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MANAGEMENT PROJECT (SIAM II)**

**COMPONENT 5.01: LAND ADMINISTRATION AND SURVEY**

**GPS GUIDELINES & RECEIVER OPERATION MANUAL**

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## **1. INTRODUCTION**

These instructions have been prepared as a guide to assist Ministry of Natural Resources, Environment & Meteorology, (MNREM) Survey staff in the operation of the Trimble 5700 GPS Receivers. They were developed by Andrew Dyson, Team Leader/Geodetic Adviser, with the assistance of Keilani Soloi, National Survey Adviser. Development was undertaken under the Government of Samoa (GoS) Second Infrastructure Asset Management Program (SIAM-2), Component 5.01 - Sustainable Management, Land Administration and Survey Technical Assistance Program.

Reece Gardner, GPS trainer, provided additional valuable input into revision of these instructions.

Most of the general instructions are applicable to any GPS survey. However, the receiver operating instructions are specific to the Trimble 5700 GPS Receivers. At the end of the document are some general guidelines to assist in the planning of GPS surveys.

Refer also to the *Trimble 5700/5800 GPS Receiver User Guide* provided with the receivers.

Samples of the GPS Field Sheets, to be used on MNREM GPS surveys, are included at the end of this document.

These instructions should be reviewed regularly and updated as required.

## **2. GENERAL INSTRUCTIONS**

The GPS and ancillary equipment is expensive high precision electronic surveying equipment. As such it must be well maintained and looked after with care. Treat it as you would a theodolite, EDM or Total Station and it will give many years of service. To operate the equipment relies on cables and batteries and these must also be treated with great care.

### **2.1 Preparation**

Ensure that tribrachs and adaptors are in adjustment.

Ensure that batteries are fully charged before starting the day's observations. See section 2.6 below for information on battery charging.

Advise local officials and property owners of activities.

Teams should ensure that their watches are synchronised to the correct local time to ensure that all teams are operating at the correct time and that observations will be simultaneous. GPS observations must be carried out simultaneously at all stations. Therefore each GPS Team must ensure that they observe at the scheduled times.

To ensure that observations start by the scheduled time, start setting up the equipment at least 30 minutes before the scheduled start time. The receiver should be switched on at least 10 minutes before the scheduled time. New operators should allow at least 15 minutes for the start up procedure.

For static control observations the observations should be started as soon as possible after setting up the equipment, do not wait until the scheduled start time.

When travelling, equipment must be carefully packed to avoid damage. GPS equipment must not be carried in the back of open vehicles.

## 2.2 Equipment Setup

The antenna must be carefully set exactly over the station mark. Unless instructed otherwise, the antenna should be set as high as possible to minimise obstructions. The survey vehicle should be kept well away from the antenna to minimise the risk of multi-path. If possible, clear all obstructions above 15° elevation.

When setting the tribrach and adaptor over a survey mark, the tube bubble must be used for precise levelling in the same way that a theodolite is levelled and centred over the survey mark. The small circular bubble should only be used for initial levelling. Always rotate the adaptor through 180° to ensure that all bubble errors are taken into account.

Check the centring over the survey mark using the optical plummet in a number of positions through the full 360° or rotation to ensure that you compensate for any errors in the optical plummet.

Adjust the bubble or optical plummet if there are large errors in either.

Ensure that the antenna setup is stable. Take particular care on hard and slippery surfaces, and when windy. It may be necessary to use sandbags with a tripod and/or to chip holes in concrete or rock or take other steps to secure the tripod/bipod legs. Sand bags **must** always be used when surveying with a range pole and bipod. The preferred position for the bipod is such that when the operator is setting it up he stands with the bipod legs either side of him and facing directly into the wind.

The threaded adaptor in the top of the tribrach adaptor should be removed from the adaptor and tightly screwed into the antenna then replaced. Do not screw the antenna onto the threaded adaptor while it is attached to the tribrach adaptor. It may also be easier to attach the antenna cable to the antenna before placing the threaded adaptor in the tribrach adaptor.

The Zephyr Geodetic Antenna (referred to as the Geodetic Antenna) will always be used for second and higher order observations. This is the larger antenna with the integrated ground plane. The Geodetic antenna must also be used at the base or reference station for third order observations.

Third order roving units will use the smaller Zephyr Antenna (referred to as the Zephyr Antenna) when using a range pole and bipod setup.

Use the appropriate length antenna cable for the situation. Connect the antenna cable to the receiver & antenna (unroll cable completely). Take care when screwing the cable to the antenna and receiver to ensure that the thread is not crossed. Particular care should be taken when connecting the 30m heavy duty cable.

The antenna should be oriented to magnetic north by pointing notch 1 and the antenna cable connection to magnetic north. The antenna should be oriented to north after the cable is attached. If necessary tie the cable to a tripod leg or the pillar to avoid any strain on the antenna. After orienting the antenna ensure that all clamps are screwed up tight to prevent the antenna from rotating during the observation.

Connect the GPS receiver to the Trimble Survey Controller (TSCe) using the black cable (PN 31288-02). Connect to the controller socket (2) on the receiver. **When connecting “lemo” plugs ensure that the red dot on the plug is aligned with the red dot on the socket.**

Protect the receiver and controller from direct sun by placing the equipment in the shade if possible or using an umbrella. Particular care should be taken to keep the controller screen out of the direct sun for extended periods.

Ensure that batteries are inserted into battery compartments at the base of the receiver and the heavy duty battery connected if appropriate. Always use at least two batteries and monitor their status during the observations.

The antenna must not be disturbed during the observations and GPS signals must not be obstructed by people or vehicles. People (especially children), animals and vehicles (including the survey vehicle) should be kept well away from the antenna, cables and receiver.

The equipment must not be left unattended, especially when observing.

If occupying the same point for consecutive observations, reset the tripod and antenna at a different height between observations and measure the antenna height before starting the next observation. This practice ensures that the second observation at the same point is independent of the first observation.

### 2.3 Observation Times

For Static observations, the start and finish times will be determined before leaving the office. Any changes to the start and finish times must be authorised by the Team Leader and will only be made if all GPS parties are in communication.

For Fast Static observations the roving teams must not start observations before the base/reference receiver is logging data. Good communications are useful and can save considerable time. The roving teams must make a decision as to when they have sufficient observations at each point before moving to the next point. This will be based on the distance from the base station and the pre-determined observation times for the number of satellites observed. See 3.6.2 & 3.6.3 below for further details.

Refer to the General Guidelines at the end of this document for the suggested length of observations for different GPS operations.

For Fast Static observations, the suggested times are for the minimum period of unbroken data. If in doubt record more data.

If observations are conducted in a remote area, where the baselines cannot be processed and validated before the field teams leave the area, consider using longer observation times.

### 2.4 Observation Guidelines

PDOP should be less than 8 and preferably less than 5 particularly for shorter observations such as Fast Static. Try to avoid periods of high PDOP when planning observations.

Satellites should be above 20° elevation if possible.

Antenna heights are critical and must be carefully measured and independently checked at the start and finish of the observations.

When using the Geodetic Antenna on a tripod, antenna heights are obtained by taking metric readings to three notches evenly spaced around the antenna. Measurements are made using the folding height of instrument rod and read to the “**bottom of notch**”. The measurements are recorded as slope measurements. Mean the three measurements and record on the field sheet. This measurement is entered into the controller before commencing the observation, check that the “*Measured to*” field is “**bottom of notch**”. As an independent check, one imperial measurement should be taken and converted to metres while on-site.

When using the Geodetic Antenna on a pillar, take the mean of three metric readings to the “**bottom of antenna mount**” using a tape measure. Measurements should be evenly spaced around the antenna. The measurements are recorded as true vertical measurements. Mean the three measurements and record on the field sheet. This measurement is entered into the controller before commencing the observation, check that the “*Measured to*” field is “**bottom of antenna mount**”. **This option must be selected before entering the antenna height.** As an independent check, one imperial measurement should be taken and converted to metres while on-site.

When using the Zephyr Antenna on a range pole, read the height before and after commencing the observation and again before completing the observation. This measurement is entered into the controller before commencing the observation, check that the “*Measured to*” field is “**bottom of antenna mount**”.

The person checking the antenna height should initial the relevant entry on the field sheet.

Ensure that each team is using a compatible *Survey Style* for the observation. In particular the observation rates must be identical. For most observations it will be 15 seconds as defined in the *Survey Styles*.

Always check that correct Pt ID and Antenna Ht have been entered into the receiver.

If the monument is not inscribed with the Pt ID, the point name and/or number inscribed on the monument must also be indicated on the GPS Field Sheet and should be entered into the receiver as a comment.

During the session, regularly monitor satellites tracked (continuous and total counts), signal to noise ratios and battery condition. Record details of anything unusual on the field sheet, including periods of high PDOP.

Note details of any obstructions, large structures, power lines, radio transmitters and any other comments on the back of the field sheet. Also note the weather conditions throughout the session.

Ensure that the GPS Field Sheet is correctly and completely filled in with a black pen.

Do not stop observations before the scheduled stop time unless instructed to do so by the Team Leader.

## **2.5 Packing Up Instructions**

Ensure that all cable connectors are kept dry, off the ground and out of dirt and water.

When removing “lemo” plugs, only remove by gripping the wire loop and pulling firmly directly away from the socket.

Replace all caps and covers. Ensure that the black “lemo” caps are aligned correctly, note the keyed slot inside the cap is to be aligned with the red dot and the raised key on the lemo plug.

The black plastic cover must be placed securely on top of the tripod immediately after the tribrach is removed.

Cables should be carefully rolled up.

Before transporting, all equipment is to be **clean and dry** before being returned to boxes or bags. Use rags to clean and dry equipment. Clean all mud and other material from the feet of tripods before placing in the bag “feet first”.

If equipment is not properly dried, it should be removed from bags and boxes on returning to the office or overnight accommodation and all items including boxes and bags thoroughly dried before the equipment is returned to its containers. No equipment must be left sealed in containers in a damp state.

Use your equipment check list to ensure that all items have been returned to their containers and stored in your vehicle before leaving the site. Carry out a visual site inspection to ensure that you haven’t left any items of survey or personal equipment and that you have removed all rubbish before leaving.

## 2.6 Battery Charging

Batteries must be charged as soon as possible after returning to the office or accommodation after completing the day's observations.

When charging batteries, ensure that cables are unwound and that batteries and chargers are in a well ventilated space.

The following batteries must be charged:

Internal Receiver batteries (2 x Lithium-ion PN 52030)

External heavy duty Receiver battery (6Ah yellow battery PN32364-00)

Survey Controller internal battery

Three battery chargers are provided with the Trimble 5700 equipment as follows:

2 x FRIWO battery chargers (for internal receiver & controller batteries)

1 x 6Ah battery charger PN 32595-00 (for external heavy duty battery)

The batteries and chargers are connected as follows:

### 2.6.1 5700 GPS Receiver

The internal receiver batteries are charged using one of the FRIWO chargers, connected to the download/charger cable PN 32345. The output plug from the charger is plugged into the back of the cable plug and the cable lemo plug is plugged into Port 2 on the receiver (see photo below).

Charging time is 4 hours per battery. Therefore allow 8 hours to charge both batteries.

Refer to the Trimble 5700/5800 GPS Receiver User Guide pages 42-48 for more information about batteries, battery charging and power supplies. Note that all batteries lose charge over time when not being used and that Lithium-ion batteries must not be allowed to discharge to less than 6 volts. Accordingly it is recommended that Lithium-ion batteries be kept on continuous charge when not in use. This won't damage the batteries or the receiver. Alternatively they must be charged regularly, be fully charged before storing for long periods, and be re-charged at least every 3 months.



### 2.6.2 External Battery

The heavy duty external battery (6Ah yellow battery PN32364-00) is charged using the 6Ah battery charger PN 32595-00. The lemo plug on the output cable from the charger is connected to the lemo plug on the battery (see photo below).

Charging time is a minimum of 6 hours per battery.



### 2.6.3 Survey Controller

The survey controller is charged using one of the FRIWO chargers, connected to the Multi Adaptor TSCe PN E0905, the output plug from the charger is plugged into the end of the Multi Adaptor and the other end is connected to the survey controller (see photo below). The controller battery should be charged for a minimum of 2 hours.



### 3. TRIMBLE 5700 RECEIVER OPERATING INSTRUCTIONS

The receiver is normally controlled from the hand held Trimble TSCe Survey Controller. Use of the controller allows for input of point numbers and antenna heights, and for detailed monitoring of the status of observations. In an emergency situation or for long sessions when the controller battery is considered inadequate for the full session it is possible to operate the receiver and record data without the controller. See section 3.8 for details.

#### 3.1 TSCe Survey Controller

The controller has a full keypad but much of the operation will be done using the controller's touch screen. When selecting options from the touch screen, only do so using the special pointer provided with the controller. **Do not touch the screen with the tip of a pen or pencil as this will damage the screen.**

**Warning:** Do not press the Close/Exit button (in top RH corner of the screen during an observation as this will immediately terminate the observation.

##### 3.1.1 Disabling/Enabling Controller Screen

To avoid accidentally interfering with the controller during an observation or when moving between observations while the controller is switched on, the touch screen can be disabled.

To disable the screen: Press CTRL (yellow button) + On/Off (green button).

To enable the screen: Press CTRL (yellow button) + On/Off (green button).

##### 3.1.2 Illumination of Controller Screen

The controller screen gives the brightest display in bright sunlight. When light conditions are poor the screen may be illuminated but note that this will reduce battery life.

To illuminate the screen: Press Shift (blue button) + On/Off (green button).

To turn off illumination: Press Shift (blue button) + On/Off (green button).

##### 3.1.3 Controller Reset

If the controller does not respond to touching the screen or keypad operations it may be necessary to "reset" the controller. Before trying to reset the controller check that the screen cannot be enabled using the steps in 3.1.1 above.

To reset the controller there are two options -- a *soft reset* or a *hard reset*. Try the *soft reset* first, if this fails use the *hard reset*.

###### *Soft reset*

[Shift]+[Ctrl]+[On/Off]

A soft reset leaves the RAM intact, but stops all running programs. It is the preferred method for dealing with lockups, and will clear all but the most severe system freezes.

###### *Hard reset*

Hold down the On/Off button for 20 seconds.

### 3.2 Starting the Observations

<b>Starting the Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
	On the Survey Controller, press GREEN on button
Trimble Startup	Select: <b>Survey Controller icon</b> (double tap). Briefly displays Trimble Survey Controller Version No.
Menu	Powers up the receiver (takes a few moments) Indicates current “Job” name in the top panel. Status Bar – top RH side of display. Survey Controller buttons – below Status Bar. Status Line – bottom of screen. Menu Icons in centre of screen
Menu	To create a “New Job” Select: <b>Files icon</b> (single tap) New job Enter Job Name: suggested format JobnameCyy-ddd-n (C=receiver colour; yy=year; ddd= day of year; n=session) eg. PrimB05-226-1 <i>Switch to Screen 2 (1/2 button)</i> Reference: Reference Station ID if Fast Static survey. Description: Project name. Operator: Your name. Notes: Any comments. Select: <b>Enter</b> <b>Accept</b> Indicates new “Job” name in the top panel.

### 3.3 Static Observation

For static observations and for base/reference receiver observations:

<b>Static Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Menu	<p>To start Static observation:</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Survey icon</b> (single tap)</p> <p style="padding-left: 40px;">Static</p> <p style="padding-left: 40px;">Start base receiver</p> <p>Enter</p> <p style="padding-left: 40px;">Point Name. (if displays “Point does not exist. Provide coords at processing time” – press OK)</p> <p style="padding-left: 40px;">Antenna Height (measured with folding pole for tripod mounted, use a tape measure for a pillar and change “Measured to” field before entering “Ant Ht”)</p> <p style="padding-left: 40px;">Measured to – select <b>Bottom of Notch</b> (tripod) or <b>Bottom of Antenna Mount</b> (pillar – change before entering “Ant. Ht”).</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Enter</b> (if displayed)</p> <p style="padding-left: 40px;"><b>Start</b></p>
Base	<p>When survey starts, indicates “Base” in the top panel.</p> <p>Displays:</p> <p style="padding-left: 40px;">Point.</p> <p style="padding-left: 40px;">Time so far</p> <p style="padding-left: 40px;">Approx memory left (Record on Field Sheet)</p> <p>Continue observation until designated stop time.</p>
Base	<p>Monitor controller throughout the observation, see <i>Monitoring Observations</i> in section 3.4 below to view the different information available during the session.</p> <p>The File name should be obtained from Review current job in accordance with the instructions in <i>Monitoring Observations</i> below.</p> <p>At designated stop time (or when instructed by the Team leader), end the survey:</p> <p>Select:</p> <p style="padding-left: 40px;"><b>End</b></p>
Survey ended	<p>Displays:</p> <p style="padding-left: 40px;">Power down receiver.</p> <p>Select:</p> <p style="padding-left: 40px;">Yes</p>

<b>Static Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Survey ended	Displays: Disconnect the cable from the controller. Remove controller cable from receiver Select: OK
Menu	Select: <b>Exit</b> Yes
Trimble Startup	Press GREEN off button

If the controller cable is not removed from the receiver before pressing OK, the receiver may switch on again. If so, press and hold the green power button on the receiver until the lights go off.

### **3.3.1 Additional Static Observations**

For second and subsequent sessions scheduled for the same day, you should use the same Job unless instructed otherwise by the Team Leader. Set up and restart the receiver in accordance with the Static Observation Instructions above.

**If occupying the same point for consecutive observations remember to reset the tripod and antenna at a different height between observations and measure the antenna height before starting the next observation.**

Start the next session as soon as the equipment is set up.

### 3.4 Fast Static Observations

For fast static observations:

<b>Fast Static Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Menu	<p>To start Fast Static observation:            Select:                <b>Survey icon</b> (single tap)            Select either:                Fast Static 5k (for distances up to 5km from base station) <b>or</b>                Fast Static 10k (for distances up to 10km from base station)                Measure points</p>
Measure Points	<p>Enter            Point Name. (if Point name already exists, will give a warning – press OK. If point number is correct proceed, if not correct and proceed)            Code (enter point code or description of mark)  <b>For pole mounted Zephyr Antenna:</b>            Antenna Height (measured from the range pole)            Measured to – select <b>Bottom of antenna mount</b>.            Select:                <b>Measure</b> (may need to press <b>Enter</b> first)</p>
Measure Points	<p>Displays:            Point name.            Code            Method (FastStatic point)            Antenna height            Measured to  <b>Check the displayed information and amend if necessary.</b>            If OK:                <i>Switch to Screen 2</i></p>

<b>Fast Static Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Measure Points	<p>Displays:</p> <p style="padding-left: 40px;"><b>Occupation times</b> as follows:</p> <p style="padding-left: 40px;">Time to go</p> <p style="padding-left: 40px;">Time so far 4 SVs</p> <p style="padding-left: 40px;">Time so far 5 SVs</p> <p style="padding-left: 40px;">Time so far 6 SVs</p> <p>This information is based on the observation times set in Configuration\Survey styles\Fast Static point\L1/L2 FastStatic times. These times are preset in the Survey style and should not be changed during an observation.</p> <p>When the minimum time is reached for any of these options, “Time to go” will show as 0h0m0s and the <b>Store</b> button will appear in the bottom RH corner.</p> <p>Monitor controller throughout the observation, see <i>Monitoring Observations</i> in section 3.4 below to view the different information available during the session, in particular the satellite information.</p> <p>It is vital that the satellite information is monitored during the observation to ensure that sufficient good data has been recorded before pressing <b>Store</b>. <b>You must not rely on the “Occupation times” alone as they take no account of the satellite signal to noise ratios(S/N) and may not indicate a break in L2 data.</b></p> <p>When you are satisfied that you have sufficient data for this observation:</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Store</b> (go to the next Measure points Panel below)</p> <p>If there are obstructions at the site that interfere with the satellite signals it is possible that you will not reach the required occupation times and it may be necessary to terminate the observation at a particular point before the <b>Store</b> button appears in the bottom RH corner. If so:</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Enter</b> (bottom RH corner)</p>
Confirm	<p>Displays:</p> <p style="padding-left: 40px;">Required time to be spent static has not yet elapsed. Continue and store point.</p> <p>If you wish to terminate the observation at that point:</p> <p>Select:</p> <p style="padding-left: 40px;">Yes</p>

<b>Fast Static Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Measure Points	<p>You may now move the antenna and move to the next point to be occupied without switching off the receiver and controller. You may disconnect the antenna cable if required.</p> <p>When set up at the next point:</p> <p>Enter</p> <p style="padding-left: 20px;">Point Name</p> <p style="padding-left: 20px;">Code</p> <p style="padding-left: 20px;">Antenna Height</p> <p style="padding-left: 20px;">Measured to</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Measure</b></p> <p>Repeat the above steps until the last point has been observed</p>
Measure Points	<p>To end the survey:</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Esc</b> (bottom LH corner)</p>
Menu	<p>Select:</p> <p style="padding-left: 40px;"><b>Survey icon</b> (single tap)</p> <p style="padding-left: 40px;">End Survey</p>
Survey ended	<p>Displays:</p> <p style="padding-left: 40px;">Power down receiver.</p> <p>Select:</p> <p style="padding-left: 40px;">Yes</p>
Survey ended	<p>Displays:</p> <p style="padding-left: 40px;">Disconnect the cable from the controller.</p> <p>Remove controller cable from receiver</p> <p>Select:</p> <p style="padding-left: 40px;">OK</p>
Menu	<p>Select:</p> <p style="padding-left: 40px;"><b>Exit</b></p> <p style="padding-left: 40px;">Yes</p>
Trimble Startup	Press GREEN off button

If the controller cable is not removed from the receiver before pressing OK, the receiver may switch itself on again. If so press the green power button on the receiver and hold until the lights go off.

### 3.5 During Observations

During the observations the status of the receiver and survey should be monitored about every five minutes.

As soon as you start logging data, the file name should be extracted from the “Current Job” and entered onto the field sheet. See - “Review Current Job” below.

Then switch to the satellites screen and monitor the data that has been logged for each satellite on both L1 & L2. This is the best indicator that data is being logged and it is suggested that you leave the L2 screen open when not looking at other screens. See – “Satellite Status” below.

The various windows that can be opened to display information may be kept open or active throughout an observation and the operator can move between these active windows using **Switch to** from the Survey Controller buttons. Alternatively, open windows may be added to the “Favourites” by selecting **Favourites** from Survey Controller buttons then Add to favourites. Windows in “Favourites” may be accessed at any time.

To monitor the observation use the following features:

<b>Monitoring Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
<b>Battery status</b>	
Base or Measure Points	<p>The battery status can be quickly checked by viewing the battery indicators at the top of the Status Bar (Top RH side of the window)</p> <p>The top battery symbol indicates the % charge of the controller battery.</p> <p>The bottom battery symbol indicates the % charge of the receiver battery currently in use.</p> <p>For more details tap the battery symbol.</p> <p>Information about battery status is also available on the front panel of the receiver. If an external battery is connected its status will be indicated rather than the internal battery. See the Trimble 5700/5800 GPS Receiver User Guide for details.</p>
<b>Review current job</b>	
Base or Measure Points	<p>Select:</p> <p style="padding-left: 40px;"><b>Menu</b> (from Survey Controller buttons)</p> <p style="padding-left: 40px;"><b>Files icon</b></p> <p style="padding-left: 40px;">Review current job</p>

<b>Monitoring Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Review current job	<p>Displays information about the current job. You can scroll through the information to check such information as “Survey Style”, “File names”, “Point Names”, “Antenna Hts” etc.</p> <p>The “File name” is an 8 digit number located on the Postprocess line. It is in the form “xxxxdayn. (xxxx = last four digits of Controller S/N, day = Julian day no, n = session. Eg 97862300). This should be recorded on the field sheet.</p> <p>It is suggested that this window is kept active throughout an observation. Alternatively, you may add it to the <b>Favourites</b></p>

<b>Monitoring Observations</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
<b>Satellite status</b>	
Base or Measure Points	<p>Select:</p> <p style="padding-left: 40px;"><b>Menu</b> (from Survey Controller buttons)</p> <p style="padding-left: 40px;"><b>Instrument icon</b></p> <p style="padding-left: 40px;">Satellites</p>
Satellites	<p>Displays:</p> <p style="padding-left: 40px;">SVs tracked.</p> <p style="padding-left: 40px;">SV Azimuths</p> <p style="padding-left: 40px;">SV Elevations</p> <p style="padding-left: 40px;">SV S/N (Signal to Noise ratios = signal strength) on L1 &amp; L2 (higher values indicate better signals. For higher elevation SVs expect L1 S/N 40-50, L2 S/N 30-40. Values less than 20 indicate poor signals and are unlikely to be of much use).</p> <p>To display satellite counts:</p> <p>Select:</p> <p style="padding-left: 40px;"><b>L1</b> (from Soft keys on the bottom line of the display)</p> <p>Displays:</p> <p style="padding-left: 40px;">Continuous counts on L1</p> <p style="padding-left: 40px;">Total counts on L1</p> <p>Select:</p> <p style="padding-left: 40px;"><b>L2</b> (from Soft keys on the bottom line of the display)</p> <p>Displays:</p> <p style="padding-left: 40px;">Continuous counts on L2</p> <p style="padding-left: 40px;">Total counts on L2</p> <p>This information is invaluable when observing fast static points as it enables the operator to determine when enough data has been collected. It is suggested that this window is kept active throughout an observation. Alternatively, you may add it to the <b>Favourites</b></p> <p><b>The S/N ratios and L2 counts are the most critical pieces of information</b></p>

<b>Monitoring Observations</b>													
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>												
<b>Satellite status</b>													
	<p><b>in determining when sufficient data has been recorded for a Fast Static observation. One of the following minimum continuous counts is required, depending upon whether you are using the Fast Static 5k or Fast Static 10k “Survey style”:</b></p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td style="text-align: center;"><b>5k</b></td> <td style="text-align: center;"><b>10k</b></td> </tr> <tr> <td style="text-align: right;">6SVs (or more)</td> <td style="text-align: center;"><b>40</b></td> <td style="text-align: center;"><b>80</b></td> </tr> <tr> <td style="text-align: right;">5SVs</td> <td style="text-align: center;"><b>60</b></td> <td style="text-align: center;"><b>100</b></td> </tr> <tr> <td style="text-align: right;">4SVs</td> <td style="text-align: center;"><b>80</b></td> <td style="text-align: center;"><b>140</b></td> </tr> </table> <p><b>If the S/Ns are below 20 you must ignore the data from that satellite.</b></p>		<b>5k</b>	<b>10k</b>	6SVs (or more)	<b>40</b>	<b>80</b>	5SVs	<b>60</b>	<b>100</b>	4SVs	<b>80</b>	<b>140</b>
	<b>5k</b>	<b>10k</b>											
6SVs (or more)	<b>40</b>	<b>80</b>											
5SVs	<b>60</b>	<b>100</b>											
4SVs	<b>80</b>	<b>140</b>											
Satellites	<p>To view a Skyplot of the satellites: Select: <b>Plot</b> (from Survey Controller buttons)</p> <p>This provides a visual representation of the satellite locations. It can be oriented to either North or the Sun, but it is suggested that in Samoa it is probably better to use North.</p> <p>To switchback to the listing: Select: <b>List</b> (from Survey Controller buttons)</p> <p>To keep the window active, press the preferred Survey Controller Button. To close the window, press <b>Esc</b>.</p>												

### 3.6 Observation Configuration – Survey Styles

To configure the Trimble 5700 receiver for different observations, “Survey Styles” are created and edited in the Survey Controller. It has numerous parameters and functions which can be configured by the user. Different “Survey Styles” are used for different measuring techniques. Several default “Survey Styles” are pre-programmed into the controller. These default styles can be copied and edited to create new styles.

You may define your own “Survey Styles” by selecting the **Configuration** icon from the Menu. Then select Survey Styles and select the style to be copied.

Three “Survey Styles” have been defined for Geodetic control activities. These are as follows:

#### 3.6.1 Static

For Static control such as Primary & Secondary Control and for Reference Station Operation using the Zephyr Geodetic Antenna with the built in ground plane on a tripod. The style is summarised as follows:

### Base Options

Logging Interval: 15 sec.  
Elevation Mask: 13°  
Antenna Type: Zephyr Geodetic  
Measured to: Bottom of Notch

### Rover Options

Logging Interval 15 sec.  
Elevation Mask 13°  
PDOP Mask 8  
Antenna Type Zephyr Geodetic  
Measured to Bottom of Notch

### 3.6.2 Fast Static 5k

For Fast Static operation of a Rover receiver using the Zephyr Antenna on a range pole and tripod for distances of up to 5km from the reference station. The style is summarised as follows:

#### Base Options

Logging Interval: 15 sec.  
Elevation Mask: 13°  
Antenna Type: Zephyr Geodetic  
Measured to: Bottom of Notch

#### Rover Options

Logging Interval 15 sec.  
Elevation Mask 20°  
PDOP Mask 8  
Antenna Type Zephyr  
Measured to Bottom of Antenna Mount

The following minimum observation times are set for continuous data for the number of satellites indicated on both L1 & L2 frequencies for this style.

<b>Fast Static 5k</b>	
<b>6 or more satellites</b>	10 mins
<b>5 satellites</b>	15 mins
<b>4 satellites</b>	20 mins

### 3.6.3 Fast Static 10k

For Fast Static operation of a Rover receiver using the Zephyr Antenna on a range pole and tripod for distances of up to 10km from the reference station. The style is summarised as follows:

### Base Options

Logging Interval: 15 sec.  
Elevation Mask: 13°  
Antenna Type: Zephyr Geodetic  
Measured to: Bottom of Notch

### Rover Options

Logging Interval 15 sec.  
Elevation Mask 20°  
PDOP Mask 8  
Antenna Type Zephyr  
Measured to Bottom of Antenna Mount

The following minimum observation times are set for continuous data for the number of satellites indicated on both L1 & L2 frequencies for this style.

Fast Static 10k	
6 or more satellites	20 mins
5 satellites	25 mins
4 satellites	35 mins

### 3.7 Editing Observation Times

To edit the observation times follow the instructions below:

Editing Observation Times	
WINDOW	ACTION/DISPLAY
Menu	Select: <b>Configuration icon</b> (single tap) Survey styles
Survey Styles	Select: Survey style to be edited
Style to be edited eg Fast Static Geodetic Ant	Select: Fast Static point

<b>Editing Observation Times</b>	
<b>WINDOW</b>	<b>ACTION/DISPLAY</b>
Fast Static Point	<p><i>Switch to Screen 2</i></p> <p>Edit L1/L2 Fast Static times for 4SVs, 5SVs &amp; 6SVs in accordance with the tables in 3.6.1 &amp; 3.6.2 above.</p> <p>Select:</p> <p style="padding-left: 40px;"><b>Accept</b></p> <p style="padding-left: 40px;">Store</p> <p style="padding-left: 40px;">Esc</p>

### **3.8 Observations without a Controller**

In some situations it may be necessary or preferable to operate the receiver without the controller. The following are examples:

- The controller cannot be operated due to a flat battery or other malfunction.
- A long session is to be observed and there is a risk that the controller battery will not last for the whole session.

Particular care should be taken when operating without the controller as it is not possible for the operator to monitor the status of observations in detail. Neither is it possible to input point numbers and antenna heights etc. Particular care must be taken in recording this information on the field sheet as it must be entered into the computer at the time of data processing.

Data is recorded to the Compact Flash card in the receiver.

Note on the field sheet, in the space for the controller serial number, that the controller is not being used. If necessary explain on the back of the sheet why the controller is not being used.

#### **3.8.1 Receiver Operation**

The equipment is set up as detailed in section 2.2 above but do not connect the controller.

Note the following when operating the receiver:

- To “press” a button means to press and then release immediately.
- To “hold” a button means to press and hold for the specified time before releasing.

##### **To switch the receiver on:**

*“Press” the green Power button on the right side of the control panel.*

Monitor receiver until the red satellite tracking LED flashes slowly.

##### **To start logging data:**

*“Press” the blue Data button on the left side of the control panel.*

The yellow Logging/Memory LED below the Data button will illuminate once data is being logged. Note on the field sheet the time that data logging commences. Initial illumination of the yellow LED is steady and may change to a slow flash. Note that a fast flash indicates that available memory is getting low.

Continue logging data until the scheduled stop time.

**To stop logging data:**

*“Hold” the blue Data button for two seconds.*

**To switch the receiver off:**

*“Hold” the green Power button for two seconds.*

Refer to the *Trimble 5700/5800 GPS Receiver User Guide Chapter 4 – General Operation* for further information.

## 4. GPS PLANNING GUIDELINES

The following guidelines are to be used for planning GPS surveys for geodetic control purposes:

### 4.1 GPS Receivers

For GPS control surveys to third order and higher specifications it is essential that survey grade GPS receivers are used. Survey grade GPS receivers are able to record both code and phase data. Receivers that can only record code data are only suitable for small scale mapping and GIS work.

Determination of the suitability of GPS receivers for control surveys should be determined by checking the manufacturer's specifications. Regardless of how well a "code only" receiver might determine a position or measure a baseline on a particular occasion, it is not suitable for control surveys.

Single frequency code & phase receivers are adequate for control surveys over shorter distances, generally less than twenty kilometres, however in the interests of efficiency it is suggested that dual frequency code & phase receivers be used wherever possible. Only dual frequency receivers can be used for Fast Static observations.

It is suggested that single frequency receivers should not be mixed with dual frequency receivers for any particular observation session.

In selecting the number of receivers to be employed on a project, consider the size of the project, the number of staff, amount of support equipment and the logistical details. As a general rule three or four receivers provide for a good level of efficiency. The use of two receivers is generally inefficient, except for very small projects. Three receivers doubles the productivity that can be achieved with two receivers.

GPS receivers must be equipped with an appropriate user interface to enable full operator control of the observation, and the entry of point IDs and antenna heights in the field. In addition they must have a display which will provide the operator with the information necessary to determine the receiver's performance, the observation status, and when sufficient data has been collected at each point.

### 4.2 Observation Times

The following times are suggested as the minimum session lengths:

#### 4.2.1 Static Dual Frequency

10 km - 20km	20 km - 30 km	30 km - 50 km	50 km - 150 km	over 150 km
1 hour	2 hours	3 hours	4 hours	6 hours

#### 4.2.2 Fast Static (Dual Frequency P-code)

	Up to 5 km	5 km to 10 km
6 or more satellites	10 mins	20 mins
5 satellites	15 mins	25 mins
4 satellites	20 mins	35 mins

For Fast Static observations, the above times are the **minimum** period of unbroken data. If in doubt record more data.

If observations are being conducted in a remote area where the baselines cannot be processed and validated before the field teams leave the area consider using longer observation times.

PDOP should be less than 8 and preferably less than 5 particularly for shorter observations such as Fast Static. Try to avoid periods of high PDOP when planning observations.

Experience in tropical conditions indicates that data from satellites below 20 degrees elevation is difficult and often impossible to process. Accordingly it is recommended that the fast static elevation mask is set at 20 degrees.

#### 4.3 Connection to Existing Control

Connections must be made to control of the same order or higher. The recommendations for connecting to existing control to achieve the appropriate level of accuracy are:

Connections to Existing Control			
To Achieve	PRIMARY	SECONDARY	TERTIARY
Minimum	3	2	2
Recommended	4 or more	3 or more	2

#### 4.4 Independent Observations

Each point must have a minimum of two independent observations to ensure redundancy. To achieve higher than third order results, more independent observations are required as follows. Each independent observation must be a different setup with different antenna heights, unless using a fixed height range pole or similar device. When using Fast Static Reference/Rover observation techniques, only one reference station should be occupied at any one time. Occupying two reference stations at the same time does not provide an independent observation and this practice must not be used. Independent observations may be on the same day, but should be at quite different times to ensure different satellite geometry.

The table below specifies the minimum and recommended number of independent observations to achieve the desired order of control.

<b>Independent Observations at each point</b>			
<b>To Achieve</b>	<b>PRIMARY</b>	<b>SECONDARY</b>	<b>TERTIARY</b>
<b>Minimum</b>	3	2	2
<b>Recommended</b>	4 or more	3 or more	2

## **4.5 Network Observation Techniques**

### **4.5.1 Second Order**

For second order observations it is recommended that the network is observed such that, depending upon the number of receivers available, a series of interconnecting triangles or quadrilaterals is created. All adjacent points should be directly connected. It is suggested that consideration be given to observing some baselines more than once to increase the level of redundancy.

Second order observations will be by Fast Static or Static techniques depending upon the baseline length. It is generally suggested that second order observations should be a minimum of 30 minutes.

### **4.5.2 Third Order**

For third order GPS control the recommended observing technique is the Fast Static Reference/Rover method. The reference stations should be second order control points. Using this technique, the required accuracies can be achieved with the minimum observation times.

One of the advantages of this technique is that many third order control points will have less than optimal satellite visibility. Provided that the second order stations that are to be used as reference stations are completely clear of obstructions quite acceptable results can be achieved. In this way the operators at the rover station can be confident that all the data they collect will be common with data from the reference station and can make a well informed judgement as to when they have sufficient data.

If observing between two stations with different obstructions it is very difficult to determine when enough data has been collected, even with good communications between parties. The result will often be that the baseline between two such stations cannot be satisfactorily reduced.

## **4.6 General**

Ensure that each team is using a compatible “Survey Style” for the observation. In particular the Observation Rates must be identical. For most observations it will be 15 seconds.

## **4.7 Rain**

The GPS equipment will operate in rain and the signals will be received, however experience indicates that during periods of continuous and very heavy rain, the data can be difficult to process and acceptable results may not be achieved. In such cases it will be necessary to reobserve affected baselines.

Accordingly it is suggested that very wet days are avoided and that as far as practicable GPS observation campaigns should be planned for the drier months.

**Samoa – Ministry of Natural Resources, Environment & Meteorology**

**GPS Field Sheet – Reference & Static Control**

<b>Island:</b>		<b>Trimble 5700 Receiver S/N:</b>	
<b>Village:</b>		<b>Trimble Zephyr Geodetic Antenna S/N:</b>	
<b>Operator:</b>		<b>Trimble Survey Controller S/N:</b>	
<b>Job:</b>	<b>Date:</b>	<b>Day No</b>	<b>Memory:</b>
<b>Description:</b>		<b>Survey Style:</b>	

	<b>Observation 1</b>		<b>Observation 2</b>		<b>Observation 3</b>	
<b>Point Number</b>						
<b>Other Reference</b>						
<b>File name</b>						
<b>Scheduled Start/Stop</b>						
<b>Actual Start/Stop</b>						
<b>Tripod/Pillar</b>						
<b>Ant Ht – Slope or T/V</b>						
<b>Ant Ht</b> <b>1</b>		Checked:		Checked:		Checked:
<b>2</b>		Checked:		Checked:		Checked:
<b>3</b>		Checked:		Checked:		Checked:
<b>Mean</b>		Checked:		Checked:		Checked:
<b>Imperial</b> (1ft = 0.3048m)	(ft) =	(m)	(ft) =	(m)	(ft) =	(m)

The “Job” is the “Job Name” entered into the Controller. The format is as follows:

JobnameCyy-ddd-n (C=receiver colour; yy=year; ddd= day of year; n=session)

eg. PrimB05-226-1

The “Point Number” is entered into the Controller under “Point Name”.

If the monument is not inscribed with the Point Number, the point name and/or number inscribed on the monument must also be indicated on the GPS Field Sheet.

If using a tripod, antenna height is a measured to the bottom of the notch and is a slope measurement.

If set on a pillar, antenna height is measured to the bottom of the antenna mount and is true vertical.

Antenna heights are to be independently checked at the start and end of the observation at each setup.

If occupying the same point for consecutive observations, reset antenna at a different height.

Detail obstructions, large structures, power lines, radio transmitters and any problems overleaf.

Note any periods of high PDOP.

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**GPS Field Sheet – Fast Static Rover**

<b>Island:</b>		<b>Trimble 5700 Receiver S/N:</b>	
<b>Village:</b>		<b>Trimble Zephyr Antenna S/N:</b>	
<b>Operator:</b>		<b>Trimble Survey Controller S/N:</b>	
<b>Job:</b>	<b>Date:</b>	<b>Day No</b>	<b>Memory:</b>
<b>Description:</b>		<b>Survey Style:</b>	

<b>Pt ID</b>	<b>Ant Ht</b>	<b>Start</b>	<b>Stop</b>	<b>Comments</b> (No of SVs, S/N ratios, PDOP, obstructions, breaks)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

The Job indicated above is the Job Name entered into the Controller. The format is as follows:

JobnameCyy-ddd-n (C=receiver colour; yy=year; ddd= day of year; n=session)  
eg. PrimB05-226-1

If the monument is not inscribed with the Pt ID, the point name and/or number inscribed on the monument must also be indicated on the GPS Field Sheet.

Add comments and sketches overleaf.

**The S/N ratios and L2 counts are critical. Minimum continuous counts required:**

	<b>Fast Static 5k</b>	<b>Fast Static 10k</b>
6SVs (or more)	<b>40</b>	<b>80</b>
5SVs	<b>60</b>	<b>100</b>
4SVs	<b>80</b>	<b>140</b>

**If the S/Ns are below 20 you must ignore the data from that satellite.**

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## GPS Equipment

MNREM's has three GPS receivers together with the necessary ancillary equipment to equip three GPS field parties. The configuration is such as to provide three fully operational sets for high precision Static geodetic surveys, or one reference/base set and two roving Fast Static and RTK sets.

The sets have been colour coded to avoid getting items of equipment mixed up. The "Red" set is for general static operations and for base/reference operations for Fast Static and RTK work. The "Blue" and "Yellow" sets are for general static operations and for rover operations for Fast Static and RTK work. The "Red" set must be supplemented by the Base Radio set of equipment for RTK work.

The sets of equipment are as follows

<b>Base/Reference Red</b>	<b>Serial number</b>
5700 Receiver PN 53592-00	220367990
Zephyr Geodetic Antenna PN 41249-00	60078750
30m antenna cable PN41300-30	
10m antenna cable PN41300-10	
2 x 5m antenna cable	
6aH yellow battery PN32364-00	
Height of instrument rod	
2 x Lithium ion internal batteries PN 52030	
1 x 6Ah battery charger PN 32595-00	
1 x power cable large for PN 32595-00	
2 x Lithium Ion charger power supply FRIWO	
2 x power cable small for FRIWO	
1 x TSCe controller PN 45185-20	49878
1 x TSCe to 5700 cable PN 31288-02	
1 x TSCe controller bag	
1 x TSCe touch screen pen	
1 x download/charger cable PN 32345	
1 x grey USB cable	
1 x multi adaptor TSCe PN E0905	
1 x tribrach grey	
1 x rotating tribrach adaptor grey	
1 x 5/8th thread silver (for tribrach adaptor)	
1 x compact flash memory card	
1 x telescopic tripod	
1 x tripod bag	
1 x receiver backpack	
Manuals	
2 x Pelican cases	
1 x torch (red)	
1 x tarpaulin	
1 x 4 plug powerboard	
1 x clipboard	

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### Base Radio Set

1 x Trimmark 3 radio PN 46000-46 4521151042  
1 x 12aH battery  
1 x battery fighter charger  
2 x power cable PN 40356 grey  
1 x power cable from battery  
1 x power cable (spade - 2 pin - lemo)  
2 x data cable PN 31288-08  
1 x antenna cable PN 22720-10  
1 x alligator power cable  
1 x protective ball for tip of antenna  
1 x telescopic pole (yellow) PN 44091-00  
1 x Antenna base PN 24253-46  
1 x 1db Antenna  
1 x 5db Antenna  
1 x Yellow carry bag for radio antennas & large washer  
Manual  
1 x Pelican case

### Other items

3 x Trimble R7,R8, 5700, 5800 CD  
3 x Trimble Survey Controller CD  
1 x Trimble Radio Communications CD  
3 x grey USB cable  
3 x RS232 cables PN 18532  
1 x Yellow cable lemo to RS232  
1 x TSCe pole bracket PN 45217-00  
Screen protectors for TSCe  
1 x TGO software CD  
1 x TGO software Manual

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<b>Rover Blue</b>	<b>Serial number</b>
5700 Receiver PN 53592-46	220363296
Zephyr Geodetic Antenna PN 41249-00	60091275
30m antenna cable PN41300-30	
10m antenna cable PN41300-10	
2 x 5m antenna cable	
6aH yellow battery PN32364-00	
Height of instrument rod	
2 x Lithium ion internal batteries PN 52030	
1 x 6Ah battery charger PN 32595-00	
1 x power cable large for PN 32595-00	
2 x Lithium Ion charger power supply FRIWO	
2 x power cable small for FRIWO	
1 x TSCe controller PN 45185-20	49786
1 x TSCe to 5700 cable PN 31288-02	
1 x TSCe controller bag	
1 x TSCe touch screen pen	
1 x download/charger cable PN 32345	
1 x grey USB cable	
1 x multi adaptor TSCe PN E0905	
1 x tribrach grey	
1 x rotating tribrach adaptor grey	
1 x 5/8th thread silver	
1 x Compact flash memory card	
1 x 20cm whip radio aerial	
1 x receiver backpack	
1 x radio aerial cable PN 22720	
1 x radio aerial with 1Db and 5Db tips	
1 x Zephyr antenna in case PN 39105-00	60054954
1 x TSCe pole bracket PN 45217-00	
1 x 2.5m range pole	
1 x range pole bipod	
1 x telescopic tripod	
1 x tripod bag	
1 x range pole & bipod bag	
Manuals	
2 x Pelican cases	
1 x antenna carry tube	
1 x torch (blue)	
1 x tarpaulin	
1 x 4 plug powerboard	
1 x clipboard	

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<b>Rover Yellow</b>	<b>Serial number</b>
5700 Receiver PN 53592-46	220357259
Zephyr Geodetic Antenna PN 41249-00	60078788
30m antenna cable PN41300-30	
10m antenna cable PN41300-10	
2 x 5m antenna cable	
6aH yellow battery PN32364-00	
Height of instrument rod	
2 x Lithium ion internal batteries PN 52030	
1 x 6Ah battery charger PN 32595-00	
1 x power cable large for PN 32595-00	
2 x Lithium Ion charger power supply FRIWO	
2 x power cable small for FRIWO	
1 x TSCe controller PN 45185-20	49580
1 x TSCe to 5700 cable PN 31288-02	
1 x TSCe controller bag	
1 x TSCe touch screen pen	
1 x download/charger cable PN 32345	
1 x grey USB cable	
1 x multi adaptor TSCe PN E0905	
1 x tribrach grey	
1 x rotating tribrach adaptor grey	
1 x 5/8th thread silver	
1 x Compact flash memory card	
1 x 20cm whip radio aerial	
1 x backpack	
1 x radio aerial cable PN 22720	
1 x radio aerial with 1Db and 5Db tips	
1 x Zephyr antenna in case PN 39105-00	60030157
1 x TSCe pole bracket PN 45217-00	
1 x 2.5m range pole	
1 x range pole bipod	
1 x telescopic tripod	
1 x tripod bag	
1 x range pole & bipod bag	
Manuals	
2 x Pelican cases	
1 x antenna carry tube	
1 x torch (yellow)	
1 x tarpaulin	
1 x 4 plug powerboard	
1 x clipboard	

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## General GPS Equipment

It is recommended that each GPS vehicle should be equipped with the following equipment for GPS operations:

- GPS Receiver, antenna and ancillary equipment in boxes

- Tripod & bag

- Plumbing pole, bipod & bag

- GPS backpack

- Two way radio

- Bush Knife

- First Aid Kit

- Hammer (large)

- Shovel

- Traffic Cones (6)

- Sand bags (3)

- Temporary Marks

- Paint

- Brushes

- Tarpaulin

- Umbrella (surveyor's)

- Equipment Box with the following items;

  - Magnetic Compass (surveyor's)

  - Clinometer

  - Torch

  - Chisel

  - 30m Tape Measure

  - 3-5m Tape Measure

  - Plumb bob

  - Pliers

  - Screwdriver Philips Head large

  - Screwdriver Philips Head small

  - Screwdriver large

  - Screwdriver small

  - Wire ties

  - Electrical Tape

  - Plastic marking tape

- Personal protective clothing (each person to have)

  - Safety jacket

  - Rubber boots

  - Raincoat

**Team Leader's Field Bag**

It is recommended that each team leader to be equipped with a strong water proof bag with the following items:

- Folder or clipboard
- Waterproof Pens (black & red
- Pencils
- Ruler
- Drawing template
- Paper
- Note book
- Field sheets
- Envelopes
- Fluorescent pens (for GPS teams) (various colours)