Survey and Land Registration Bureau
Kingdom of Bahrain

Data Capture Standards and Specifications for As-built Field Survey

Release v4.2
30 May 2021

Data Capture Standards and Specifications: As-built Field Survey

Revision History

Version	Date	Amendments
1.0	19th March 2015	First release of this document.
1.1	7th May 2015	Ministry of Housing Version.
2.0	20th August 2015	Revamp into new format
3.0	31 January 2016	Second Release
4.0	31 October 2016	Final amendments after feedback
4.1	23 April 2018	New transformation parameters
4.2	30 May 20201	Update person of contact and official email for clarification

Contents

1 Introduction

This is a working document which will develop with time and provides standards, specifications and procedures for as-built surveys for the update of topographic base mapping for which the Survey and Land Registration Bureau (SLRB) is custodian. The data update will be maintained through systematic review and inclusion of as-built data on a project by project basis.

All work shall be performed and presented in accordance with the following requirements to ensure that SLRB maintains, (and enhances) the standard, quality and procedure of data capture and data content.

It is important to note that this document does not take any responsibility away from the Contractor or Consultant and is for POSITIONAL LOCATION of features/structures ONLY and does not include other types of as-built checks which should be carried out such as condition, type and quality of products used.

The main body of the text gives the general standards and specifications that will be imposed on all as-built surveys in all projects. The details for each type of as-built survey for the various project i.e. housing or roads or utilities will be supplied in more detail in the relevant Appendixes.

The Organisation responsible for the project will define at which stages the different (interim) as-builts should be carried out which will be defined in the contract document. The minimum requirement is to carry out a full as-built survey at the completion of the project which will be used by the Client for final certification and by SLRB to update the National base mapping. However, as-built surveys of buried infrastructure must be carried out at open-trench stage. These specifications are to be used for ALL as-builts whether interim or final.

Furthermore the features and structures listed in the as-built specifications in the code list are at a high level and do not cover all the attributes that may be required by the responsible Organisation. The goal of these specifications is to obtain the true 3D position of the feature/structure with an identifying code so if further attributes are required these can be collected by the Engineer by visual inspection and added afterwards.

Any requests for clarification should be directed to;

As-Built Team
Topographic Survey Directorate
Survey and Land Registration Bureau
P.O. Box 332, Manama
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2 Definitions and Standards

2.1 General Instructions

2.1.1 Purpose

These requirements for as-built survey information provide the outline of information required by Topographic Survey Directorate (TSD) of SLRB. The as-built data shall enable update of the 1:1,000 scale topographic mapping maintained by SLRB. All surveys are to be carried out on the National Survey Datum of Bahrain.

2.1.2 Scope

The document is to provide the standards and specifications for all as-built surveys and must be included in specifications for contracts by any company or Ministry responsible for carrying out or having responsibility for such surveys. The document is divided into 5 sections, this section which covers general survey standards, section 3 and 4 which cover data capture by specific methods, section 5 for data and CAD specifications and finally the general QA procedures and survey review that must be demonstrated to have been carried out. A glossary of terms used throughout the document is given to ensure the reader does not misunderstand the text. Finally Appendixes cover the typical kind of data and report formats expected along with special instructions/guidelines for each type of as-built scenario which will alter depending on the user of these standards and specifications. Note that where the accuracies for an as-built survey are higher than that of SLRB's requirements, these will be stated clearly and should be used in these circumstances.

2.1.3 Geodetic Datum

All surveys carried out in Bahrain must be carried out on the National Survey Datum.

The National Survey Datum used in Bahrain is defined as follows:

Name: Ain Al-Abd
Transformation Model: Bursa-Wolf
Ellipsoid A: WGS 1984
- Spheroid: World Geodetic System 1984 (WGS84)
- Datum: ITRF 2005
- Semi major axis: 6378137.000 m
- Inverse Flattening: 298.2572236

Ellipsoid B: International 1924 (Hayford 1909)
- Spheroid: Hayford
- Datum: Ain Al Abd
- Semi major axis: 6 378 388 m
- Inverse Flattening: 297

Transformation Parameters:[1] *(from WGS84 to Ain Al Abd)*
- dx: 97.238075m
- dy: 358.434928m
- dz: -13.152499m

[1] These transformation parameters were derived during the establishment of the Bahrain Permanent Reference Network (PRN).

Rx:	-0°00'01. 47912"
Ry:	-0°00'00. 45994"
Rz:	0°00'03. 26023"
SF:	-5.8999 ppm

Projection:	Universal Transverse Mercator (UTM)
Zone:	39N

A good approximation of this transformation can be implemented using the EPSG 20499 datum information.

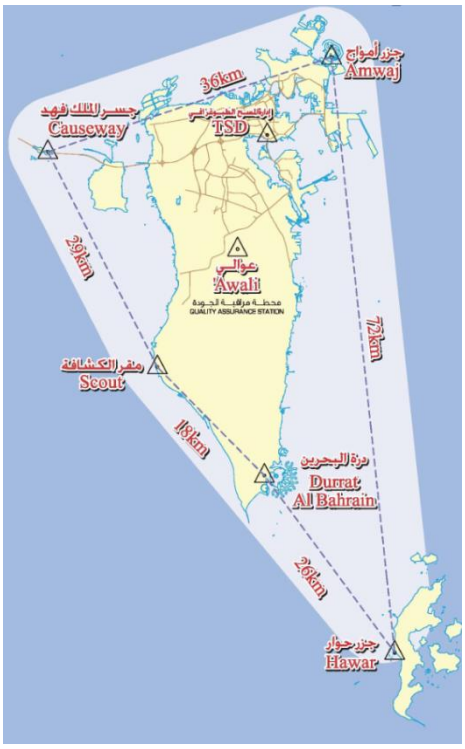
CSCS transformation

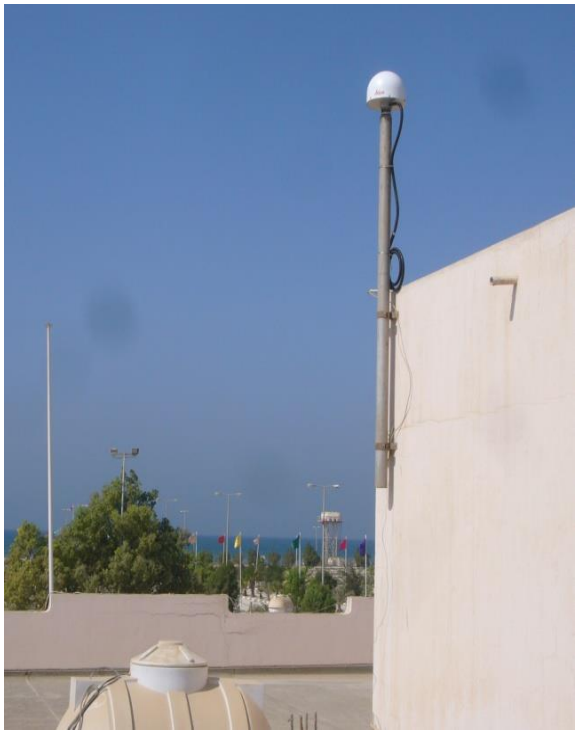
The set of CSCS corrections are shift grid corrections stored in a binary file intended to be applied to the grid coordinates of points measured by the Bahrain Permanent Reference Network in oder to fit the Ain Al Abd Datum. These binary file will be supplied by SLRB. The CSCS transformation was created in 2008 to fix the non-homogeneity of the existing control network used to define all cadastral parcels. It became necessary because the distortion cannot be modelled by a single purely geometric transformation. The nodes containing the delta corrections are evenly spaced in the E and N directions at 0.5km grid.

2.1.4 Control

The fundamental control is now represented by the 6 permanent reference stations (an example of which is shown below) that are situated around the Kingdom of Bahrain to give good coverage for RTK GPS usage

Map of Base Stations





Example of Reference Station

Tertiary control is any other control that is established from the PRN or secondary control for any project and may or may not be permanent and be of varying quality depending on how it is established and is not the responsibility of SLRB.

2.1.5 Units of measurement

All surveys in Bahrain are to use the metric system with the base unit of measurement being metres.

2.1.6 Accuracy

Accuracy is defined statistically as the root mean square error (rmse) or maximum tolerance. The rmse is equivalent to 67% tolerance and 90% tolerance is 1.65 times the rmse when a representative sample of points is tested. Thus, an rmse of ±5 mm (band 1 Accuracy below) indicates that when a representative sample of 100 points is tested not less than 67 of the 100 shall be better than ±5 mm and not less than 90 points shall be correct to better than ±8 mm. Any errors exceeding three times the rmse, in this case ±15 mm may be regarded as mistakes.

Accuracy has been considered in relation to "Bands". The higher the Band, the more accurate the survey is. However, where a survey has been created for one user and another user wishes to utilise the same survey for an alternative purpose the new user needs to satisfy themselves that the survey is "fit for their purpose" by undertaking some validation of the data.

Survey Accuracy Band Table

Band	**Vertical mm**	**Horizontal mm**
Band 1	± 5	± 5
Band 2	± 20	± 20
Band 2A	± 5	± 20
Band 3	± 50	± 50
Band 4	± 100	± 100

2.1.7 Survey of Features

All features will be surveyed in accordance with the Feature Catalogue which states the accuracy band to which each featured should be surveyed to. A summary of the feature accuracy bands is given below.

Theoretical reference frame	Datum
Physical reference frame	PRN Base Station
National control points	Secondary Control
Band 1	Tertiary Control
Band 2	Hard Detail
Band 2A	Hard Detail where high level/height accuracy required
Band 3	Soft Detail
Band 4	Not well defined soft detail

The highest accuracy is the Datum itself which are represented on the practical terms by the 6 Base stations of the PRN. From this primary control Secondary can be established using certain methods to ensure an accuracy of +/- 5mm relative to the Primary control, which are typically the old Bahrain Primary (BP's) and more recently Reference Marks (RMs) or benchmarks in height.

Control established by less rigorous means either direct from the PRN or traversing and levelling, but still achieving and accuracy of +/- 5mm would form tertiary control and be represented in band 1.

Band 2 are for topographic features surveyed directly using the PRN and RTK methods or total station from well-established tertiary control. Ensuring good practice is followed would achieve an accuracy of +/- 20mm. This should be the method used to survey all "hard detail" i.e. constructed features such as buildings, walls, roads, kerb lines, utility services and well defined street furniture.

Band 2A is the same as Band 2 except for certain projects where a greater height accuracy is required so levelling techniques have to be employed. A typical example of this is manhole and pipe invert levels for an infrastructure project for Ministry of Works or Housing

Band 3 is for "soft features" often natural features whose position are more difficult to define such as trees, edge of grass surfaces,

Band 4 are for ill-defined features which often need some interpretation such as top and bottom of banks, tree canopies, burial mounds, coastline, etc.

2.1.8 Data Precision and Density

Whereas accuracy is a measure of how close the measured location of an individual point recorded by the survey instrument or sensor is to its true position, precision is

defined as how accurately the complete feature is represented on the map or plan, especially if the feature is not a regular shape. An example of this is a curved road edge. The precision required would be the maximum arc to chord distance that is acceptable. This can be associated with the accuracy bands in that the precision can be requested to the same level as the accuracy of the individual point.

Density is the number of points required to actually achieve a certain precision or is often used in a way of stating the requirement for spot heights. In the terms of recording points around a curve a maximum distance can be set i.e. points should be surveyed at 10m intervals around a curve. For spot heights the definition is usually stated as a grid distance i.e. Spot heights should be observed to show a true representation of the ground by surveying any change in slope and at a 10m grid interval. Alternatively it can be given as a precision i.e. Spot heights should be observed to show a true representation of the ground such that the precision is less than half the minimum contour interval which is 0.5m.

2.1.9 Roles and responsibilities

The Topographic Survey Directorate (TSD) of SLRB is custodian of base map data of the Kingdom of Bahrain which is surveyed at 1:1000 scale. It is also responsible for the standards and specification to be used by any Surveyor who is carrying out an as-built survey that will be eventually incorporated into the National base map. TSD routinely carries out quality control checks required before the data is accepted and suitable for the National base map and acts as a referee regarding the suitability of firms or individual surveyors to carry out such surveys, judged by the quality of their submissions as monitored by TSD.

Most of the as-built surveys for the above purpose will be initiated by Ministry and non-government organisations, who will ensure that these as-built survey standards and specifications are incorporated into the Tenders they let and ensure that the surveys are done in a timely manner so that TSD can carry out quality checks so as not to delay further construction or development. They will oversee the immediate work and inform TSD if any further assistance is required. It will be important for all Ministries to have a responsible person for interaction with TSD so that communication and data flow is not hindered.

The actual survey will be carried out by the Contractor himself or more likely he will use the services of a professional survey firm. In any case it will be the responsibility of whoever carries of the survey to be fully aware of the these standards and specifications and provide surveys which adhere to them with sufficient quality control checks in place to prove that the required accuracy and specifications have been met in a professional manner. Should further clarification be required then this should be raised to TSD through the Ministry that has employed them.

2.1.10 Health and Safety

All survey work will be carried out under the Health and Safety rules set out in the contract and/or site Health and Safety procedures put in place by the Contractor including attending any site induction courses and wearing of appropriate safety equipment. It is assumed that the Contractors H&S will have been approved by the client's Engineer. It is very important that no confined spaces are entered without having attended the appropriate courses and clearance by Health and safety officer for the project.

2.1.11 Quality Assurance

The Surveyor shall implement quality management procedures to ensure that the information and materials supplied comply with the Conditions of Contract, Technical Specification, specific job requirements and fitness for purpose in terms of quality, completeness and standard of presentation and timely delivery.

The Surveyor shall be responsible for implementing full quality control and assurance procedures at each stage of the work, including documented self-checks and independent checks, to ensure that mistakes, errors and omissions are identified and corrected prior to delivery of the results. Surveys shall not be deemed delivered until received by the client in a form that complies with the specification.

TSD shall be entitled to inspect the work in progress at any time, on site or at the Surveyor's office.

TSD is entitled to undertake an independent validation of the results. Should significant errors be found, TSD reserves the right to claim for the cost of the validation survey from the Surveyor. The Surveyor shall co-operate with the TSD's validation of the survey by honouring all reasonable requests for data and information. The Surveyor remains responsible for his work whether or not the client has undertaken validation checks.

The Surveyor shall ensure that he/she detects and corrects/controls systematic errors.

3 Data Capture Specifications

3.1 General Instructions

3.1.1 Purpose

This document is not intended to provide a manual on Practise and Procedures for Field Survey. Instead, the document provides guidelines for interpretation and collection of topographic features to enable delivery of data according to SLRB data delivery requirements.

3.1.2 Field Survey

The SLRB utilisation of field survey techniques currently has a heavy emphasis on GNSS RTK data collection although it is recognised that some of the building as-built surveys will be carried out by total station. This document specifically refers to the use of GPS for control or data capture with RTK GNSS equipment implemented using the Kingdom of Bahrain PRN facility.

3.1.3 Field Survey Requirements

All field survey work and associated office processing will comply with General Directorate of Survey requirements applicable at the time of survey. At present these requirements are;

a. *Servicing and calibration of all equipment.*
   All equipment shall be serviced and calibrated at least once every twelve (12) months. The servicing and calibration is to be undertaken and certified by a SLRB approved service centre.

b. *SLRB approved data supplier*.
   All survey work is to be undertaken by a data supplier approved by the Bureau. Such approval must be in writing and obtained prior to any data collection. Requests for approval shall be made to SLRB's Director of Topographic Survey.

c. *GNSS Survey*
   Any work undertaken using GNSS survey methods must utilise the Kingdom of Bahrain Permanent Reference Network (PRN).

d. *Documentation*
   All field captured data shall be separately supplied as feature coded ascii files in addition to the CAD data. The ASCII file shall contain point, line and polygon features coded according to the feature list in Appendix A as well as date and time of capture, agency or company name and surveyor name and QC file. All text in the ASCII file shall be in the English language.

3.2 GNSS data capture specifications

3.2.1 Field Survey Instrument Configuration – use of Geodetic Datum

Any RTK GNSS equipment should be configured to record UTM projection coordinates directly in the National Survey Datum, as specified in 2.1.3 of this document, when collecting data for topographic map update.

In addition, an interpolation grid can be implemented to recover localised, systematic distortion of the control network. When correctly applied this grid enables direct matching to physical control mark coordinates across the country taking due to consideration of localised inconsistencies[2].

Any usage of GNSS equipment should be based on the Permanent Reference Network (PRN). Connection to the service through a specific user account can be readily arranged through the Director at TSD.

The field survey controller should be configured to enable coded recording of data according to the feature list described in Appendix A of this document. This coding arrangement has been configured for SLRB Leica SmartRover and Trimble 5700 rovers. The configuration files are available through the Director TSD if required. If a Surveyor decides to use his own coding he must ensure features are put into the correct CAD level after down loading of the data and provide a detailed code list with feature descriptions.

3.2.2 Equipment and Accuracies

The as-built data will be collected using a Geodetic GNSS receiver with the following minimum specifications:

i. Dual frequency receiver

ii. Activated to utilise Bahrain PRN RTK correction information. Access to the Bahrain PRN can be arranged through the Director TSD.

iii. Capability to apply a 7-parameter transformation, supplied by SLRB, enabling direct display of Ain Al Abd coordinates in the field

iv. Capability to apply an interpolation grid, supplied by TSD, to enable higher degree matching to existing control network.

The coordinates of surveyed features should be within an accuracy of ±10mm in all three dimensions. Control should be to ±5mm for adjacent stations.

3.2.3 Field Survey Procedures

The Surveyor shall implement best practice surveying procedures to ensure that the information and materials supplied comply with the specification and survey guidelines and are fit for purpose in terms of quality, completeness and standard of presentation and timely delivery. This should include but not limited to highlighting correctly set accuracy, point data collection time, GDOP values and minimisation of mutli-pathing.

[2] The interpolation model is implemented both as a Leica CSCS model and a Trimble Shift Grid and obtainable from SLRB.

3.2.4 Field Survey Quality Assurance

The Surveyor shall implement quality management procedures to ensure that the information and materials supplied comply with the specification and survey guidelines and are fit for purpose in terms of quality, completeness and standard of presentation and timely delivery. This should include but not limited to check points throughout the day and other good practice internal checks.

3.3 Total Station data capture specifications

3.3.1 Field Survey Instrumentation

3.3.2 Equipment and Accuracies

The as-built data will be collected using either:

Electronic total station with;

i. angular accuracy of 5 arc-seconds or better
ii. electronic distance metre accuracy of 5mm+/-5ppm, or better

The coordinates of surveyed features should be within an accuracy of ±10mm in all three dimensions. Control should be to ±5mm for adjacent stations.

Should the detail be surveyed from control stations, located and coordinated by traversing from SLRB control stations the traverse should be carried out between at least two known control points with at least two independent reference marks at start and end of the traverse. The misclosure should be better than 1:20,000.

3.3.3 Field Survey Procedures

The Surveyor shall implement best practice surveying procedures to ensure that the information and materials supplied comply with the specification and survey guidelines and are fit for purpose in terms of quality, completeness and standard of presentation and timely delivery.

3.3.4 Field Survey Quality Assurance

The Surveyor shall implement quality management procedures to ensure that the information and materials supplied comply with the specification and survey guidelines and are fit for purpose in terms of quality, completeness and standard of presentation and timely delivery. This should include but not limited to evidence of checking RO after data collection, and other good practice self-checking QA procedures.

4 Data and CAD Specifications

4.1 Feature Interpretation Guidelines

The following information will enable consistent data capture for all field surveyors providing data to SLRB.

4.1.1 Feature Classifications

The features in Appendix A can be grouped into the following main categories;

a. Buildings
b. Construction and Installation (C&I)
c. Historic
d. Hydrology
e. Surface cover
f. Topography
g. Transportation
h. Utilities
i. Vegetation

The features in each category are described in detail to aid interpretation and consistent data capture. The various text layers are in place for any annotation that may be required for the corresponding feature layers See Appendix E.

4.1.2 CAD layers, symbology and text

To ensure the correct layering and symbols, (see Appendix E) are used in the production of the CAD drawing, the seed file/template for Microstation and AutoCad is provided along with the feature catalogue (Appendix A) on the SLRB website after registration in the as-built section. For the organisations/firms that use TerraSurvey to produce the drawings within Microstation, if the codes within this document are adopted an import file converting the codes to the correct layers/levels and symbology is also available on the website.

4.1.3 General Building Requirements

a) Shapes – All features classified under the Buildings category should be captured as Shapes (Closed Polygons) not as any other element (geometry) type.

b) Components – If a building has portions of different elevations, each different portion should be captured as a separate shape. Ensure that each portion is properly snapped together.

c) Existing buildings – Should the new as-built abutt up to an existing building the common building line of the existing building should also be surveyed. If existing buildings remain in the new site they should also be surveyed.

d) Snapping – When capturing Buildings, the vertices should be snapped to the property line or fence/wall or to the existing building side wherever required.

e) Orthogonality – Buildings should be captured as orthogonal shapes (squared) to the maximum extent possible (i.e. 90º angle should be maintained between sides and the sides should be straight) except for the buildings which are truly irregular in shape.

f) Attachment of buildings – If a building feature is not clearly attached to another building (for example garage or carport to main house) then it should be plotted as a separate structure.

g) Building Void Areas – Open space areas inside the main outline of a building should be plotted if the planimetric area is greater than 5m².

h) Balconies and Verandahs – A balcony is a cantilever extension of a floor area designed to be used as an external living area. Generally a balcony can be ignored. A verandah area that extends to the ground (or other building segment) below should be included as a main building outline shape.

4.2 Data Capture instructions

4.2.1 Data Generalisation

The field surveyor should capture X, Y, & Z coordinates of all the features within the entire assigned area of update.

4.2.2 Data precision

The typical precision of capture will be dependent on the specific capture technique utilised and the definition of the features. In defining precision consideration is given to 'hard' (easily definable and interpretable) such as buildings and walls.

As a guide;

- Data captured by field survey methods should be within a maximum tolerance of 5cm.

However, irrespective of the capture technique and precision, relative location of features should be maintained at all times.

4.2.3 Data density

Every vertex should be individually measured. The density of points on linear features should be adjusted to accurately define the feature in 3D. On well-defined features;

- The true horizontal position of any point on the feature shall be within 0.2m of the surveyed feature.

For example, road edges and curved buildings/ walls should be surveyed at sufficient density to satisfy the above planimetric requirements.

4.2.4 Capture of shape/polygon features

All shape features should be captured in an anti-clockwise direction. Voids, courtyards etc that are considered and "inner ring" should be captured in a clockwise direction

4.3 CAD instruction

4.3.1 Snapping - CAD

New data is to be added as appropriate ensuring that features are snapped and areas are closed. Care should be taken to adjust snapping for 2D or 3D snaps where appropriate.

4.3.2 Data cleanliness - CAD

There should be no duplication of captured features (in whole or in part), and no overshoot/under shoot or sliver polygon in the 3D DGN/DWG file in which straight forward edit and update have been completed.

4.3.3 Data Capture

All data shall be captured and edited to maintain consistency within a 3D environment. Most features, will therefore, need to be captured with an accurate height.

4.3.4 Continuity of features -CAD

At the completion of data capture any individually captured parts of a single feature should be consolidated to a single element such as line or line-string. Linear features represented by complex strings are not acceptable.

4.3.5 Feature Classification -CAD

As far as possible all features should be categorised according to the existing data structure (as shown complete in Appendix A). The features are classified as either point, line or shape (otherwise called polygon). Additionally text (or annotation) is to be placed as required on the appropriate text level.

Any feature that cannot logically be classified according to the existing data structure (as shown in Appendix A) should be captured as a Miscellaneous Feature. The data checking and field review will be responsible for classification of these features.

4.3.6 Graphic type restrictions - CAD

There should be no element type of Arc/Curve/B-spline/B-spline Curve/B-spline Surface in the completed update of the active 3D DGN file. Data can be plotted as arcs at capture stage but must be stored as a line-string.

4.4 Data QA and Review

4.4.1 General Instructions

Key tasks of data checking prior to acceptance by the SLRB supervisor are;

- Completeness
  - All additions have been made
- Consistency
  - All data conforms to specified level structure and attributes (symbology)
- Cleanliness
  - No duplicate elements remain in the file
  - Snapping has been done correctly – either 2D or 3D as appropriate
  - No sliver polygons exist – particularly in adjoining buildings.
  - No feature enters a building (kerb, wall, spot heights, vegetation)
  - Symbols have been removed where redundant
  - Spot height (centroid) placed inside every flat roof

4.4.2 Deliverables

All deliverables should be supplied electronically on a CD or by e-mail with all documents contained in a .Zip file (Compressed folder) to TSD using an address assigned by TSD.

Report – in .pdf or .docx format

A report template with the main headings has been include in Appendix B and should be used as the basis of the report supplied. The report should include as a minimum.

Title page with project name and company name and date of survey along with address of properties.

List of equipment used including instrument type and serial numbers and staff employed with grade and number of years' experience.

Brief summary of the methodology used to carry out the survey including reference to use of equipment and survey software (capture and processing)

Schedule of control if any that was used and new control established, with traverse diagram if relevant

Traverse misclosure/residuals achieved including computations

A quality management report describing the procedures used to test the accuracy, completeness and reliability of data and the results of tests including an interpretation of results supplied

Field Data – ASCII format

An ASCII file of the field data which should incorporate the coordinates and heights of all the points along with the corresponding code in the order that the points have been surveyed. The file should be according to SLRB specification, and also include date of collection, instrument type, positional accuracy etc.

An example of a typical files is shown in Appendix C

Digital drawing

This should be submitted in Microstation .dgn or AutoCad .dwg format and must be coded and in the correct levels/layers as specified in Appendix A using coordinates with respect to Ain Al Abd datum and at a plotting scale of 1:1000.
Note all features should be annotated with suitable text which describes the feature and put into the "text" level/layer. The title block should contain as a minimum, Legend, scale, datum, project title, address and use of building, company name, date of survey, survey and cad persons initials.

SLRB will be able to provide a seed file, through the SLRB website, to ensure coding and levels/layering in the CAD files are correct and according to the file structure defined by SLRB.

4.4.3 Data QC and Review

Upon receipt by SLRB, the as-built information will be subject to checking and approval by SLRB. The duration of this process shall be no more than 3 working days.

All data shall be exchanged electronically according to a process acceptable to SLRB.

Further enquiries regarding these specifications and the supply of topographic data should be directed to:

As-Built Team
Topographic Survey Directorate
Survey & Land Registration Bureau
P.O. Box 332, Manama
Kingdom of Bahrain

Tel: +973 1751 5321/ +973 1751 5374/ +973 1751 5339
e-mail: asbuilt@slrb.gov.bh

4.5 Data Review

Data review is the process of checking data and managing the re-integration to the mapping database. This process is to be done by others within the Bureau outside of normal field survey operations.

The following key tasks should be included in this process;

- Categorisation of any miscellaneous features
- Checking of overlapping features and implementation of correct topological representation
- Accumulation of individual building shape components into single building (planimetric) definitions
- Extrusion of buildings into 3D shapes according to supplied centroids
- Modification/compilation of shape outlines and patterning or filling.

4.6 Field Review

The following key tasks should be included in the data review and re-integration to mapping database;

- Correct identification of buildings

5 Glossary

Term	Description
As-built	As-built refers to data collected by such survey techniques as field survey and photogrammetry to map a true state of feature locations. Simple stamping of design drawings as "as-built" is unacceptable.
DGN	File extension for Design files in the Bentley Microstation software.
DTM	Digital Terrain Model. In this case defined by a grid of nominal spacing of 5m with additional spot heights and breaklines to define the shape of terrain. Estimated accuracy within 25cm in height.
DWG	File extension for Drawing Files in AutoCad software
EDM	Electronic Distance Meter
GPS	Global Positioning System
GNSS	Global Navigation Satellite System
LMB	Logical Map Block. The precisely defined polygon generally relates to a Bahrain addressing block. The block boundary has been specially routed so that in general no point or linear feature intersects (or crosses) the boundary.
PRN	Permanent Reference Network. The Kingdom of Bahrain network of permanent GNSS reference stations established primarily to aid high accuracy, high reliability cost-effective GNSS survey.
RTK	Real-Time Kinematic
SLRB	The Survey and Land Registration Bureau of the Kingdom of Bahrain. http://www.slrb.gov.bh/
TSD	Topographic Survey Directorate. The Directorate under the General Directorate of Survey of the Survey and Land Registration Bureau mandated as custodians of topographic mapping and geodesy in the Kingdom of Bahrain.
WGS84	World Geodetic System 1984. The ellipsoid defined in support of GPS.

Appendix A – FEATURE CATALOGUE SPREADSHEET AND DOCUMENT

Please refer to Feature Catalogue document release version 4.0 dated 31 October 2016

Appendix B - REPORT TEMPLATE

General

The report should be typed, in the English language, on company letterhead and signed by the surveyor who was responsible for the work and the principal of the company with the company seal and COEPP registration number

Title page

With project name address and company name and date of survey along with address of property

Introduction

This should include the Scope of survey works, date survey carried out, including a summary of the planned and actual programme of work and delivery schedule.

Personnel and Equipment

This should be a description/listing of the survey equipment (incl. serial nos.), surveying software (capture and processing), and staff employed on the project.

Methodology

Survey Network -This should be a description of the methods employed, and control used.

Adjustment procedure -This should provide a description of the method of adjustment of the horizontal and vertical net including GNSS and Star*Net listing (.txt file) or computations.

Detail Survey -Method used to capture detail.

It should include a quality management report describing the Quality assurance procedures used to test the accuracy, completeness and reliability of data in the field, during the processing and the results of tests including an interpretation of results supplied.

Deliverables

This should be an explanation and listing of what has been delivered.

Conclusions and recommendations

This should include comments on the specification, results and recommendations for future work.

Appendixes

Schedule of control if any that was used and new control established with description

Horizontal and vertical control network diagrams (True to scale or schematic)

Traverse Control Observations, Bowditch Traverse Closures and/or Least Squares Block Adjustment of Traversing

Photographs of Site

Appendix C – TYPICAL ASCII FILE OUTPUT

OPRATOR: MOHAMMED AL MURBATI

INSTRUMENT : Leica 1200 SN:301002
PROJECT NAME: SRAYA

Point Id	Code	Easting	Northing	Orth. height	Time	Coordinate quality	Orientation ellipse [rad]
1	RDASPH	455375.6	2884035	55.4459	11/7/2013 7:03	0.0116	-0.20411508
2	RDASPH	455380.2	2884035	55.4191	11/7/2013 7:03	0.0177	-0.19795822
3	RDASPH	455383.2	2884035	55.4316	11/7/2013 7:04	0.012	-0.20760121
4	RDASPH	455386.4	2884035	55.4211	11/7/2013 7:04	0.0151	-0.19391093
5	RDASPH	455389.1	2884033	55.4354	11/7/2013 7:04	0.013	-0.20804569
6	RDASPH	455391.6	2884031	55.4524	11/7/2013 7:04	0.0359	0.29499608
7	RDASPH	455393.5	2884028	55.4897	11/7/2013 7:04	0.0142	-0.21437637
8	RDASPH	455395.5	2884024	55.5531	11/7/2013 7:04	0.012	-0.19173858
9	RDASPH	455400	2884013	55.6643	11/7/2013 7:04	0.0141	-0.3664393
10	RDASPH	455407.3	2883995	55.9266	11/7/2013 7:05	0.0127	-0.37160462
11	RDASPH	455413.8	2883979	56.1412	11/7/2013 7:05	0.0147	-0.37674458
12	RDASPH	455416.9	2883971	56.234	11/7/2013 7:05	0.0984	0.22862028
13	RDASPH	455419.8	2883962	56.302	11/7/2013 7:05	0.0187	-0.38354137
14	RDASPH	455422	2883954	56.4101	11/7/2013 7:05	0.0122	-0.25188365
15	RDASPH	455423.3	2883945	56.5535	11/7/2013 7:05	0.0129	-0.25836279
16	RDASPH	455424.4	2883937	56.6874	11/7/2013 7:06	0.0113	-0.26271323
17	RDASPH	455425.1	2883927	56.9639	11/7/2013 7:06	0.0123	-0.24444351
18	RDASPH	455425.6	2883919	57.2303	11/7/2013 7:06	0.0131	-0.26703617
19	RDASPH	455425.5	2883913	57.4375	11/7/2013 7:06	0.0181	-0.21654824
20	RDASPH	455425.4	2883910	57.583	11/7/2013 7:06	0.0632	0.37549171
21	RDASPH	455423.7	2883907	57.4862	11/7/2013 7:06	0.013	-0.26990413
22	RDASPH	455421.7	2883905	57.3603	11/7/2013 7:06	0.0123	-0.26553868
23	RDASPH	455421	2883904	57.322	11/7/2013 7:06	0.0183	-0.26739436
24	RDASPH	455419.9	2883904	57.2606	11/7/2013 7:06	0.015	-0.27901799
25	RDASPH	455408.2	2883903	56.9807	11/7/2013 7:07	0.0139	-0.27320632
26	RDASPH	455394.1	2883903	56.8947	11/7/2013 7:07	0.0138	-0.290902
27	RDASPH	455394.4	2883897	56.9916	11/7/2013 7:07	0.0103	-0.27165943
28	RDASPH	455399.3	2883897	57.0024	11/7/2013 7:07	0.0141	-0.29219247
29	RDASPH	455402.5	2883897	56.9991	11/7/2013 7:07	0.0281	0.24980861
30	RDASPH	455404	2883897	56.9902	11/7/2013 7:07	0.0612	0.38949648
31	RDASPH	455404.9	2883896	57.0419	11/7/2013 7:07	0.0116	-0.2820428
32	RDKERB	455404.8	2883896	57.0488	11/7/2013 7:08	0.0124	-0.30463133
33	RDKERB	455404.8	2883890	57.1388	11/7/2013 7:08	0.0282	-0.30884752
34	RDKERB	455419.2	2883890	57.1322	11/7/2013 7:08	0.0263	-0.38394527
35	RDKERB	455419.2	2883896	57.1774	11/7/2013 7:08	0.0559	1.16921477
36	RESSOH	455419.1	2883896	57.5452	11/7/2013 7:09	0.0266	0.46473334
37	RESSOH	455405	2883896	57.5662	11/7/2013 7:09	0.0201	0.52414162
38	RESSOH	455404.9	2883890	57.5718	11/7/2013 7:09	0.0199	0.53256653
39	RESSOH	455419.2	2883890	57.5417	11/7/2013 7:10	0.0184	0.5058599
40	RDFP	455420.2	2883897	57.2599	11/7/2013 7:10	0.0207	0.49463354
41	RDFP	455425.9	2883894	58.14	11/7/2013 7:10	0.0203	0.57776816
42	RDFP	455427.7	2883887	58.7008	11/7/2013 7:10	0.0174	-0.34160347
43	RDFP	455429.6	2883880	58.9791	11/7/2013 7:10	0.0165	-0.37609402

Appendix D – MINISTRY OF WORKS SPECIFICATIONS

Limits and detail to be surveyed

1. The limits of the survey area will be the entire project site to include any boundary division plus all buildings at Ground Level.
2. The final as-built survey will include the location of all above ground features, which have been constructed as part of the project works plus all as-built features of underground features from interim as-built surveys. Ground levels are to be measured after backfilling and site clean-up is complete. Any control station used/installed should also be shown
3. Any feature within the project area defined above which has been modified or otherwise changed, in whole or in part either by these project works or any other works, and are therefore no longer correctly represented in the map data shall be shown in the DGN file.
4. The topographic map data will be fully updated within the area defined above.
5. The data will be supplied in conformance with specifications, current at the time of survey, provided by SLRB for as-built data. The current feature list (level structure) is available from TSD in full but a subsidiary set (supplied in relevant Appendixes) can be used in each type of project and is explained in fuller detail later. These will be supplied in both DGN and PDF format, (Appendix A).
6. Ministry of Works - TO (as-built.MoW@slrb.gov.bh) - all deliverables shall be sent to this email address in .ZIP (compressed file) format.

Appendix E - CODE LIST, CAD LEVELS AND SYMBOLOGY

Please refer to Code List and CAD Levels document release version 4.0 dated 31 October 2016