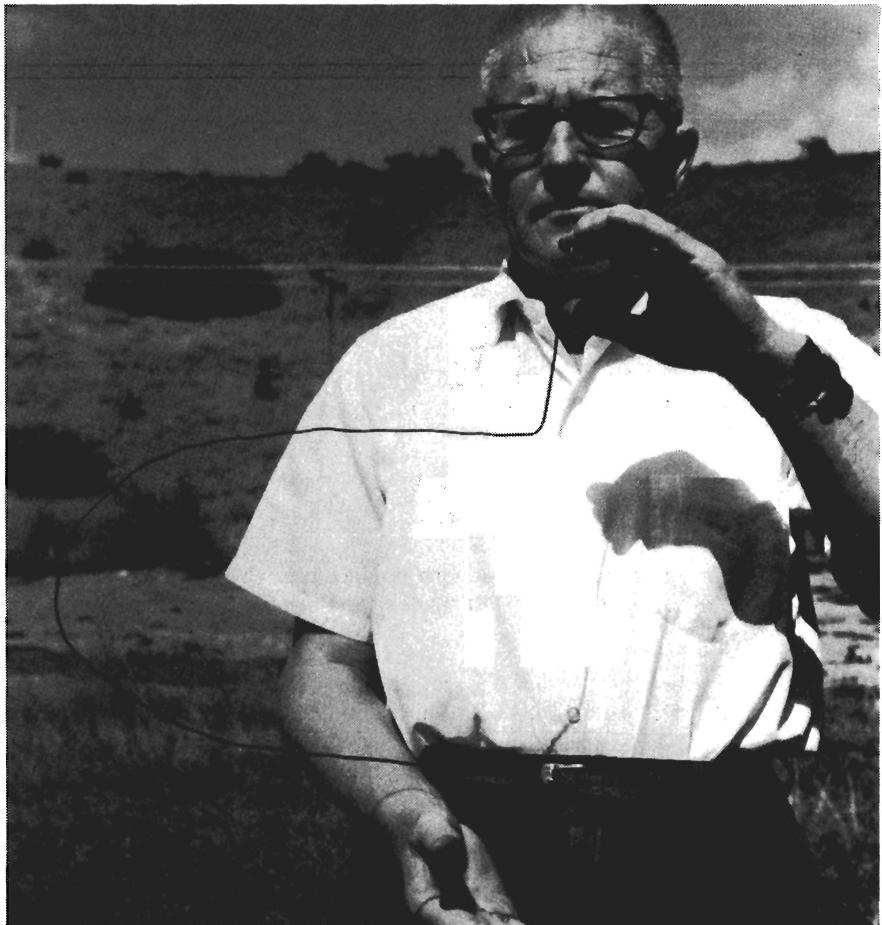
Regardless of the type of dowsing device used, observations made during the project would indicate that experienced dowsers hold the device in such a manner that it acts as a high gain mechanical amplifier. Consequently, slight involuntary hand motion can cause a large mechanical output. In the case of the "L" shaped rods, the center of gravity (CG) of the rod is above the point of contact with the hand, and the



**Figure 1.** Dowsing devices made of No. 10 ga. steel wire (clothes hanger wire).



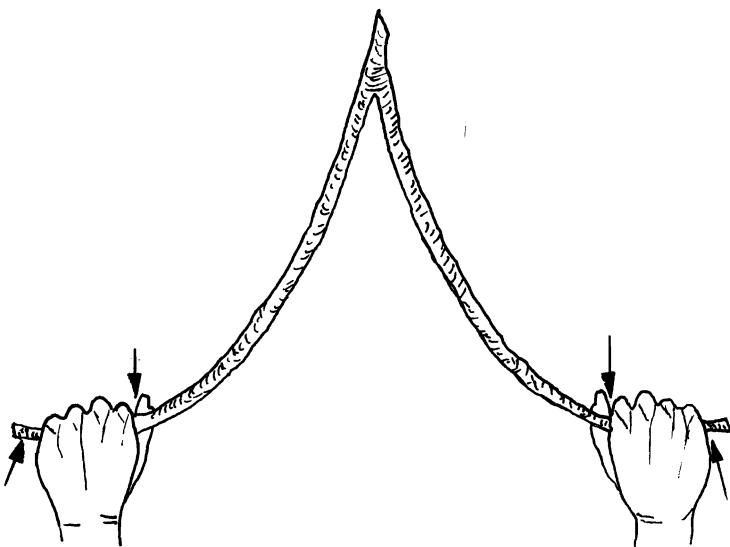
**Figure 2.** Dowsing rods with low-friction handles made of copper tubing.



**Figure 3.** Flying dowsing device made of baling wire.

rod is loosely held near the point of zero stability. Slight, if not imperceptible hand motion, can cause the outer extremity of the rod to swing 90° until it interferes with the other hand or rod. If it is assumed that the hand moved 0.05 inch in a steady systematic direction and the resultant output (or tip of the rod) swung in a 15 inch arc, the motion amplification is  $15 \div .05$  or 300 to 1.

A comment should also be made regarding the "force" acting on the forked stick. Some people have experienced a turning moment which seemingly "pulls" the stick down with such force that it cannot be restrained. If the dowsing is done with a green willow in the spring or early summer when the sap is flowing freely, the bark may actually be twisted loose from the wood. This feat may be as surprising to the novice dowser who experiences it as it is to bystanders. The principle of the mechanical amplifier still applies, however. When the stick is held, it is flexed by the hands such that forces are applied by the hands at points represented by the arrows shown in Figure 4. If these forces are maintained exactly in a plane represented by the plane of the paper, no turning moment is experienced. If the hands twist slightly out of the plane of the paper, possibly as a result of a subconsciously induced muscle



**Figure 4.** Diagram of forked stick showing points where chief pressure is applied. If this pressure shifts from the plane of the paper a turning moment results.

potential, they give a turning moment or a rotational component to the system. The fingers gripping the stick can restrain rotation to some extent but if the misalignment becomes appreciable the turning moment or torque is much greater than is the restraining torque caused by the grip of the fingers. This is apparent when one considers that the turning moment is proportional to the distance between the arrows on either side (roughly the width of the hand) and the restoring force is proportional to the radius of the stick. Clearly, the former (turning moment) may be much greater than the latter (restoring force).

If a large diameter stick were used, i.e., 2 inches in diameter, the forked stick would fail to rotate downward since the finger grip is much more efficient in restraining rotation than formally and the turning moment associated with the large stick is not as great as it is with the small flexible willow.

The forked stick had limited use in a modified form for experimentation on this project. It consisted of two flexible nylon rods connected at one end and held in the hands similar to that shown in Figure 4. The tendency for it to be sensitive to rotation was enhanced by the small diameter of the nylon material, hence it was hard to grip but responded readily to the misalignment forces causing rotation.

### The geophysical field

A number of natural fields existing in and about the earth are grouped into what can be called the overall geophysical field (Tromp, 1949). These fields are enumerated as follows:

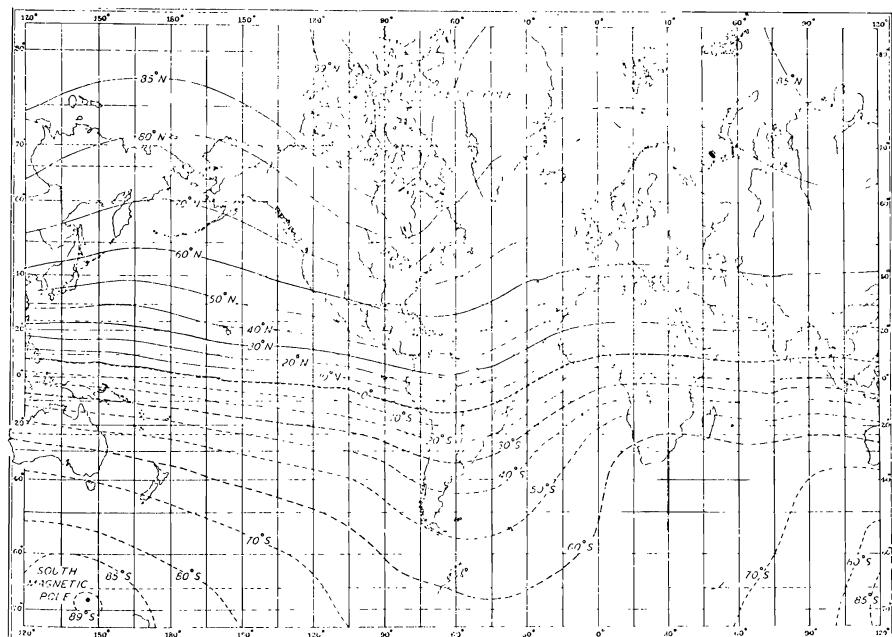
- (a) The gravitational field.
- (b) The magnetic field.
- (c) The electric field.

- (d) The radioactive field.
- (e) The seismic field.
- (f) The geothermal field.
- (g) The geochemical field.

A variation in one or more of the fields may have some detectable effect on man, and it is conceivable that a dowser may react according to one or more of these changing force fields. The magnetic field of the earth's crust as it might affect a dowser was the one selected for study. Budget and time limitations would not permit an indepth study to be made of the effects each field may have on a dowser. The effect of a changing magnetic field was chosen because it is one of the most pronounced fields and it can be readily altered by artificial means. Water can also affect it as later discussed. Further information on the earth's magnetic field and the type of instrument used to measure it is discussed in the following section.

### **Earth's magnetic field**

The ambient magnetic field of the earth existing in the area where dowsing experiments were made is about 50,000 gammas (0.5 gauss).<sup>1</sup> The geomagnetic inclination or the angle at which the field enters the earth is about 65° from the horizontal. The two maps indicating this information are shown in Figures 5 and 6.



**Figure 5. Angle between magnetic field and earth's horizontal plane. (Source: Varian Instrument Handbook.)**

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<sup>1</sup> 1 gamma =  $10^{-5}$  gauss.

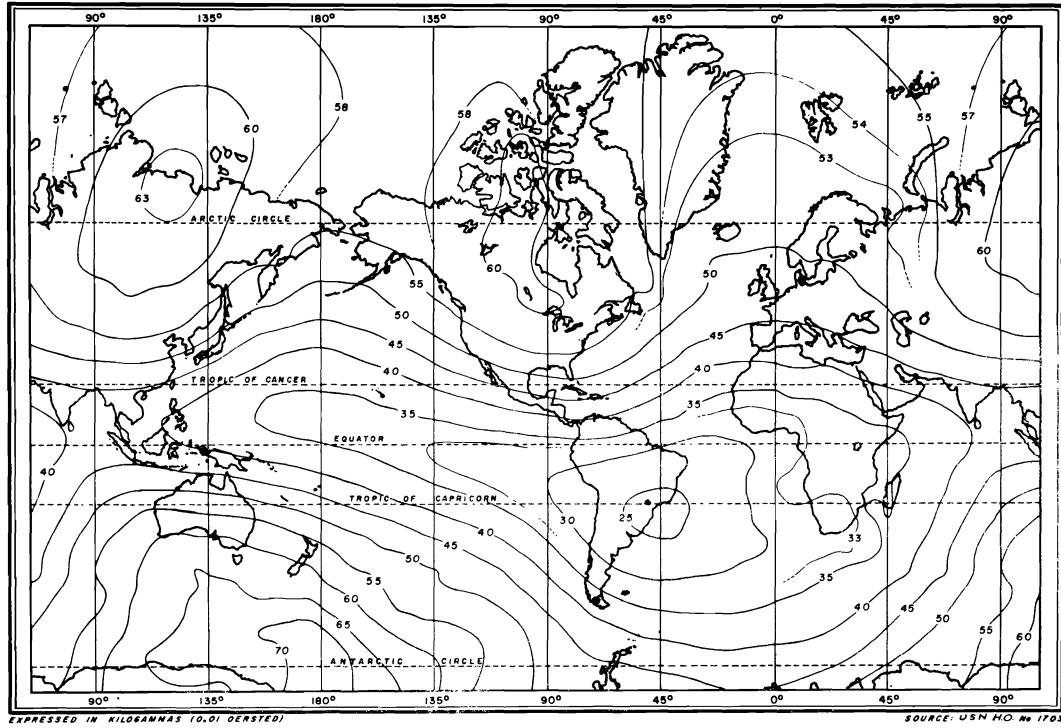


Figure 6. Intensity of earth's magnetic field. Numbers are expressed in kilogammas.

In addition to this ambient field, the magnetic noise level varies approximately sinusoidally a few tenths of a gamma in a period of 10-30 seconds (Figure 7). In addition to this short-term magnetic field fluctuation, there is also a slower fluctuation which may have a period length of hours or days. Excursions of tens of gammas with periods of 5-30 minutes can be expected. Excursions of 100 gammas or up to 1000 gammas may occur in ten minutes during magnetic storms.

### Calculations of Perturbations of Earth's Magnetic Field

Several water related factors can theoretically have an effect on the earth's magnetic field. Knowledge of their contribution to field perturbations is important in order to assess the probability of relating the presence of groundwater to the magnetic variation of the area in question. A definitive treatment of this broad subject is beyond the scope of this project, but a cursory examination can be informative.

Sample calculations were carried out to determine what the magnitude of the magnetic perturbations near the earth's surface would be due to (1) magnetic inhomogeneities, (2) flux-cutting potential, (3) streaming potential, and (4) magnetic susceptibility of water. A plot typical of the earth's field resulting from the various magnetic anomalies is shown in Figure 8.

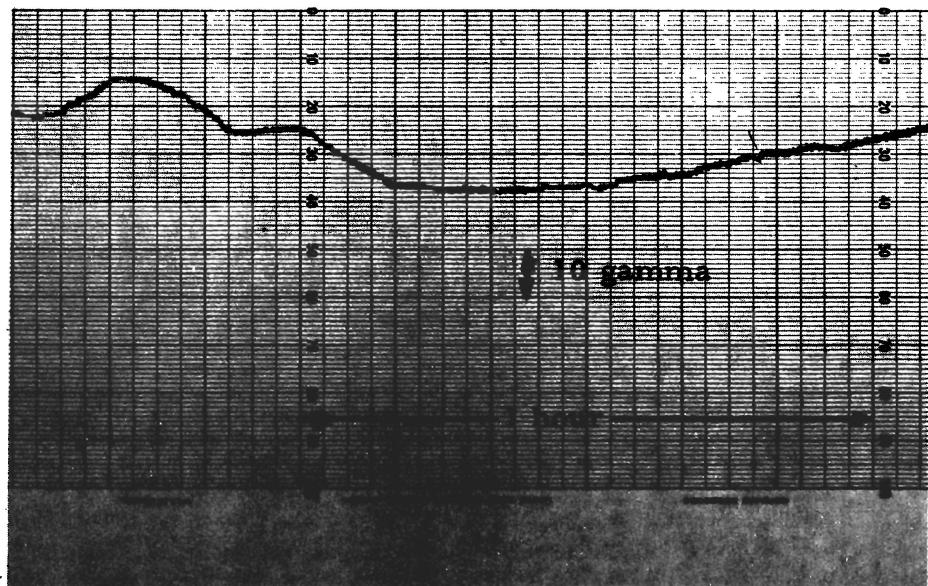
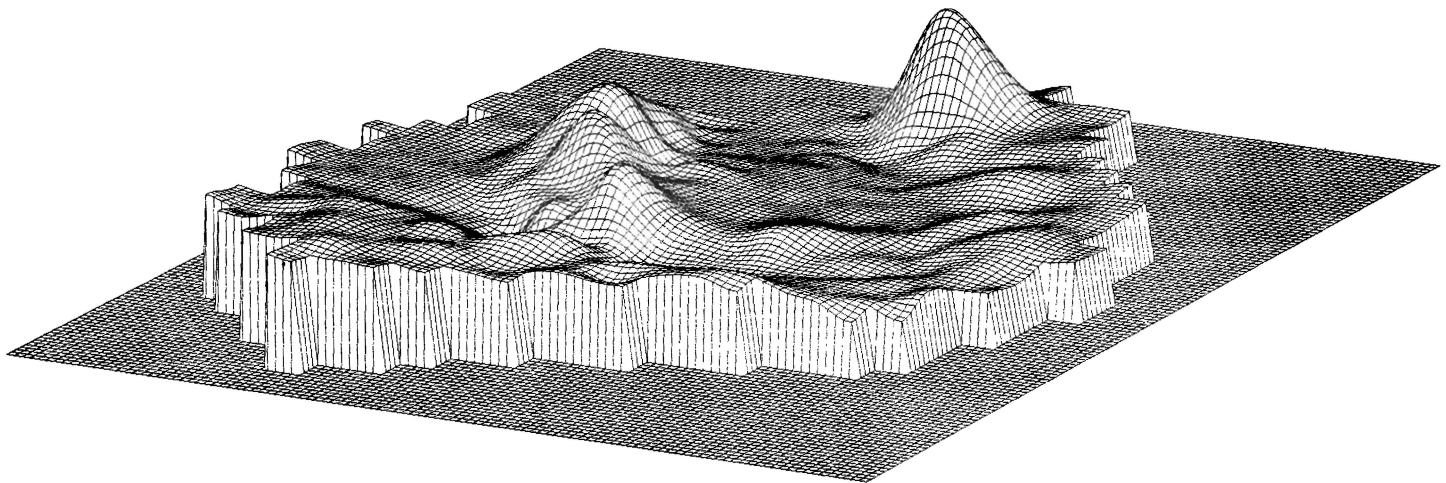


Figure 7. Short term fluctuation in earth's magnetic field at a given point.



**Figure 8.** Perspective presentation of magnetic intensity over a unit area. (Source: GeoMetrics.)

The simplifying geometric shapes used in the analysis are for mathematical convenience and, of course, do not exactly represent the actual condition. They are considered representative enough, however, to give an engineering approximation useful in making judgments in regards to the possible impact this phenomenon may have.

(1) Considering the magnetic field caused by magnetic inhomogeneities: Assume a cylindrical aquifer with a diameter of 1 meter. (See Figure 9). The magnetic perturbation at any distance from the aquifer is given by the following equation derived in Appendix I.

$$B = B_o \left[ 1 - \frac{a^2}{r^2} \left( \frac{\mu_o - \mu}{\mu_o + \mu} \right) \right]$$

in which

$B_o$  = initial field

$a$  = diameter of aquifer

$r$  = distance to point where  $B$  is measured

$\mu_o$  = permeability of aquifer

$\mu$  = permeability of surrounding material

Assume  $B_o = .5$  gauss,  $a = 1$  meter, and  $r = 10$  meters.

The maximum susceptibility for soil is between 1 and  $1\frac{1}{2}$  (Fleming, 1939). Assume that the susceptibility,  $k$ , is 1.

$$\mu = \mu_o + 4\pi k \mu_o = (1 + 4\pi) \mu_o = 13.6 \mu_o$$

$$B = .5 \left[ 1 - \frac{1}{100} \left( \frac{1 - 13.6}{1 + 13.6} \right) \right] = .5 (1 + .00863)$$

$$= .5043 \text{ gauss}$$

$$\Delta B = .5043 - .5 = .0043 \text{ gauss} = 430 \text{ gamma}$$

Although these calculations were for the magnetic field inside the earth the percentage change in the field outside should be of the same order of magnitude. This would apply only to the H-field. The B-field would vary due to the difference in permeability between the air and ground.

$B_o$  was assumed to be 0.5 gauss in the calculations. This value is a typical one for air. Below the surface it would vary widely depending on location, surrounding terrain, etc. A higher initial value, however, would also mean a higher variation due to presence of the aquifer.

(2) Considering the flux-cutting case: For the hydraulic channel, a square aquifer was assumed for convenience of calculations with a width of 1 meter, at a

distance of 10 meters below the surface of the earth. The velocity of the water was assumed to be 1 m/sec which admittedly is much too high but is convenient for computation. Figure 9:

With a transverse magnetic field as shown and direction of water flow into the paper, the resultant current due to flux-cutting is as shown in Figure 10. In order to obtain an approximation to the field produced near the earth's surface assume that the current flows in a channel in the rock surrounding the aquifer and does not spread out as it would if the rock were of uniform conductivity. The width of each channel will be 1/2 meter, since the current will split at top and bottom and flow on both sides of the aquifer. If the length of the channel is assumed small then more current would flow; however, the magnetic effect at a given distance from the current would be reduced due to smaller area of the loop.

Assume the electrical current flow channel to be circular with a diameter of 1 meter.

Assume that the resistivity of the channel is 2000  $\Omega\text{-cm}$ , a typical value for groundwater in the Logan, Utah, area.

Assume that the field is to be calculated at a point directly above one of the current loops.

Assume that the water flows in the aquifer for a distance of 10 meters, 5 on each side of point where the magnetic field strength is desired.

Assume the earth's field to be 0.5 gauss. The magnitude of voltage generated is

$$e = Blv = (5 \times 10^{-5} \text{ webers}) (1 \text{ m}) (1 \text{ m/sec}) \\ = 5 \times 10^{-5} \text{ volts}$$

The nominal resistance of the return path current flow can be calculated as

$$R = \frac{\rho l}{A} = (2500 \Omega\text{-cm}) \left( \frac{1 \text{ m}}{100 \text{ cm}} \right) \left( \frac{2 \text{ m}}{2 \text{ m}^2} \right) = 25 \Omega$$

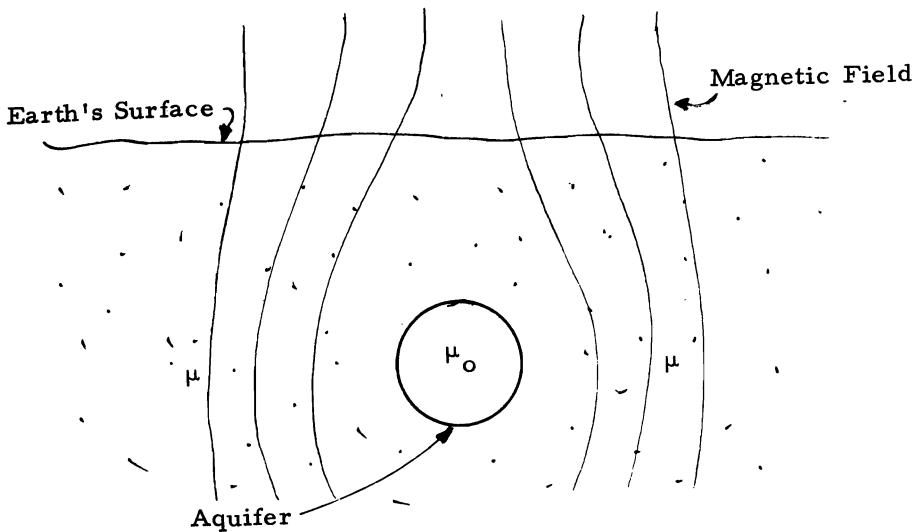
$$I = \frac{5 \times 10^{-5}}{25} = 2 \times 10^{-6} \text{ amps.} \approx 2 \times 10^{-6}$$

The magnetic field produced by the water flowing through the ground is similar in configuration to that of a solenoid. The magnetic field of a solenoid is calculated by the equation (Hollen, 1962):

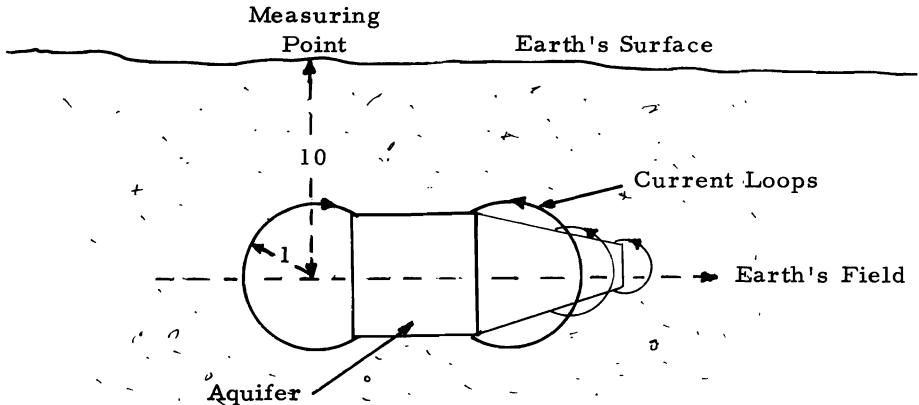
$$B_x = \frac{\mu IN}{1} \left( \frac{\Omega(1) - \Omega(0)}{2\pi} \right)$$

in which

- $B_x$  = horizontal magnetic field
- $I$  = current in solenoid
- $N$  = number of turns
- $\Omega(1)\Omega(0)$  = solid angles of ends of the solenoid as seen by the point where  $B_x$  is desired



**Figure 9.** Magnetic inhomogeneity of an aquifer, where  $\mu_0$  of aquifer is  $< \mu$  of nonwater bearing region.



**Figure 10.** Flux-cutting current and associated field (all dimensions are in meters).

[Note: The signs of the solid angles will be the same if they are on opposite sides of the point of measurement.]

The total current calculated,  $3.98 \times 10^{-6}$  amp., can be used in place of IN in the above formula. Since water flows for equal distances on both sides of the measuring point, there will be no vertical magnetic field produced.

$$\text{Area of the end of the current loop} = \pi (1)^2 = \pi \text{ m}^2$$

To find the solid angle this must be reduced by  $\cos \rho$  where  $\rho$  is the angle between the axis of the current loop and the line to the point of measurement.

$$\text{Distance to measuring pt.} \cong \sqrt{10^2 + 5^2} = 11.2 \text{ m}$$

$$\cos \rho = \frac{5}{11.2} = .446$$

$$\text{Area} = \pi \times .446 = 1.4 \text{ m}^2$$

Since this area is flat and not on a spherical surface, the solid angle is not exactly this value divided by  $r^2$ ; however, it is reasonably close.

$$\text{solid angle} = \frac{1.4}{(11.2)^2} = 1.12 \times 10^{-2} \text{ steradians}$$

$$B_x = \frac{(4\pi \times 10^{-7})(1.99 \times 10^{-6})(2)(1.12 \times 10^{-2})}{4\pi (10 \text{ m})} \\ = 4.46 \times 10^{-16} \text{ w/m}^2 = 4.46 \times 10^{-12} \text{ gauss}$$

This is the field for one current loop. To find the field produced by the other, similar calculations must be carried out.

$$\text{Distance between loop centers} = 1 + 1 + 0.5 = 2.5 \text{ m}$$

$$\text{Distance to measuring point} = \sqrt{10^2 + 5^2 + 2.5^2} \approx \sqrt{131} = 11.45$$

$$\cos \pi = \frac{5}{11.45} = 0.436$$

$$\text{Area} = \pi \times .436 = 1.37 \text{ m}^2$$

$$\text{solid angle} = \frac{1.37}{(11.45)^2} = 1.045 \times 10^{-2} \text{ steradians}$$

$$B_x = \frac{(4\pi \times 10^{-7})(1.99 \times 10^{-6})(2)(1.045 \times 10^{-2})}{4\pi (10 \text{ m})}$$

$$= 4.16 \times 10^{-12} \text{ gauss}$$

The net field will be the difference between the fields produced by the two loops since they are in opposing directions.

$$B = (4.46 - 4.16) \times 10^{-12} \text{ gauss} = 3 \times 10^{-13} \text{ gauss}$$

$$= 3 \times 10^{-8} \text{ gamma}$$

This field is extremely small and should be considered as being so much smaller than other field perturbations its effect would be completely masked and, therefore, undetectable.

(3) Consideration is next given to the streaming potential. This is a potential occurring due to a stripping of charges from the water molecule as the water passes over a stationary surface. In a laboratory experiment using a cylindrical duct containing sand with an area of  $61.48 \text{ cm}^2$ , and for water flowing through it at  $10 \text{ cm}^3/\text{sec}$ , the streaming current is approximately  $300 \times 10^{-9} \text{ amp}$ .

From a graph by Abaza (1966) the current is shown to be approximately proportional to the rate of flow. For an aquifer with greater area the current should be proportional to the area.

Assume a cylindrical aquifer (B) with area of  $1 \text{ m}^2$  located 10 meters below the surface of the earth, Figure 11.

Assume also that part of the return current flows back through an aquifer (A) somewhat removed from the region generating the source current. Assuming the conductivities of these two aquifers (A) and (B) are of the same order of magnitude, half the electric current flows through each.

Assume that the velocity of the water is  $0.01 \text{ m/sec}$ . The magnetic field perturbation can be found as follows: From the previous experimental data the flow velocity  $v$  was,

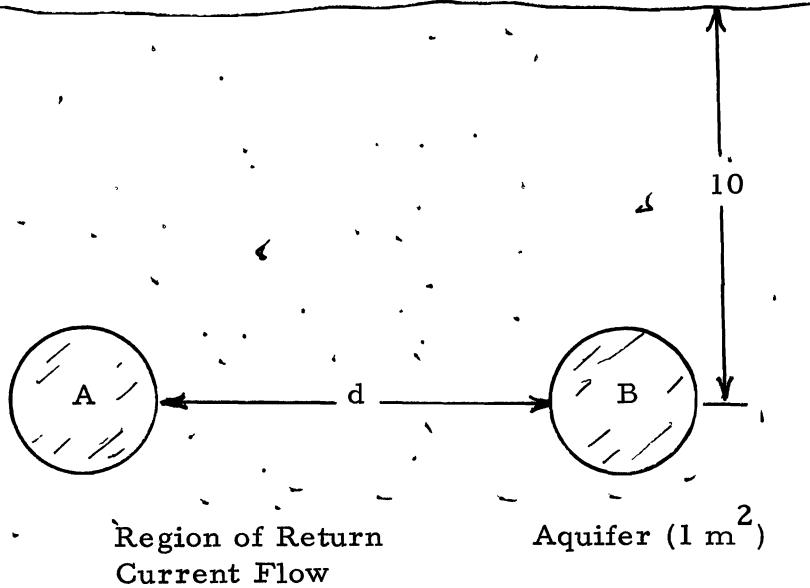
$$v = (10 \text{ cm}^3/\text{sec}) / (61.48 \text{ cm}^2) = 0.1625 \text{ cm/sec}$$

$$= 1.625 \times 10^{-3} \text{ m/sec}$$

The streaming current can now be calculated.

$$A = 1 \text{ m}^2 = 10^4 \text{ cm}^2$$

## Earth's Surface



**Figure 11. Streaming current (d is considered as a large distance, i.e. 100 meters).**

$$I_s = 300 \times 10^{-7} \times \frac{0.01 \text{ m/sec}}{1.625 \times 10^{-3} \text{ m/sec}} \times \frac{10^4 \text{ cm}^2}{61.48 \text{ cm}^2}$$

$$= 0.30 \text{ ma}$$

Since one-half of the current is assumed to return through the aquifer where it was generated, the effective current is reduced to 0.15 ma.

$$B = \frac{\mu I}{2\pi R} = \frac{(4\pi \times 10^{-7})(1.5 \times 10^{-4})}{2\pi(10)}$$

$$= 3 \times 10^{-12} \text{ webers/square meter} = 0.003 \text{ gamma}$$

The field, computed by the above equation, is larger than that produced by the flux-cutting potential but it is still very small. If a larger more realistic cross section of aquifer is present the resulting magnetic field might be measurable.

(4) The fourth factor considered concerns the magnetic susceptibility of water which is slightly less than 1 (0.999987). Since water displaces earth materials which have magnetic susceptibilities considerably greater than 1, the effect of the susceptibility of water is masked by the larger effect resulting from corresponding perturbations in soil-rock density. Consequently, this term is assumed to be undetectable.

The largest water related perturbation on the earth's magnetic field was produced by the difference in permeability between the aquifer and surrounding nonaquifer material. The effects produced by the flux-cutting potential and magnetic susceptibility were so small as to be practically negligible, while the effect produced by the streaming potential, although small, may be measured by modern instruments.

### Preliminary Dowsing Test Considerations

A characteristic of human nature is for one to do the best that he possibly can when required to perform in front of others or in competition with them. As a result, considerable caution must be exercised when conducting any type of dowsing test. The slightest hint may give the person under test all of the knowledge required to make the correct choice. The hint need not be apparent. The subconscious may quickly associate the small hints with the correct response. Several good examples of this fact are illustrated by Vogt and Hyman (1959).

Since no known "how-to-do-it" book on dowsing tests existed, a learning process of experimentation and measurements prevailed while capabilities and limitations of the magnetometer and of the dowsers were explored. Numerous preliminary tests of various kinds were made at several locations. As experience was gained in conducting the tests, it became apparent that it was desirable to modify the nature of the test somewhat. For example, the length of the first dowsing course extended one-half mile through a field. Dowsing reactions were recorded to the nearest fence post. Later the test bed length was reduced to a few hundred feet and the dowsing reaction was recorded to the nearest one-half foot. The reason for this change was a practical matter. There was difficulty in obtaining an unobstructed half-mile area all segments of which are equally free from "suggestive" inclines, declines, green spots, trees, fences, people, etc. One test area was a harvested wheat field but the subsequent plowing operation rendering it impractical to use on a continuing basis.

During the investigation, some variations in instructions were occasionally made pertaining to the dowsing procedures. There were no noticeable dowsing improvements observed while operating under various sets of instructions. There were no rigorous evaluations made in this regard. Several times a change in test results seemed to occur when a person was asked to try a new dowsing technique. Perhaps such results are to be expected. An individual usually favors those things which are familiar to him. When asked to try something new, the person may feel unnatural and his performance may reflect that fact. This is particularly true in the subjective type of test that exists in the instance of the dowsing phenomena.

From the initiation of the project, no thought was entertained regarding the drilling of wells to prove or disprove dowsing. To get conclusive results could be extremely expensive. There have been tens of thousands of wells dowsed and a still greater number of useful wells drilled that were not dowsed. The percentage of well failures of those dowsed, versus those not dowsed is not known. If the number were known and it were favorable to dowsing, this is not to imply that dowsing per se is the reason for the improved percentage unless one accepts the premise that the conscious or subconscious geologic expertise that a dowser may have acquired through successes and failures is part of the dowsing "package." In view of this, and also the expense factor of drilling wells, a decision was made to conduct simple

statistical dowsing tests in an effort to obtain large quantities of data without much cost. The main idea behind the statistical test was to see to what extent different people tended to get the same dowsing reactions. The presumption was that if people did tend to get the reactions at the same place it would demonstrate the desirability to conduct further research. If the dowsing reactions were shown to be random in nature, or in other words "noise," then there is not as cogent a reason to further pursue dowsing tests.

The preliminary observation can be made that if a dowser is sensitive to small magnetic gradient changes caused by the presence of an aquifer, so might he be sensitive to random extraterrestrial magnetic influx which may be unrelated to the geographical location of water.<sup>1</sup> Assuming that the dowser is sensitive to the small magnetic field perturbations regardless of the emanating source, reactions would be experienced in a random manner as influenced by extraterrestrial magnetic noise, and at systematic locations as determined by fixed perturbations in the earth's crust. At a given time, perturbations appearing in the earth's field may be canceled by perturbations of opposite polarity emanating from extraterrestrial sources. This fact can tend to submerge the steady state data so that the data may be hard to recognize.

If dowsing reactions from various individuals do have correlation it is important to have means of measuring quantitatively the degree that correlation exists. Upon consultation with an applied statistician a method was chosen in which this could be expressed. A discussion of the statistical technique used follows.

### **Chi-square representation of test significance**

Some practical method must be used to evaluate the dowsing response. The method chosen was a chi-square statistical significance criteria which can indicate if dowsing test results are deterministic, and, if so, approximately to what degree.

A literature review on the subject of dowsing shows almost a universally "yes it works," or "no it doesn't" type approach. Very little statistical "meat" is made available to study possible gray areas which may have useful information.

For completeness of this report, data are plotted and other information is presented so that the apparent significance of each test can be seen. There is included a chi-square numerical quantity with each test summary. The statistical results are determined by the application of a computer program developed for the convenience and speed of analysis (Sokal and James, 1969). An example of the statistical calculation is shown in Appendix II.

Several facets to the chi-square criterion and its adaptability to dowsing tests should be mentioned. First, the criterion is based on the assumption that the variate, number of dowsing reactions, follows some particular distribution. The hypothesis proposes that the probability of obtaining a dowsing reaction is the same within each specific incremental distance, or "window," at all locations within the test area. The validity of this hypothesis can possibly be negated by such things as the physical

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<sup>1</sup>Unfortunately this fact was not recognized until late in the project, the possible effects of the extraterrestrial magnetic perturbations is, as yet, unknown.

characteristics of the test area or by giving the individuals under test the slightest hint about where to expect a reaction. To prevent such occurrences, the test areas were carefully selected to be free from visible indications of possible reaction locations. The start and end points for the actual test areas were not indicated to the participants, and neither the expected nor achieved results were discussed with the individuals before they participated.

Before the actual dowsing tests were evaluated via the chi-square test, verification that the digital computer program was giving creditable results was needed. Several sets of data were collected which supposedly were random. The random data were then used to verify the chi-square computer program. The "random" data, consisted of pencil dots placed by various individuals along a fold in a sheet of 8½" x 11" white paper. One sheet of paper was used for each person participating in the test. No hint was given as to how many dots should be placed or that they should be placed in any particular order or lack of order. None of this group had dowsed before.

After the pencil dot data were collected they were arbitrarily put into three groups. Each group of data was then subjected to the chi-square test. Subsequently, all of the data were combined into one set of data and again tested for randomness.

In each of the tests the calculated value for chi-square indicated that the data were quite random, giving chi-square values around the 0.5 value. A sample of the results is illustrated in Table 1. An explanation for the need for successive iterations as illustrated in the table is fully explained in the next section dealing with window sizes. For the present it is sufficient to recognize that the maximum value calculated for chi-square for any of the iterations is 14.59 which is close to the 50 percent probability level of 14.34. This illustrates that the computer program is functioning and that the test data are quite random as anticipated.

### Window size determination

Application of the chi-square criterion requires that the number of dowsing reactions found in an incremental path length or "window" be compared against reactions found in each of the other "windows" located in tandem along the course.

**Table 1. Chi-square test results for a random pencil dot test made along a fold in a white sheet of 8½" x 11" paper.**

Iteration No.	Degrees of Freedom(D.F.)	Chi-square	Chi-square for p = 0.5
1	14	13.31	13.34
2	15	12.98	14.34
3	15	10.84	14.34
4	15	14.59	14.34
5	14	11.51	13.34
6	15	8.34	14.34

(These windows only exist as dowsing path segments which are delineated mathematically and are not anything visible or physical.) The chi-square criterion can indicate if there is a random grouping pattern of data within the windows that can logically be attributed to chance. The problem arises regarding how large these windows should be to maximize the effectiveness of the test.

The location of the dowsing reactions were measured and recorded to the nearest one-half foot. Therefore, window sizes smaller than this could not logically be justified. In determining an upper limit, the following reasoning prevails. The dowser walks over the course and in effect advances his position digitally with each step taken. The step length of the dowser varies but it will generally be from two to three feet long. A simplifying assumption is also made that once a dowsing reaction is recognized by the participant, his stopping distance is typical of others who are taking a similar test. This may be an oversimplification, but no data were taken to permit a more sophisticated approach. Based on this line of reasoning, the window size might logically be set at approximately three feet. If the windows were much longer than this, there may be a tendency to lump nondowsing zones with dowsing zones. This is undesirable since in the statistical evaluation, the windows having no response are also statistically significant. This significance of "no reaction" can be readily visualized if one considers a thousand ink dots scattered seemingly at random over a piece of paper except for one well defined square which has none. Such a phenomenon is not likely to occur and, therefore, has significance.

One of the major difficulties in grouping independent dowsing reactions by use of discrete windows may arise due to the variation in the sensitivity of the participants. Some were noted to get many reactions; some a few. The presumption is that one dowser is more "sensitive" than another. If this is the case, one may obtain a reaction from the same stimulus at a more distant point from the source than does another. Also some people were noted to walk faster than others, take less notice of what they were doing, etc. Admittedly, these perturbations in response might cause a great deal of scatter in the data. Supposedly though, if enough people were tested their characteristics would tend to center around some norm which still leaves things statistically manageable.

One other problem regarding the use of windows should also be discussed. The windows of fixed sizes placed mathematically adjacent to each other along the dowsing course are periodic in longitudinal distance. Dowsing reactions, if they are a result of some geophysical phenomena, would probably be aperiodic in longitudinal distance. The result is that since windows are periodic they are not optimally positioned for all data. Some of the window boundaries may cut through the grouping of data thus reducing its intensity at some given location. The end result is a bias in the statistical result which will tend to give pessimistic answers. In order to help evaluate and also minimize this effect, statistical evaluations were made starting at different zero points to give different window boundary locations. Thus the statistical values were calculated for a given set of window locations, then all windows were shifted one-half foot down the course and the evaluation was repeated. Six such operations were carried out for a 3-foot window. Such a procedure does not eliminate the problem, but does help to get the best results under the adapted procedure. Results of this technique are tabulated in the section discussing test results.

## Determining the locations of dowsing reactions

Determining just when a dowsing reaction occurs is somewhat arbitrary. As indicated in the previous section, some dowsers walked very slowly; others quite fast. Variations in speed would be judged to range from 1/2 mph to 3 mph. The inertia of the rods, however, would be nearly a constant. Thus, once a dowsing reaction is initiated more ground can be covered by a fast walker than by one who walks slowly. No effort was made, however, to categorize data as a function of speed of walking. One other item regards the "location" of the reaction. In order to keep procedural instructions to a minimum, the comment was made that if a dowsing reaction occurred they were to stop, drop a wooden block as a marker, readjust the rods to the normal position, and then proceed. Most dowsers were observed to drop the block in front of them from hand height. There was a tendency for the block of wood to bounce, occasionally as much as a foot. Others were observed to place the block by their side instead of in front of them. The result of this procedure was effective in that it did not create confusion but neither was it very precise.

The effect of approaching a dowsing location from different directions is not known. If one gets a dowsing reaction walking in one direction then tests for it while walking in the opposite direction, his second reaction may be influenced by his knowledge of the location of his first reaction. Consequently, each test conducted was dowsed in one direction only.

There is another problem in determining locations of the dowsing reactions. This constitutes an element of judgment regarding whether or not a reaction occurred. The element of subjectivity is quite evident in dealing with "gray" areas. No clear cut solution to this is submitted at this time. It is recognized as a problem deserving further consideration, however, if one is to minimize the "noise" level.

## Dowsing Tests

A discussion of the specific procedure and results for a particular test are presented in the appropriate subsections that follow. However, several general comments concerning the tests are presented here to eliminate repetition.

Most of the participants used the "L" shaped rods shown in Figure 1. The rods were formed from ordinary wire clothes hangers. They were about 26 inches overall length. The wire was first straightened and then an 8 inch length was bent at right angles at one end. The participants were instructed to loosely hold the rods parallel to each other, chest high, and to hold the horizontal element at a slight declination. This declination serves to lower the overall center of gravity of the device and to give the rods a slight positive stability. Participants were also instructed to keep their arms and muscles relaxed and to think of some trivial subject while walking. If they noticed the rods either swinging in, i.e., crossing each other, or diverging, they were to stop. At each such location they were to place a block of wood. After they had "dowsed" the course, walking alone, and in one direction only, they were excused from dowsing and those conducting the experiment measured and recorded the location of each spot that a wooden block was found. The blocks were, of course, removed prior to the next dowsing test.

The majority of the participants had no previous dowsing experience. They were shown how to hold the rods and told what to expect when they obtained a reaction. Many of them did practice briefly by walking over a length of iron wire lying on the ground in plain view. The suggestion was made that the wire lying on the ground should cause a reaction; generally speaking it did.

In the tests conducted, the various participants did not watch each other during the tests. In all cases, only one person was on the course at a time, and there was no discussion about the test between participating individuals until the specific test was completed. At the time of this writing none of the individuals participating have been apprised of their relative performance.

### Dowsing tests in apple orchard

*Test No. 1.* The first official test area selected was an apple orchard located on University property about one-half mile from the Utah Water Research Laboratory. The area was selected because of its seclusion, close proximity to the laboratory, and because it provided several independent test courses, each over 400 feet long. A layout of the area is given in Figure 12. The test courses were selected between the various rows of trees as indicated in the area layout.

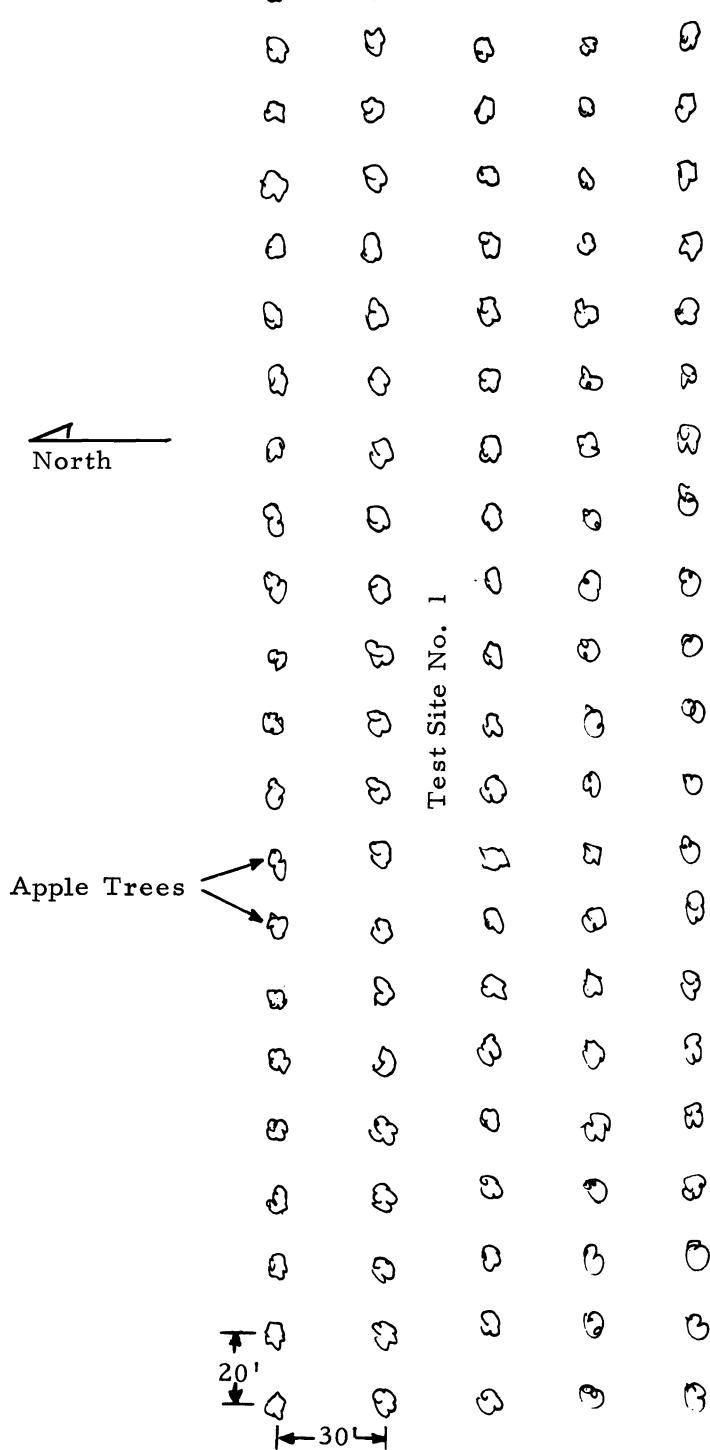
A small diameter iron rod was driven in the ground about one-half foot below the ground surface; this was done without disturbing the vegetation. The rod was located at tree number 14 in test course number two. The people participating did not know of the existence of the rod in the test area. The area was covered with vegetation and this made it impossible to see any sign of the rod, even upon careful scrutiny.

Twelve people participated in the first dowsing experiment conducted in the orchard. They walked from west to east between rows two and three. Nine of the 12 people were novices at dowsing; the other three did not claim they were dowsers but had at least tried it beforehand.

The results of this first experiment are illustrated in Figure 13. Also shown in this figure is a plot of the magnetic field, as measured on a magnetometer. At the time this test was made, the importance of making accurate measurements of the location of the reaction was not fully recognized. As a result, measurements were rounded off to the nearest 3 feet. Later a 3-foot resolution was determined to be inadequate and subsequent tests were conducted where reactions were recorded to the nearest one-half foot.

The necessity to also greatly reduce the window size from that originally planned, viz. one rod in width, was illustrated when wide windows demonstrated a tendency to average a number of possibly unique reactions into a nonunique situation. Consequently, since data of Figure 13 were not measured by the uniform criteria later adopted, no further analysis was made of this particular set of data.

*Test No. 2.* The second test was similar to the first, except the number of dowsers participating was 17 and measurements were made to the nearest one-half foot. These 17 people were a different group of people than the original 12 in test No. 1. All made a single west-to-east walk. Most had never dowsed before. All 17



**Figure 12.** Orchard test area, test site No. 1.

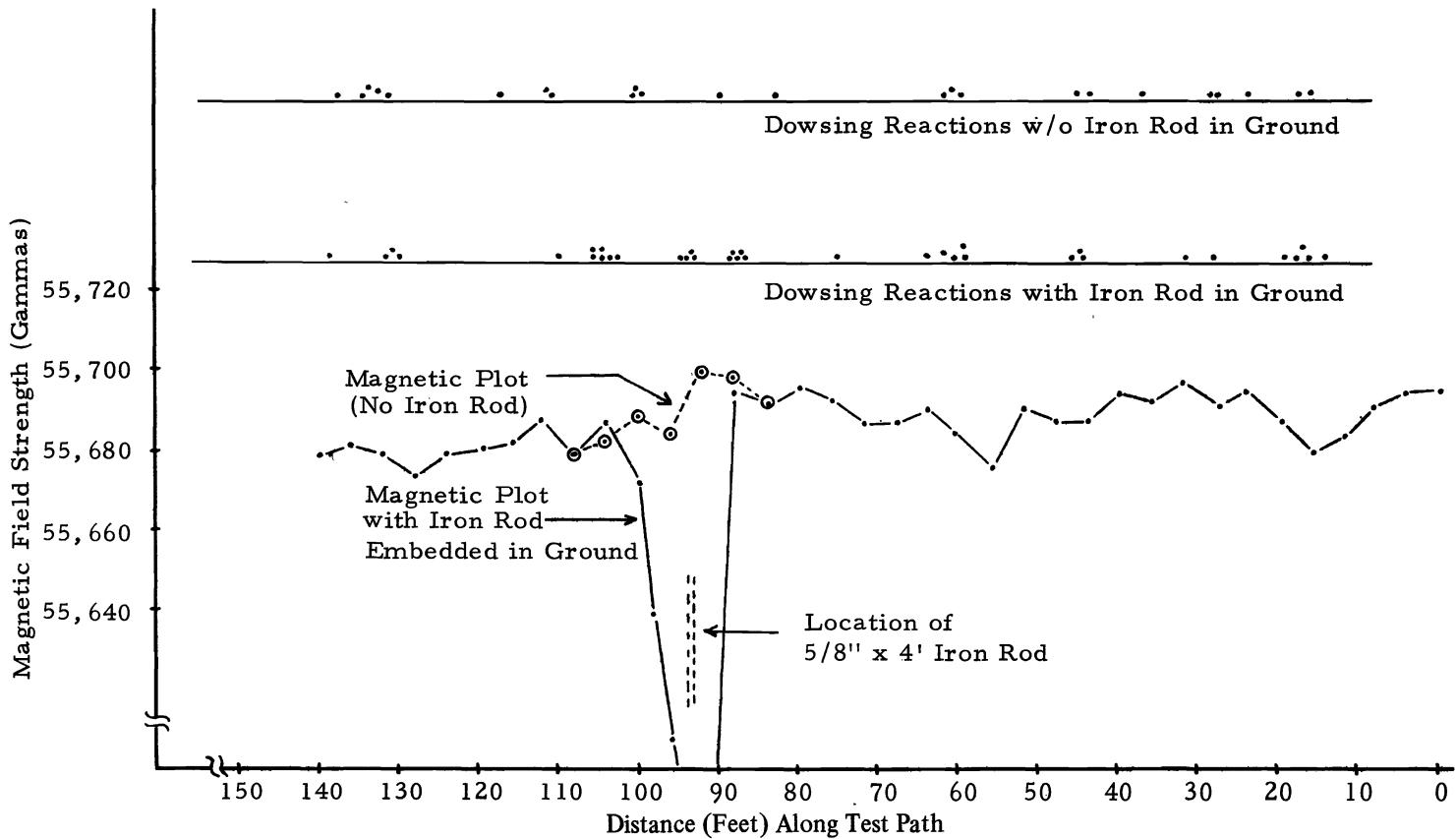


Figure 13. Change in dowsing reactions and magnetic field with addition of rod.

experienced dowsing reactions; the highest number of reactions per dowser was 34 and the lowest was 4.

A plot of the results is shown in Figure 14. The reactions of each participant are depicted by dots on the graph. The position of each reaction was recorded and the data submitted to the chi-square program to determine the significance level, if any, of the test.

The results of the test are presented in Table 2. The columns of numbers are explained as follows:

“Iteration,” column 1, numbers represent the different window locations used. Each succeeding row of numbers indicates that all window boundaries are shifted to the right 6 inches from their previous position.

**Table 2. Chi-square test results for dowsing data taken at orchard test site No. 1. Results are tabulated for three different window sizes: 3.0 feet, 3.5 feet, and 4.0 feet. The windows are incremented by 0.5 foot, course length 400 feet.**

Iteration	D.F.	Chi-square	3.0 foot windows	0.50	0.05	0.01	0.0005
1	8	20.97		7.34	15.51	20.09	27.84
2	7	7.20		6.35	14.07	18.48	26.04
3	8	26.60		7.34	15.51	20.09	27.84
4	8	12.78		7.34	15.51	20.09	27.84
5	9	29.18		8.34	16.92	21.67	29.70
6	9	27.38		8.34	16.92	21.67	29.70
3.5 foot windows							
1	9	26.83		8.34	16.92	21.67	
2	9	10.01		8.34	16.92	21.67	
3	10	31.07		9.34	18.31	23.21	
4	8	16.92		7.34	15.51	20.09	
5	8	18.42		7.34	15.51	20.09	
6	8	31.92		7.34	15.51	20.09	
7	8	23.11		7.34	15.51	20.09	
4.0 foot windows							
1	10	27.58		9.34	18.31	23.21	
2	10	58.13		9.34	18.31	23.21	
3	9	13.75		8.34	16.92	21.67	
4	8	8.98		7.34	15.51	20.09	
5	8	15.37		7.34	15.51	20.09	
6	8	6.74		7.34	15.51	20.09	
7	9	13.69		8.34	16.92	21.67	
8	9	12.62		8.34	16.92	21.67	

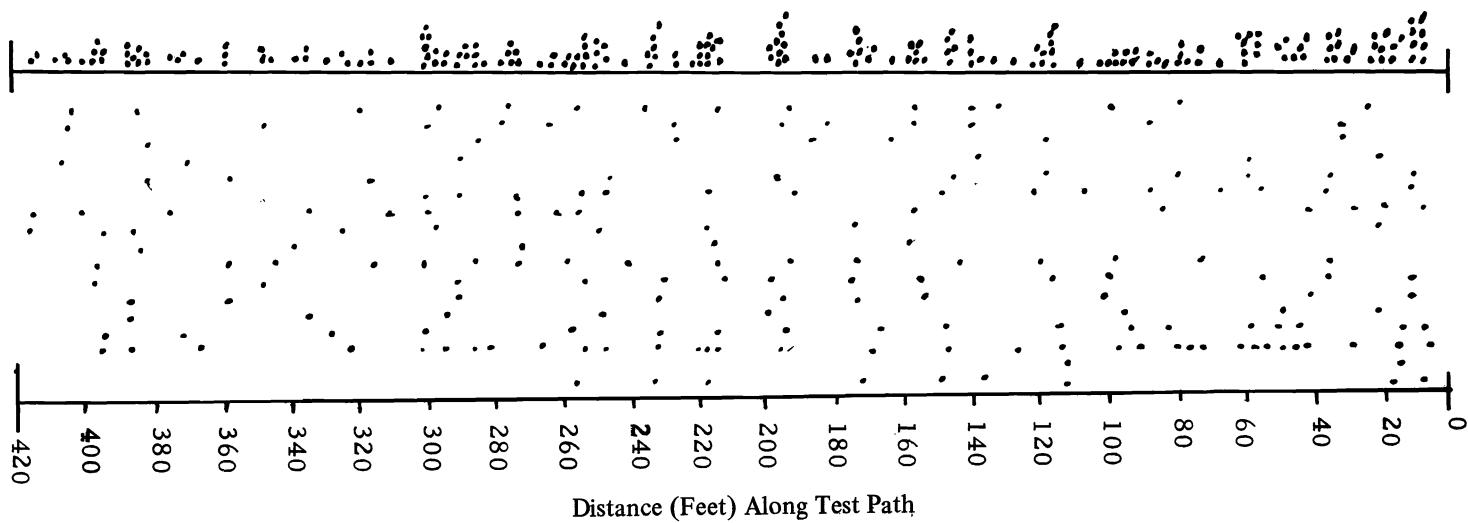


Figure 14. Dowsing reactions for orchard test site No. 1. Data are plotted twice, once to illustrate grouping and the second time it is spread vertically so that individual reactions from various participants can be identified.

"D.F." or degrees of freedom is the maximum number of data points, less one, which falls in any window.

Chi-square is a computed number obtained for the data analyzed. The succeeding columns represent the corresponding values of chi-square for significance levels at the 50, 5, 1, and 0.05 percent level. Thus for Iteration No. 1 the chi-square value of 20.97 is a slightly larger value than that for the 1 percent figure. This implies that there is slightly less than one chance in one hundred that random data would be this well ordered.

The chi-square value for Iteration No. 2 is close to the 0.50 or 50 percent level. The reason that variations occur in chi-square, as a function of window position, is discussed under the section "Window Size Determination." From the reasoning presented in that section, one can see that there is justification to select the highest value for chi-square and even then it may give a pessimistic answer since ideally the window should be aperiodic in position since dowsing responses are aperiodic. If this reasoning prevails, then the highest value of chi-square obtained can be considered as closest to the right answer. In this instance chi-square being 29.18, a statistical significance of nearly 0.0005 is obtained, meaning that once in 2000 times would random data be so well ordered.

Also in Table 2, other window sizes are used and corresponding values of chi-square computed. These initial results appear sufficiently positive to suggest some "intelligence" is present in the data. Because of the seemingly positive nature of these results, some intuitive reasoning was employed to find out what physical features may exist that might give subtle or subconscious suggestions to the dowser. What earlier should have been obvious became apparent. The systematic placement of the trees along the path were suspected of being an influence in giving systematic dowsing data. Subsequently, a test was contrived to help determine if tree placement had anything to do with dowsing reactions. A discussion of this test follows.

### **Dowsing test in orchard without dowsing rods**

A group that had not previously participated in tests at the orchard location was asked to walk along the test site and drop a small wooden block "whenever you feel like it." Each of the participants were given 30 blocks, which was the same number given to the dowsing group. The number of blocks dropped by the last group was about equal to the number dropped by the group using dowsing rods. The total number of people tested was 17, also numerically equal to the number of participants in the previous test.

Each individual was tested without any knowledge of the results obtained by other participants of his group or of the efforts of the first group. The exact nature of the test was not disclosed to the participants. They were instructed not to worry about the number of blocks deposited and to refrain from attempting to guess where the blocks "should" be placed. The effort was to keep the participants completely relaxed and to prevent the apprehension normally associated with a test. Since most of the participants had no dowsing experience, this technique was considered an approach to the attainment of unbiased data. Had they been instructed to place a block down only when and where they received some kind of a dowsing reaction,

participants may have traversed the entire course length without dropping a single block. They could be confused in their effort to determine just what a dowsing reaction was like and to know where to mark its location.

A plot of the results for the random block drop test is shown in Figure 15. The chi-square program was used to analyze the data. The computer outputs for a 3½ foot window are given in Table 3 along with the standard values for probabilities of 0.50 and 0.05. Note that without the use of dowsing rods, the participants placed the markers somewhat more consistently than would be expected for a random pattern, i.e., 10 percent level instead of the 50 percent level, but they did not have as high a statistical significance as did the first test which used dowsing rods.

There is still, of course, the question, was the apparent significance of the chi-square values in either case attributable to the periodic spacing of the trees on either side of the course.

Careful examination of the test results and comparison of the data with a plot of the area failed to identify any recognizable correlation between the data and the tree locations. However, to dispel questions as to the objectivity of the study and to ascertain any possible effect of the trees on dowsing results, the tests were repeated at other locations. A discussion of these tests and the results obtained are presented in the following sections.

#### Dowsing tests at trailer area

The trailer test area, test site No. 2, was located immediately to the west of the orchard test courses. A plot of the area layout is shown in Figure 16. The site was a flat area, covered with a low lying grass-weed mixture void of trees. A specific path was designated for the testing and carefully marked to facilitate the task of relocating it for the various tests that were conducted over the period of three months. The test course was the shortest one used, being only 62 feet long and extended in a south to north orientation.

A single iron rod was driven about six inches below the ground surface and directly across the path at a location 26 feet from the south end of the course. There

**Table 3. Chi-square test results for random block-drop data taken at orchard test site No. 1 using 3.5 foot window. Windows are incremented by 0.5 foot, course length 400 feet.**

Iteration	D.F.	Chi-square	0.50	0.20	0.05
1	8	11.04	7.34	11.20	15.51
2	9	13.49	8.34	12.42	16.92
3	8	9.94	7.34	11.20	15.51
4	8	11.18	7.34	11.20	15.51
5	9	13.34	8.34	12.42	16.92
6	9	4.19	8.34	12.42	16.92
7	8	7.25	7.34	11.20	15.51

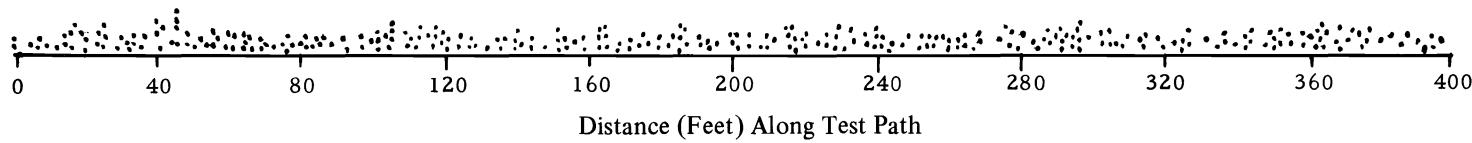


Figure 15. Plot of responses from random block drop experiment in apple orchard; statistical significance is low.

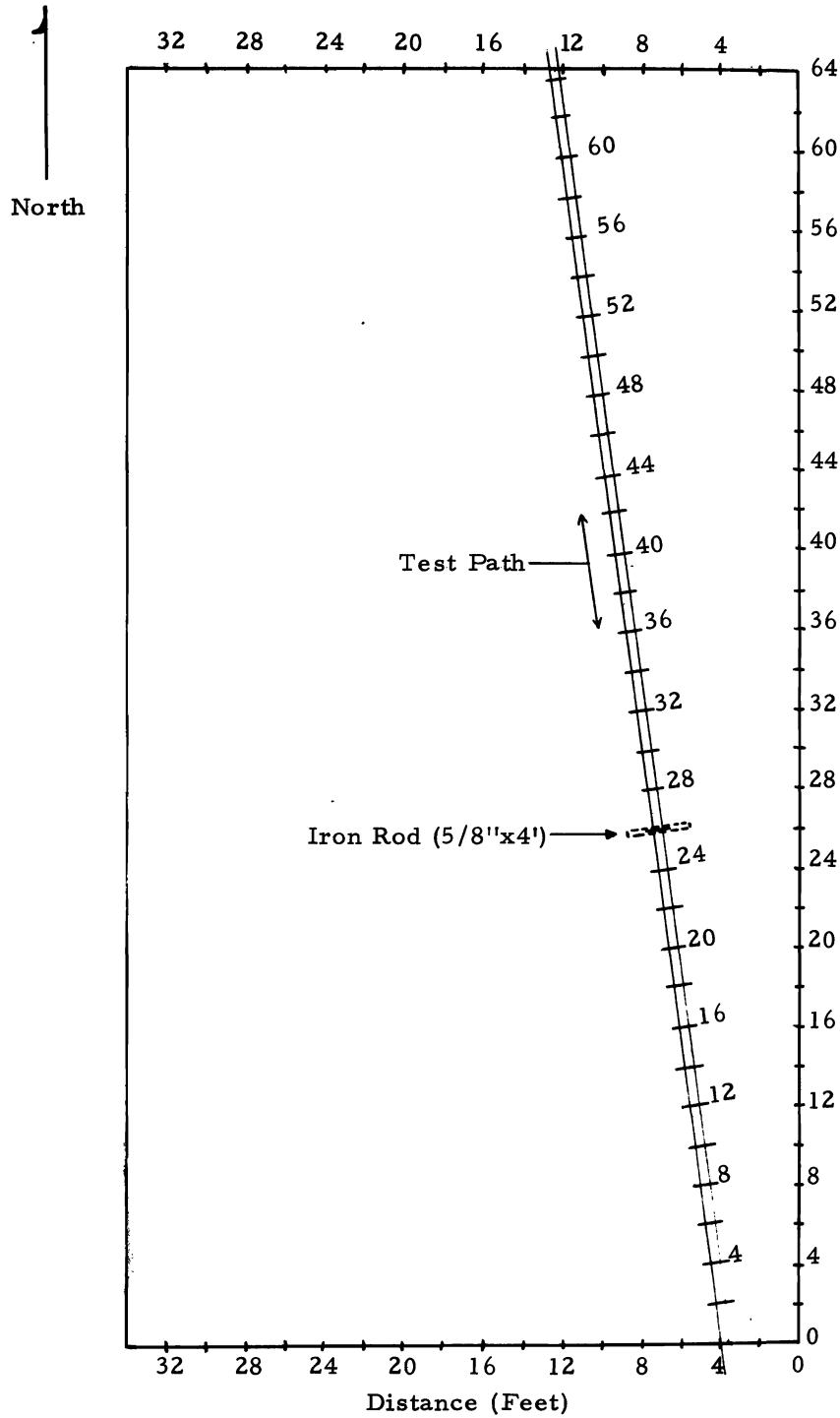


Figure 16. Trailer test area, test site No. 2.

was absolutely no visible indication of the rod's presence and the participants were not informed about its placement in the course.

Twenty individuals participated in the tests. Approximately one-half of them had some previous experience principally on earlier tests, and the others made the test for the first time. Each person participated in only one test, which consisted of dowsing once in a south to north direction only. The location of dowsing reactions was marked in the manner discussed earlier.

A total of 74 reactions were obtained and clustered into seven different groupings as shown by a data plot in Figure 17. The number of reactions acquired per individual varied from one to ten. Each of two participants obtained only a single reaction, one at 25 feet and the other at 26 feet, respectively. The first individual had participated in previous dowsing tests and the second person was making his first attempt at dowsing.

The test results were subjected to the chi-square program for analysis. The computer outputs for both 3 and 3½ foot window sizes are given in Table 4. The window position was incremented again by one-half foot intervals. The standard values for probabilities of 0.50, 0.01, and 0.0005 are also given for comparison with the calculated values. The high values of chi-square obtained here were much higher than they were for the orchard test. This tends to discount positive effects that the trees may have had on the dowsers. The very high chi-square values obtained were rather surprising and a decision was made to run tests at other locations for further evaluation.

**Table 4. Chi-square test results data taken at trailer area test site No. 2, with 3.0 foot windows are incremented 0.5 foot, course length 60 feet.**

Iteration	D.F.	Chi-square	0.5	0.01	0.0005
1	13	139.42	12.34	27.69	36.53
2	13	137.93	12.34	27.69	36.53
3	16	3,162.99	15.39	32.00	41.28
4	18	58,980.44	17.39	34.81	44.46
5	14	222.54	13.40	29.14	38.08
6	12	49.60	12.34	26.22	34.80
3.5 foot windows					
1	16	775.32	15.34	32.00	41.28
2	18	10,596.80	17.34	34.81	44.46
3	19	43,462.79	18.34	36.19	45.98
4	14	109.13	13.34	29.14	38.08
5	12	49.93	12.34	26.22	34.80
6	14	83.20	13.34	29.14	38.08
7	14	122.62	13.34	29.14	38.08

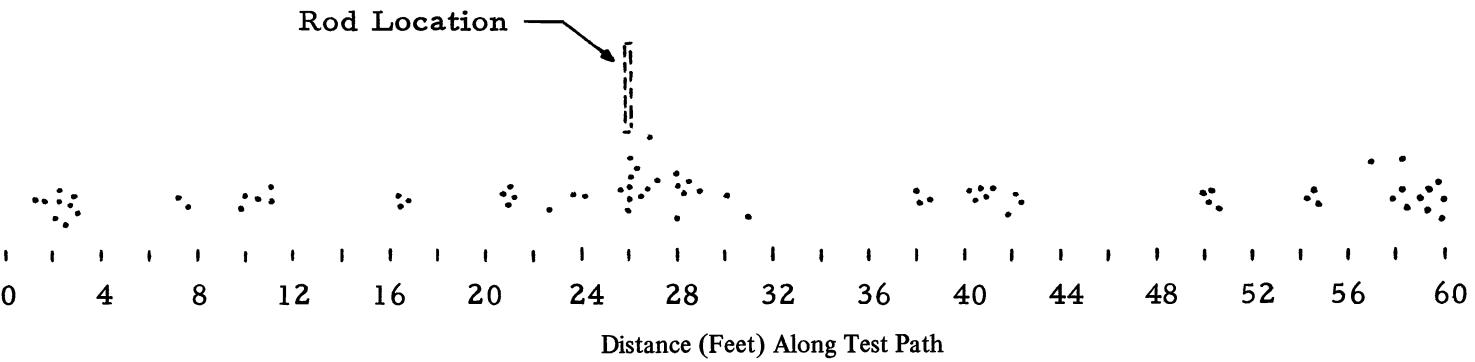


Figure 17. Dowsing reactions at trailer test area, test site No. 2. Each reaction is represented by a dot.

## Dowsing tests at North Logan Park

The North Logan City Park was a third site selected as a dowsing test site since it offered a large grass-covered area, providing a uniform, level test-path surface and void of any plants or other visible structures that would influence the reactions of the participants.

The course was established in a north to south orientation as shown in a layout of the area in Figure 18. A small wire was hidden at a point 60 feet from the actual starting point of the course. Unknown to the participants, the actual starting point was located some 12 feet beyond the place where the testing commenced. (Starting and stopping points of the test did not necessarily coincide with the point where the dowser started and stopped. This was done to increase the homogeneity of the test area proper.)

With generally sunny skies, with temperatures in the 80's and with variable light winds on occasion, 48 individuals participated in the dowsing tests over a four day period. Thirty-six of the participants had no previous dowsing experience; the other 12 individuals had taken part in at least one other dowsing test. Each individual was given a number of blocks and instructed to walk beside a guide string and to place a block at the location of any dowsing reaction obtained. After each person had completed the test, the location of each block was determined.

One individual failed to register a single reaction along the course. That person had made previous tests and had always obtained the same result. The number of reactions indicated by the other participants varied between 2 and 28. A total of 543 reactions were obtained, resulting in an average of 11.3 for each participant.

The chi-square statistical test of the North Logan Park data is presented in Table 5. Four of the eight window positions show significance levels in excess of one chance for randomness in 2000. The other four sets of window positions fall in positions such that they bisect data grouping and thereby reduce the degree of statistical significance. Data used for the chi-square test are plotted in Figure 19.

**Table 5. Chi-square test results for data taken at North Logan Park, test site No. 3. 3.5 foot windows incremented by 0.5 foot, course length 190 feet.**

Iteration	D.F.	Chi-square	0.5	0.20	0.0005
1	23	131.93	22.34	28.43	52.21
2	22	58.60	21.34	27.30	50.60
3	21	28.12	20.34	26.17	48.93
4	19	29.67	18.34	23.90	45.60
5	19	23.18	18.34	23.90	45.60
6	23	116.18	22.34	28.43	52.21
7	21	36.10	20.34	26.17	48.93
8	23	116.22	22.34	28.43	52.21

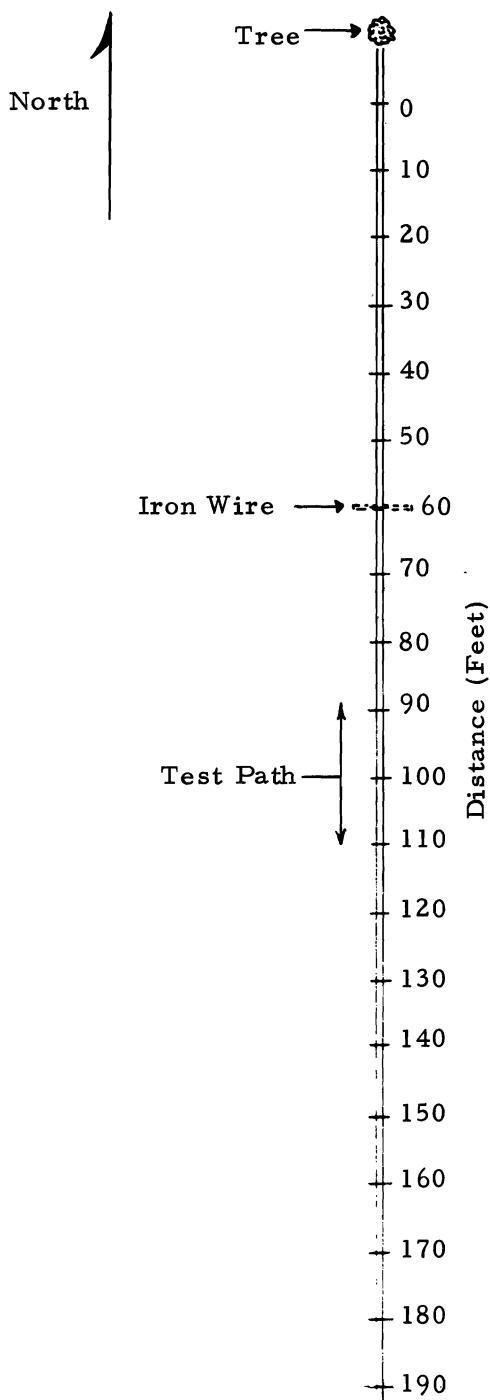


Figure 18. North Logan Park test course, test site No. 3.

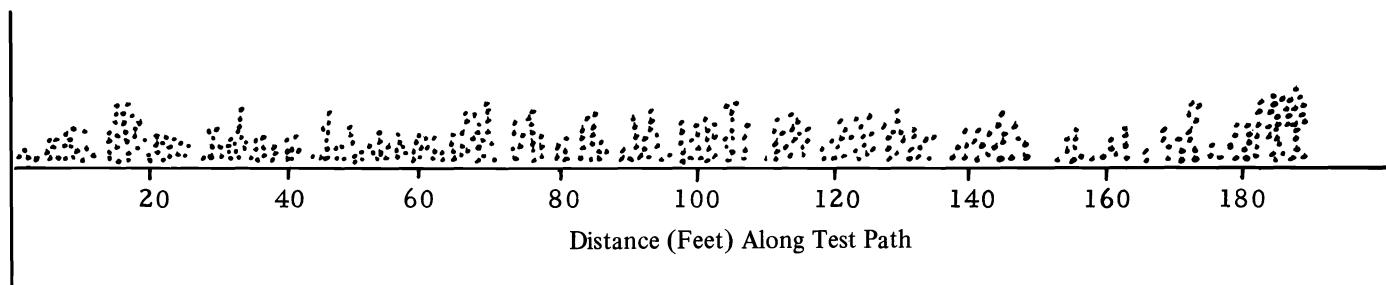


Figure 19. Dowsing reactions obtained by 48 individuals at North Logan Park, test site No. 3.

With this degree of significance, it was again decided to conduct a block drop experiment at the same location, sans dowsing rods, and compare the results with those just presented.

### Dowsing test at North Logan Park without devices

The procedures discussed with regards to dowsing tests without devices in the orchard area were followed for a second test. The test site was the course used at the North Logan City Park. Five of the participants used in the random block drop test in the orchard and 12 others with no previous test experience were given a number of blocks and asked to walk beside a guide string lying on the grass and to place blocks at any locations they desired.

The tests were conducted before noon with cloudy conditions and a temperature of 72°. The number of blocks placed varied from 6 to 29 with an average number of 10.6 blocks for each participant. (The average is approximately equal to the 11.3 blocks placed by the dowsers with devices.)

The data were analyzed with the chi-square program using a 3-foot window size and a one-half foot incremental window shift for each succeeding iteration. The computer outputs are shown in Table 6 along with the standard values for probabilities of 0.50 and 0.05. The highest chi-square value obtained was 16.40 which shows significance at the 5 percent level. This data compares favorably with that of a similar test taken in the orchard without dowsing devices.

### Dowsing test at Lorton, Virginia

Near the conclusion of the project an opportunity arose to attend a dowsing meeting convened at the home of Dr. Z. V. Harvalik in Lorton, Va. Those in attendance were members of the Washington, D.C. Chapter of the American Dowsers Society, their wives, and a number of invited guests.

**Table 6. Chi-square test results for a random block drop test at North Logan Park, test site No. 3. 3.5 foot windows incremented by 0.5 foot, course length 190 feet.**

Iteration	D.F.	Chi-square	0.5	0.05
1	9	8.26	8.34	16.92
2	9	8.82	8.34	16.92
3	9	14.27	8.34	16.92
4	10	9.70	9.34	18.31
5	9	16.40	8.34	16.92
6	9	11.16	8.34	16.92
7	8	11.96	7.34	15.51
8	9	6.71	8.34	16.92

During the events of the day, a dowsing test was conducted similar to those previously reported. Twenty-three people participated in the test, about half of whom would be classified as experienced dowsers. The others had had little or no experience. The entire group was most cooperative and all were found very willing to participate.

The test course was located parallel to, and about 20 feet from the shores of the Potomac River. This hardly seemed the ideal location to "dowse for water" but the site was selected because it was a secluded spot and out of sight of those attending the meeting. Tests could thus be made without disturbance from bystanders. The course length was 90 feet long with several randomly spaced trees growing on either side of the pathway. On the day of the test, August 2, the temperatures were in the low 90's and humidity was high but not measured.

All persons tested obtained dowsing reactions. The least number of reactions was two; the most was nine. A plot of these reactions is shown in Figure 20.

The data obtained from the test at Lorton were checked for statistical significance and the resulting chi-square values are presented in Table 7.

Of the various dowsing tests conducted using dowsing devices this particular test was lowest in statistical significance. The highest chi-square value for the best window configuration being 19.01 indicates a significance at about the 6 percent level. This level being the lowest value obtained in any of the tests that used dowsing devices, is puzzling since there were more experienced dowsers participating in this test than in any other test conducted during the project. Separating the results of the experienced versus inexperienced dowsers did not affect the results materially.

There may be some reasons for the apparent departure from that which had formerly been experienced. So many possibilities could be mentioned, all of which are conjecture at this time, that little attempt is made to explain the seeming departure from answers previously obtained. Since the test was made at the end of the project period at a location remote from the base of operations it was not possible to pursue it further at this time. Several facts, however, can be stated which may be used at some later date when additional information may be available for

**Table 7. Chi-square test results for dowsing test taken at Lorton, Va. Window size is 3.5 feet. The window shift increments are 0.5 foot.**

Iteration	D.F.	Chi-square	0.5	0.10	0.05
1	9	8.22	8.34	14.68	16.92
2	8	6.83	7.34	13.36	15.51
3	10	3.48	9.34	15.98	18.31
4	10	2.14	9.34	15.98	18.31
5	10	10.42	9.34	15.98	18.31
6	11	6.71	10.34	17.28	19.68
7	11	19.01	10.34	17.28	19.68

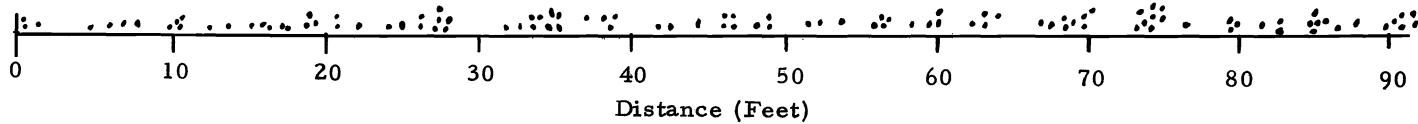


Figure 20. Dowsing course along banks of Potomac River at Lorton, Va., test site No. 4. Dots represent locations where dowsing reactions were recorded by 23 separate dowsers. Dots are spaced in vertical plane solely for purpose of display. The dowsing path is represented by the solid line.

further evaluation. These observations were considered unique with respect to other tests that were conducted, viz.:

1. Temperatures were about ten degrees higher and the humidity level, though not measured was considered to be much higher than experienced in Utah, i.e. 15 percent versus 80-90 percent.
2. This test was the only dowsing test made along the side of a river.
3. Small wave action was noted and occasionally large waves were created by passing boats. (Wave action is known to cause magnetic anomalies, Weaver, 1965.)
4. This was the only test conducted with so many experienced dowsers participating.

#### Dowsing test made by a single dowser

An interesting dowsing test was conducted by a single dowser where a repeated, or partially repeated, dowsing test was taken by a single dowser over a period of 2½ months. The dowser used the flying  $\checkmark$  device which gave a directional (left-right) component in addition to the conventional reaction. Twice the test was started in different locations in an effort to break what might become a remembered routine. The results of the test are shown in Figure 21. (Comments regarding the magnetic field plotted on this figure are made in the next section.) The true independence of this type of test can, of course, be seriously questioned, since the same person is taking the same test, over the same plot of ground. Statistical evaluation of the data, however, (Table 8) shows it to be not as statistically significant as the statistics compiled at test site No. 2 by a group of dowsers each testing once. As directional information was not obtained in other tests, that aspect of the data cannot be compared.

Despite objections to this test, since the various inputs cannot be proven to be independent, it does demonstrate a certain uncanny ability possessed by the dowser to get quasi-repeatable results in trials taken over a long period of time.

The real reason for conducting this kind of test is to capitalize on the consistency of a single dowser. Hopefully, a single individual will have a more nearly constant reaction time to magnetic impulses, should such reactions actually exist, and will behave more consistently to given reoccurring stimuli than would two

**Table 8. Test results of a single dowser making repeated tests over the same location taken over a 2½ month period.**

Iteration	D.F.	Chi-square	0.5	0.01	0.0005
1	6	15.25	5.35	16.81	24.12
2	6	11.93	5.35	16.81	24.12
3	5	6.20	4.35	15.09	22.10
4	5	2.97	4.35	15.09	22.10
5	7	33.76	6.35	18.48	26.04
6	7	33.63	6.35	18.48	26.04

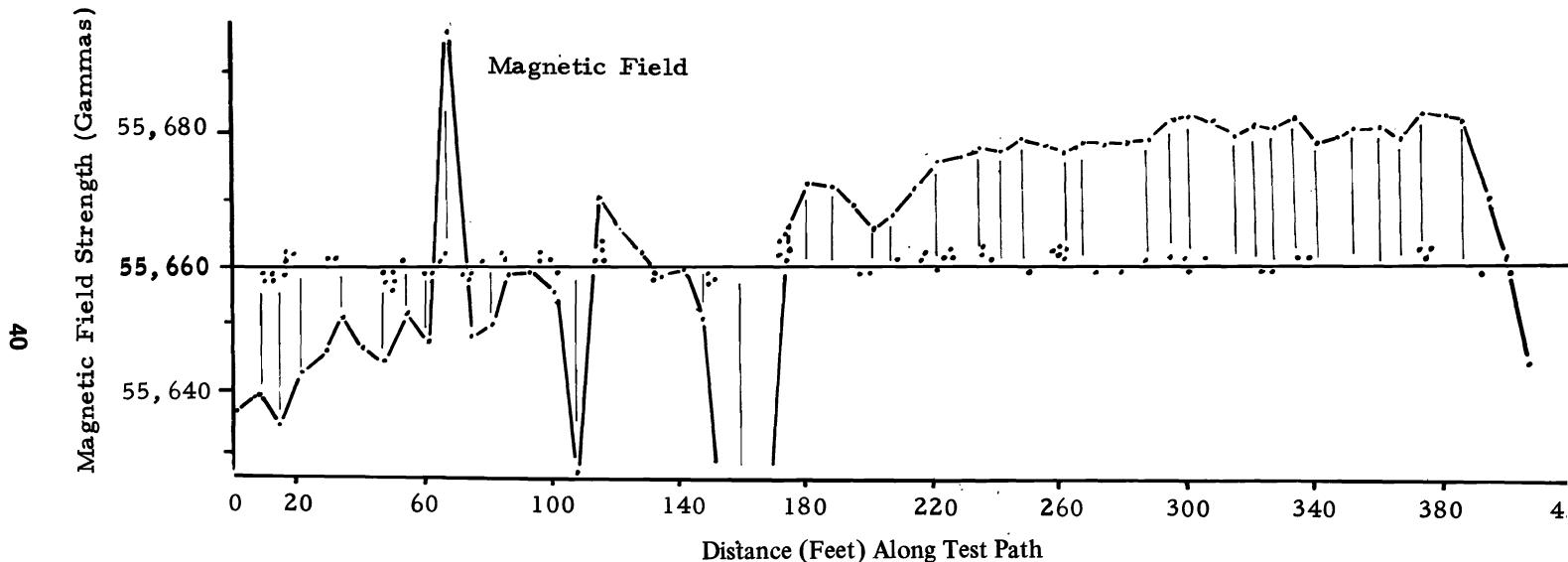


Figure 21. Dowsing reactions using flying  $\checkmark$  device. Dots above and below the upper horizontal line, representing the dowsing path, indicate north and south pointing reactions respectively. Vertical lines indicate position of magnetic slope changes.

separate individuals. Therefore if magnetic gradients cause dowsing reactions, perhaps more information about this can be obtained using a single individual than can be obtained using many individuals who have variations in their threshold sensitivities, etc. The degree of magnetic-dowser reaction correlation obtained in this manner is discussed following the next section on the magnetic field survey.

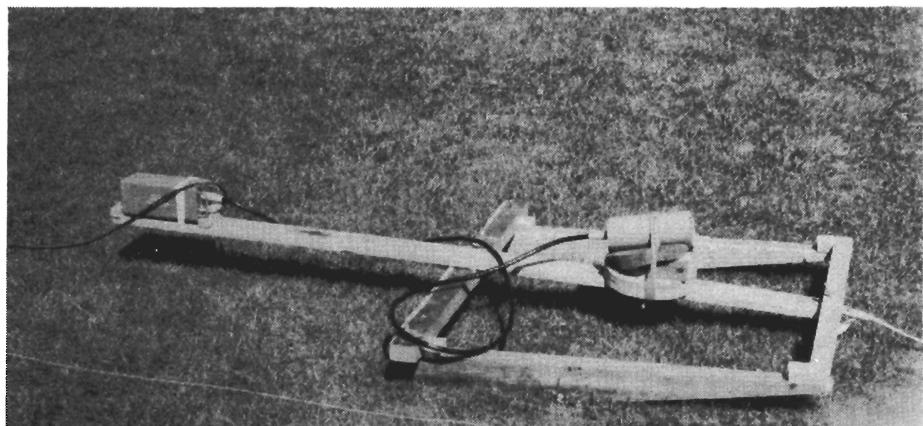
### Magnetic field survey of test areas

After the dowsing tests were taken in test sites 1, 2, and 3, a magnetic survey was made along the dowser's path using the cesium vapor magnetometer. Test site No. 4 was magnetically surveyed immediately prior to the dowsing test, however, those conducting the test did not see the results of the magnetic survey prior to the dowsing test.

The magnetic surveys were made by establishing a fixed reference magnetometer and then using the second magnetometer as an exploratory probe. The differential reading thus obtained between the two magnetometers represented the point-to-point fluctuation of the magnetic field along the path on which the exploratory probe traversed.

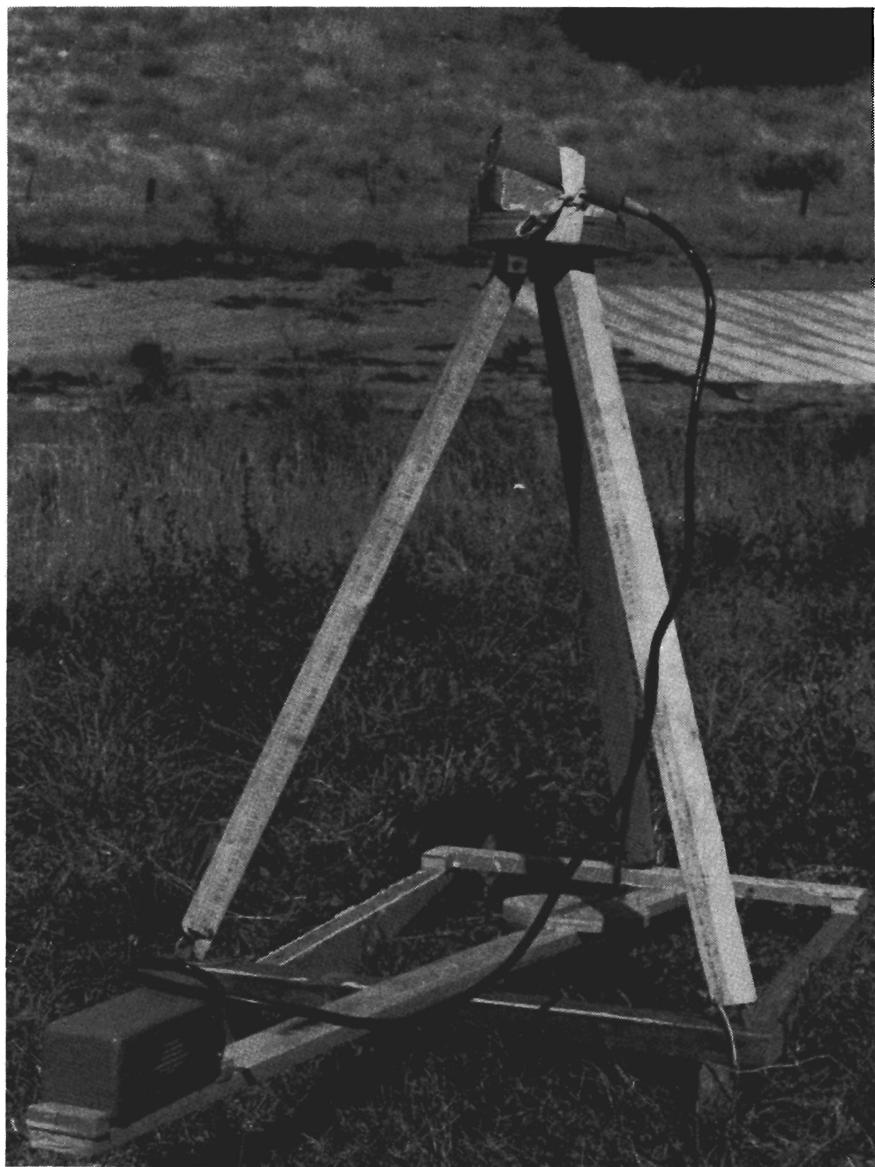
Since the readout of the magnetometer probe was a discrete frequency count of its natural oscillations, point-by-point measurements were made every few feet along the path instead of a continuous type record which is the more desirable.

For convenience in transporting the magnetometer along the dowsing path, a wooden sled, held together with nonmagnetic screws, was constructed on which the magnetometer was mounted, Figure 22. The sled was pulled along the path by means of a nylon cord attached to it. With the magnetometer mounted on the sled, the



**Figure 22.** Wooden sled holding the magnetometer sensor 8 inches above ground. This unit coupled with its preamplifier (mounted on appendage) is connected to the digital display device (counter) via a 250 foot coaxial cable.

magnetic survey was made at an elevation of 8 inches above the ground. In some instances, a second survey was also made along the dowsing path at an elevation of 40 inches, Figure 23. A considerable difference in the two surveys is shown in Figure 24. This difference in the magnetic field probably was caused by local anomalies located near the surface of the earth which would affect the lower elevation magnetometer more than it would affect the higher one.



**Figure 23. Magnetometer sensor 40 inches above ground. Mounted on tripod which is conveyed via wooden sled.**

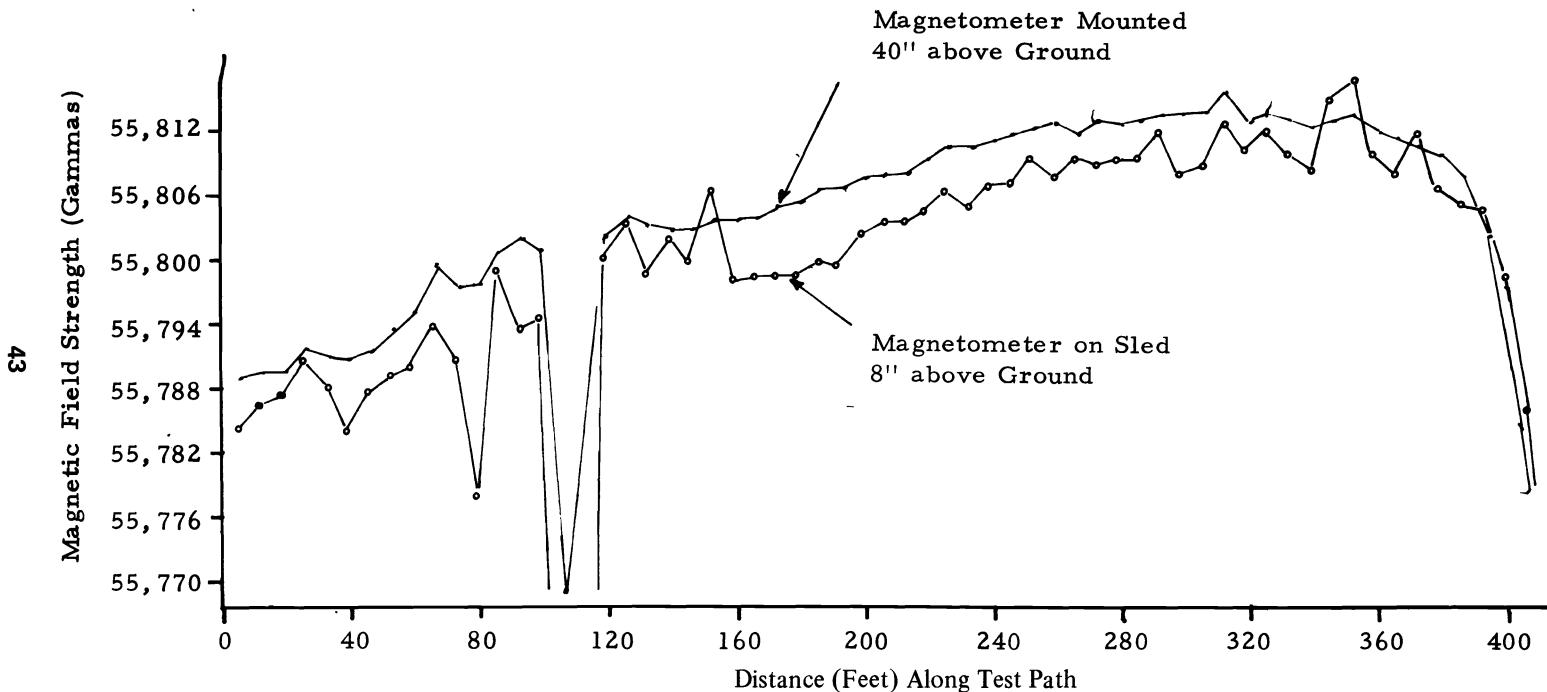


Figure 24. Comparison of magnetic fields taken at an 8" and a 40" elevation above ground level.

Plots of the magnetic fields at the various test site areas are shown in Figures 24, 25, 26 and 27. These were all taken at an 8 inch elevation from the ground level with the exception of the single, higher elevation plot included in Figure 24.

Some care should be exercised in the interpretation of the indicated point where the magnetic gradient was observed to change. The exact point where the slope changes can only be indicated to the nearest point where a measurement was taken which was typically every 2-6 feet, depending on the particular course being surveyed.

### **Correlation between magnetic gradient and dowsing reaction**

In attempting to correlate the magnetic field gradient change with the dowsing reaction, some difficulty is encountered. The problem centers around three factors. The first problem is one of selecting a criteria for the magnitude of gradient change that may cause a dowsing reaction. This is complicated by the variations of sensitivity existing between dowsers and also variations a single dowser may experience periodically. Possibly, as some dowsers have indicated, sensitivity can depend on dowser fatigue, physical comfort, ambient temperature, wind conditions, etc.

A second factor to consider in studying definitive correlations between the dowser and the magnetic field concerns "which field," the field at ground level, arm level, head level, or is it the gradient existing in the vertical plane instead of the horizontal plane, etc.

The third factor concerns the possible influence of extraterrestrial magnetic influx. No magnetic monitoring was made during the times dowsing tests were being conducted. Thus no information is available regarding these possible extraterrestrial influences. Doubtlessly, future tests should be conducted either with the aid of a continuously recording magnetometer or the tests should be conducted in an area that is magnetically shielded from randomly induced magnetic influx.

Overlooking the possibilities of an extraterrestrial magnetic flux reaction, perhaps the most information about naturally occurring dowsing reactions as they may relate to magnetic gradients under field conditions is to review the responses of a single dowser and compare them to magnetic field plots. Such a comparison can be drawn from Figure 21.

In connection with data of Figure 21, the following test was performed to determine if the majority of dowsing reactions occur near a change in the magnetic gradient. The orchard course was divided into 10-foot windows. If a significant slope change was noted to occur within the window, i.e. 1/2 gamma per foot slope change, this window was arbitrarily determined to be a dowsing zone. If the magnetic slope change was less than this, it was said to be a nondowsing zone. Upon counting the reactions and comparing them to the dowsing versus nondowsing zones the average number of reactions in the dowsing zones was 2.1. The average number in the nondowsing zone was 1.3.

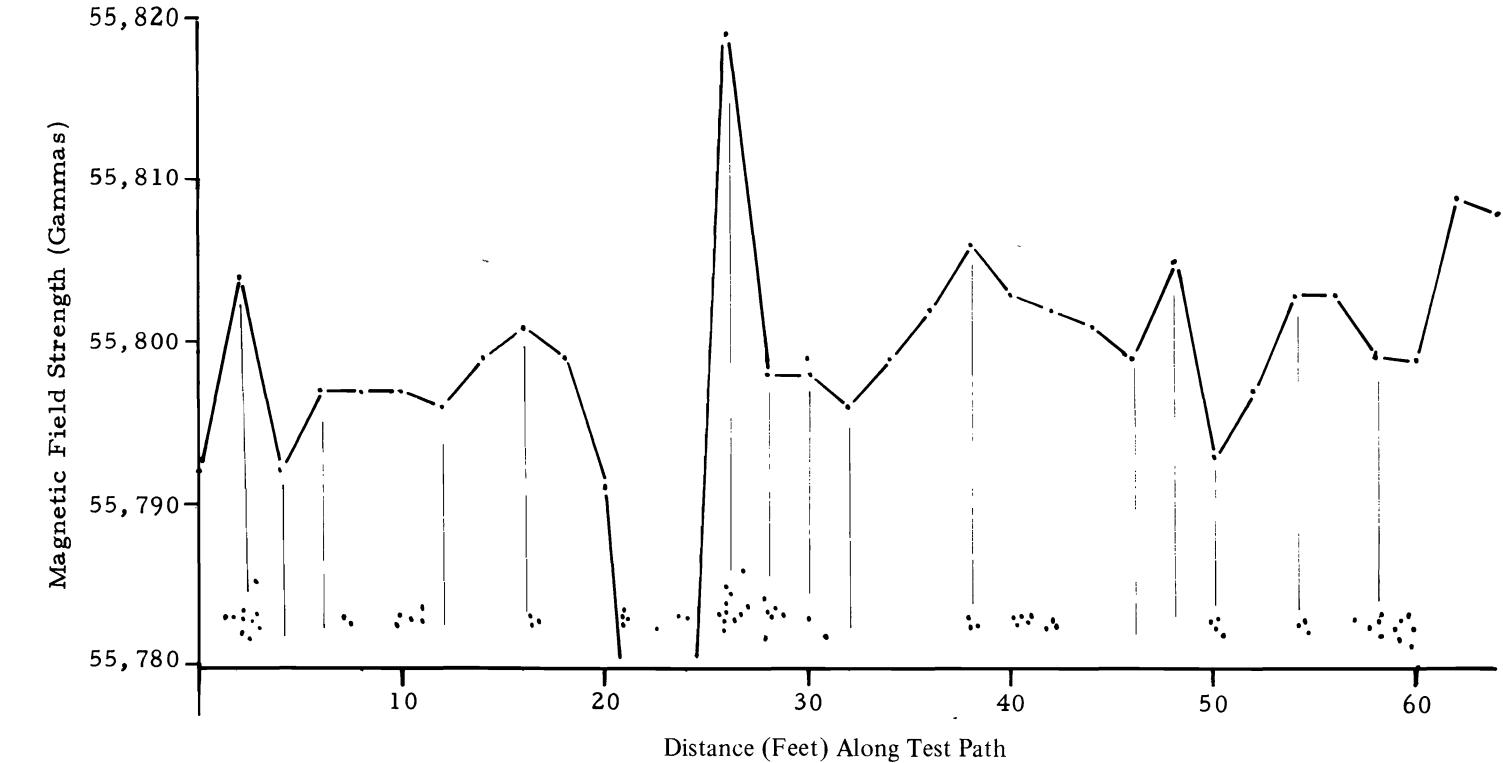


Figure 25. Magnetic field plot of trailer area. Dots represent location where a dowsing reaction was obtained.

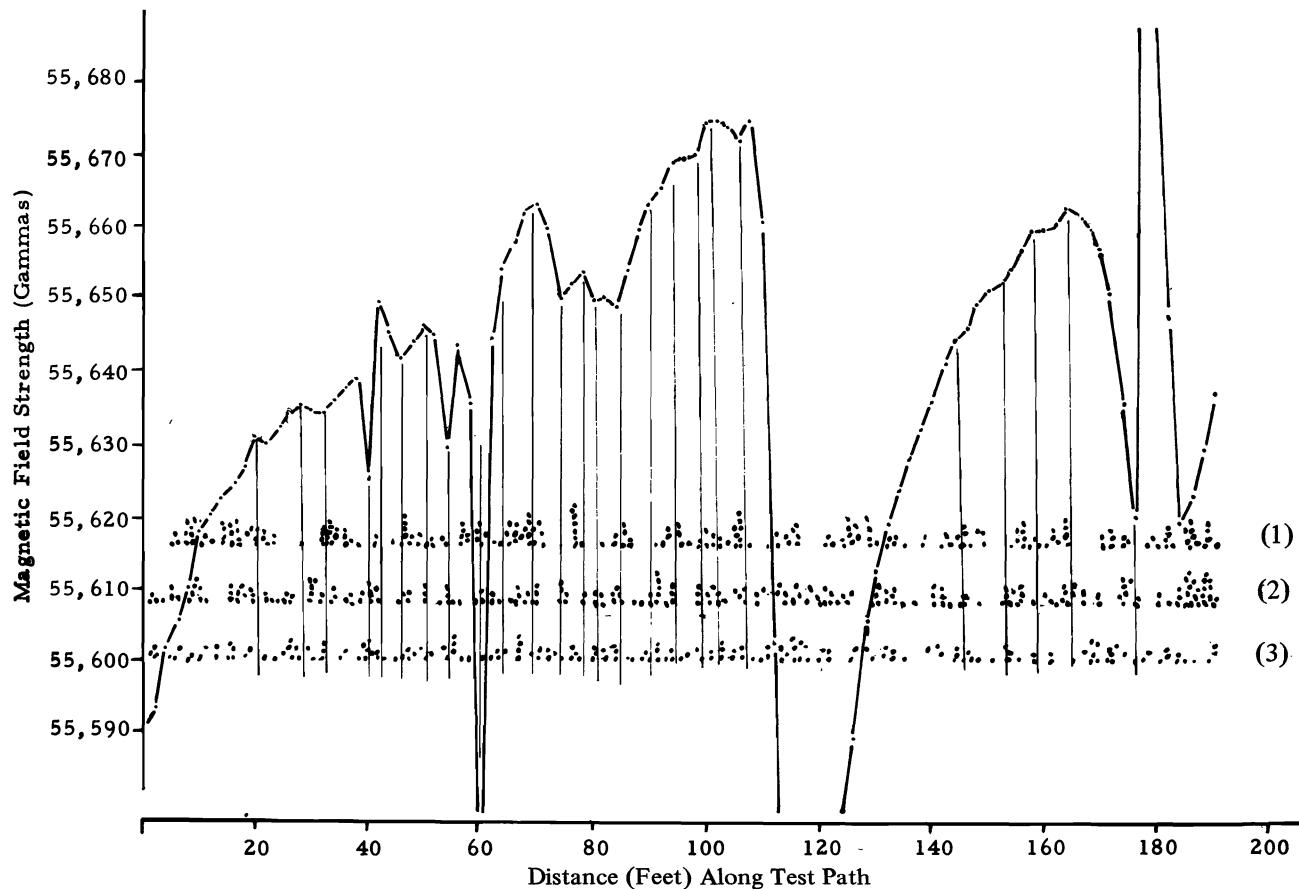


Figure 26. Magnetic field plot of North Logan Park area. Top row of dots represent dowsing location obtained by dowsers July 20-22, 1970. Second row represents dowsing location obtained August 8, 1970. Bottom row represents random block drop test taken July 22.

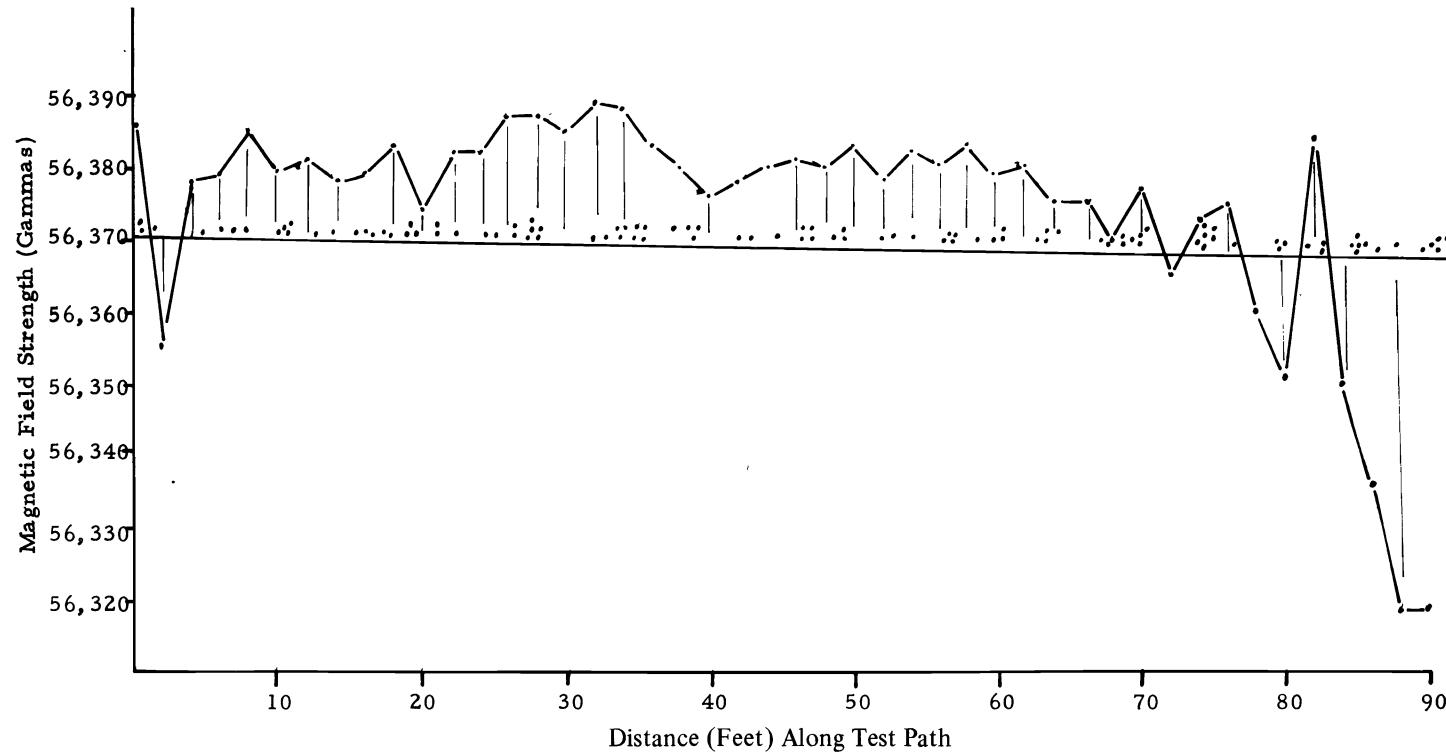


Figure 27. Magnetic field plot of dowsing course at Lorton, Va.

A similar test was made for data of the trailer test area, plotted in Figure 25. The results showed the dowsing zones to have an average of 3.2 reactions and the nondowsing zones to have an average of 0.8 reactions. (This is also the plot which has the highest chi-square values.)

Similar tests were conducted on data plotted in Figure 26. The slope criteria for establishing a dowsing zone on these tests was arbitrarily increased to 1 gamma per foot change in slope in a 10-foot segment. Data on line 1 have 5.7 reactions per dowsing zone versus 4.6 reactions per nondowsing zone. Data on line 2 have 5.8 reactions per dowsing zone versus 4.8 reactions per nondowsing zone. Data on line 3 have 4.7 reactions per dowsing zone and 4.7 (same) reactions per nondowsing zone. (Data on line 3 are taken from the random block drop experiment.) Data recorded at Lorton, Va., have 2.6 reactions per dowsing zone and 1.6 reactions in the nondowsing zones.

In obtaining the previous data no attempt was made to optimize the gradient change criteria. Selection of the 1/2-1 gamma per foot was made so that there would be a representative number of dowsing versus nondowsing zones. Gradients smaller than this would not leave any nondowsing zone regions, gradients larger than this were not selected because of the large number of reactions occurring in regions where magnetic gradients were of this order of magnitude.

There also appears to be fair correlation in Figure 21 between positive gradients and a north swinging dowsing rod (flying  $\checkmark$  type) and also negative gradients and a south swinging dowsing rod. Points marked above the line indicate the former and below the line, the latter. There are, of course, contradictory areas and gray areas where not much can be determined. This test illustrates why the extraterrestrial variable should be either continuously monitored or shielded from the dowser during the dowsing test. Eliminating an unknown variable in this manner may make results more concise.

Because of the factors discussed regarding correlation or lack of correlation between dowsers and the fluctuation in sensitivity for a single dowser, great care must be exercised in evaluation procedures that positively relate or disassociate the magnetic field and the dowser. Careful analysis of this subject could constitute a major research effort.

## Summary

The presence of groundwater, while theoretically affecting the earth's magnetic field in several ways, was calculated to manifest only one way in which the magnetic field might be altered sufficiently in amplitude to measure reliably with existing state-of-the-art magnetic equipment, i.e., a cesium vapor magnetometer. Various geologic formations have differing magnetic signatures. Some of these formations are water bearing; some are not. Thorough knowledge of this phenomenon, coupled with careful magnetic surveys, could be helpful in determining the location where the best water bearing material can be found.

The major effort of this research project was placed in dowsing tests to see if water dowsers: (1) obtained results which were independently corroborated and (2) obtained results which correlated in some way with magnetic field plots of the dowsed area.

Numerous dowsing tests were conducted which involved over 150 different people. They were randomly selected from the faculty and student population, both male and female. About 90 percent of those tested had never dowsed before nor had they seen others do so. Of all those participating, only one individual reported that no dowsing reaction occurred, all others had one or more reactions in every test taken. This fact that practically everybody may expect to get a dowsing reaction was surprising and is considered to be new information.

Numerous independent, individual dowsing tests were made at four principal locations. Information combined for each area showed statistical significance when submitted to the chi-square test; the significance level ranged from 6 percent to < .05 percent chance for randomness.<sup>1</sup>

When subjects "dowsed" without dowsing rods (the random block drop experiment), the statistical significance level was at the 5-10 percent chance for randomness. When dowsing rods were used in the same area by different but similarly inexperienced people, the statistical significance level jumped to the < .05 percent level. This raises the question, can dowsing rods enhance or amplify latent responses to physical fields, or increase accuracy of extrasensory perception, etc.? Some of the evidence presented herein indicates they may do so.

The magnetic field perturbations were plotted for each course subsequent to the dowsing tests. Quantitatively, some correlation appears to be present which links magnetic gradient changes to dowsing zones. In each dowsing test the number of reactions occurring near a change in the magnetic field was greater than the number of reactions occurring in a non-changing field. Further tests are indicated wherein the real-time extraterrestrial magnetic influx is monitored and/or shielded from the subject taking the dowsing test. Tests thus taken under such controlled conditions should further clarify the present question of human responses to magnetic gradient changes.

There is concern that by taking statements out of context this report may be used to prove that dowsing is an effective means of finding water. It should be emphasized that no wells were dug, a limited number of tests with experienced dowsers did not noticeably have better results than did novices, and only by statistical means was it shown that some kind of information, as yet undefined, might be present.

This project has been exploratory in nature. Considerable effort has been expended to obtain quantitative information which could be accepted by the scientific community and dowser alike in that no preconceived notions were held, and tests were made in as objective a manner as possible. Results indicate to the researchers that there is sufficient evidence of deterministic results to warrant further investigations.

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<sup>1</sup> These values are based on optimal window spacing as discussed in the body of the report.

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## Appendix I

To illustrate the calculation of the effects of magnetic materials on the earth's magnetic field, consider the following example.

A long cylinder of radius  $a$  and permeability  $\mu$  representing a change in normal homogeneity, is placed in the earth's magnetic field  $\vec{B}_o$ , such that the axis of the cylinder is at right angles to  $\vec{B}_o$ . The value of the magnetic induction  $\vec{B}_1$  subsequent to this action can now be calculated at any distance  $r$  from the cylinder.

When no transport currents exist inside magnetic materials the fundamental magnetic equations in these regions are given by

Eq. 2 implies that  $H$  can be expressed as the gradient of a scalar field.

where  $U$  is a magnetic scalar potential due to all sources.

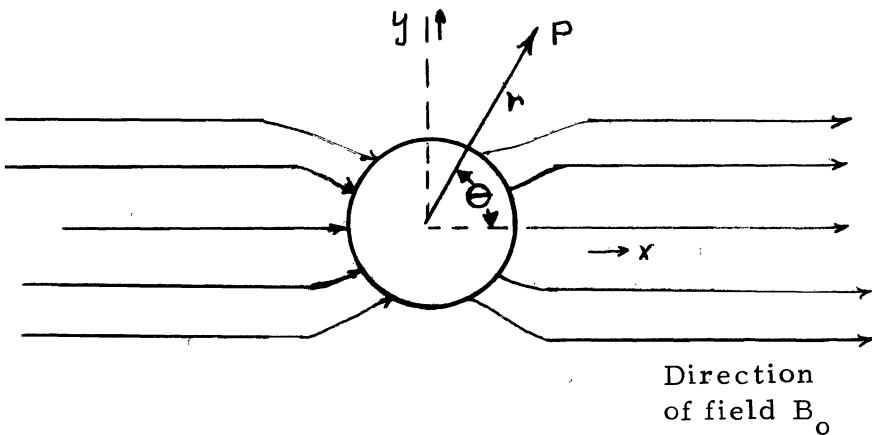
In this example it is assumed a linear or approximately linear magnetic material for which  $B = \mu H$ . Therefore Eq. 1 reduces to

$$\operatorname{div} \vec{H} = 0 \quad \dots \quad (4)$$

combining Eqs. 3 and 4

which is Laplace's equation. Thus we are required to find a solution to Laplace's equation which satisfies the boundary conditions.  $\vec{H}$  can then be calculated from Eq. 3 and  $\vec{B}$  obtained from  $\vec{H}$ .

Because of the geometry of the problem we will use cylindrical coordinates with  $\hat{r}$ ,  $\hat{\theta}$  and  $\hat{z}$  being unit vectors in each of the coordinate directions. The origin is the axis of the cylinder.



Since the cylinder is assumed long the solution will depend on  $r$  and  $\theta$  but not on  $z$ .

The required solutions to Laplace's equation for the case are the so-called cylindrical harmonics:

$$1,$$

$$\ln r,$$

$$r^n \cos n\theta,$$

$$r^{-n} \cos n\theta,$$

$$r^n \sin n\theta,$$

$$r^{-n} \sin n\theta,$$

with  $n$  being an integer

These functions form a complete set of solutions in cylindrical coordinates and the magnetic potential function  $U$  will be developed by superposition of cylindrical harmonics with the coefficients of the different terms being determined by the boundary conditions. By the geometry of the situation and the choice of coordinate directions all terms can be eliminated except the cosine terms with  $n = 1$ .

$$U_1 = A_1 r \cos \theta + A_2 r^{-1} \cos \theta \quad (\text{for the region outside the cylinder})$$

$$U_2 = C_1 r \cos \theta + C_2 r^{-1} \cos \theta \quad (\text{for the region inside the cylinder})$$

At distances far from the cylinder  $\vec{B}$  retains its uniform character, i.e.  $\vec{B} = \vec{B}_0$

$$U_1 \rightarrow A_1 r \cos \theta \text{ as } r \rightarrow \infty$$

and since  $\vec{H}_1 = -\text{grad } U_1$

$$\vec{H}_1 \Big|_{r \rightarrow \infty} = (-A_1 \cos \theta) \hat{r} + (A_1 \sin \theta) \hat{\theta}$$

$$\vec{B}_1 \Big|_{r \rightarrow \infty} = \mu_0 A_1 (-\hat{r} \cos \theta + \hat{\theta} \sin \theta)$$

where  $\mu_0$  = permeability of free space.

$$|\vec{B}_1| = |\vec{B}_0| = B_0$$

and direction  $\vec{B}_1 = \text{direction } \vec{B}_0$

$$\text{Thus } A_1 = -B_0 / \mu_0$$

Since  $U_2$  and its associated magnetic field cannot become infinite at any point, the coefficient  $C_2$  must be set equal to zero.

The boundary conditions at an interface between two media can be expressed as follows:

1. The component of  $\vec{B}$  normal to the interface is continuous across the interface, i.e.  $B_{1n} = B_{2n}$
2. The component of  $\vec{H}$  tangential to the interface is continuous across the interface, i.e.  $H_{1t} = H_{2t}$

using Eq. 3 with the assumed solutions

$$H_{1n} = \frac{B_0}{\mu_0} \cos \theta + \frac{A_2}{r^2} \cos \theta$$

$$H_{2n} = -C_1 \cos \theta$$

or

$$B_{1n} = B_0 \cos \theta + \frac{\mu_0 A_2}{r^2} \cos \theta$$

$$B_{2n} = - \mu C_1 \cos \theta$$

where  $\mu$  is the permeability of the cylinder material

$$H_{1t} = - \frac{B_o}{\mu_o} \sin \theta + \frac{A_2}{r^2} \sin \theta$$

$$H_{2t} = C_1 \sin \theta$$

Thus applying the boundary conditions at  $r = a$

$$B_o + \frac{\mu_o A_2}{a^2} = - \mu C_1$$

$$- \frac{B_o}{\mu_o} + \frac{A_2}{a^2} = C_1$$

Solving the two equations

$$A_2 = \frac{B_o a^2}{\mu_o} \left( \frac{\mu - \mu_o}{\mu + \mu_o} \right)$$

$$C_1 = - \frac{2 B_o}{\mu + \mu_o}$$

Substituting these coefficients

$$U_2 = - \frac{2 B_o}{\mu + \mu_o} r \cos \theta$$

$$\vec{H}_2 = \hat{r} \frac{2B_o}{\mu + \mu_o} \cos \theta - \hat{\theta} \frac{2B_o}{\mu + \mu_o} \sin \theta$$

$$\vec{B}_2 = \frac{2\mu B_o}{\mu + \mu_o} (\hat{r} \cos \theta - \hat{\theta} \sin \theta)$$

or in cartesian coordinates

$$\vec{B}_2 = \frac{2\mu B_o}{\mu + \mu_o} \hat{x}$$

i.e.  $\vec{B}_2$  is in the same direction as the original uniform field  $\vec{B}_o$ .

$$U_1 = - \frac{B_o}{\mu_o} r \cos \theta + \frac{B_o a^2}{\mu_o} \left( \frac{\mu - \mu_o}{\mu + \mu_o} \right) r^{-1} \cos \theta$$

$$\vec{B}_1 = \mu_o (-\text{grad } U_1)$$

$$= B_o \left[ \left( \cos \theta + \frac{a^2}{r^2} \left( \frac{\mu - \mu_o}{\mu + \mu_o} \right) \cos \theta \right) \hat{r} \right.$$

$$\left. - \left( \sin \theta - \frac{a^2}{r^2} \left( \frac{\mu - \mu_o}{\mu + \mu_o} \right) \sin \theta \right) \hat{\theta} \right] \dots \dots \quad (6)$$

If the field strength is investigated at a point directly above the cylinder,  $\theta$  can be considered as being  $90^\circ$ , the equation then reduces to

$$\vec{B}_1 = B_o \left[ 1 - \frac{a^2}{r^2} \left( \frac{\mu - \mu_o}{\mu + \mu_o} \right) \right]$$

## Appendix II

A chi-square ( $\chi^2$ ) statistical test can be used to determine the probability for randomness of events. This test has been applied to dowsing reaction data in the following manner:

1. Count the number of windows with 0, 1, 2, 3, etc. dowsing reactions in them. (Regarding window size, an event should be infrequent. That is, the windows should be small.)
2. Let  $n_x$  be the number of windows with  $x$  events in them. Let  $t$  be the largest number of events observed in any window, then calculate

$$\sum_{x=0}^t n_x / \sum_{x=0}^t n_x = \lambda$$

3. Next, assuming the data follows a Poisson distribution

$$\frac{e^{-\lambda} \lambda^x}{x!} = p$$

where  $p$  is the probability of having a window with  $x$  events in it.

4. The expected number of windows with  $x$  events in them is

$$\left( \frac{e^{-\lambda} \lambda^x}{x!} \right) N = e_x \text{ for } x < t$$

where  $N$  is the total number of windows

The expected number of windows with at least  $t$  events in them is

$$\left( 1 - \sum_{x=0}^{t-1} \frac{e^{-\lambda} \lambda^x}{x!} \right) N = e_t$$

5. Since  $n_x$  is the observed number of windows with  $x$  events in them, calculate

$$\sum_{x=0}^t \frac{(n_x - e_x)^2}{e_x} = \chi^2(t)$$

6. The calculated value of  $\chi^2_{(t)}$  can now be looked up in a table of chi-square values. This is a value which, for the parameter  $t$  has a probability =  $1 - \alpha$  of being exceeded if the distribution of events in space is really random. If the  $\chi^2_{(t)}$  obtained is larger than  $\chi^2_{(t) 1-\alpha}$  (the table value) only  $100\alpha\%$  of the time will such a large value be obtained if true randomness holds. Hence in the event of a large value of  $\chi^2_{(t)}$  one must reason that either a highly unlikely series of events has occurred or that the distribution of events is not random.

