Republic of the Philippines

Department of Environment and Natural Resources

LAMP

MANUAL
FOR
DENSIFICATION OF
THE GEODETIC NETWORK
TO SUPPORT
LAND RECORDS MANAGEMENT &
CADASTRAL SURVEYING

REPORT D4

Land Administration & Management Project

Prototype Implementation Office II

Quezon City

Version 1.3 (30 June 2002)

DOCUMENT VERIFICATION & APPROVAL

Title:	**Manual for Densification of the Geodetic Network to Support Land Records Management & Cadastral Surveying**
General Description:	Procedure Manual for densification of the geodetic network for the Philippines Land Administration and Management Project (LAMP).
Referenced Documents:	

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REVISIONS & DISTRIBUTION

Revisions:					
Ver No.	Date	Description	By	Chkd	Approved
1.0	14 April 02	First distribution by Andrew Dyson.	AD		
1.1	16 June 02	First revision.	AD		
1.2	20 June 02	Second revision	AD		
1.3	30 June 02	Third revision	AD		

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1. INTRODUCTION

These instructions and procedures are intended to be used as guidelines for densification of the geodetic network in support of the creation of Cadastral Index Maps (CIM), production of orthophoto maps and control of future cadastral surveying. As such they should be regularly reviewed and updated as necessary.

They are based on the techniques and procedures used in LAMP Prototype 2 in Quezon City (PIO2) and are applicable to other similar situations. However it may be necessary to vary them depending upon circumstances. They were developed by Andrew Dyson, Survey Control Adviser, under the Philippine – Australia Land Administration & Management Project Technical Assistance Program. Assistance and comments were provided by PIO2 staff and CGSD/NAMRIA staff involved in the GPS control operations.

1.1 The Value of a Geodetic Network.

A national geodetic network provides the fundamental support for land surveying, mapping, engineering and related applications and is the basis for the integration of all such activities. It is the basic reference framework for all surveying, mapping and land related information. A geodetic network controls the position, extent and orientation of surveys. To provide this support, a geodetic network must be both accurate and homogeneous.

A network must be of sufficient quality to ensure that mapping, cadastral and general surveys are based on a homogeneous coordinate system. Without such a system, development takes place in a disjointed and unrelated manner that ultimately leads to unnecessary expense when neighbouring surveys meet. The advantages of a suitable geodetic network are:

- The accuracy of surveys is controlled and maintained and the propagation of errors is reduced. (An adequate network allows surveyors to work from the whole to the part, a standard survey practice, not from the part to the whole).
- A network enables uniform scale and orientation to be maintained.
- As surveys are connected to the network, they are directly interrelated to each other.
- All future surveys connected to the network can be integrated into one system, avoiding duplication and wasted effort.
- Cadastral surveys are related to mapping and other geographical land information through proper connection to a geodetic network.

1.2 The Need for Densification.

The Philippine Geodetic Network was established and observed by GPS from 1988-91, as part of the Natural Resources Management & Development Project (NRMDP). The project provided about 330 stations to first order standards, about 100 second order and about 40 third order stations. The first order stations are spread throughout the nation generally at a nominal spacing of 50 km, but in places the spacing is reduced to about 25 km. The remaining stations were established in three pilot study areas.

The new coordinate set developed from the 1988-91 observations is referred to as the Philippine Reference System 1992 or PRS92. It was intended that all future mapping and surveying activities should be referenced to PRS92. Since 1993 there have been a series of Executive Orders stipulating that PRS92 was to have been adopted as the standard reference system for all surveying and

mapping activities. However as each deadline approached the transition period has been extended and now stands at 2005, some thirteen years after completion of the Geodetic Network.

Given the spacing of stations in the Philippine Geodetic Network, it provides only the basic skeletal framework and is not accessible to most surveyors. This appears to be the main reason for repeated extension of the deadline. To gain maximum benefit from the network, densification is required to provide an accessible network of third order control points throughout the nation. LAMP has made a commitment that all surveys and mapping will be on PRS92. To meet this commitment the network must be densified to support LAMP's survey and mapping activities and to provide ongoing control for all future survey and mapping activities.

The National Mapping & Resource Information Authority's (NAMRIA) Coast & Geodetic Survey Department (CGSD) was initially the only agency responsible for the densification of the Philippine Geodetic Network and has included the densification of the network among its other projects since 1991. However, CGSD has been limited by its commitment to other important projects and a lack of resources, and accordingly has achieved only limited densification to date.

Since 19?? some of the responsibility for densification has passed to the regional offices of DENR using the resources of their Field Network Survey Parties (FNSP). They have been equipped with basic GPS equipment (usually two single frequency receivers) but it would appear that their capabilities are very limited and they lack the necessary level of expertise.

1.3 Summary of Geodetic Control Requirements to Support Land Title Verification Activities

An accurate and homogeneous geodetic network is essential to support the mapping requirements of the Land Title Verification Program. Such a network will ensure that the position, extent and orientation of surveys and mapping are controlled thereby preventing the creation of gaps or overlaps. All surveys and mapping will be conducted using the PRS92 coordinate reference system.

Within Quezon City no systematic cadastral survey was performed and in all probability the isolated surveys are not homogeneous making the integration of survey and mapping data across the five project barangays very difficult. Surveys in the eastern part of the prototype (Payatas Estate) are supposedly connected to BLLM1 in Montalban, Rizal which was about 8km away. A field search by project staff has confirmed that BLLM1 does not exist, yet surveys continue to show connection to it! In the south west (Piedad Estate), the surveys are probably not connected to control. It is suspected that these surveys are not homogeneous. Anecdotal evidence from a geodetic engineer involved in surveys in the area suggests that this is the case.

In summary geodetic control was required to support the following activities:

- Within the barangays of Batasan Hills and Holy Spirit, identifiable boundary features were coordinated to enable the plotting of the existing isolated surveys on the CIM.
- Orthophoto mapping will be used as the base control for plotting the CIM in the remaining areas. The mapping is being produced over the entire pilot area. Geodetic control on PRS92 was required to support production of the orthophoto mapping.
- To adequately and efficiently control all future cadastral surveys, monumented third order control is required throughout the pilot barangays at approximately one kilometre spacing.

The preferred method of survey was to utilise GPS technology, supplemented by observations with Total Stations when circumstances prevent GPS observations.

2. STRATEGY

2.1 Control Requirements for production of Orthophoto Maps

The Technical Specifications for orthophoto mapping at 1:1000 scale stipulate that horizontal and vertical control is required around the perimeter and within the photogrammetric block at a spacing of not more than 2km. The specified accuracies being:

- Horizontal +/-0.05m;
- Vertical +/-0.15m

To meet the control requirements in the Technical Specifications, 37 photo control points were required in and around the five pilot barangays (24 horizontal and vertical, 13 vertical). The preferred approach to provide control was to establish three second order control points and then use fast static GPS techniques to coordinate the photo control points to third order specifications features selected by the photogrammetrists.

The second order control points must be selected in locations with optimum satellite visibility, any obstructions at these points will seriously affect the quality of the third order observations.

2.2 Control Requirements to Support Cadastral Surveying

There was no existing geodetic control within the five pilot barangays. The common practice within the area is to connect surveys to adjoining parcels and to compute the bearing and distance of the tie line from BLLM1 of Montalban, Rizal to the first point of the technical description of the land.

To enable any future surveys in the five pilot barangays to be recorded onto the CIM it is important that all new surveys be connected to at least two control points on the PRS92 coordinate system. For this constraint to be reasonable for geodetic engineers, it was proposed that the Project provide new control at approximately 1km spacing in the 5 barangays. It is not a requirement that the control points be placed such that they are intervisible.

This amounted to about 40 monumented third order control points. The points were to be established in safe and secure locations where the monuments have the maximum chance of survival, with minimal obstructions above 15 degrees elevation. They were coordinated using fast static GPS from the three second order reference stations.

Using the appropriate techniques, geodetic engineers can traverse between control points and by calculation adjust the azimuth of their survey to the PRS92 coordinate system. Jan van der Kevie, International Parcel Mapping Adviser, has developed Traverse Calculator software to assist surveyors in orienting and adjusting their surveys to the PRS92 coordinate system. This software should be made freely available to surveyors.

2.3 Control Requirements to Support CIM activities

In the absence of the orthophoto mapping, boundaries within the barangays of Batasan Hills and Holy Spirit were coordinated to control the plotting of the CIM on PRS92.

It was suggested that a boundary point should be coordinated near the corner of each CIM. About 60 points were required in Batasan Hills and about 40 points in Holy Spirit.

2.4 Accuracy Standards

The following relative positioning standards apply to the second and third order control at the 95 percent confidence level:

Second Order	20 parts per million;
Third Order	50 parts per million.

2.5 Field Sheets

2.5.1 Reconnaissance Information Sheets

A Reconnaissance Information Sheet is to be completed for each point allocated a number. It is important that sufficient information is recorded to enable another survey team to locate the monument without assistance. It is suggested that approximate coordinates from a hand held GPS should be entered on the sheet.

The following information is to be shown:

- Point number;
- Approximate coordinates (using a hand held GPS unit);
- Description of monument;
- Location of monument including a sketch;
- Detailed access information from an easily locatable and recognisable landmark;
- Satellite visibility (full details to be shown on the GPS Station Visibility Sheet);
- Name of the owner of the property if the monument is to be located on private land or the adjoining property owner if located on public land;
- If assistance is required to locate the survey mark, provide details;
- Name and signature of the officer completing the Reconnaissance Information Sheet in the field, together with the date of the reconnaissance.

An example of the Reconnaissance Information Sheet is included as Appendix 1

The Reconnaissance Information Sheets must be checked by the team leader to ensure that they are complete and provide sufficient information.

2.5.2 GPS Station Visibility Sheets

A GPS Station Visibility Sheet should be completed for each point intended to be surveyed with GPS. This sheet will allow the project supervisor to review the suitability of each point for GPS observations. The teams should be equipped with a compass and clinometer. In the absence of a clinometer, a theodolite or transit may be used to determine the elevation of obstructions

The following information is to be shown:

- Point number
- Height above ground level that the visibility plots applies to.
- Elevation and magnetic bearing of obstructions above 15 degrees elevation from the horizon.

- Any obstructions or other structures which may cause multi-path.
- Any relevant comments
- Name and signature of the officer completing the GPS Station Visibility Sheet in the field, together with the date of the reconnaissance.

An example of the GPS Station Visibility Sheet is included as Appendix 2.

2.5.3 Traverse Pages

A Traverse Page has been developed for use on the project and should be completed for all traversing to points unsuitable for GPS.

All entries to be neat and legible **in black ink**

The following information is to be shown on the front of the page:

- Enter the appropriate details. Traverse Page number to be entered later
- Note that north is up the page.
- Draw a clear sketch utilising the space available to indicate the points being observed and the relationship between the points

The following information is to be shown on the back of the page:

- Enter make, model and serial number for theodolite and EDM.
- Enter date.
- Enter observer's name, recorder's name and computer's name (the recorder is normally the computer).
- HIs and HTs (Heights of instruments and targets) are measured from the center of the instrument or target to the top of the survey mark – **not the ground**.
- As the data is recorded it should be reduced/computed.
- After completing the observations, the computations must be thoroughly checked, usually by the observer, to confirm that they are OK before moving the equipment.
- The checker must sign the Traverse Page.
- Note that up to 5 pointings can be accommodated on the Traverse Page.

An example of the Traverse Page is included as Appendices 3 & 4.

Two instructions have been prepared regarding Traverse Pages, they are *"Guidelines for using Traverse Pages"* and *"Traverse Page Reductions"* and are included as Appendices 5 & 6.

2.6 Point Numbering

Every monumented point is to be allocated a **unique number** within the existing CGSD point numbering system. The format of the number is MMA-nnn (where MMA refers to Metro Manila and nnn is the unique number assigned to the point in the province, eg MMA-94 or MMA-161). Compliance with this system will enable the simple integration of all data into the CGSD data base, the *Geodetic Station Information System*.

The relevant details for all control points are entered onto a Point Number Allocation Sheet. This list is maintained as a Word Document.

Care must be exercised in the allocation of point numbers to avoid any mistakes. A batch of numbers should be obtained from CGSD and they should be kept informed which numbers have been allocated.

3. PROCEDURES

The procedures for densification of the Philippine Geodetic Network are divided into the following sections:

(i) Second Order Control

(ii) Orthophoto Control

(iii) Monumented Third Order Control

(iv) Boundary Control for CIM Production.

3.1 Second Order Control

Second order control should be provided throughout the project area at a spacing of about 5 kilometres. The new control points will be coordinated from the adjacent primary and secondary control points. If possible the second order control should be established over a fairly wide area between existing primary and secondary control in one operation so that it can be adjusted as one discrete area, rather than as small individual projects.

The new second order control points will be used as reference stations for all subsequent GPS activities **and must be clear of any obstructions at elevations greater than fifteen degrees above the horizontal**. It is essential to ensure that personnel are familiar with the requirements for selecting GPS sites.

3.1.1 Office Preparation

It is important to make the following preparations before commencing field activities.

(v) Obtain the best available maps of the area from the NAMRIA sales office, if there is not recent mapping the most recent aerial photography at a reasonable scale should be obtained.

(vi) Obtain details of geodetic control in and around the area from CGSD and mark on a suitable scale map.

(vii) Select the preferred locations for second order control points at a spacing of about 5 kilometres around the perimeter and across the project area and mark on the map. A copy of this plan will be used in the field.

(viii) Consider using existing lower order control points or bench marks.

3.1.2 Reconnaissance

The following are suggested procedures for selection of sites for second order control points:

(i) Prior to commencement of reconnaissance activities, visit Municipal and Barangay Officials and other groups as necessary such as home owners' associations.

(ii) Reconnaissance teams should be equipped with the necessary maps and plans.

(iii) Coordinate with land owners/occupiers if necessary to enter private property.

(iv) In selecting sites for second order control points, they must be clear of any obstructions at elevations greater than fifteen degrees above the horizontal, be accessible to survey teams, and in a safe and secure location that will not be disturbed.

(v) Consider selecting sites on the top of concrete structures, particularly public buildings, and in the grounds of public buildings, but before doing so ensure that no construction activities are proposed that will destroy, damage, restrict access or adversely affect satellite visibility.

(vi) If possible select an existing station such that it meets the above requirements.

(vii) In areas where no existing stations are suitable, select an alternative location such that it meets the above requirements.

(viii) If monumentation is to be done at a later date, the location of each new control point will be marked with a suitable temporary marker to enable the correct location to be determined at the time of construction.

(ix) Use a hand held GPS to obtain the approximate location of new control points.

(x) Allocate the next available number to the new points and existing monuments that are to be coordinated and complete the Point Number Allocation Sheet. The format of the number will be MMAnnn (eg MMA94 or MMA161)

(xi) A Reconnaissance Information Sheet will be completed for each point that has been allocated a number. It is important that sufficient information is recorded to enable another survey team to locate the monument without assistance. The approximate coordinates from the hand held GPS should be entered on the sheet. The Reconnaissance Information Sheets must be checked regularly by the team leader to ensure that they are to the required standard.

(xii) Indicate the location and the number allocated on the maps and photography provided, this information should be added to the office copy.

(xiii) Advise land owners/occupiers of the selected location, that a monumentation team will be visiting in the near future to construct the permanent monument followed by GPS and other survey teams. Ensure that the owners/occupiers understand the importance of the monument for the project and all future surveying activities in the area and that it should not be disturbed for any reason. If for some reason in the future, the monument must be moved or destroyed, the owner/occupier should contact DENR OSS for approval.

3.1.3 Monumentation

(i) Unless part of substantial concrete structures, new second order control points will be established as follows:

- concrete monuments, poured on-site,with the following minimum dimensions:

  0.3m x 0.3m cross section at the top;

  0.4m x 0.4m cross section at the base;

  0.6m long;

  protruding 0.2m above ground level (normally);

  in some situations, where the stability of the ground is questionable, a larger monument may be appropriate.

(ii) The monuments will have a steel rod or 0.1m copper nail set in the centre and be inscribed with the appropriate point number, the name of the agency establishing the monument and the year.

(iii) If established on substantial concrete structures, new second order control points may be:

- copper or concrete nails in cement patties,
- drill holes,
- screws or bolts set in drill holes (possibly with a washer inscribed with the point number).

3.1.4 GPS Observations

(i) For more detailed instructions on GPS observations refer to the *GPS Guidelines & Receiver Operation Manual* or other instructions as appropriate.

(ii) Coordinate second order stations from adjacent primary or secondary control, preferably observed as a network with adjacent stations directly connected. All points must be in a minimum of two independent sessions to ensure true redundancy and preferably three. An independent observation includes resetting the antenna at a different height. Independent observations may be on the same day, but should be at quite different times to ensure different satellite geometry.

3.1.5 GPS processing and validation

(i) GPS Baselines to be processed using propriety software, refer to the *GPS Processing & Adjustment Manual.*

(ii) Minimally constrained (or free net) least squares adjustment to be carried out to determine the quality and consistency of the data.

(iii) Analyse the results of the baseline processing and more particularly the adjustment in (ii) above to determine the need to reobserve any baselines.

(iv) Carry out any necessary reobservations, process and add to the adjustment.

3.1.6 Final adjustment of data

(i) Constrained adjustment to be carried out to determine final coordinates.

(ii) Data to be sent to CGSD for integration into National Geodetic Data Base and certification.

3.2 Orthophoto Control

The organisation that is to produce the orthophoto mapping will select the preferred locations (visible features) for photo control points. These locations will be marked up on enlargements for use by the surveyors in the field. The mapping organisation will also specify the area within which alternative points may be selected in the event that some of the preferred points are deemed unsuitable for GPS observations by the field survey teams. They may also indicate alternative preferred locations.

The preferred approach to provide control is to use the second order control points as reference stations for fast static GPS to the photo control points. Each photo control point must be have two completely independent observations from two different reference stations. To ensure redundancy,

only one reference station should be occupied at any time. All other available GPS receivers should be used as roving receivers. This is the most efficient method and ensures true redundancy. The two closest second order points should be selected as the reference stations for each photo control point.

Photo control points will not usually be suitable for permanent marking as monumented control, however in locations where it is appropriate it should be considered as this may reduce the total number of control points to be coordinated.

The following procedures assume that the second order control has already been established:

3.2.1 Office Preparation

It is important to make the following preparations before commencing field activities.

(i) Obtain photo enlargements showing the preferred locations of photo control points.

(ii) Obtain a suitable scale map indicating the location of the second order control points.

3.2.2 Reconnaissance

The following are suggested procedures for selection of sites for photo control points:

(i) Prior to commencement of reconnaissance activities, visit Municipal and Barangay Officials and other groups as necessary such as home owners' associations.

(ii) Reconnaissance teams should be equipped with the necessary maps and plans.

(iii) Coordinate with land owners/occupiers if necessary to enter private property.

(iv) In assessing the suitability of the selected sites for photo control points, they should be relatively clear of any obstructions at elevations greater than fifteen degrees above the horizontal and in a safe and secure location.

(v) Where sites are suitable for permanent marking, consider the safety, security, accessibility and the chances of a monument being disturbed. If appropriate consider placing a permanent monument.

(vi) Where sites are unsuitable for GPS due to limited satellite visibility or for some other reason, it may be necessary to select an alternative location such that it meets the requirements of the mapping organisation.

(vii) If it is necessary to provide control in a location that is unsuitable for GPS, then it will be necessary to establish a pair of GPS control points in suitable locations nearby and a connection will be made using a Total Station or theodolite and EDM. The points must be established in locations such that sufficient redundant observations can be made to the existing mark.

(viii) If monumentation is to be done at a later date, the location of each new control point will be marked with a suitable temporary marker to enable the correct location to be determined at the time of construction.

(ix) Use a hand held GPS to obtain the approximate location of new control points.

(x) Allocate the next available number to any points to be monumented and complete the Point Number Allocation Sheet. The format of the number will be MMAnnn (eg MMA94 or MMA161)

(xi) A Reconnaissance Information Sheet will be completed for each point that has been allocated a number. It is important that sufficient information is recorded to enable another survey team to locate the monument without assistance. The approximate coordinates from

the hand held GPS should be entered on the sheet. The Reconnaissance Information Sheets must be checked regularly by the team leader to ensure that they are to the required standard.

(xii) Indicate the location and the number allocated on the maps and photography provided, this information should be added to the office copy.

(xiii) For points to be monumented, advise land owners/occupiers of the selected location, that a monumentation team will be visiting in the near future to construct the permanent monument followed by GPS and other survey teams. Ensure that the owners/occupiers understand the importance of the monument for the project and all future surveying activities in the area and that it should not be disturbed for any reason. If for some reason in the future, the monument must be moved or destroyed, the owner/occupier should contact DENR OSS for approval.

3.2.3 Monumentation

(xiv) Unless part of substantial concrete structures, new third order control points will be established as follows:

- concrete monuments, poured on-site, with the following minimum dimensions:

  0.20m x 0.20m cross section at the top;

  0.30m x 0.30m cross section at the base;

  0.5m long;

  protruding 0.1m above ground level (normally);

  in some situations, where the stability of the ground is questionable, a larger monument may be appropriate.

(xv) The monuments will have a steel rod or a 0.1m copper nail set in the centre and be inscribed with the appropriate point number, the name of the agency establishing the monument and the year.

(xvi) If established on substantial concrete structures, new third order control points may be:

- copper or concrete nails in cement patties,
- drill holes,
- screws or bolts set in drill holes (possibly with a washer inscribed with the point number).

(xvii) To enable a GPS antenna to be set securely over the mark when using a range pole and bipod set up on fast static surveys, it is essential that the rod, nail, screw or bolt used to mark the point is punched with a center punch, or has a cross cut in it or some other suitable alternative is provided to prevent the tip of the range pole slipping from the point during the observation.

3.2.4 Traversing

(i) As soon as the monuments have been established, traversing to points that are not suitable for GPS observations should commence.

(ii) In addition all short intervisible distances between GPS control points should be measured with EDM

(iii) Traversing is to be done with either a Total Station or using a theodolite and EDM.

(iv) Sufficient redundant observations must be made to provide confidence in the results.

(v) If possible all angles and distances should be observed to provide a closed figure.

(vi) A minimum of two sets of angles must be observed, each to consist of a forward and reverse pointing.

(vii) Slope distances are to be recorded and heights of instruments and targets recorded for each setup.

(viii) A minimum of a forward and reverse vertical angle must be observed for each distance.

(ix) All data is to be recorded on the Traverse Page developed for the project.

(x) All data is to be recorded in permanent black ink.

(xi) If it is necessary to change some information, a neat line should be drawn through the incorrect information and the correct value added.

(xii) A sketch showing the relationship of the points being observed is to be drawn on the front of the Traverse Page.

(xiii) All instrument and other details are to be recorded.

(xiv) The observations should be reduced and checked before packing up the instrument for each setup.

(xv) A sample Traverse Page is included as Appendix 2.

(xvi) Coordinates of points unsuitable for GPS may be determined by entry of the traverse data into the adjustment or by using the Traverse Calculator software developed for the project.

3.2.5 GPS Observations

(i) For more detailed instructions on GPS observations refer to the relevant instructions.

(ii) Coordinate third order stations from the two nearest primary or secondary stations. All points must be in a minimum of two independent sessions. Points should be coordinated using a reference station and rover technique. For any observation session there should only be one reference station. Using two reference stations does not provide a redundant observation and is not acceptable.

3.2.6 GPS processing and validation

(i) GPS Baselines to be processed using propriety software.

(ii) Minimally constrained (or free net) least squares adjustment to be carried out to determine the quality and consistency of the data.

(iii) Analyse the results of the baseline processing and more particularly the adjustment in (ii) above to determine the need to reobserve any baselines.

(iv) Carry out any necessary reobservations, process and add to the adjustment.

3.2.7 Final adjustment of data

(i) Traverse data to be added to the GPS data.

(ii) Constrained adjustment to be carried out to determine final coordinates.

(iii) If points are monumented, data should to be sent to CGSD for integration into the National Geodetic Data Base and certification of the coordinates.

3.3 Monumented Third Order Control

Third order control is to be provided throughout the project area at a spacing of about one kilometre. The control points will be coordinated from the adjacent primary and secondary control points using fast static GPS. These reference points must be clear of obstructions above 15 degrees elevation. The points to be established in safe and secure locations where the monuments have the maximum chance of survival, with minimal obstructions above 15 degrees elevation.

3.3.1 Office Preparation

It is important to make the following preparations before commencing field activities.

(i) Obtain details of geodetic control in and around the area from CGSD and mark on a suitable scale map.

(ii) Select the preferred locations for third order control points at a spacing of about one kilometre around the perimeter and across the project area and mark on the map. A copy of this plan will be used in the field.

(iii) Consider using any existing lower order control points or bench marks.

3.3.2 Reconnaissance

The following are suggested procedures for selection of sites for second order control points:

(i) Prior to commencement of reconnaissance activities, visit Municipal and Barangay Officials and other groups as necessary such as home owners' associations.

(ii) Reconnaissance teams should be equipped with the necessary maps and plans.

(iii) Coordinate with land owners/occupiers if necessary to enter private property.

(iv) In selecting sites for third order control points, they must be relatively clear of any obstructions at elevations greater than fifteen degrees above the horizontal, be accessible to survey teams, and in a safe and secure location that will not be disturbed.

(v) Consider selecting sites on the top of concrete structures, particularly public buildings, and in the grounds of public buildings, but before doing so ensure that no construction activities are proposed that will destroy, damage, restrict access or adversely affect satellite visibility.

(vi) If possible select an existing station such that it meets the above requirements.

(vii) In areas where no existing stations are suitable, select an alternative location such that it meets the above requirements.

(viii) If monumentation is to be done at a later date, the location of each new control point will be marked with a suitable temporary marker to enable the correct location to be determined at the time of construction.

(ix) Use a hand held GPS to obtain the approximate location of new control points.

(x) Allocate the next available number to the new points and existing monuments that are to be coordinated and complete the Point Number Allocation Sheet. The format of the number will be MMAnnn (eg MMA94 or MMA161)

(xi) A Reconnaissance Information Sheet will be completed for each point that has been allocated a number. It is important that sufficient information is recorded to enable another survey team to locate the monument without assistance. The approximate coordinates from the hand held GPS should be entered on the sheet. The Reconnaissance Information Sheets must be checked regularly by the team leader to ensure that they are to the required standard.

(xii) Indicate the location and the number allocated on the maps and photography provided, this information should be added to the office copy.

(xiii) Advise land owners/occupiers of the selected location, that a monumentation team will be visiting in the near future to construct the permanent monument followed by GPS and other survey teams. Ensure that the owners/occupiers understand the importance of the monument for the project and all future surveying activities in the area and that it should not be disturbed for any reason. If for some reason in the future, the monument must be moved or destroyed, the owner/occupier should contact DENR OSS for approval.

3.3.3 Monumentation

(i) Unless part of substantial concrete structures, new third order control points will be established as follows:

- concrete monuments, poured on-site, with the following minimum dimensions:

  0.20m x 0.20m cross section at the top;

  0.30m x 0.30m cross section at the base;

  0.5m long;

  protruding 0.1m above ground level (normally);

  in some situations, where the stability of the ground is questionable, a larger monument may be appropriate.

(ii) The monuments will have a steel rod or a 0.1m copper nail set in the centre and be inscribed with the appropriate point number, the name of the agency establishing the monument and the year.

(iii) If established on substantial concrete structures, new third order control points may be :

- nails in cement patties,
- drill holes,
- screws or bolts set in drill holes (possibly with a washer inscribed with the point number).

(iv) To enable a GPS antenna to be set securely over the mark when using a range pole and bipod set up on fast static surveys, it is essential that the rod, nail, screw or bolt used to mark the point is punched with a center punch, or has a cross cut in it or some other suitable alternative is provided to prevent the tip of the range pole slipping from the point during the observation.

3.3.4 GPS Observations

(i) For more detailed instructions on GPS observations refer to the relevant instructions.

(ii) Coordinate third order stations from the two nearest primary or secondary stations. All points must be in a minimum of two independent sessions. Points should be coordinated using a reference station and rover technique. For any observation session there should only be one reference station. Using two reference stations does not provide a redundant observation and is not acceptable.

3.3.5 GPS processing and validation

(i) GPS Baselines to be processed using propriety software.

(ii) Minimally constrained (or free net) least squares adjustment to be carried out to determine the quality and consistency of the data.

(iii) Analyse the results of the baseline processing and more particularly the adjustment in (ii) above to determine the need to reobserve any baselines.

(iv) Carry out any necessary reobservations, process and add to the adjustment.

3.3.6 Final adjustment of data

(i) Constrained adjustment to be carried out to determine final coordinates.

(ii) Data to be sent to CGSD for integration into the National Geodetic Data Base.

3.4 Boundary Control for CIM Production.

In the absence of the orthophoto mapping, boundaries may be coordinated directly with GPS to enable plotting of the CIM on PRS92. If this approach is adopted, it is suggested that a boundary point should be coordinated near the corner of each CIM.

Wherever it is possible to set an antenna above the selected location, control will be provided directly on the boundary. In some instances it may not be possible to coordinate the selected boundary point, because of restricted satellite visibility, or for some other reason a GPS antenna cannot be set up over the point. In such cases, it is proposed that GPS control be provided as close as possible to the boundary point and a connection made from the GPS point to the boundary point by compass and tape.

To enable as many of the selected boundary points as possible to be coordinated directly with GPS it is suggested that an extension pole should be used to mount the antenna as high as possible in locations where it is necessary to maintain satellite visibility. A 5 metre pole is suggested. In addition it is suggested that each GPS teams should be equipped with a wooden ladder to enable them to place the antenna on high walls.

Project staff will select the preferred locations for control by inspecting the preliminary CIM. They should accompany the GPS reconnaissance teams and will be responsible for locating the preferred boundary locations. The GPS personnel will advise if the locations are suitable for GPS observations.

Depending upon radio coverage over the area to be controlled, it may be possible to utilise Real Time Kinematic (RTK) GPS to coordinate the boundaries. RTK should provide an appropriate level of accuracy from a single observation, however it is essential that a second independent observation is taken to avoid the risk of gross errors. RTK should be used with caution, radio coverage may be hard to maintain and satellite visibility conditions may also make the operation difficult. The

second order control points will be required as base stations for the RTK observations. If possible, they should be established in suitable locations for broadcast of radio signals over the pilot area.

If conditions prevent good radio coverage it will be necessary to use fast static GPS. The second order control points will be used as reference stations for fast static GPS to the boundary control points. Although a single fast static observation should provide an appropriate level of accuracy each boundary control point should have two completely independent observations to avoid the risk of gross errors. To ensure redundancy, only one reference station should be occupied at any time. All other available GPS receivers should be used as roving receivers. This is the most efficient method and ensures true redundancy. The two closest second order points should be selected as the reference stations for each boundary control point.

For the coordination of boundary points a suitable system must be implemented to number the boundary points and any GPS offset points. This system must enable unambiguous determination of the point observed. It is suggested that consideration be given to utilising a similar system to the CGSD system but a two letter code is allocated to each barangay. As an example a point in Holy Spirit would HSnnn

An alternative system would be to allocate a number for each point based on the CIM sheet number.

The following procedures assume that the second order control has already been established:

3.4.1 Office Preparation

It is important to make the following preparations before commencing field activities.

(i) Mark the preferred locations for boundary control points on copies of the preliminary CIM or survey maps.

(ii) Obtain a suitable scale map indicating the location of the second order control points.

3.4.2 Reconnaissance

The following are suggested procedures for selection of sites for boundary control points:

(i) Prior to commencement of reconnaissance activities, visit Municipal and Barangay Officials and other groups as necessary such as home owners' associations.

(ii) Reconnaissance teams should be equipped with the necessary maps and plans.

(iii) Coordinate with land owners/occupiers if necessary to enter private property.

(iv) In assessing the suitability of the selected sites for boundary control points, they should be relatively clear of any obstructions at elevations greater than fifteen degrees above the horizontal from the expected antenna position.

(v) When it is not possible to coordinate the selected boundary point, because of restricted satellite visibility, or for some other reason a GPS antenna cannot be set up over the point. Select a GPS control point as close as possible to the boundary point and a connection will be made from the GPS point to the boundary point by compass and tape. In this case it may be necessary to establish some form of monument.

(vi) If monumentation is to be done at a later date, the location of each new control point will be marked with a suitable temporary marker to enable the correct location to be determined at the time of construction. It may be appropriate to monument to third order specifications depending upon the location of the point and other control in the locality.

(vii) Use a hand held GPS to obtain the approximate location of new control points.

(viii) Allocate the next available number to any points to be monumented and complete the Point Number Allocation Sheet. The format of the number will be MMAnnn (eg MMA94 or MMA161).

(ix) For boundary points allocate the appropriate number and complete the Point Number Allocation Sheet.

(x) A Reconnaissance Information Sheet will be completed for each point that has been allocated a number. It is important that sufficient information is recorded to enable another survey team to locate the monument or boundary point without assistance. The approximate coordinates from the hand held GPS should be entered on the sheet. The Reconnaissance Information Sheets must be checked regularly by the team leader to ensure that they are to the required standard.

(xi) If the boundary point is not directly coordinated with GPS, enter the compass and tape connection on the Reconnaissance Information Sheet. The measurements should be independently checked by a second person and these measurements entered on the sheet.

(xii) Indicate the location and the number allocated on the maps and photography provided, this information should be added to the office copy.

(xiii) For points to be monumented, advise land owners/occupiers of the selected location, that a monumentation team will be visiting in the near future to construct the permanent monument followed by the GPS teams. Ensure that the owners/occupiers understand the importance of the monument for the project and all future surveying activities in the area and that it should not be disturbed for any reason. If for some reason in the future, the monument must be moved or destroyed, the owner/occupier should contact DENR OSS for approval.

3.4.3 Monumentation

(i) Unless part of substantial concrete structures, new third order control points will be established as follows:

- concrete monuments, poured on-site, with the following minimum dimensions:

  0.20m x 0.20m cross section at the top;

  0.30m x 0.30m cross section at the base;

  0.5m long;

  protruding 0.1m above ground level (normally);

  in some situations, where the stability of the ground is questionable, a larger monument may be appropriate.

(ii) The monuments will have a steel rod or a 0.1m copper nail set in the centre and be inscribed with the appropriate point number, the name of the agency establishing the monument and the year.

(iii) If established on substantial concrete structures, new third order control points may be :

- nails in cement patties,
- drill holes,

- screws or bolts set in drill holes (possibly with a washer inscribed with the point number).

(iv) To enable a GPS antenna to be set securely over the mark when using a range pole and bipod set up on fast static surveys, it is essential that the rod, nail, screw or bolt used to mark the point is punched with a center punch, or has a cross cut in it or some other suitable alternative is provided to prevent the tip of the range pole slipping from the point during the observation.

(v) For monumented control points that will not be new third order control points select an appropriate semi-permanent method of marking, such as a length of rebar driven well into the ground.

3.4.4 GPS Observations

(i) For more detailed instructions on GPS observations refer to the relevant instructions.

(ii) Coordinate third order and boundary control points from the two nearest primary or secondary stations. All points must be in a minimum of two independent sessions. Points should be coordinated using a reference station and rover technique. For any observation session there should only be one reference station. Using two reference stations does not provide a redundant observation and is not acceptable.

3.4.5 GPS processing and validation

(i) GPS Baselines to be processed using propriety software.

(ii) Minimally constrained (or free net) least squares adjustment to be carried out to determine the quality and consistency of the data.

(iii) Analyse the results of the baseline processing and more particularly the adjustment in (ii) above to determine the need to reobserve any baselines.

(iv) Carry out any necessary reobservations, process and add to the adjustment.

3.4.6 Final adjustment of data

(i) Compass and tape data to be added to the GPS data.

(ii) Constrained adjustment to be carried out to determine final coordinates.

(iii) If points are monumented, data should to be sent to CGSD for integration into the National Geodetic Data Base.

Appendix 1 Reconnaissance Information Sheet

PRS Reconnaisance Information Sheet

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES LAND ADMINISTRATION AND MANAGEMENT PROJECT, PIO-1 PROVINCE OF LEYTE	PRS DESIGNATION	PAGE NO.

MONUMENT: _____ **ESTABLISHED BY:** _____
DATE ESTABLISHED: _____

ISLAND: _____ **PROVINCE:** _____ **MUN.:** _____ **BRGY:** _____

DESCRIPTION OF MARK:

ACCESS:

REMARKS:

SKETCH:

PREPARED BY: **Date:**

Appendix 2 GPS Station Visibility Sheet

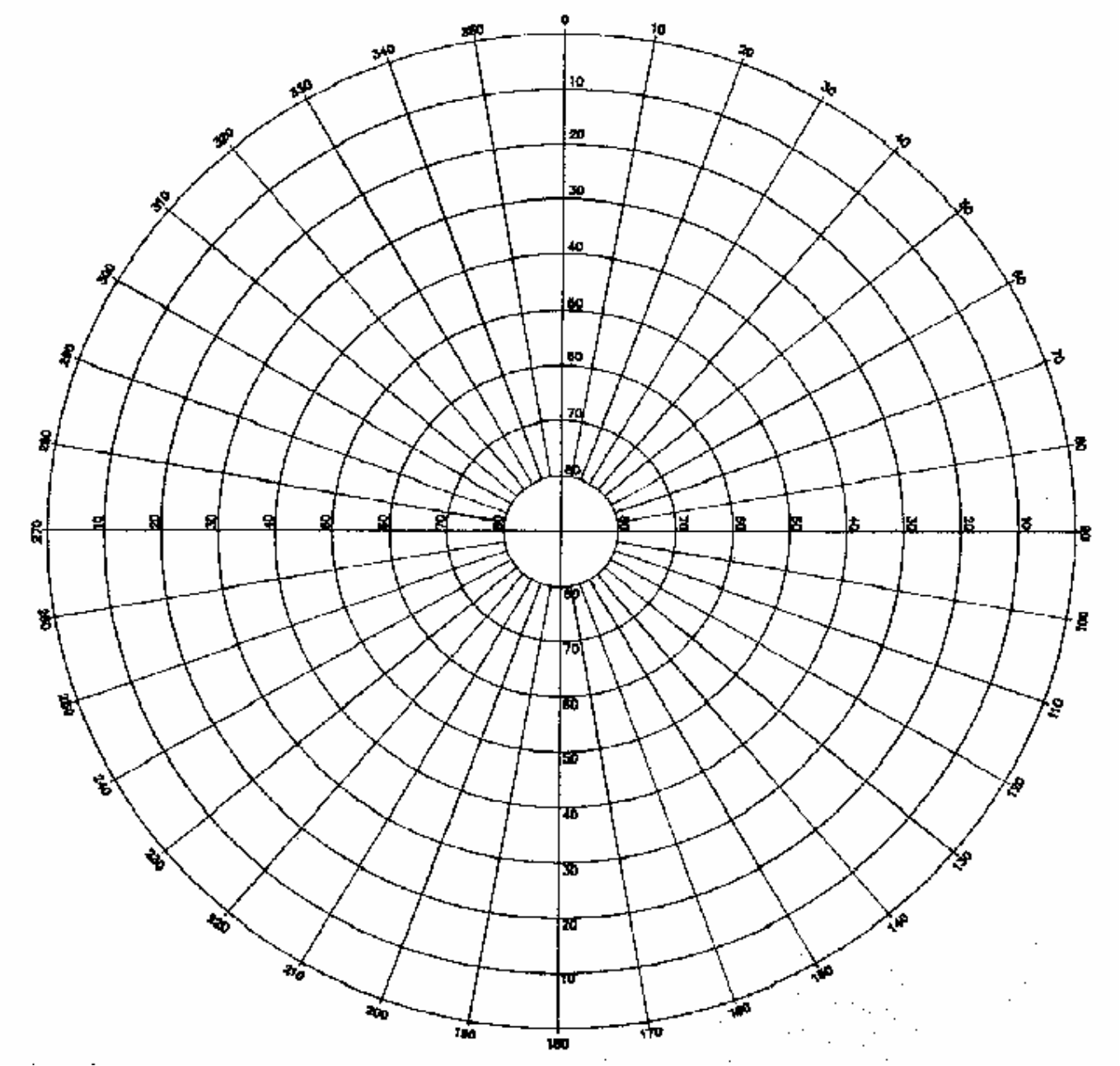
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

LAND ADMINISTRATION AND MANAGEMENT PROJECT

GPS STATION VISIBILITY

Station: . . . . . Height above ground level . . . .

Plot all obstructions above the horizon; note the nature of each obstruction and whether or not it can be removed. If necessary, use another visibility sheet for a higher instrument set-up. Note below details of any obstructions which may cause reflection of GPS signals.



Comments : .....

.....

(Use other side. If necessary)

Surveyor : ..... Date of Survey : .....

Appendix 3 Traverse Page (front)

Prov.	Mun.	Project: LAMP	T.P.
Brgy.	Sitio		Stn. No.

N

Surveyed by	Date

Appendix 4 Traverse Page (rear)

AT														

From H.I.	To	Observed Distance 1	2	3	Mean Obs. Distance	Prism Corr.	Mean Slope Distance	Vertical Angle Direct	Reverse	Z.D.	H.T. Remarks

T.P.		Observed: Recorded: Computed: Checked:	Date:		Theod: E.D.M.

Appendix 5 Guidelines for Using Traverse Pages

GUIDELINES FOR USING TRAVERSE PAGES

General Information:

All entries to be neat and legible **in black ink**.

All spaces must be filled with the relevant information.

Front (Sketch side):

Enter the appropriate details on the front of the page. Traverse Page number to be entered later.

Note that north is up the page.

Draw a clear sketch utilising the space available to indicate the points being observed and the relationship between the points.

Back (Observation side):

Enter make, model and serial number for theodolite and EDM.

Enter date.

Enter observer's name, recorder's name and computer's name (the recorder is normally the computer).

His and HTs (Heights of instruments and targets) are measured from the center of the instrument or target to the top of the survey mark – not the ground.

As the data is recorded it should be reduced/computed.

After completing the observations, the computations must be thoroughly checked, usually by the observer, to confirm that they are OK before moving the equipment.

The checker must sign the Traverse Page.

Note that up to 5 pointings can be accommodated on the Traverse Page.

Appendix 6 Traverse Page Reductions

TRAVERSE PAGE REDUCTIONS

General Information:

All entries to be neat and legible in black ink.

Data should be reduced as it is recorded.

Horizontal Angles:

Mean direct & reverse readings to each point as the observation to each point is completed for the particular set.

Show two digits (eg: 35, 02).

Mean to the nearest second, suggest that take 0.5 up to the next whole digit.

Be careful where the minute values are different.

Always subtract the mean back sight value from the mean fore sight value.

Repeat for the second set.

Compare the reduced mean angles for each fore sight. The difference should be less than 10 seconds on shorter lines (less than 100m). Consider that 1 second over 100m is equivalent to .0005m.

Calculate the mean observed angles and enter on the TP. Look carefully to ensure that the minutes are correct and that the reduced angle looks correct.

Distances:

Mean the three observed distances and enter on the TP.

Vertical Angles:

The reduced vertical angle is the Zenith Distance which is the angle measured from the zenith.

The Zenith Distance is determined as follows (Direct VA + 360 – Reverse VA)/2

After computing all observations, the computations must be independently checked before moving the instrument and targets.

Appendix 7 Reconnaissance Equipment

- Hand held GPS
- Hand held radio
- Bolo
- First Aid Kit
- Hammer (large)
- Shovel
- Traffic Cones (6)
- Temporary Marks
- Paint
- Brushes
- Umbrella (surveyor's)
- Equipment Box with the following items;
  - Magnetic Compass (surveyor's)
  - Clinometer
  - Chisel
  - 30m Tape Measure
  - Plastic marking tape
- Personal protective clothing (each person to have)
  - Safety jacket
  - Rubber boots
  - Raincoat
  - Skull guard

Appendix 8 Monumentation Equipment

- Crowbar
- Bolo
- First Aid Kit
- Hammer (large)
- Shovels (2)
- Water containers (3)
- Traffic Cones (6)
- Temporary Marks
- Paint
- Brushes
- Umbrella (surveyor's)
- Heavy duty masonry drill (12v)
- Equipment Box with the following items;
  - Chisel
  - Palita
  - Wooden Float
  - Fabricated Lettering Templates
  - Center Punch
  - Hacksaw & spare blades
  - 30m Tape Measure
  - 5m Tape Measure (steel)
  - Plastic marking tape
- Personal protective clothing (each person to have)
  - Safety jacket
  - Rubber boots
  - Raincoat
  - Skull guard
  - Safety Boots
- Materials
  - Sand
  - Gravel
  - Steel bars
  - Cement
  - Copper nails
  - Concrete nails
  - Lumber
  - Plywood
  - Nails
  - Tie wire
  - Drill Bits (masonry)

Appendix 9 GPS Equipment

- GPS Receiver, antenna and ancillary equipment in box
- Tripod & bag
- Plumbing pole, bipod & bag
- Spare batteries
- Spare cables (antenna & power)
- Target carrier
- GPS backpack
- Two way radio
- Bolo
- First Aid Kit
- Hammer (large)
- Shovel
- Traffic Cones (6)
- Sand bags (2)
- Temporary Marks
- Paint
- Brushes
- Tarpaulin
- Umbrella (surveyor's)
- Equipment Box with the following items;
  - Magnetic Compass (surveyor's)
  - Clinometer
  - Flashlight
  - Chisel
  - 30m Tape Measure
  - 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
  - Skull guard

Appendix 10 Traversing Equipment

- Total Station and ancillary equipment in box
- Tripods & bags (3)
- Tribrachs (2)
- Target Carriers (2)
- Prisms / targets (2)
- Plumbing pole & bag
- Spare batteries
- Spare cables
- GPS backpack
- Hand held radios (2)
- Bolo
- First Aid Kit
- Hammer (large)
- Shovel
- Traffic Cones (6)
- Temporary Marks
- Paint
- Brushes
- Tarpaulin
- Umbrella (surveyor's)
- Equipment Box with the following items;
  - Chisel
  - 30m Tape Measure
  - 5m Tape Measure
  - Plumb bobs (3)
  - 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
  - Skull guard

Appendix11 Team Leader's Field Bag

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)