RELATIONSHIP BETWEEN FRACTURED ZONES AND OVER FLOWING TUBE WELLS IN MONARAGALA DISTRICT

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DECLARATION

The work describe in this thesis was carried out by me at the Department of Natural Resources, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, under the supervisor of Professor Mahinda Rupasinghe, Head, Department of Natural Resources and Doctor A.L.T.Hewawasam, senior Lecturer, Department of Natural Resources, Faculty of Applied Sciences Sabaragamuwa University of Sri Lanka & Mrs I.G.C.I. Kularathne, project officer, Ground Water Section, Water Supply and Drainage Board, Monaragala. A report on this has not been submitted to any other university for another degree.

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ABSTRACT

Overflowing tube wells are the wells those given water without any pumping. This research was carried out through out the Monaragala district. There is a drinking water problem in Monaragala district in dry period. Evaluate any relationship between overflowing tube wells and fractured zones in Monaragala, resulting a map that contains overflowing tube wells and fractured zones in Monaragala and giving locations of good aquifers are main objectives of this research. This task can be performed using Aerial photos of Monaragala and GIS technology. In addition locations of good aquifers to construct tube wells are given through this map. Aerial photos interpretation methodology was used to find out fractured zone's global positioning coordinates. When, identfying fractured zones had to use ArcView GIS 3.2 software package. Digital map software used for located fractured zones and overflow tube wells locations. After observation of developed map, found availability of relationship of above relationship. Actually there is a relationship between overflow tube wells and fractured zones. Seventh of overflowing tube wells out of ten overflowing tube wells were intersected with fractured zones.

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ABBREVIATIONS

App	Appendix
NWSDB	National Water Supply and Drainage Board
GIS	Geographical Information System
GPS	Global Positioning system

CHAPTER 01

1.1 General introduction

Deep tube wells are wells of high capacity, tapping water from more than one aquifer. Their depth usually ranges from 60-300m. In Sri Lanka, most deep tube wells are state owned. Deep tube wells may be strainer wells or gravel pack wells, depending upon the characteristics. Tube wells under this category are classified as water table wells, semi artesian wells and hard rock bore wells. The classification is based on the location of the well and the characteristics of the aquifer. Wells may be defined as water table artesian wells, depending upon whether they tap a water table aquifer or an artesian aquifer.

Artesian wells are further classified as semi-artesian wells and flowing artesian wells. Tube wells bored in hard rock formations are classified as hard rock bore wells. Semi-artesian wells are installed under semi-artesian conditions of aquifer. The water is under pressure, but not so high as to flow out of the well. Artesian well a flowing well gets its supply from an aquifer where the water is under such high pressure that it overflows at the top. The well is so named because the initial knowledge about such wells was derived from Artois in France. (Michael and Khepar, 1989)

1.2 Introduction of the research

Ten overflowing artesian tube wells have been constructed in Monaragala.(Drilled log data from NWSDB) These are in widely extended locations and they having different flowing rates. This research work was carried out of all over the Monaragala district. The research was done for 15 weeks during 4th April to 21st July of 2006 in the dry season. This wells are located at Wasanapura, Pussallawa, Badalkumbura, Muthukandiya, Maduruketiya ,Hulandawa Left,Wallawaya, Kukurampola. Although all of these artesian tube wells are not in a ideal(continuous flow) condition, but they having considerable overflow rate.

1.3 Study area map

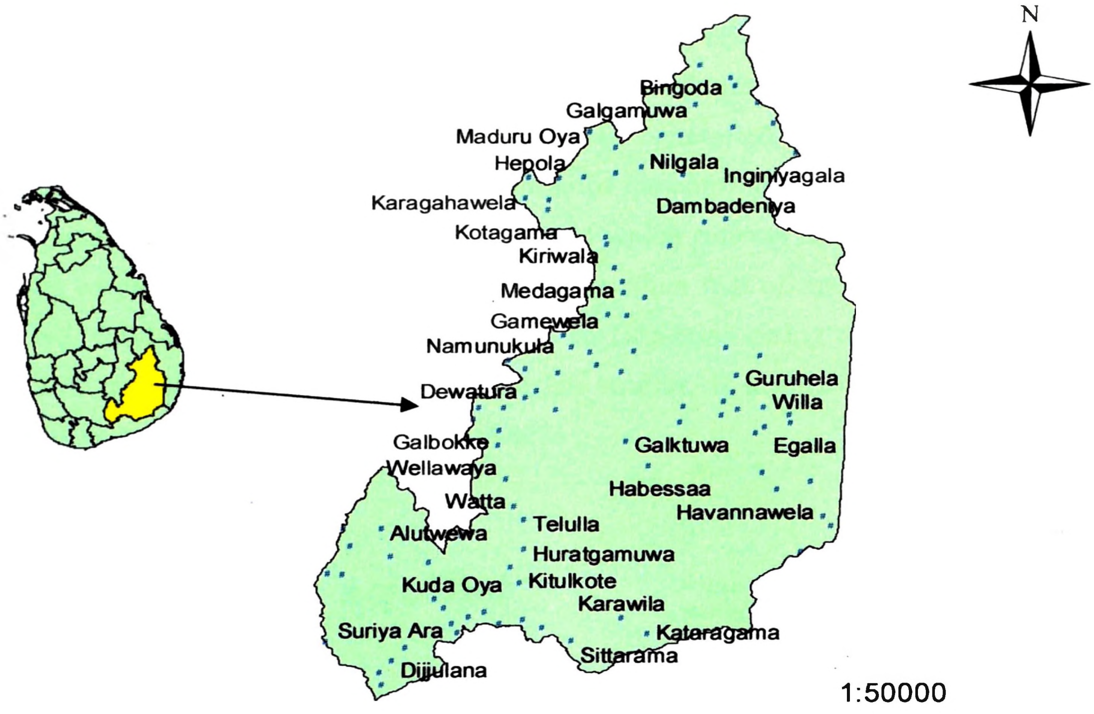


Figure.1.1 Locations of over flowing tube wells in Monaragala district.

1.4 Main objectives

- To evaluate any relationship between overflowing tube wells and fractured zones in Monaragala.
- To develop a map that contains overflowing tube wells and fractured zones in Monaragala.
- To give locations of good aquifers exist in crystalline terrains.

CHAPTER 02

Literature review

2.1 Occurrence of ground water in artesian aquifers.

A confined or artesian aquifer has an overlying confining layer of lower permeability than the aquifer and has only an indirect or distant connection with the atmosphere water in an artesian aquifer under pressure and when the aquifer is penetrated by a tightly cased well or peizometer, the water will rise above the bottom of the confining bed to an elevation at which it is in balance with the atmospheric pressure and which reflects the pressure in the aquifer at the point of penetration. If this elevation is greater than that of the land surface at the well, water will flow from the well. The imaginary surface conforming to the elevation to which water will rise in wells penetrating an artesian aquifer, is known as the potentiometric or piezometric surface.(David Keith Todd, 1980)

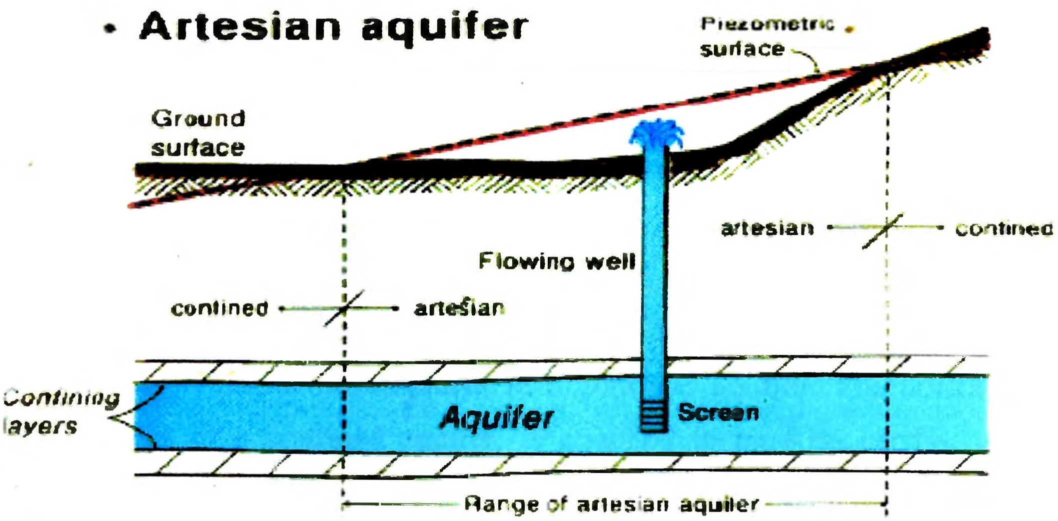


Figure.2.1. Occurrence of ground water in artesian aquifer

A portion of a confined aquifer in which the piezometric surface is not only above the ceiling of the aquifer, but also above ground surface, is referred to as an artesian aquifer. A well in an artesian aquifer is a flowing well, i.e., water will flow out of the well without pumping. (Figure 2.1)

2.2 Aquifer characteristics influencing yield of wells

The properties of the aquifer that influence well performance are depth, aerial extend, number of water bearing formations exposed to the well, and the hydraulic properties of the aquifer. An aquifer performs two functions, viz., storage as a conduit. The properties of an aquifer may be expressed in terms of it's hydraulic conductivity, transmissibility, storage coefficient and specific yield. In case of semi-confined aquifers, two additional properties viz., leakage factor and hydraulic resistance, are also important.(Michael, Kliepar, 1993)

2.3 Computation of ground water resources in confined aquifers

For confined aquifers, which are hydrologically separate from shallow water table aquifers, the ground water available is the quantity of water transmitted through these aquifers. This can be estimated using Darcy's law.

$$Q = T\,I\,L$$

Where Q = Rate of flow through a cross section of aquifers, m^3/day.
T = Transmissibility, m^2/day.
I = Hydraulic gradient, m/km.
L= Average width of cross section, km

The transmissibility may be computed from pumping test data of tube wells. Leakage from overlying or underlying aquifers may be accounted for in the computation of the quantity of ground water available for development in a confined aquifer. The utilizable resource for irrigation, in case of a confined aquifer, is assumed to be 85% of the quantity of water transmitted through the aquifer. Tube wells tapping deep confined aquifers should be treated separately and can be used for the quantitative assessment of deep confined aquifers. The draft of these tube wells is taken as the gross draft, of which 30% is taken as recycled water and added to the contribution of shallow aquifers. The computation of lateral flow in the confined aquifer is also done by flow net analysis, by computing all the parameter reflected in Darcy's equation. (Michael, Kliepar, 1993)

2.4 Development of wells in hard rock

Open hole wells drilled in hard rock supposedly do not benefit from development, but experience has shown this to be error. In consolidated granular materials, a mud cake forms and fines are forced in to the walls of the hole by the drilling operation. In fractured and jointed rocks where water yield depend upon the interception by the well bore of water-filled cracks or solution openings, such openings are frequently sealed by much the same action as well as by mud inversion. Practically all the methods used in developing screened wells can be used effectively in open-hole hard-rock wells. Under some circumstances however, some additional practices may also be effective.(Nath, Patra, Shahid, 2000)

2.5 Geologic formations as aquifers

A geologic formation that will yield significant quantities of water has been defined as an aquifer. Many types of formations serve as aquifers. A key requirement is their ability to store water in the rock pores. Porosity may be derived from intergranular spaces or from fractures. Table below summarizes the geologic origin of aquifers in terms of type of porosity and rock type. (David Keith Todd, 1980)

Table.2.1 Geologic origin of aquifers based on type of porosity and rock types. (Karanth, 1993)

Type of porosity	Sedimentary			Igneous and Metamorphic	Volcanic	
	Consolidated Unconsolidated	Unconsolidated		Carbonates		Consolidated
Intergranular		Gravelly sand Clayey sand Sandy clay		Weathered zone of Granite-gneiss	Weatherd Zone.of Basalt	Volcanic ejecta Blocks fraGments,Ah
Intergranular And Fracture	Braccia Conglomerate Sandstone Slate		Zoogenic Limestone Oolitic Limestone		Volcanic tuff Cinder Volcanic Braccia	
Fracture			Limestone Dolamite Dolamitic limestone	Granite Gniess Gabbro,Quartze,Diorie	Basalt Andesite Rhyolite	

2.6 Fractures and Fracture structures

2.6.1 Fractures in Rocks

Relations of Fractures to zones of the lithosphere, when a mass of rock is not strong enough to resist forces that are tending either to compress it or to stretch it, the rock suffers deformation. The change of form is brought about by flowage in the deeper parts of the lithosphere and by fracture in the upper parts.

The zone of fracture for any particular rock seldom coincides with that for another, because rocks differ in their capacity to "Flow" under stress. However, since every rock which has been naturally exposed through erosion is within its zone of fracture, outcrops on the earth surface are invariably and conspicuously traversed by cracks.

A large majority of these fissures belong to the class called joints. Other types of rock fracture are faults, fracture, cleavage, and breccia structure. Besides these there are certain kinds of fracture which are principally the effects of surface agencies. Such are orescentic fractures of glacial origin, exfoliation cracks along which spalls separate from a disintegrating rock. Etc. (Lahee, 1987)

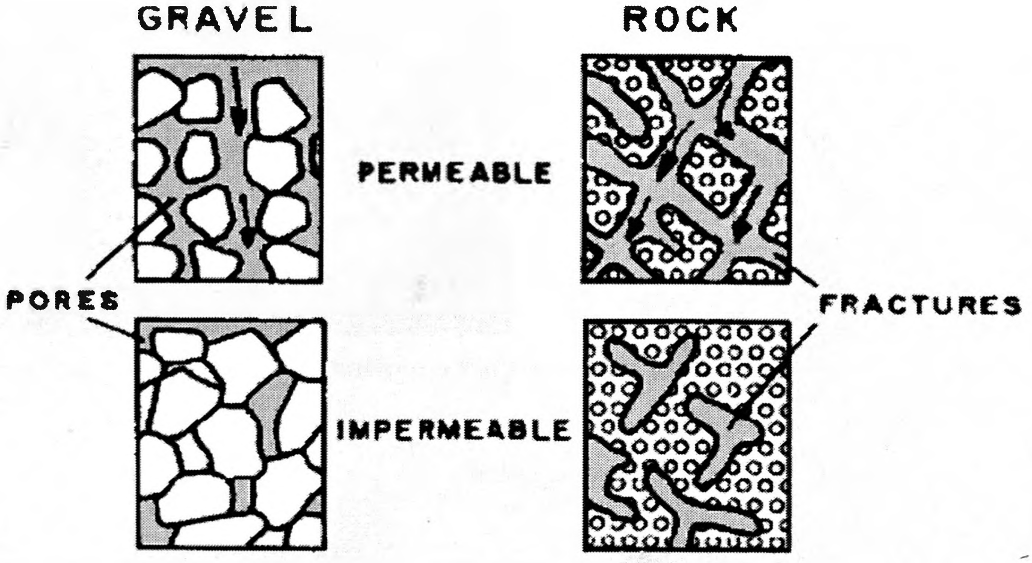


Figure.2.2.Difference types of ground water occurence

2.6.2 Faults

2.6.2.1 General nature of faults

A fault may be defined as a fracture along with there has been slipping of the contiguous masses against one another points formerly in contact have been dislocated or displaced along the fracture faulting may result from compression, tension, or torsion some faults in loose or weakly consolidated clays, sand and gravels are produced by the removal of a support.

In many cases, especially near the earth's surface, the process of dislocation is probably intermittent, although the stresses may be applied continuously and uniformly. This is because the rock does not break until it resistance is overcome.

Then it gives way suddenly, and the relief is followed by another period of quiet during which the stresses again accumulate until they occasion another movement, generally on the old fractures. Thus faulting may be accomplished a little at a time, until the tension or the compression, as the case may be, ceases to be operative. (Mathur, 2001)

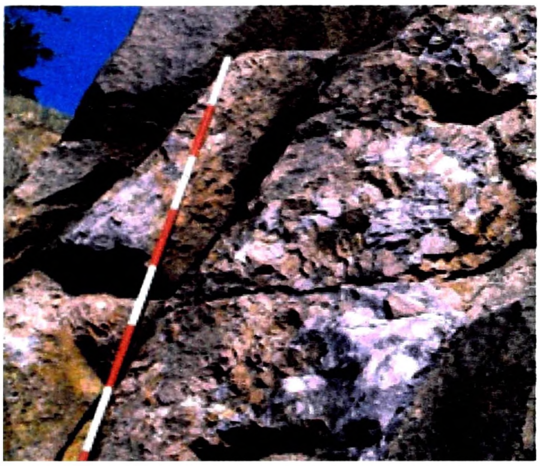


Figure.2.3. A photograph showing a fault in a hard rock.

2.7. Use of Aerial Photographs and Other Remote Imaginary

2.7.1 Conventional Aerial photographs

Geologic use remotely sensed images of the earth's surface to identify geologic features before or during the field season, to evaluate terrains for mapping routines, and as a base for geologic mapping in the field. The imagery used most commonly by geologists and photographers are black and white photographs taken from an airplane with an optical camera.(Figure.2.4) Most of these are vertical photographs, taken with a camera pointing precisely downward, thus giving a map view of the earth's surface. Vertical photographs have been made at one time or another, and many areas have been photographed several times and at different scales. (Nath, Patra, Shahid,2000)

Most available photographs can be purchased from government agencies, either as contact prints or enlargements. In the Sri Lanka, information coverage and scales can obtain from the National Survey Department. The inquiry should specify acceptable scales as well as the exact location of the area. The instructions sent by National Survey Department will include information on costs and availability of photograph indexes and enlargements.

The maps make excellent bases for geologic mapping in areas of low relief where vegetative pattern is variable, as in marshland and complexly cultivated areas. They do not have sharp detail and subtle tonal images of individual contact prints to an orthophotomap more easily than to a topographic map. (Nath, Patra, Shahid,2000)

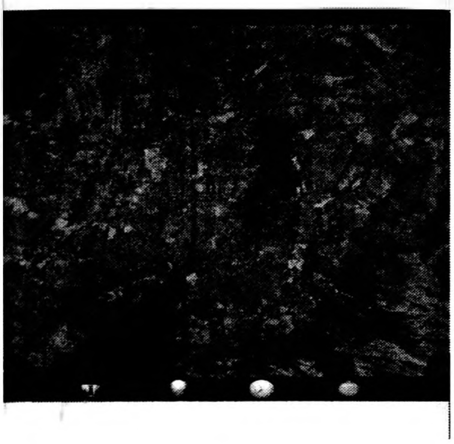


Figure.2.4. Aerial photograph covering a part in Monaragala.

2.8 Using various sources for ground water studies.

2.8.1 Aerial photographs

In many areas aerial photographs must serve as a substitute for topographic maps. Such photographs are available either as contact print or enlargements at scales ranging from 1:20000 to 1:4000. Where the photographs have been taken with sufficient overlap, they may use with a stereoscope to obtain a three-dimentional view of the terrain. Also mosaics compiled from numerous individual pictures covering large areas are frequently available.(Ahrens, Ham, 1985)

2.8.2 Topographic maps

Although topographic maps may not be necessary for all ground water studies, appreciation and understanding of topography are useful if not essential. For some reconnaissance studies, either a good planimetric map or aerial photographs may be used in the field study instead of a topographic map. However, for more detailed studies, good topographic map are a necessity. (Ahrens, Ham, 1985)

2.8.3 Geologic maps

Geological mapping comprises of recording information on the extent and distribution of different rock types and their structural deformation, through satellite imageries and ground checks.

Geologic maps and section especially when a accompanied by adequate reports, are useful in most ground water investigations and are essential where complex stratigraphy and structures are involved. Analyses of reports and maps give information on recharge areas, possible aquifers, water level conditions, structural and stratigraphic control of water movement, and related factors. (Ahrens, Ham, 1985)

2.9 Geographical Information System (GIS)

A GIS is a computer system capable of capturing, storing, analyzing, and displaying geographically referenced information; that is, data identified according to location. Practitioners also define a GIS as including the procedures, operating personnel, and spatial data that go into the system.(Figure.2.9.1)

2.9.1 Mapmaking

Researches are working to incorporate the mapmaking processes of traditional cartographers into GIS technology for the automated production of maps. One of the most common products of a GIS is a map.

Maps are generally easy to make using a GIS and they are often the most effective means of communicating the results of the GIS process. Therefore, the GIS is usually a prolific producer of maps. The users of a GIS must be concerned with the quality of the maps produced because the GIS normally does not regulate common cartographic principles. One of these principles is the concept of generalization, which deals with the content and detail of information at various scales. The GIS user can change scale at the push of a button, but controlling content and detail is often not so easy. Mapmakers have long recognized that content and detail need to change as the scale of the map changes.

Figure.2.5. Main components of GIS.

CHAPTER 03

Materials and Methods

3.1 Materials

GPS (Global Positioning System)
Aerial photographs
Stereo viewer
Stop watch
Geological maps
Topographical maps
Color pens
Oil papers
Pencil
Volume measuring buckets
Thermometer
Drilled log data and location data of tube wells

3.2 Locations

Correct marking on maps of the positions of tube wells observed in the field was essential for this research work. This was done by the process called location with the development of the Global Positioning System (GPS), précised location and time,and collection of various kinds of geographical data

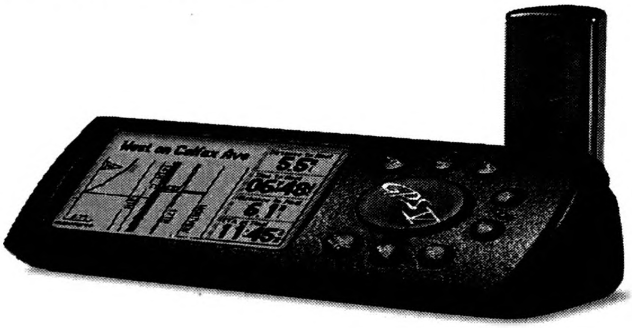


Figure.3.1. Garmin GPS.

A small, hand-hold receiver, the size of an amateur 35mm camera, receives the signals from at least four satellites and is able to locate it's position in latitude and longitude in degrees and minutes correct to the third place of decimal. Following position coordinates were recorded which belonging to their location number and their addresses. (Table.3.2)

Table.3.1 Location address, well number(assigned by the NWSDB) and GPS coordinates of ten overflowing tube wells.

Location No.	Address	Well No.	GPS coordinates
01	Wasanapura ,16 post, Badulla road, Nakkala.	31-280	06^0 53.220’N 081^{0}17. 000’E
02	Pussallawa-1, Badalkumbura road.	32-164	06^0 53.450’N 081^{0}53.000’E
03	Pussallawa-2, Badalkumbura road, Thalawagama .	–	06^{0}54.000’N 081^{0}15.000’E
04	Karawila road, Badalkumbura .	32-288	06^{0}54.000’N 081^{0}14.000’E
05	Anil stores, Muthukandiya reservoir road, Siyambaladuwa.	80-452	06^{0}57.000’N 081^{0}31.000’E
06	Maduruketiya	32-199	06^0 50.644’N 081^{0}19.334’E
07	Hulandawa left Road	–	06^0 49.604’N 081^{0}19.300’E
08	12 mile post, Thelulla , Thanamalwila road, Wallawaya .	–	06^0 53.852’N 081^{0}08.106’E
09	Kukurampola, Buttala.	32-265	06^0 42.095’N 081^{0}12.110’E
10	Wallawaya	32-296	06^0 45.490’N 081^{0}06.230’E

3.3 Use of Aerial photographs

A set of aerial photographs of Monaragala were used to identify fractured zones in the study area. Those are fallen in to the 70th box of index diagram of metric sheet Sri Lanka, designed by the Survey Department of Sri Lanka before 1980. Following methodology was used to identify fractured zones.

3.3.1Stereoscopic viewing

Vertical photographs were taken in parallel strips(flight lines)spaced so that the photographs of adjoining lines overlap sideways, and at intervals that resulted in an overlap of about 60% between adjoining photographs of one line(figure.3.2). Any two consecutive photographs of flight lines are called “stereo pairs” because they can be used to see stereoscopic views of images in the overlap area. This was done with a stereoscope, a simple optical instrument that directed one eye toward one photograph and the other eye toward the other photograph. Because the two photographs were taken from different positions, their images were melded in the viewer’s brain as a three-dimentional view, as in normal vision of nearby objects.
The folding pocket stereoscope (figure.3.3) was used in field studies because it is compact, inexpensive, and gives a moderately magnified view of the terrain.

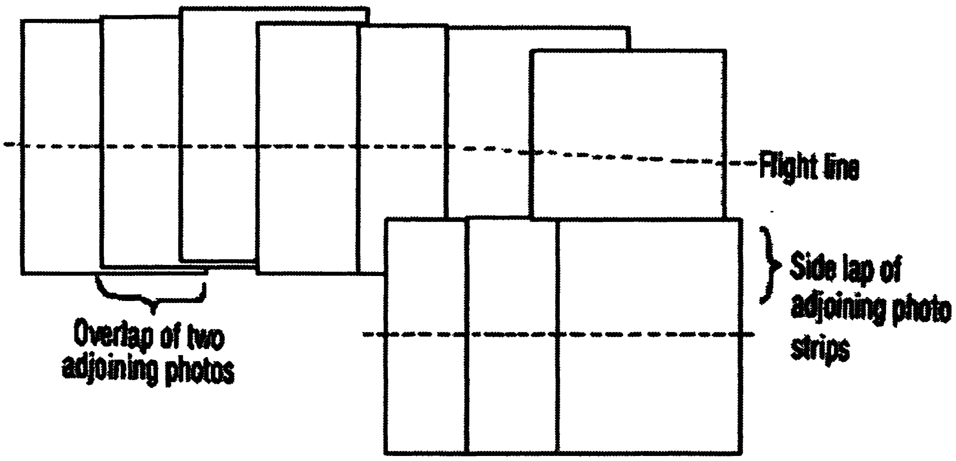


Figure.3.2. Overlapping consecutive aerial photos.

In order to avoid eye strain, it was used as follows:

1. Adjusted the stereoscope so that the centers of the lenses are the same distance apart as the pupils.

2. Placed a stereo pair on a smooth surface and in the same order as in their flight line. (figure.3.2)

3 .Selected a distinctive feature lying near the center of the overlapped area.

4 Placed one photograph over the other so that images were superimposed; then shift one photograph in the direction of the flight line until the features selected were as far apart as the distance between the centers of the of the two lenses.

5. Placed the stereoscope over the photographs so that the two images lied under the centers of the two lenses.

6. By looking into the stereoscope, the viewer should be able to see a three-dimentional image; if not, the two-dimentional images could be brought together by shifting one photograph in the direction of the flight line or by rotating one of the photographs slightly. The latter adjustment was typically required for images with great relief, only small parts of which could be viewed stereoscopically at one time.

7. To viewe the concealed part of the overlapped area, bend back the upper photograph, but not so sharply as to crease it. (Nath, Patra, Shahid,2000)

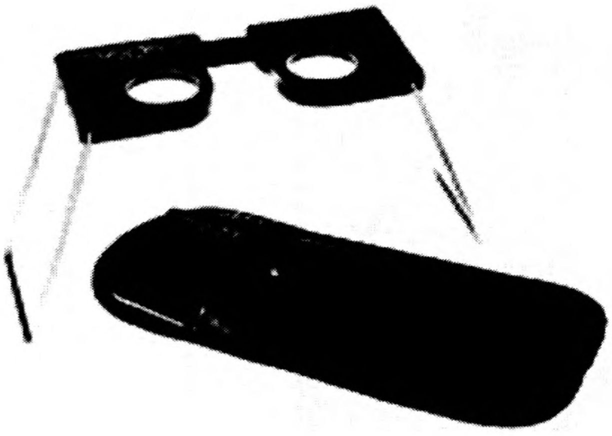
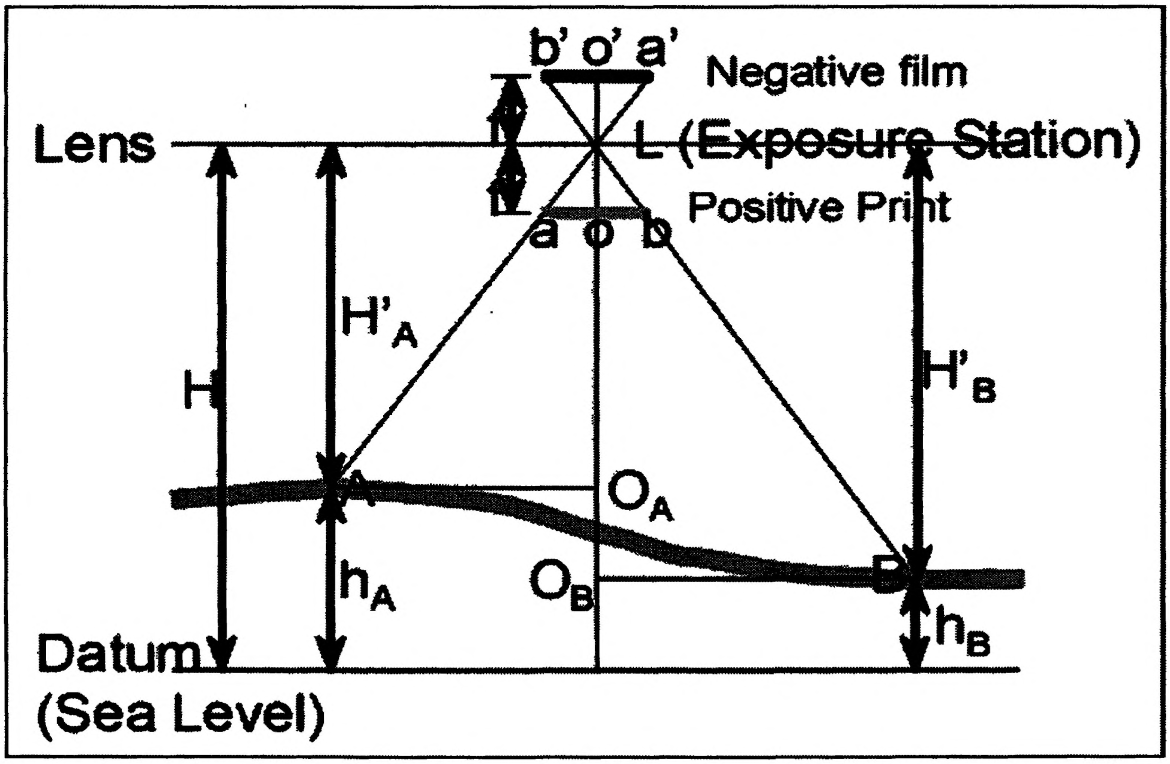


Figure.3.3. Stereo viewer.

3.3.2 Determining aerial photo scales

On a large scale map, the effect of curvature of the Earth's surface is negligible and the map is planimetrically correct. Map scale can therefore be defined as the ratio of map distance to ground distance, usually expressed as a representative fraction. On an airphoto, scale can be thought of as the ratio of photo distance to ground distance. We can estimate the scale as the ratio of the photo distance between the principal point and the conjugate principal point to the air base (ground distance between exposure stations). However, because the airphoto is a perspective view, this ratio is only approximately correct. Airphoto scale varies from the centre towards the edges of the image. (www.pca.state.mn.us, 2005)

Airphoto scale can also be determined based on the camera focal length and the altitude of the front nodal point of the camera lens at the instant of exposure. However, an implication of this is that airphoto scale varies with terrain elevation. Higher elevations are closer to the camera lens and are therefore shown on the image at larger scale than areas of lower elevation that are further from the lens. This is illustrated in the following diagram. (figure.3.4)



3.4. Determining aerial photo scale.

The scale at point A can be determined as the ratio of the image distance **ao** in the positive image plane to the ground distance **AO_A**. Since the triangles **Loa** and **LO_AA** are similar triangles (same shape but different sizes), **$oa/O_AA = Lo/LO_A = f/H'_A$**., where f is the camera focal length and H'_A is the height of the front nodal point of the lens above the ground at point A. This relationship proves that airphoto scale is equal to the focal length divided by the height of the lens above the terrain.(www.pca.state.mn.us, 2005)

The airphoto metadata provide values for the focal length (f) and the height of the lens above sea level (H). To determine the scale at points A and B, we need to know their elevations above mean sea level. This information can be obtained by inspecting a topographic map of the area. Once we know the elevations of the two we, we can calculate the scale at these locations using scale = $f / (H - h_A)$. Assume that the ground elevation at A is 3000 m, the ground elevation at B is 1500, and the height of the lens above mean sea level is 4500m. Then

- scale at A = $f / (H - h_A)$ = 150 mm / (4500 m - 3000 m) = 1 / 10,000
- scale at A = $f / (H - h_B)$ = 150 mm / (4500 m - 1500 m) = 1 / 20,000

3.3.4 Factors Affecting Airphoto Scale

Airphoto scale is thus a function of several factors including: camera focal length, flying height of the aircraft, and ground elevation above sea level. A camera with a wide angle lens (shorter focal length) has a wider field of view and thus produces a smaller scale image for a given film format. Conversely, a telephoto lens, with its longer focal length, views a smaller area and produces a larger scale image.

Flying height also affects photo scale. The higher the altitude of the aircraft (or satellite), the smaller the scale of the resulting image. Variations in ground elevation are the main reason for scale distortion in airphotos.

Higher elevations are closer to the camera and thus appear at larger scale in the image. It is general practice to try to minimize scale distortion by ensuring that the maximum relief of the area represented in the airphoto is less than 10% of the flying height.

This implies that in where the maximum relief is unlikely to exceed 200 m, a flying height of 2000 m is adequate to minimize scale distortion. However, in the Rockie Mountains where maxmimum relief might be 3,000 m, a flying height of 30,000 m would be required. (www.pca.state.mn.us, 2005)

3.3.4.2 Distortion in Airphotos

There are several types of distortion in airphotos. Scale changes are primarily due to changes in terrain elevation but there can also be scale changes between successive images along a flight line due to changes in flying height between prints. This can occur due to turbulence that prevents the pilot from maintaining a constant altitude. (www.pca.state.mn.us, 2005)

Further distortion can occur due to the camera not being level to the ground at the instant of exposure. This can occur if the nose of the aircraft is slightly up or down (pitch) or if a wing is tilted up or down (roll). Both conditions can be caused by turbulence or by manoeuvering to stay on course.(www.pca.state.mn.us, 2005)

The result is the introduction of distortion due to obliqueness in the image. Obliqueness is measured by the angle between a vertical plumb line through the centre of the lens and the optical axis of the camera lens. The principal point (P) is always at the intersection of the optical axis of the camera lens and the image plane. The nadir (N) is the intersection of the vertical plumb line through the centre of the lens and the image plane. On a true vertical airphoto, the principal point and the nadir are the same point but on an oblique airphoto they are at different positions on the image plane. (www.pca.state.mn.us, 2005)

3.3.4.3 Obliqueness in Airphotos

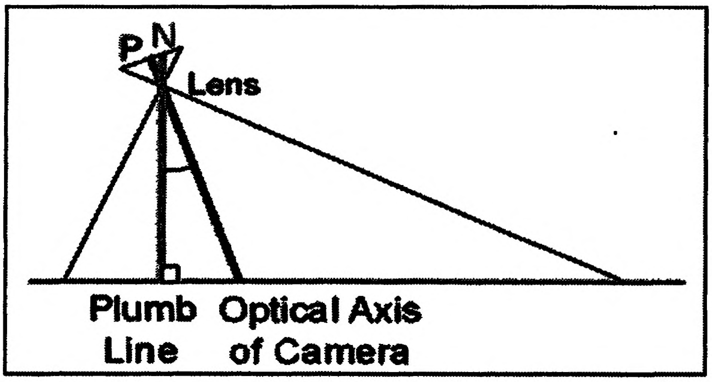


Figure.3.5. Obliqueness in Air photos.

3.3.4.4 Radial Displacement

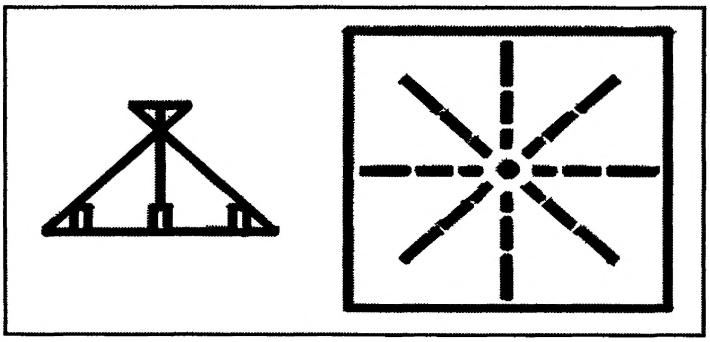


Figure.3.6.Radial displacement.

Radial displacement is a source of distortion and can result in tall objects that are close to the nadir hiding objects that are further away from the nadir.Radial displacement can also make 3-d viewing difficult if objects appear too dissimilar in successive images. This is especially a problem if the scene contains tall objects. Nevertheless, radial displacement can be useful.

Radial displacement of objects results in the sides as well as the tops of objects being visible in the airphoto. This can facilitate interpretation since objects such as office buildings and apartment buildings that may be difficult to distinguish from a plan view may be distinguished based on the appearance of the sides of the buildings, e.g. whether or not there are balconcies which are more likely to be found on an apartment building. (www.pca.state.mn.us, 2005)

Since radial displacement is always outward from the nadir of the image, we can locate the nadir by finding the intersection of lines showing the direction of object displacement, e.g. lines representing the corners of buildings that have vertical walls. As will be discussed in the next section, we can also use radial displacement as a means of calculating the heights of objects in the image.(www.pca.state.mn.us, 2005)

Distortion due to scale changes, obliqueness and radial displacement can make it difficult to transfer detail from airphotos to maps. This is most likely to be a problem in mountainous terrain where there is significant loca relief. The effect is to dramatically change the shape of objects as they appear in successive images along a flight line. (www.pca.state.mn.us, 2005)

3.3.4.5 Distortion in Airphotos

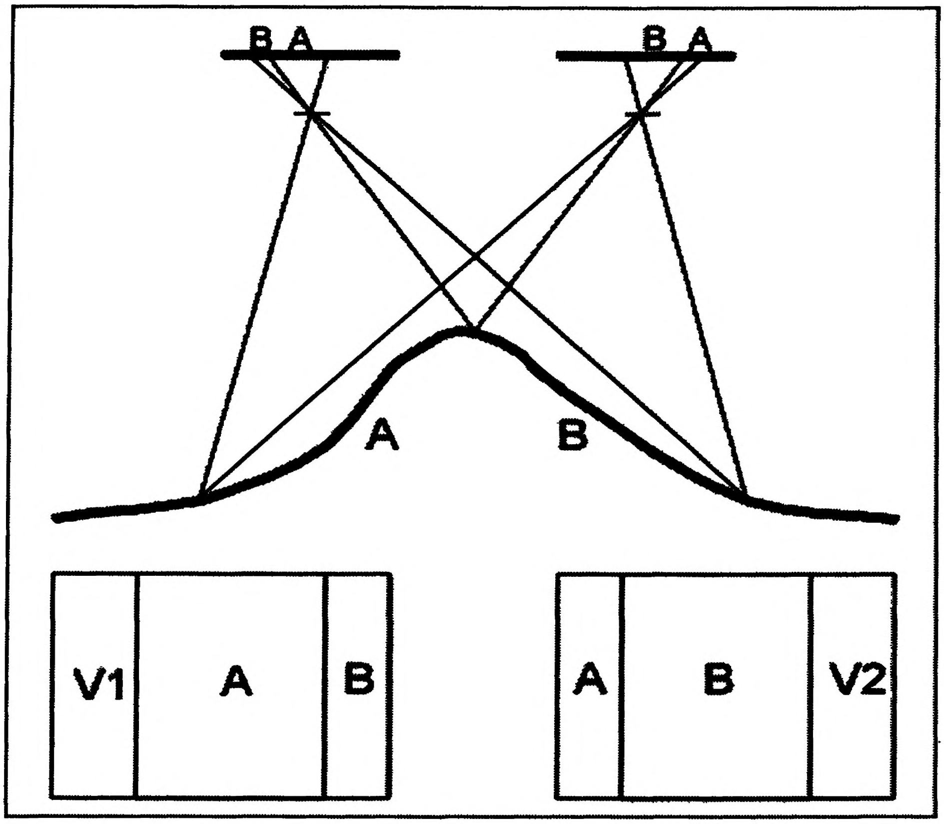


Figure.3.7.Distortion in Airphotos.

The above diagram illustrates an extreme case in which successive images along a flight line have been taken from opposite sides of a mountain ridge. Left hand image, side A of the mountain occupies most of the image while side B is a narrow sliver. The opposite is true in the right hand image. (www.pca.state.mn.us, 2005)

The extreme difference between the two images will make it difficult to view this pair of images in three dimensions and will also make it difficult to represent the mountain ridge accurately on a map. This problem can be minimized by: flying at higher altitudes to minimize scale variations and radial displacement (relief distortion); flying along valleys; using more overlap so that you have more principal points and more images to compare. (www.pca.state.mn.us, 2005)

3.3.5 Height Calculations

The height of objects in airphotos can be calculated using two different methods: the radial displacement method and the shadow length method.

The logic of the radial displacement method is illustrated in the following diagram. The vertical line **pq** represents an object, e.g. a building, whose height (**h**) we want to calculate. On the image, the building is appears as the line **aq**. Because of radial displacement of objects in the image, the top of the building is displaced outwards on the image relative to the base of the building. **D** is the length of the side of the building on the image. **R** is the distance from the nadir (**n**) of the image to the top of the building on the image. In this example, we are assuming that we have a vertical airphoto so the nadir and principal point are the same. The triangles **ONA**, **PQA** and **Ona** are similar triangles (same proportions but differ sizes). Therefore, **h/H = D/R**. Thus the height of the building can be calculated using: **h = H*D/R**.

Object Height Using Radial Displacement Method (www.pca.state.mn.us, 2005)

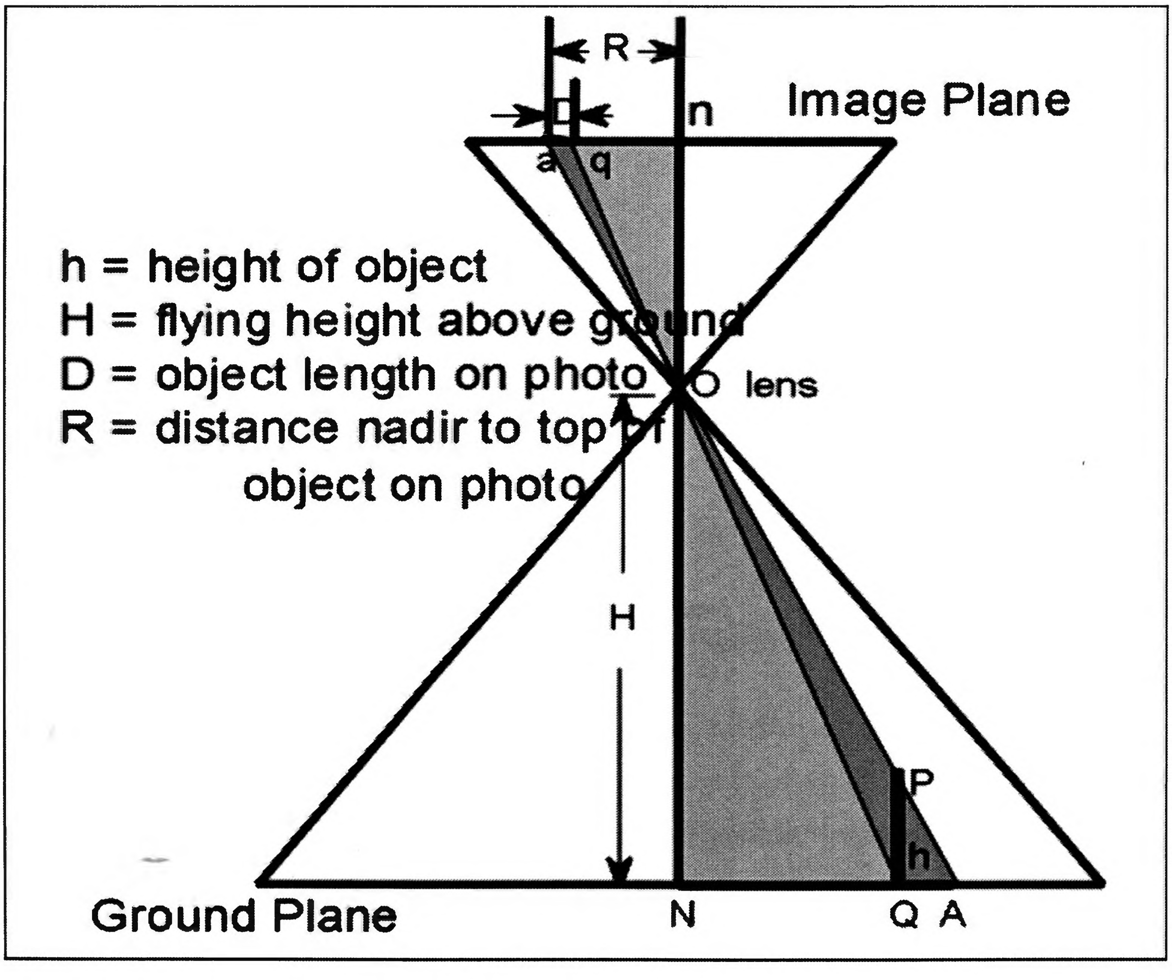


Figure.3.8. Height calculation of objects in Aerial photos.

An alternative method for calculating object heights is based on the shadows cast by the object on the image.Objects that are located very close to the nadir will have little radial displacement, making estimation of height by the radial displacement method prone to measurement errors. However, objects on images taken under clear sky conditions do cast shadows, regardless of their position on the image.

Although we cannot directly measure the height of objects on the image, we can measure the length of their shadows and can use the shadow length of the object to calculate its height provided that we know the solar angle at the time the image was taken.

Airphotos include a clock that gives the the time of exposure in Grenwich Mean Time. We can convert this into local time if we know the longitude of the object. To get the solar angle, we would need to know the latitude of the object and the date of the image. There are now several web sites that have calculators that determine sun angle for a given location and time of day. (www.pca.state.mn.us, 2005)

The tangent of the solar angle is equal to the height of the object divided by the length of its shadow. Thus if we know the solar angle(□) and the length of the shadow(**l**), we can calculate the height (**h**) of the object as h = l*tan(□).

Object Height Based on Shadow Length

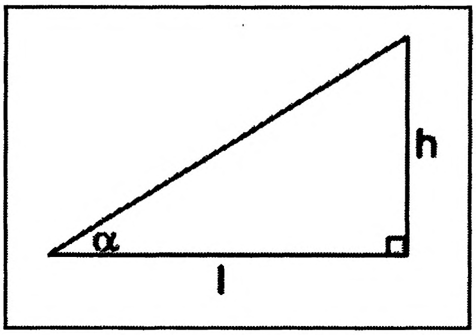


Figure.3.9.Solar angle.

3.4 Application GIS technology for map development

Aerial photos in the form of a .jpg can easily be added to an existing data frame in ArcMap, but because they contain no geographical registration information they are assigned arbitrary coordinates. The question, then, is how to correctly align the air photos with the other layers in the data frame. This can be done using the **georeferening** tools. These tools allow the user to rotate, translate, scale, and even deform the aerial photos so that they match the existing map coordinate system. The user manually makes links between features that are visible in both the aerial photo and the existing map (www.pca.state.mn.us, 2005)

The Aerial photo-GIS-method was based on the following steps:

The study sites were delineated on the aerial photo. For each site we used one or several couples of photos for a stereoscopic interpretation that was performed.

Step1: Stereoscopic aerial photo interpretation

Two consecutive aerial photos were overlapped in order of 60% coincide of each other and observed features using a stereoscopic viewer.

Step 2: Production of orthophotos

The photos were scanned with a Digital Scanning Workstation

Step 3: Data integration into a GIS

The orthophotos were geo-referenced and integrated into a GIS, using the ArcView GIS 3.2 software package. I added slope and geographic-aspect maps derived from the Digital Elevation Model, road networks and a layer of the forest areas.

Step4: Lineament and spatial distribution

By means of the GIS we drew up fractured zones distribution maps and calculated the density of lineaments both for each study site and for a selection of n random stands in each site (cf. Validation by field measurements).

3.5 Measurement of overflow rate of tube wells Using a volume known bucket measured the time to spill over it by water. Stop watch was used to count the time for each tube well. Different flow rates were taken for each tube wells. Five times taken rates of each of tube well and after calculated the mean flow rate. (www.pca.state.mn.us, 2005)

CHAPTER 04

Results and discussion

4.1 Results

The orientation of identified fractured zones are presented in tabe 4.1. Well No, GPS location, over flow state and overflow rate. Details of overflowing wells are given in table 4.2 were obtained from the people who have been using these tube wells. The highest yeild of overflow had occurred in tube well 80-452, it was reported that on 26th December 2004,on the Tsunami day. Six major fractured zones were identified using 26 of Aerial photographs which fallen in to the 70th box of index map of Sri Lanka.

Table.4.1 Coordinates of fractured zones in units of degrees and meters.(Degrees were converted into meters by using Geocalc software)

Lineament No	Coordinate XY in degrees	Coordinates XY in meters
1	81^0 9.788’/6^0 56.380’ 81^0 8.838’/6^0 55.405’	241800/192600 240000/190700
2	81^0 11.027’/6^0 57.622’ 81^0 8.379’/6^0 55.190’	245500/194400 240000/190700
3	81^0 15.351’/6^0 49.406’ 81^0 12.972’/6^0 51.243’	252860/179700 247330/183380
4	81^0 14.432’/6^0 45.459’ 81^0 21.135’/6^0 52.702’	251020/172330 263900/185240
5	81^0 28.378’/6^0 57.189’ 81^0 31.783’/6^0 48.702’	276780/194470 282330/177900
6	81^0 16.702’/6^0 00.000’ 81^0 11.513’/6^0 58.216’	254680/199970 245480/196280

Table.4.2 Field location data.

Location No.	Address	Well No.	GPS coordinates	Over flow state	Over flow rate(lpm)site
01	Wasanapura ,16 post, Badulla road, Nakkala.	31-280	06^0 53.220’N 081^{0}17.000’E	Only rainy period	0.5
02	Pussallawa-1, Badalkumbura road.	32-164	06^0 53.450’N 081^{0}53.000’E	Only rainy Period	0.7
03	Pussallawa-2, Badalkumbura road, Thalawagama .	–	06^{0}54.000’N 081^{0}15.000’E	Ideal (continuously)	0.9
04	Karawila Badalkumbura .	32-288	06^{0}54.000’N 081^{0}14.000’E	Only rainy period	2
05	Anil stores, Muthukandiya reservoir road, Siyambaladuwa.	80-452	06^{0}57.000’N 081^{0}31.000’E	Only rainy period	3
06	Maduruketiya	32-199	06^0 50.644’N 081^{0}19.334’E	Only rainy period	2
07	Hulandawa left Road	–	06^0 49.604’’N 081^{0}19’ 300’’E	Ideal (continuously)	10
08	12 mile post, Thelulla , Thanamalwila road, Wallawaya .	–	06^0 53’ 852’N 081^{0}08.106’E	Ideal (continuously)	15
09	Kukurampola, Buttala.	32-265	06^0 42.095’N 081^{0}12.110’E	Only rainy period	0.3
10	Wallawaya	32-296	06^0 45.490’N 081^{0}06.230’E	Only rainy period	0.4

4.1.1 Site location of wells

Site locations were recorded from drilled log data of Water Supply and Drainage Board, Ground water Section Monaragala. Out of hundreds of drilled log data following ten drilled log data were only in a overflowing condition. (Table.4.3)

Table.4.3 Site location data.

Location No.	Well No	Geomorphology	Soil type	Rock type
01	31-280	Top of ridges	Sandy clay	Biotite gneiss
02	32-164	Top of ridges	Sandy clay	Not visible
03	_	Flat undulated area	Residual soil	fracture
04	32-288	Undulated area	Sandy clay	Granitic gneiss quartzite
05	80-452	Flat area	Sandy clay	Granitic gneiss
06	32-199	Flat undulated area	Sandy clay	Biotite gneiss
07	_	Flat undulated area	Sandy clay	Gneiss
08	_	Flat undulated area	Sandy clay	Hornblend biotite gneiss
09	32-265	Undulating terrain	Residual soil	Fracture
10	32-296	Almost flat land	Sandy clay	Quartzite and garnet sillimanite biotite gneiss

Aerial photographs belonging to the 70th box of index map of Sri Lanka were observed and identified lineaments/fractured zones.

After the interpretation of Aerial photographs, above global positioning coordinates were taken which relation to fractured zones. (Table.4.1)

Overflowing tube wells located map and fracture zones located map were overlaid each other by using GIS technology. This developed map was revealed availability of a relationship between overflowing tube wells and fractured zones.

The resulting map indicates a relationship between the fractured zones and overflowing tube wells.

Relationship between Over flowing tube wells and fractured zones

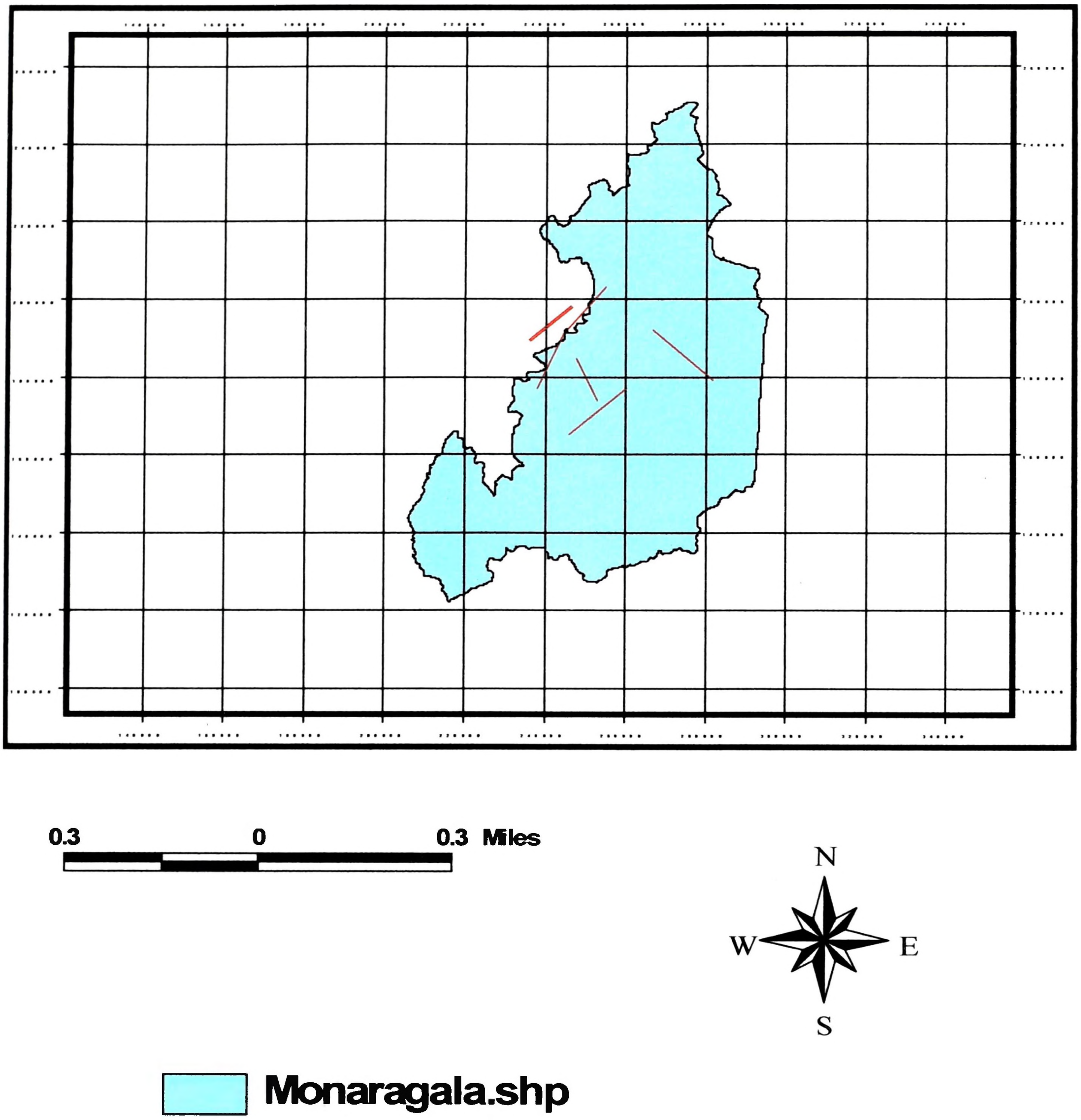


Figure 4.1 Map showing the orientation of fractured zones in Monaragala

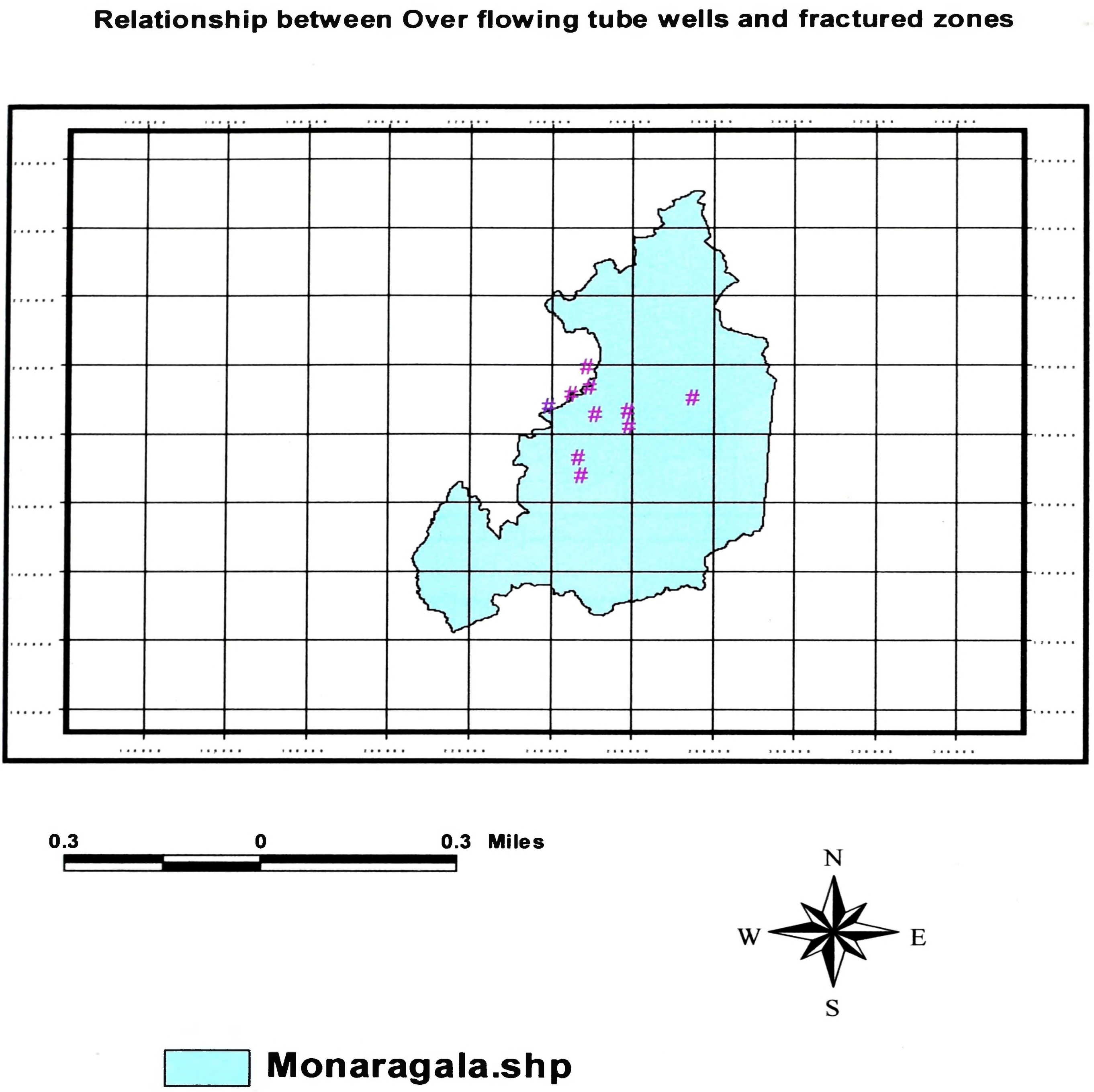


Figure 4.2 Map showing the orientation of Ten overflowing tube wells in Monaragala.

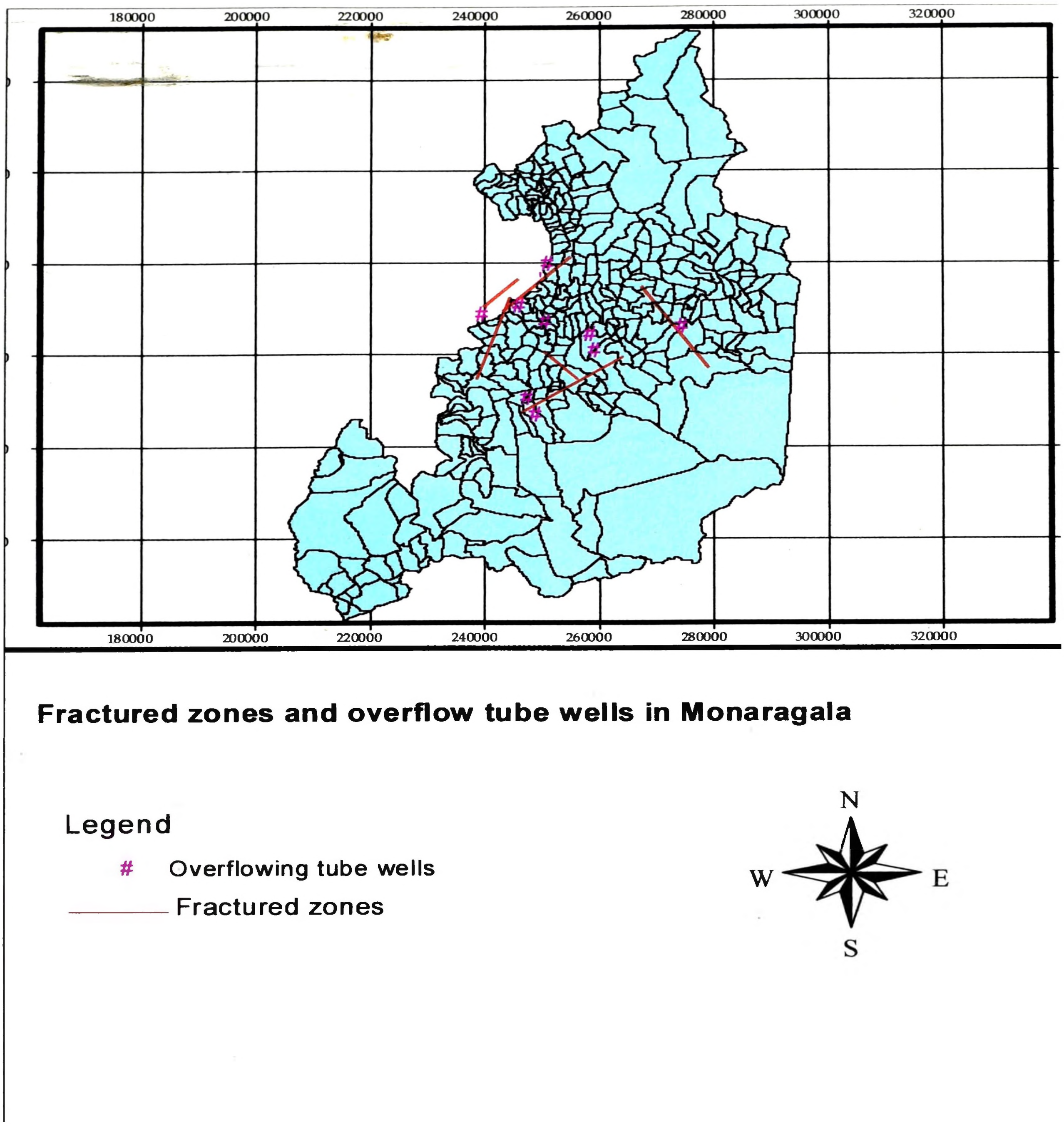


Figure 4.3 Map showing the orientation of fractured zones and locations of overflowing tube wells in Monaragala.

This all of maps were produced by using Arcview GIS 3.2 software package.

4.2 Discussion

Most of tube wells were on the paths of lineament, also there is a relation to fractured pattern. Other reasons may be governed the overflow condition, such as soil type, rock type and other hydrogeological reasons. Out of ten of my observed tube wells only three wells in the ideal condition, but other wells drying in dry period. However all of wells give full of yield in the rainy period.

Overflowing tube well in Thelulla near to Wallawaya in Thanamalwila, Wallawaya road is the ideal artesian tube well in Monaragala. (Figure.4.2.1) This well have high yield in both dry and wet seasons.

Figure 4.4. Thelulla overflowing tube well.

Despite of Thelulla, Hulandawa left and Pussallawa-2 wells other over flow tube wells become dry.

Figure 4.5. Karawila overflowing tube well.

In above figure is showing that how to dry tube wells in dry period and having a big problem of water take.

Main objective of this my research work is development of locations for construct tube wells with high performance. But I have done this work only on the aerial photo graphs. If I had been used satellite imageries I can be develop a good map than this map. Structural study involves the mapping of linear features representing major faults or joints(lineaments), detection uncomformities, mapping of bedding planes and folds of regional extent. Satellite imageries provide the most useful single tool for initiating a regional analysis of large scale tectonism and structural deformation as they provide synoptic views of large areas ata constant low azimuth sun angle thereby creating an apparent relief and accentuating minor variation in the morphology.

CHAPTER 05

Conclusion and Recommendations

5.1 conclusion

In according to final results can be concluded as there is a relationship between overflowing tube wells and fractured zones. Seven tube wells out of ten tube wells were intersected with lineaments.(Figure.4.3) Most of identified fractured zones were directed toward upland catchments such as Badulla, Bandarawela and Passara. Therefore can be determined as overflowing tube wells are created long confining aquifers that overlaying and underlying by hard rock formations.

5.2 recommendations

Considerably there are hundreds of tube wells constructed in the Monaragala district under supervision of Water Supply and Drainage Board, but they do not in a position to supply water for demand in future long droughts. Monaragala is a district which belonging to the dry and intermediate zone of the rainfall. This region is the margin of mountains of Badulla and Bandarawela and contains many sustain ground water bodies.

Many overflowing tube wells appear in this region, reason of the underground streams flow seaward through artesian aquifers from catchments of uplands such as Badulla and Bandarawela. These wells are energy saving wells due to without pumping and giving high yield of water. Tube wells with high performance can be constructed after finding locations of underground streams movement in a sustainable manner.

With the advancement in technology, man is changing the face of the earth rapidly. In order to give the development a proper direction with due consideration to environmental preservation, a planner needs to have an overall picture of the status of the region and it's resources. Conventional methods of data collection are extremely time consuming and are normally outdated. In such circumstances, earth resource monitoring by space platforms is the only answer. The generation of accurate and reliable information at a cost-effective and short turnaround time, coupled with a wide range of earth resource monitoring applications has led to the acceptance of this as technology by the scientific community

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