

**MOKOLO AND CROCODILE
WATER AUGMENTATION PROJECT
PHASE 2 (MCWAP-2)**

TENDER NO 054/2024/PMID/MCWAP2/RFB

**PART C3.1
SPECIFICATION**

SECTION 5

SURVEY AND SETTING OUT

PART C3.1 SPECIFICATION

SECTION 5 SURVEY AND SETTING OUT

TABLE OF CONTENTS

	PAGE
SECTION 5	1
5.1 SCOPE.....	1
5.2 DEFINITIONS.....	1
5.2.1 Definitions	1
5.2.2 References.....	1
5.3 GENERAL.....	2
5.4 PROTECTION OF NATURAL FEATURES.....	2
5.5 CONTROL BEACONS.....	2
5.5.1 Project Reference Marks and Line Control.....	2
5.5.2 Internal Consistency of PRMs	3
5.5.3 Subsidiary Beacons, Survey Stations and Bench Marks	3
5.6 PRESERVATION AND REPLACEMENT OF PROJECT REFERENCE MARKS.....	3
5.7 SURVEY OF GROUND PROFILES	4
5.7.1 Original Ground Profiles.....	4
5.7.2 Excavated, Final Ground Profiles and Constructed Levels	4
5.8 SETTING OUT OF THE WORKS.....	5
5.8.1 General.....	5
5.8.2 Setting Out for Underground Work.....	6
5.8.3 Setting Out for Pipe Works.....	6
5.9 SETTING OUT CHECKS	6
5.10 SITE BASED LASER TERRESTRIAL SURVEY REQUIREMENTS	6
5.10.1 General.....	6
5.10.2 Equipment and Operators	7
5.10.3 UAV Trajectory	7
5.10.4 LiDAR Points	7
5.10.5 Image Capturing	7
5.11 MEASUREMENT AND PAYMENT	8

SECTION 5

SURVEY AND SETTING OUT

5.1 SCOPE

This Section deals with the requirements for the setting out of the Works, survey control and measurement required for survey of the Works.

5.2 DEFINITIONS

5.2.1 Definitions

- a) **“Absolute accuracy”** is defined as the accuracy of any individual reference mark within the Survey Network.
- b) **“Beacon”** means a subsidiary survey control point that is to be used for setting out of the Works. All subsidiary survey beacons and bench marks that are placed, either by the Engineer or Contractor, for control and setting out of the Works shall be set out with reference to the Project Reference Marks.
- c) **“Bench Mark”** is a control point that is used for fixing levels on the construction Works.
- d) **“GPS”** means Global Positioning System.
- e) **“IMU”** means Inertial Measurement Unit.
- f) **“LiDAR”** means Light Detection and Ranging.
- g) **“LiDAR – Survey/Aerial mapping”** is an aircraft or drone-based remote sensing technology, using laser scanning to measure the shape of the ground surface.
- h) **“Project Reference Marks”** mean the primary survey control points which have been fixed within the Contract coordinate system by the Employer for the purpose of survey reference and setting out. Although the system is based on the WGS 84 Hartebeeshoek 94 datum Lo 27 co-ordinate system it has been refined for use in this Contract due to the unavailability of reliable elevation control in the Contract area.
- i) **“Relative accuracy”** is defined as the accuracy of a reference mark relative to its closest neighbouring reference marks.
- j) **“UAV/Drone based surveys”** means surveys done using a suitable unmanned aerial vehicle or drone piloted by remote control by a qualified operator.

5.2.2 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

5.3 GENERAL

This Section shall be read together with the requirements of Clause 4.7 of the Conditions of Contract regarding setting out.

All reference points given on the Drawings are based on the Project coordinate system. Dimensions of structures given on Drawings are corrected for the mean level of the Works above sea level unless specifically stated otherwise and shall be used without further correction.

To avoid any errors, only the Project Reference Marks, location and survey coordinates indicated on the design Drawings should be used for all construction setting-out and level purposes.

All necessary sight rails, pegs, and other items required for the proper alignment of the Works shall be erected by the Contractor to the satisfaction of the Engineer. The Contractor shall record all field observed data calculations for setting out and check surveying in a suitable permanent form, which shall be available to the Engineer on request at all times. These records shall accompany field setting out sketches showing the setting out marks, templates, stakes, batter boards, beacons and pegs, etc., and their relation with the Permanent Works. The Contractor shall supply two copies of any such calculations to the Engineer on request through the document control system where the Engineer will then sign the transmittal to acknowledge receipt.

The Contractor shall, at his own expense, make all templates where necessary for the proper setting out of the Works and support of items to be built in. All surveying works shall be recorded on hard copies and electronic format, and kept available for the Contractor and the Engineer.

The Contractor shall have available on site at all times a sufficient number of properly maintained GPS's, total stations, levels, laser equipment, accurate steel tapes, ranging rods, boning rods, and other instruments and appliances as may be necessary for the correct setting out of the Works and control of the construction process and the calibration of all survey equipment shall be done as per the manufacturers' specifications.

The Contractor shall also maintain regular UAV/drone surveys at agreed intervals that are aligned with the selected construction production rates. These surveys shall capture all stages of the construction process at a specific site or along a progressing linear train of sequential production operations. It shall also include the active borrow pits and spoil areas. In parallel with the execution of these surveys still images shall be taken as part of the photographic record.

5.4 PROTECTION OF NATURAL FEATURES

The Contractor shall not deface, paint, damage or mark any natural features (e.g. rock formations, trees etc.) situated in or around the Site for survey or other purposes. Any features affected by the Contractor in contravention of this clause shall be restored / rehabilitated to the satisfaction of the Engineer, and may attract a penalty as defined in Section 4 – Environmental Management.

5.5 CONTROL BEACONS

5.5.1 Project Reference Marks and Line Control

Project Reference Marks (PRMs) have been provided by the Employer adjacent to the Works. These PRMs shall be the sole points of reference for setting out and levelling purposes. The Contractor will however be required to check the internal consistency of the PRMs.

PART C3.1 - SPECIFICATION

The Contractor shall note that the PRMs have been surveyed and the results reduced to reflect the following accuracies for the reference marks within the Project Ground Control Survey Network:

**TABLE 5/1
ACCURACY LEVEL OF PRM POINTS**

DISCIPLINE	ABSOLUTE ACCURACY	RELATIVE ACCURACY
Control Point Horizontal Position (Y and X)	100 mm	20 mm
Control Point Elevation (Level)	100 mm	10 mm

These PRMs consist generally of a 12 mm round steel peg placed in 250 mm diameter concrete, 200 mm deep and identified with a stamped metal tag. Where these PRMs are located outside of the servitude area they should be marked with at least 3 clearly visible Y-standards painted white, spaced equally around the PRM, of appropriate length to be visible above grass and shrubby vegetation, placed adjacent to the PRM.

The coordinates and reduced levels of the PRMs are provided on the Drawings.

5.5.2 Internal Consistency of PRMs

Before commencing construction of any part of the Permanent Works, the Contractor shall check that all the PRMs provided by the Employer in accordance with Clause 5.5.1 are internally consistent and are sufficiently accurate for the construction of the Works to the required tolerances. The Contractor shall either notify the Engineer in writing of any discrepancies found or confirm in writing his acceptance of the said PRMs.

5.5.3 Subsidiary Beacons, Survey Stations and Bench Marks

The Contractor shall establish, permanently tag and protect subsidiary beacons, survey stations and bench marks required for accurate setting out and level control during construction of the Works. Survey stations shall be of rigid construction and be protected from damage and the design and construction thereof shall be agreed with the Engineer. Pegs placed by the Engineer which may be disturbed during construction shall be referenced by the Contractor by surveying and placing other pegs nearby in safe positions and all such pegs shall be carefully protected to the satisfaction of the Engineer.

The Contractor shall ensure that the necessary ground control are in place prior to every UAV/drone survey.

The Contractor shall supply the Engineer with the coordinates, levels and other relevant information relating to subsidiary beacons, survey stations and bench marks.

5.6 PRESERVATION AND REPLACEMENT OF PROJECT REFERENCE MARKS

Once the Site has been handed over to the Contractor he shall take responsibility for the safeguarding of all the PRMs which will be used to set out and construct the Works. If at any time during the Works the Engineer suspects that one of the PRMs previously established by the Employer has been disturbed, the Contractor shall have the PRM surveyed and the bench mark re-

PART C3.1 - SPECIFICATION

levelled. Any setting out which was undertaken after the PRM and/or bench mark was disturbed shall then be rechecked and corrected if necessary, including any remedial work required for the Works, by the Contractor without any additional payment.

Where a PRM, beacon or bench mark is likely to be disturbed during construction operations, the Contractor shall establish suitable replacement reference beacons or bench marks at locations where they will not be disturbed during construction. No PRM, beacon or bench mark shall be covered, disturbed or destroyed before accurate replacement reference beacons or bench marks have been established and details of the position and levels of such replacement beacons or bench marks have been submitted to the Engineer and approved by him. These replacement PRMs, beacons or bench marks shall be placed to avoid damage to property or injury to animals, and should be marked as required.

The Contractor's reference beacons or bench marks shall be of at least the same quality and durability as that of the existing PRMs and bench marks. Before constructing replacement beacons, the Contractor shall obtain the Engineer's approval for his proposals. Such requests for approval shall include the position, construction details and motivation for the proposed replacements.

The Contractor shall be responsible for the safety of any Government survey beacons, survey bench marks, PRMs and boundary beacons encountered. If any reference points are disturbed or destroyed by the Contractor, they shall be replaced without additional payment to the Contractor, within three weeks or a period agreed to by the Engineer where these points falls within the working area, by a Registered Land Surveyor.

5.7 SURVEY OF GROUND PROFILES

5.7.1 Original Ground Profiles

The Employer has through a LiDAR survey obtained original ground levels, to a resolution of 100 mm or better (for an estimated 80% of the results) in horizontal and vertical position, of the Contract area, approximately 350 m to either side of the pipeline centreline and including those borrow pits and spoil areas located outside the pipeline survey corridor. The results of the LiDAR survey (x, y, z points) will be made available to the Contractor in electronic format on specific request.

The accuracy of the LiDAR survey is defined in the Site Data Pack in Part C4 of the Contract: C4.1 Survey Data. For the purpose of the Contract, the LiDAR survey data shall define the original ground profiles.

5.7.2 Excavated, Final Ground Profiles and Constructed Levels

The Contractor shall survey all excavated and final surfaces for the purpose of recording as-constructed details and, where applicable, for the measurement of quantities. Specifically the aims of this survey are:

- a) Confirmation of actual rock levels;
 - Method 1: On completion of excavation to rock level and prior to commencement of drilling and blasting;
 - Method 2: On completion of excavation to the final required level, subsequent to drilling and blasting, the actual rock level is to be marked and surveyed as part of the final excavation survey;

PART C3.1 - SPECIFICATION

- b) Confirmation of actual final excavation levels on completion of the excavation and prior to placing bedding, concrete or other work and after placing bedding and prior to pipe laying and backfilling;
- c) Confirmation of backfilled levels: On completion of placing backfill, concrete or other work;
- d) Confirmation of bottom and top of floors, top levels of structures, invert and top of slab levels, top of plinth levels for pumps and any other levels required by the Engineer; and
- e) Confirmation of Final Ground Profiles: On completion of landscaping and topsoiling.

The information so obtained shall be recorded by the Contractor on a three dimensional digital terrain model (DTM) which shall be approved by both the Contractor and the Engineer. The Contractor shall then provide the Engineer with a monthly progress update of the model to serve as a permanent record for the purpose of determining both the quantities of excavation and earthworks carried out in the construction of the Permanent Works and the extent to which Temporary Works shall be removed or temporary excavations shall be refilled upon completion of the Works. In addition to the copy of the progressed DTM, the Contractor shall provide a Drawing in three dimensional digital format – “AutoCAD/DXF” or similar approved presentation of the status of the Works.

5.8 SETTING OUT OF THE WORKS

5.8.1 General

The Contractor shall perform all setting out and check surveying of the Works in accordance with methods approved by the Engineer before work commences. Arrangements for access to private property shall be made in accordance with the requirements as contained in Section 4 – Environmental Management. The methods and programme of checking shall be such as to ensure the construction of every part of the Works to the correct line and level, subject to the tolerances specified. The Engineer may at any time request the Contractor to submit proof that the setting out has been satisfactorily checked. The Contractor shall also follow the ISO Quality System where the Quality Control Officer and the Surveyor will ensure that the Quality System is implemented on site.

Specific to all set out sections of work, the Quality Manager and/or Surveyor shall ensure that the following are implemented and adhered to on site:

- Quality and Technical Specifications, and where such is unclear, the Engineer be consulted for clarification;
- Only the latest Approved for Construction (AFC) Drawings, as issued by the Engineer are used on site; and
- All drawings are controlled as per the Contractor's Quality Control system.

The number of points required for setting out as well as the spacing between these points shall be determined by the Contractor together with the Engineer in accordance with the type of the work. In addition to any co-ordinated points and datum levels that the Contractor establishes for his own use, the Engineer may require that certain or all of the given points and datum levels be clearly tagged during construction in such a way that these tags can be retained after completion of construction. Where this is not possible for any reason, the Contractor shall inform the Engineer in writing and an alternative position will be agreed with the Contractor and confirmed in writing.

The Contractor shall not amend the approved method of survey control without the approval of the Engineer.

5.8.2 Setting Out for Underground Work

The Contractor shall use an approved system whenever possible to control the alignment of underground work and shall use suitable precision survey equipment for setting out and check surveying.

If at any time during the excavation, it is evident that the alignment of the excavations is outside the specified tolerances then, before proceeding further with the excavation, the Engineer and the Contractor shall agree the necessary corrections to the alignment, and the Contractor shall forthwith make the said corrections.

5.8.3 Setting Out for Pipe Works

The Contractor shall install sufficient sight rails, batter boards, pegs, level markers or other survey points to accurately control construction of the pipeline, structures and services. Where necessary or specified, the Contractor shall install a laser system to control construction of certain aspects of the work as applicable.

The Contractor shall check the actual ground cover above the top of the pipe as shown on the Drawings that can be obtained relative to the actual ground levels at the pipe centreline at least 21 days prior to commencement of the trench excavation. The Contractor shall notify the Engineer in writing at least 14 days prior to commencement of the trench excavation of any points where the actual achievable cover is less than 1.0 m or where the actual cover exceeds the specified cover by more than 0.5 m.

The equipment and methods employed by the Contractor for setting out and controlling excavation shall be subject to the approval of the Engineer.

The Contractor shall carry out an accurate survey of the levels of structures interfacing with the pipeline to ensure that the specified levels and layout relative to the pipeline have been achieved.

5.9 SETTING OUT CHECKS

The Engineer will undertake regular check surveys during the course of construction and the Contractor shall cooperate with and provide assistance for this as required by the Engineer.

The Contractor is expected to liaise with the Engineer to programme the setting out check surveys to be carried out during non-production periods or in parallel such that the minimum delay or inconvenience is caused to production work, wherever and whenever possible. The Contractor shall afford the Engineer every cooperation and assistance in this regard including, but not limited to, the provision of drainage, lighting and ventilation and the removal or placing of Contractor's Equipment and other obstructions such that they do not interfere with the setting out checks.

5.10 SITE BASED LASER TERRESTRIAL SURVEY REQUIREMENTS

5.10.1 General

The Contractor shall provide and maintain fully integrated UAV/Drone based LiDAR survey technology combined with high resolution still image camera technology and IMU/GPS systems for the duration of construction. This technology is required for cost efficient construction production

surveying, improved accuracy of measuring and agreeing quantities, producing accurate construction records and creating detailed sequential areal photographic records.

5.10.2 Equipment and Operators

The equipment shall include the drone (UAV), LiDAR point cloud sensor, camera, geo-referencing trimble, accessories, custom mounts, software and spares. The equipment shall be compatible with the LiDAR information provided by the Employer.

The equipment shall be operated by fully qualified drone pilots and data processing staff.

The Contractor shall submit a detailed method statement for approval by the Engineer prior to commencement of this function. The Engineer reserve the right to reject equipment that is not reliable or does not produce the required quality as specified below.

5.10.3 UAV Trajectory

The following minimum performance aspects are applicable:

- a) Minimum requirements for the GPS/IMU combination are:
 - GPS frequency minimum of 1 Hz; and
 - IMU minimum frequency of 100 Hz.
- b) Post-processing is required and a maximum error of 50 mm is required for the final trajectory.

5.10.4 LiDAR Points

The following minimum performance aspects are applicable:

- a) LiDAR point cloud is required. No photogrammetric point clouds or hybrid point clouds shall be permitted;
- b) LiDAR point density shall be minimum 100 points per square metre;
- c) LiDAR points shall be scanned within the trench and separately for volumes above the rock line and below the rock line;
- d) Point cloud cleaning of ground features shall be performed;
- e) Full swath-to-swath corrections shall be performed and no error shall exceed 50 mm;
- f) 3D models shall be developed from which excavation and fill volumes can be measured; and
- g) Excavation and fill volumes to be reported in line with the LiDAR data accuracy.

5.10.5 Image Capturing

The following minimum performance aspects are applicable:

- a) The image capturing shall be performed with a lab-calibrated metric camera;
- b) Images shall be geotagged;
- c) Image pixel resolution shall be 40 mm or less;
- d) A fixed lens focal length shall be used during flight or image capture (no adjustment permitted);

PART C3.1 - SPECIFICATION

- e) Full image rectification shall be performed and ortho-images shall be created;
- f) Image-to-Image and overall colour balancing and contrast balancing shall be performed;
- g) Image seamline correction shall be performed (no seamlines cuts permitted); and
- h) The images shall be submitted in an approved accessible digital format.

5.11 MEASUREMENT AND PAYMENT

The rates tendered under this section shall not include for the general obligations and work deemed to be covered by the items provided in Section 1 – General.

No separate measurement or payment apart from that specified in item 5.001 below shall be made to the Contractor for his compliance with the conventional survey requirements of Section 5 - Survey and Setting Out and compensation for the work involved and any inconvenience or delays to the Works caused by survey, setting out, and setting out checks by the Engineer shall be deemed to be included in the rates tendered for the respective items of work included under the Contract.

Separate measurement and payment items are provided for the protection of survey beacons outside the servitudes and the Site based laser terrestrial survey services. Refer to items 5.002 and 5.003 respectively.

5.001 Internal survey consistency check**Unit: lump sum (Sum)**

A lump sum shall be priced by the Contractor for carrying out a check of the internal consistency of all the Project Reference Marks provided by the Employer. Such item shall include for the provision of all necessary equipment, apparatus, reports, transport and the like and all personnel necessary to perform the checks accurately.

5.002 Protection of beacons outside servitude**Unit: (No)**

A rate per unit (No.) shall be priced by the Contractor for supplying protection at PRMs and subsidiary beacons placed outside the pipeline servitude. Such rate shall include for the provision of all necessary material, equipment and labour to supply and erect such protection.

5.003 Site based laser terrestrial surveys**Unit: (Sum)**

An all-inclusive rate per unit (Sum) shall be priced by the Contractor for rendering the required UAV/Drone surveys, processing and modelling volumetric and linear quantities, generating the monthly areal photographic construction record, producing a monthly progress report, generating as constructed survey records, maintaining the survey data base and maintaining equipment. The number of surveys required per month depends on the planned production rates which shall be clearly indicated in the Contractors Method Statement. The impact of unapproved variations in production rates remains the Contractors risk.