

Appendix B

Revised topographical survey



TOPOGRAPHIC, RIVER SECTION & UAV/LIDAR SURVEY

RIVER DEE, BALLATER

MARCH 2022

PROJECT REF: A8094

REV: 00

Client:

RPS Consulting Engineers

Elmwood House
74 Boucher Road
Belfast
BT12 6RZ



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Annex 1: Survey Drawing

Annex 2: Equipment Datasheets

DOCUMENT ISSUE RECORD

DATE	REVISION	COMPILED	CHECKED	NOTES
01/04/2022	00	EB	RM	FIRST ISSUE

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1. Introduction

On the instruction of RPS Consulting Engineers, Aspect Land and Hydrographic Surveys Ltd (herein ALHS) were commissioned to undertake a topographic, river cross-section, & UAV/LiDAR survey on the River Dee, Ballater.



FIGURE 1 - SURVEY LOCATION (GOOGLE EARTH IMAGE)

The survey included cross sections of the river, flood bank defences, and LiDAR of the adjacent flood plains. The survey extents can be seen in figure 2 below.

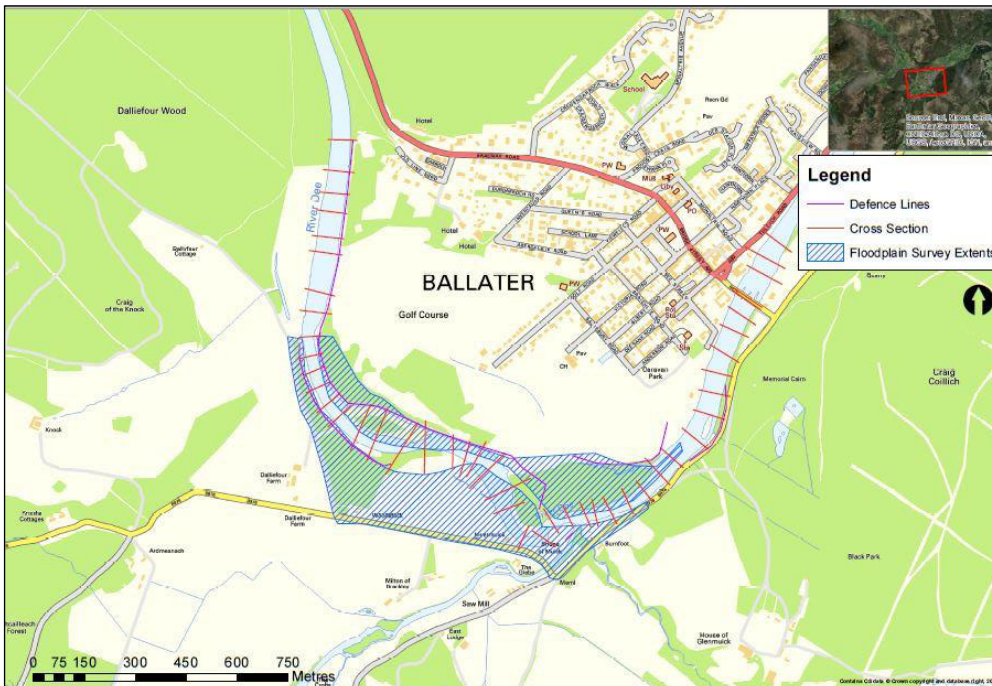


FIGURE 2 - SURVEY EXTENTS (AS PROVIDED BY CLIENT)

2. Topographic & Cross Section Survey

The topographic survey was carried out using a combination of Trimble S6 Total Station & Trimble R10 GPS and was completed in March 2022.

National Grid coordinates were established using Trimble RTK GPS, utilising corrected OS Rinx data, with the data gathered over a four-hour period and post processed using Trimble Business Centre software.

Once National Grid coordinates had been established for the survey station control points, the survey was rotated and transformed. It must be noted that National Grid control was anchored relative to the base station position and therefore local to that point i.e. Scale Factor 1.0000.

Survey detail is published as per the RICS Surveys of Land Buildings and Utility Services guidelines, the standard to which professional land surveyors should adhere.

All data was post-processed within LSS digital terrain modelling software with final reporting in AutoCAD DWG format.

3. Summary

The area was originally surveyed in September 2017 and since then various defences have been constructed to alleviate any future flooding. As well as 45 cross sections, these flood defences were also surveyed to provide an as-built level.

Additionally, LiDAR of a large section of flood plain along the river was required. This was carried out utilising UAV LiDAR to produce a 3D point cloud. It should be noted that there is a No-Fly Zone (See figure 8) in place at the SW corner of the survey extents where LiDAR could not be gathered as permission could not be granted at the time of survey. There are also patches where the vegetation was too dense for LiDAR to penetrate. The point cloud has been cleaned as much as possible, removing any spikes on vegetation but some may still remain.

On the right bank, sections extended onto mostly farmland until section R_DEE_1099 where then section goes across B976. On the left bank the sections ran on to the golf course but at section R_DEE_00635 it runs into a camp site. For the flood defences, there wasn't much change from previous site visit.

A number of photographs were taken during the survey to better illustrate and provide a visual record of the conditions across the site at time of survey. Copies of these images are noted below.



FIGURE 3 – ROAD BRIDGE



FIGURE 4 – FLOOD BANK ON RIGHT BANK



FIGURE 5 – FLOOD DEFENCES LEFT BANK



FIGURE 6- FLOOD PLAIN ON GOLF COURSE



FIGURE 7- FLOOD PLAIN AT CAMPSITE

4. UAV Mobile Mapping

Aerial mapping system used for UAV survey:

Survey Platform	DJI Matrice 600 Pro
GPS Correction Source	Post Processed GNSS Corrections (PPK)
LIDAR	Velodyne HDL-32E
Motion Compensator	SBG Ellipse 2D INS

The DJI Matrice 600 Pro is a dynamic, lightweight airframe, and multi-functional UAV offering increased in-flight efficiency and stability for survey grade data collection.

The UAV's trajectory is determined from Post Processed GNSS observations within Applanix POS-UAV software. Similar to RTK positioning this method of positioning assumes that the GNSS antennas on the UAV are receiving the same satellite errors as the base reference station and therefore cancelling the error.

All UAV trajectory was post processed to GNSS static observations collected at a local base station. Again, all UAV mapping has been quality assured against the RTK observations taken across the survey extents. It was found to tie into $\pm 50\text{mm}$ on short grass and $\pm 100 - 250\text{mm}$ in vegetated areas (with the exception of overlooked spikes).



FIGURE 8- NO FLY ZONE (IN RED)



FIGURE 9- DJI MATRICE 600 PRO

5. Personnel

The following personnel were involved during the survey:

NAME	POSITION
E. Brown	Land Surveyor
J. Kirkland	Land Surveyor
L. Durnan	UAV Pilot/Surveyor
M. Scott	Client Liaison
S. Norman	Health & Safety Representative
R. Maider	QA & Data Release

6. Drawing Register

The following drawing files and documents are issued in conjunction with this project:

TITLE	DESCRIPTION
A8094.DWG	Topographic Survey - 2D
A8094.PDF	Topographic Survey - 2D
A8094_LiDAR_3D.DWG	Topographic Survey - 3D
A8094_LiDAR_XYZ.CSV	XYZ File of LiDAR Survey
A8094_Report	Survey Report
A8094_EASCD	EASCD File

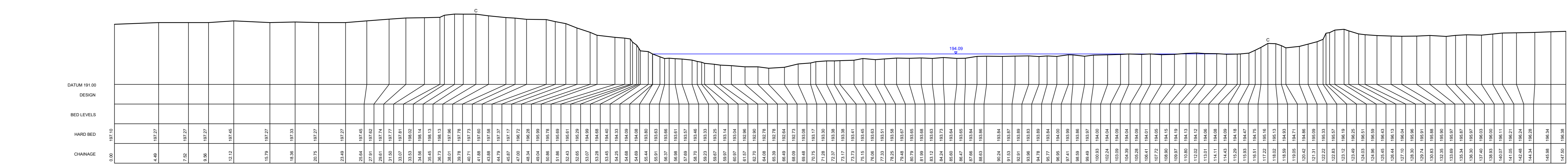
7. Equipment Register

- Trimble S6 Total Station
- Trimble R10 GPS
- DJI Matrice 600
- Velodyne HDL-32E

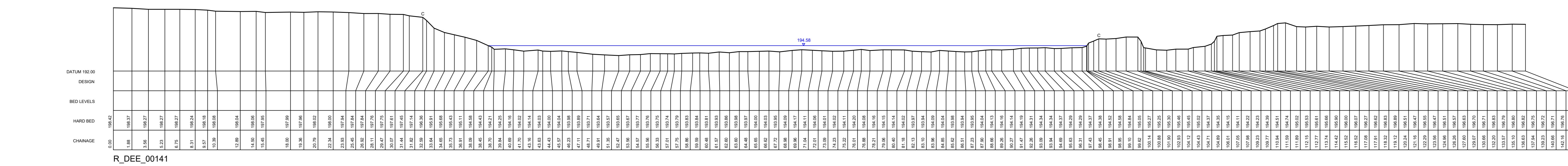
Equipment datasheets can be found in Annex 2.

Quality Assurance Statement

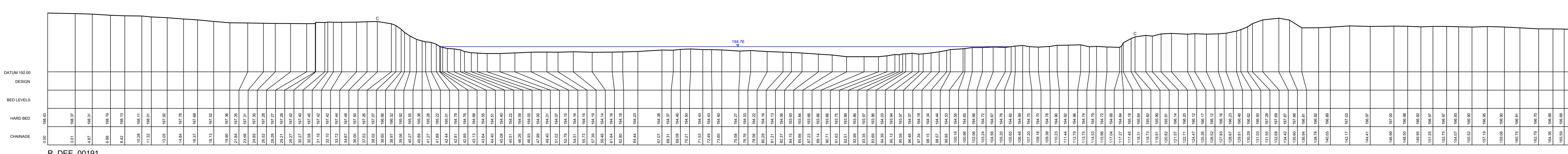
Aspect Land & Hydrographic Surveys Ltd is an ISO PAS 99 accredited company offering a full range of topographic, hydrographic, geophysical, oceanographic and marine environmental survey services, with expertise in combining multiple disciplines into single projects. ALHS produce work to the highest quality, certified by our accreditation to numerous organisations including the Royal Institute of Chartered Surveyors, the Institute of Civil Engineering Surveyors and The Scottish Hydrographic Society. Our administrative procedures are fully audited to ISO9001:2008 standard and vigorously maintained via stringent quality control procedures. We are also accredited to Category B1 with Achilles via the UVBD scheme. These standards are audited annually by external consultants to ensure continued, on-going compliance and copies of these certificates can be submitted if required.



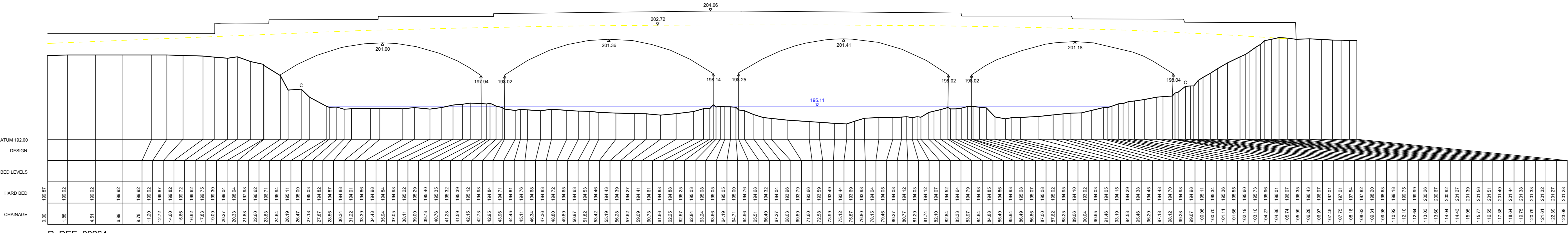
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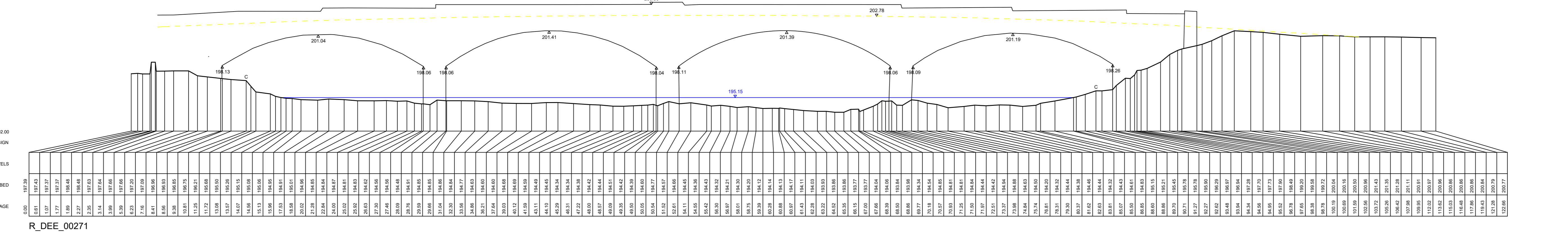
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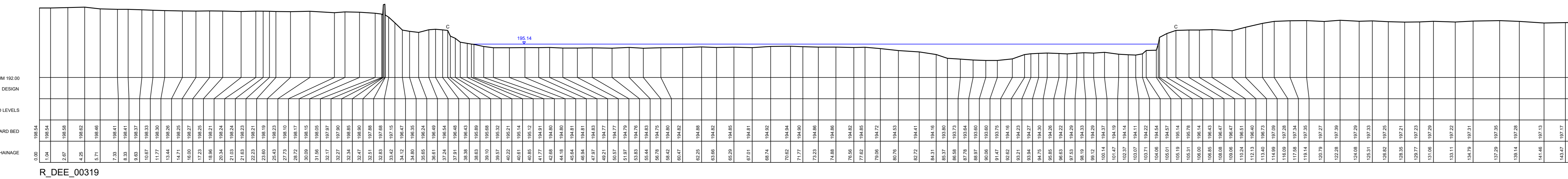
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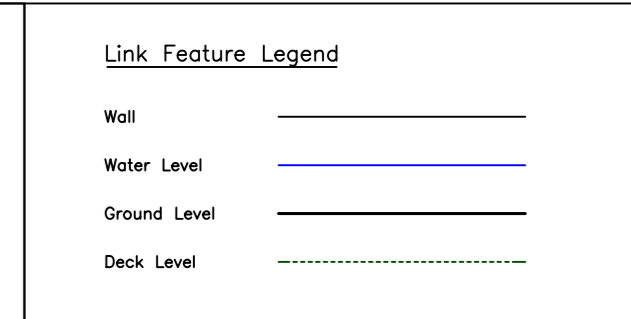
R_DEE_00264



R_DEE_00271



R_DEE_00319



Notes: Horizontal Control points are relative to the NATIONAL GRID. All levels are relative to ODENANCE DATUM. The datum was established using corrected OS River data and post processed using Trimble Business Centre Software.

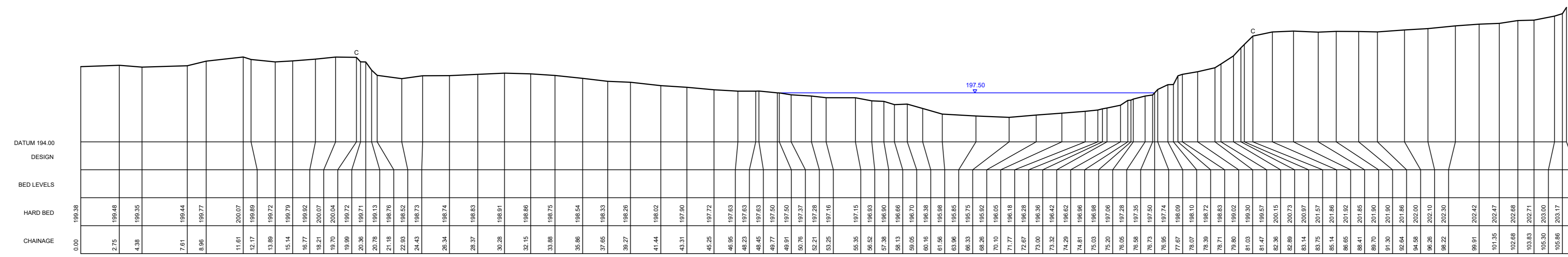
Table with columns: CONTROL, STATION, EASTING, NORTHING, COORDINATES, LEVEL. It contains one row of data with station numbers and their corresponding coordinates.

Aspect Land + Hydrographic Surveys CHARTERED SURVEYS Thornhouse Business Centre. Tel: 01294 313399. E-mail: info@aspecturveys.com. Web: www.aspecturveys.com

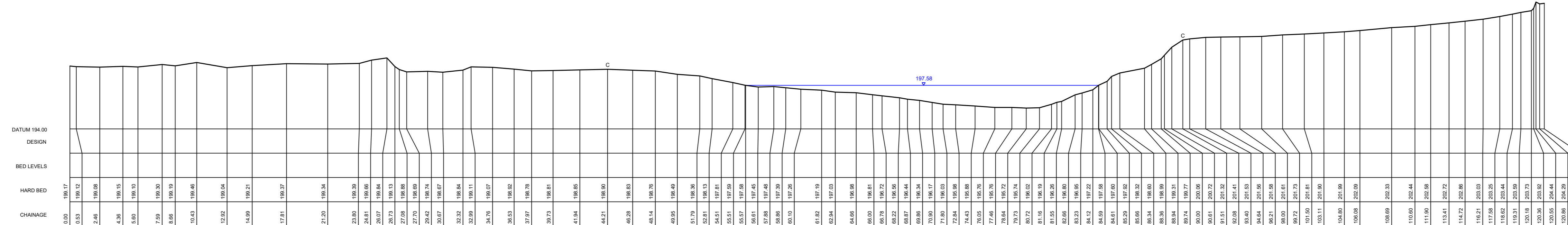
Client: RPS CONSULTING ENGINEERS, ELMWOOD HOUSE, 74 BOUCHER ROAD, BELFAST, BT12 6RZ

Project file: TOPOGRAPHIC, RIVER CROSS-SECTION & UAV/LIDAR SURVEY, RIVER DEE, BALLATER

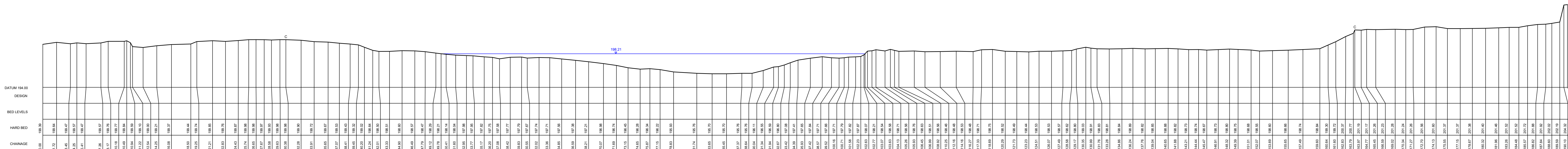
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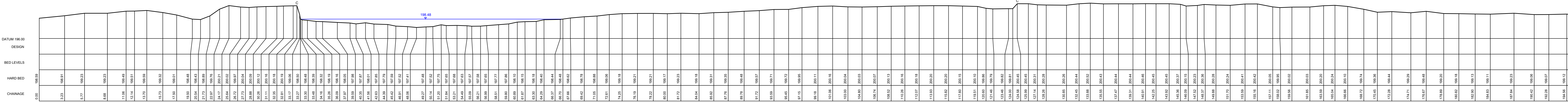
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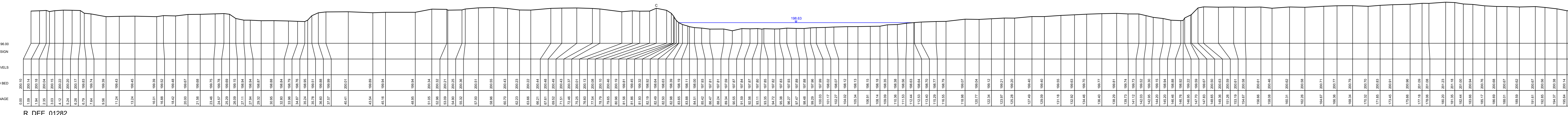
R_DEE_01099



R_DEE_01180



R_DEE_01228



R_DEE_01282

Link Feature Legend

- Wall
- Water Level
- Ground Level
- Deck Level

Note:
 Horizontal Control points are relative to the NATIONAL GRID.
 All levels are relative to ORDNANCE DATUM.
 The datum was established using corrected OS River data and post processed using Trimble Business Centre Software.

CONTROL STATION COORDINATES

STN	EASTING	NORTHING	LEVEL
-----	---------	----------	-------

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 Land + Hydrographic Surveys
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Client:

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 ELMWOOD HOUSE
 74 BOUCHER ROAD
 BELFAST
 BT12 6RZ

Project file:

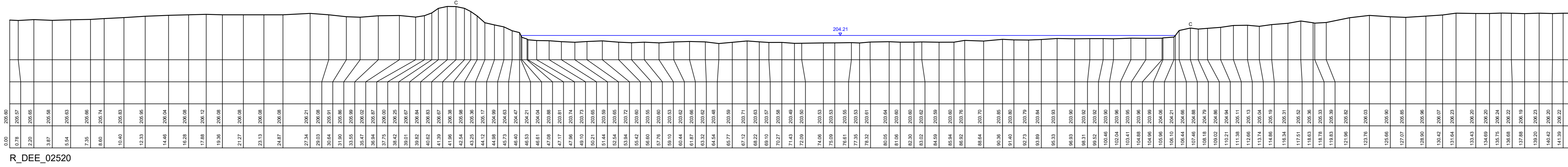
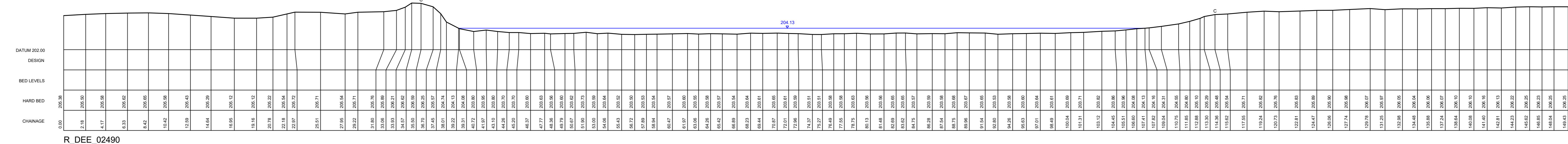
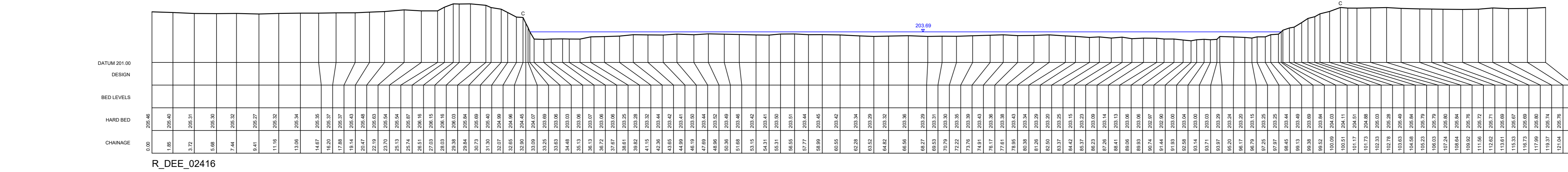
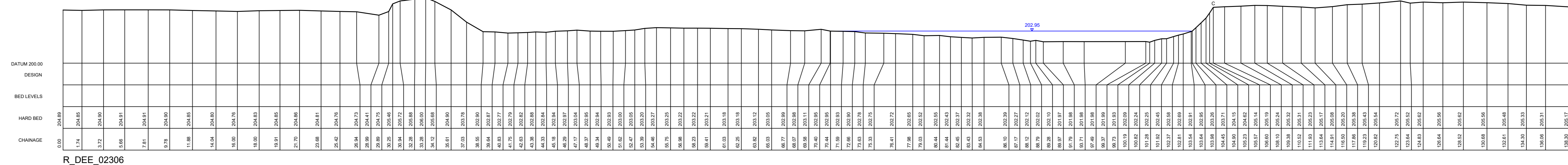
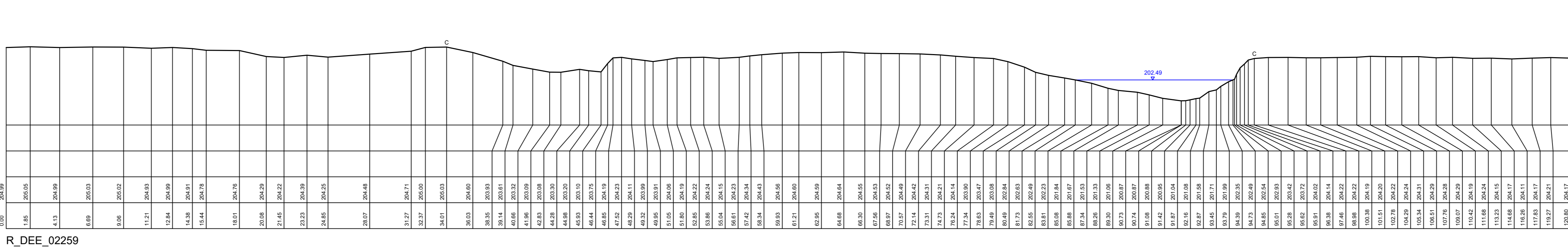
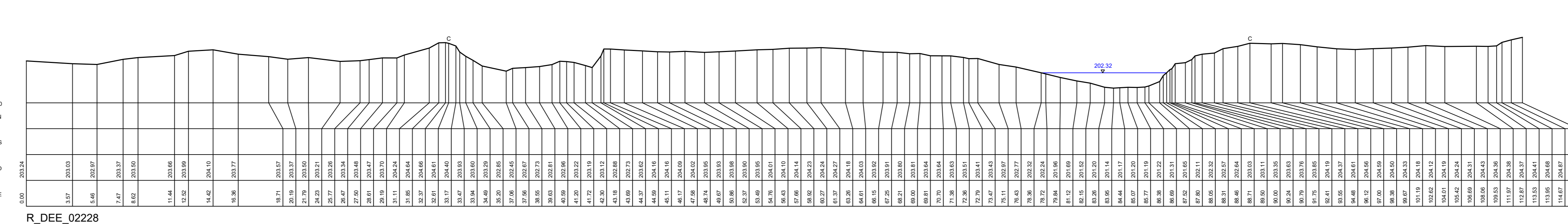
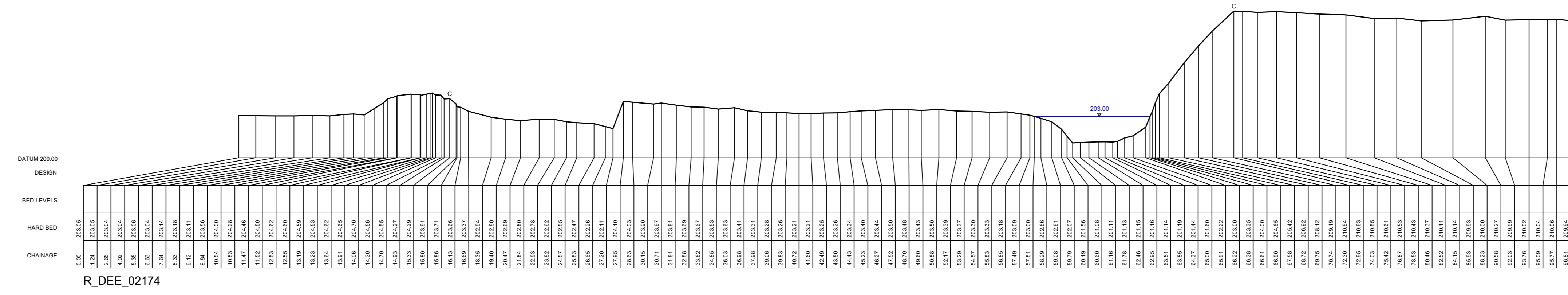
TOPOGRAPHIC, RIVER CROSS-SECTION & UAV/LIDAR SURVEY
RIVER DEE
BALLATER

Project No: A8094 Scale: 1:200

Surveyed on: 29th March 2022 Issue date: 6th April 2022

Surveyed by: EB Checked by: RM

Sheet No: 4 of 8 Plot Scale: 1:1 @ A0



Link Feature Legend

Notes:
 Horizontal Control points are relative to the NATIONAL GRID.
 All levels are relative to ORDNANCE DATUM.
 The datum was established using corrected OS River data and
 post processed using Trimble Business Centre Software.

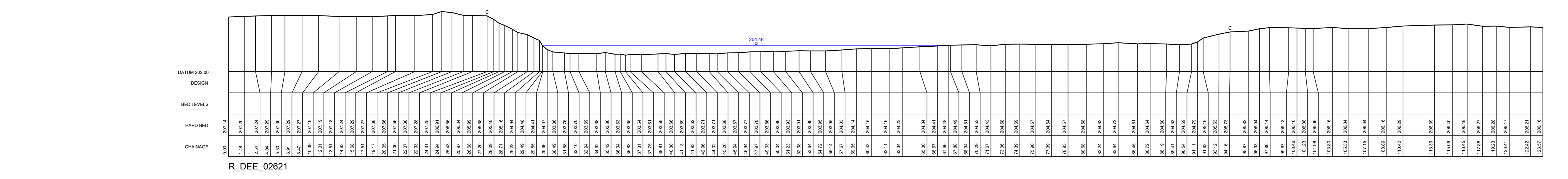
CONTROL STATION COORDINATES			
STN	EASTING	NORTHING	LEVEL

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 Web: www.aspect-surveyors.com

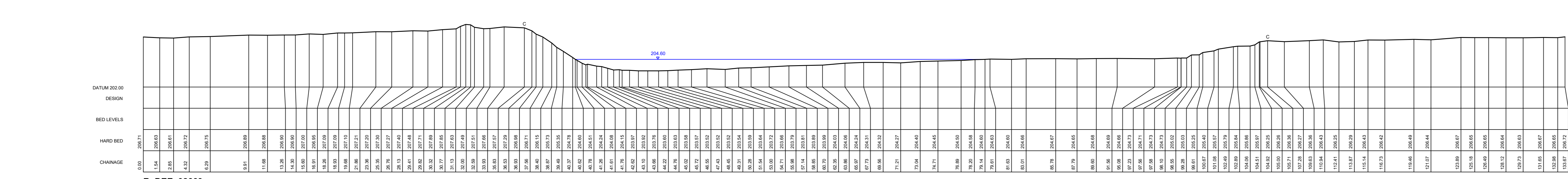
Date: RPS CONSULTING ENGINEERS
 ELMWOOD HOUSE
 74 BOUCHER ROAD
 BELFAST
 BT12 6RZ

Project File: TOPOGRAPHIC RIVER CROSS-SECTION &
 UAV/LIDAR SURVEY
 RIVER DEE
 BALLATER

Project No: A8094 Scale: 1:200
 Surveyed date: 29th March 2022 Issue date: 6th April 2022
 Surveyed by: EB Checked by: RM
 Sheet No.: 7 of 8 Plot Scale: 1:1 @ A0



R_DEE_02621



TRIMBLE S6 TOTAL STATION

KEY FEATURES

Now available with **Trimble VISION** technology for video robotic control and scene documentation

Powerful and flexible, ready for anything

Trimble DR Plus technology for long range and superior accuracy

Unmatched fast and smooth performance with **MagDrive servo technology**

Trimble SurePoint accuracy assurance automatically corrects instrument pointing

POWERFUL AND FLEXIBLE

The Trimble® S6 Total Station provides the power and flexibility required by today's Surveying Professionals. With the industry's most advanced technology and available feature set, the Trimble S6 Total Station will meet the changing needs of your business, allowing your investment to go further.

TRIMBLE VISION TECHNOLOGY

Now available with optional Trimble VISION™ technology, the Trimble S6 gives you the power to see everything the instrument sees without a trip back to the tripod. Direct your survey with live video images on the controller. Now you are free to capture measurements, to prism or reflectorless surfaces, remotely, and with point-and-click efficiency.

The on-board camera integrates surveyed data with the live scene images, so you can verify the work that you've done before leaving the job site. Calibrated photo documentation provides customers with deliverables they know they can trust.

TRIMBLE DR PLUS TECHNOLOGY

Trimble DR Plus™ range measurement technology provides extended range of Direct Reflex measurement without a prism to exceptionally long range distances. Hard-to-reach or unsafe targets are no obstacle to the Trimble S6. Trimble DR Plus, combined with MagDrive™, creates unmatched capability for quick and safe measurements, without compromising on accuracy.

MAGDRIVE SERVO TECHNOLOGY

The Trimble S6 Total Station redefines surveying instrument performance with unsurpassed integration of servos, angle sensors and measurement technology. The instrument's advanced error compensation provides fast, accurate measurement every time. With smooth, silent MagDrive servo motors, the Trimble S6 offers exceptional speed.

TRIMBLE SUREPOINT ACCURACY ASSURANCE

The Trimble S6 Total Station aims and stays on target through windy weather, vibrations, handling, and sinkage. Trimble SurePoint™ technology enables the Trimble S6 to actively correct for unwanted movement ensuring accurate pointing and measurement every time. Reduce aiming error, avoid costly re-measurement and be confident in your results with Trimble SurePoint.

With its exclusive MultiTrack™ technology and Target ID capabilities, surveyors can choose the type of target, passive or active, that best suits the jobsite conditions and be confident that they will find and lock to the correct target.

ELIMINATE SEARCH TIME WITH GPS SEARCH

With GPS Search the Trimble S6 locks onto a prism in just seconds. Using a consumer grade GPS card with Bluetooth receiver or your survey grade GNSS in a Trimble I.S. rover configuration, GPS Search uses GPS positioning at the robotic rod to locate or reacquire targets rapidly. With GPS Search, waiting for target search becomes a thing of the past.

INTEGRATED SURVEYING

Put the equipment in your truck or van to the best possible use by combining your GNSS with your robotic rod into a Trimble I.S. Rover™. In clear sky, enjoy the high productivity of GNSS measurements. In obstructed areas, Trimble Access seamlessly switches to optical measurements. Or collect both GNSS and optical data simultaneously for redundant results. With the Trimble I.S. Rover, you have the freedom to use the best tool for the jobsite conditions, optimizing your productivity.



TRIMBLE S6 DR PLUS

PERFORMANCE

Angle measurement

Sensor type Absolute encoder with diametrical reading

Accuracy (Standard deviation based on DIN 18723) 0.2" (0.6 mgon)
3" (1.0 mgon), or 5" (1.5 mgon)

Angle Display (least count) 0.1" (0.01 mgon)

Automatic level compensator

Type Centered dual-axis

Accuracy 0.5" (0.15 mgon)

Range ± 5.4' (±100 mgon)

Distance measurement

Accuracy (RMSE)

Prism mode

Standard 2 mm + 2 ppm (0.0065 ft + 2 ppm)

Standard deviation according to ISO17123-4 1 mm + 2 ppm (0.003 ft + 2 ppm)

Tracking 4 mm + 2 ppm (0.013 ft + 2 ppm)

DR mode

Standard 2 mm + 2 ppm (0.0065 ft + 2 ppm)

Tracking 4 mm + 2 ppm (0.013 ft + 2 ppm)

Measuring time

Prism mode

Standard 1.2 sec

Tracking 0.4 sec

DR mode

Standard 1–5 sec

Tracking 0.4 sec

Range

Prism mode (under standard clear conditions^{1,2})

1 prism 2500 m (8202 ft)

1 prism Long Range mode 5500 m (18,044 ft) (max. range)

Shortest range 0.2 m (0.65 ft)

DR mode

	Good (Good visibility, low ambient light)	Normal (Normal visibility, moderate sunlight, some heat shimmer)	Difficult (Haze, object in direct sunlight, turbulence)
White card (90% reflective)³	1,300 m (4,265 ft)	1,300 m (4,265 ft)	1,200 m (3,937 ft)
Gray card (18% reflective)³	600 m (1,969 ft)	600 m (1,969 ft)	550 m (1,804 ft)

Shortest range 1 m (3.28 ft)

DR Ranges (typically)

Concrete 600 m–800 m (1968–2624 ft)

Wood construction 400 m–800 m (1312–2624 ft)

Metal construction 400 m–500 m (1312–1640 ft)

Light rock 400 m–600 m (1312–1968 ft)

Dark rock 300 m–400 m (984–1312 ft)

Reflective foil 20 mm 1000 m (3280 ft)

DR Extended Range Mode

White Card (90% reflective)³ 2000 m–2200 m

Gray Card (18% reflective)³ 900 m–1000 m

Accuracy 10 mm + 2 ppm (0.033 ft + 2 ppm)

Camera

Chip Color Digital Image Sensor

Resolution 2048 x 1536 pixels

Focal length 23 mm (0.07 ft)

Depth of field 3 m to infinity (9.84 ft to infinity)

Field of view 16.5° x 12.3° (18.3 gon x 13.7 gon)

Digital zoom 4-step (1x, 2x, 4x, 8x)

Exposure Automatic

Brightness User-definable

Contrast User-definable

Image storage Up to 2048 x 1536 pixels

File format JPEG

GENERAL SPECIFICATIONS

EDM SPECIFICATIONS

Light source	Pulsed laserdiode 905 nm, Laser class 1
Laser pointer coaxial (standard)	Laser class 2
Beam divergence	
Horizontal	4 cm/100 m (0.13 ft/328 ft)
Vertical	8 cm/100 m (0.26 ft/328 ft)
Atmospheric correction	-130 ppm to 160 ppm continuously

Leveling	
Circular level in tribrach	8/2 mm (8'/0.007 ft)
Servo system	MagDrive servo technology, integrated servo/angle sensor electromagnetic direct drive

Rotation speed	115 degrees/sec (128 gon/sec)
Rotation time Face 1 to Face 2	2.6 sec
Positioning time 180 degrees (200 gon)	2.6 sec
Clamps and slow motions	Servo-driven, endless fine adjustment

Centering	
Centering system	Trimble 3-pin
Optical plummet	Built-in optical plummet
Magnification/shortest focusing distance	2.3x/0.5 m-infinity (1.6 ft-infinity)

Telescope	
Magnification	30x
Aperture	40 mm (1.57 in)
Field of view at 100 m (328 ft)	2.6 m at 100 m (8.5 ft at 328 ft)
Shortest focusing distance	1.5 m (4.92 ft)-infinity
Illuminated crosshair	Variable (10 steps)

Tracklight built in	Not available in all models
Operating temperature	-20 °C to +50 °C (-4 °F to +122 °F)
Dust and water proofing	IP55
Humidity	100% condensing

Power supply	
Internal battery	Rechargeable Li-Ion battery 11.1 V, 5.0 Ah
Operating time ⁴	
One internal battery	Approx. 6.5 hours
Three internal batteries in multi-battery adapter	Approx. 20 hours
Robotic holder with one internal battery	13.5 hours
Operating time for video robotic ⁴	
One battery	5.5 hours
Three batteries in multi-battery adapter	17 hours

Weight	
Instrument (servo/Autolock)	5.15 kg (11.35 lb)
Instrument (Robotic)	5.25 kg (11.57 lb)
Trimble CU controller	0.4 kg (0.88 lb)
Tribrach	0.7 kg (1.54 lb)
Internal battery	0.35 kg (0.77 lb)
Trunnion axis height	196 mm (7.71 in)
Communication	USB, Serial, Bluetooth ^{®5}
Security	Dual-layer password protection; available on some models

TRIMBLE S6 TOTAL STATION

ROBOTIC SURVEYING

Autolock and Robotic Range ²	
Passive prisms	500 m–700 m (1,640–2,297 ft)
Trimble MultiTrack Target	.800 m (2,625 ft)
Autolock pointing precision at 200 m (656 ft) (Standard deviation) ²	
Passive prisms	<2 mm (0.007 ft)
Trimble MultiTrack Target	<2 mm (0.007 ft)
Shortest search distance	
Type of radio internal/external	2.4 GHz frequency-hopping, spread-spectrum radios
Search time (typical) ⁶	.2–10 sec

GPS SEARCH/GEOLOCK WITH THE TRIMBLE MULTITRACK TARGET

GPS Search/GeoLock360 degrees (400 gon) or defined horizontal and vertical search window
Solution acquisition time ⁷15–30 sec
Target re-acquisition time<3 sec
RangeAutolock & Robotic range limits

1 Standard clear: No haze. Overcast or moderate sunlight with very light heat shimmer.
 2 Range and accuracy depend on atmospheric conditions, size of prisms and background radiation.
 3 Kodak Gray Card, Catalog number E1527795.
 4 The capacity in –20 °C (–5 °F) is 75% of the capacity at +20 °C (68 °F).
 5 Bluetooth type approvals are country specific. Contact your local Trimble Authorized Distribution Partner for more information.
 6 Dependent on selected size of search window.
 7 Solution acquisition time is dependent upon solution geometry and GPS position quality.

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Trimble R10 GNSS System

Key Features

Cutting-edge **Trimble HD-GNSS** processing engine

Precise position capture with **Trimble SurePoint** technology

Trimble CenterPoint RTX provides RTK level precision anywhere without the need for a base station or VRS network

Trimble xFill technology provides RTK coverage during connection outages

Advanced satellite tracking with **Trimble 360** receiver technology

Sleek ergonomic design for easier handling

A NEW LEVEL OF PRODUCTIVITY

Collect more accurate data faster and easier – no matter what the job or the environment, with the Trimble® R10 GNSS System. Built with powerful technologies like Trimble HD-GNSS, Trimble SurePoint™, Trimble CenterPoint™ RTX, and Trimble xFill™, integrated into a sleek design, this unique system provides Surveyors with a powerful way to increase productivity in every job, every day.

Trimble HD-GNSS Processing Engine The next generation of core positioning technology

The advanced Trimble HD-GNSS processing engine provides markedly reduced convergence times as well as high position and precision reliability while reducing measurement occupation time. Transcending traditional fixed/float techniques, it provides a more accurate assessment of error estimates than traditional GNSS technology.

Trimble SurePoint
Faster measurements, increased accuracy, and greater quality control with electronic bubble
With this system, surveyors don't have to switch focus from the controller screen to the pole bubble to check that the pole is plumb. The Trimble controller displays an electronic bubble.

Full Tilt Compensation
The system constantly monitors pole tilt and compensates while the point is automatically or manually measured. If a point is measured with pole tilt beyond a user-defined setting, Trimble Access™ software will give an alert and prompt the surveyor to accept or discard the point. Trimble SurePoint even uses the pole tilt as a controlling input. After a point is measured, tilting the pole causes the system to automatically prepare to measure the next point.

Data Traceability
As insurance that all of your data is traceable, the Trimble R10 can record the pole tilt information for measured points. These records include tilt and compass data for 100% data traceability.

Trimble 360 Receiver
Future Proof Your Investment
Powerful Trimble 360 receiver technology in the Trimble R10 supports signals from all existing and planned GNSS constellations and augmentation systems. With two integrated Trimble Maxwell™ 6 chips, the Trimble R10 offers an unparalleled 440 GNSS channels. Trimble delivers business confidence with a sound GNSS investment for today and long into the future.

Trimble CenterPoint RTX
RTK Level Precision Anywhere
Trimble CenterPoint RTX delivers RTK level precision anywhere in the world without the use of a local base station or Trimble VRS™ Network. Survey using satellite delivered, CenterPoint RTX corrections in areas where terrestrial based corrections are not

available. When surveying over a great distance in a remote area, such as a pipeline or utility right of way, CenterPoint RTX eliminates the need to continuously move base stations or maintain connection to a cellular network.

Trimble xFill
More continuous surveying, less downtime
Leveraging a worldwide network of Trimble GNSS reference stations and satellite datalinks, Trimble xFill seamlessly fills in for gaps in your RTK or VRS connection stream. Extend xFill indefinitely with a subscription to CenterPoint RTX.

Ergonomically Designed
As the smallest and lightest integrated receiver in its class, the Trimble R10 is ergonomically designed to provide the surveyor with effortless handling and operation. Designed for ease of use, the progressive design incorporates a more stable center of mass at the top of the range pole, while its sleeker, taller profile provides the durability and reliability for which Trimble is known.

The Trimble R10 receiver incorporates a quick release adaptor for simple and safe removal of the receiver from the range pole. Additionally the quick release adaptor ensures a solid, stable connection between the range pole and receiver.

An Intelligent Solution
A smart lithium-ion battery inside the Trimble R10 system delivers extended battery life and more reliable power. A built-in LED battery status indicator allows the user to quickly check remaining battery life.

Advanced Communication Capabilities
The Trimble R10 system provides a number of communications options to support any workflow. The latest mobile phone technology is built in to receive VRS corrections and connect to the Internet from the field. Access Trimble Connected Community to send or receive documents while away from the office. Using WiFi, easily connect to the Trimble R10 system using a laptop or smartphone to configure the receiver without a Trimble controller.

The Complete Solution: Trimble hardware and software
Bring the power and speed of the Trimble R10 system together with trusted Trimble software solutions, including Trimble Access and Trimble Business Center™.

Trimble Access field software provides specialized and customized workflows to make surveying tasks quicker and easier while enabling teams to communicate vital information between field and office in real time. Back in the office, users can seamlessly process data with Trimble Business Center software.

The R10 GNSS system, a new era of surveying productivity beyond GNSS for professional surveyors.



Trimble R10 GNSS System

PERFORMANCE SPECIFICATIONS

Measurements

- Measuring points sooner and faster with Trimble HD-GNSS technology
- Increased measurement productivity and traceability with Trimble SurePoint electronic tilt compensation
- Worldwide centimeter level positioning using Trimble CenterPoint RTX satellite delivered corrections
- Reduced downtime due to loss of radio signal with Trimble xFill technology
- Advanced Trimble Maxwell 6 Custom Survey GNSS chips with 440 channels
- Future-proof your investment with Trimble 360 GNSS tracking
- Satellite signals tracked simultaneously:
 - GPS: L1C/A, L1C, L2C, L2E, L5
 - GLONASS: L1C/A, L1P, L2C/A, L2P, L3
 - SBAS: L1C/A, L5 (For SBAS satellites that support L5)
 - Galileo: E1, E5a, E5B
 - BeiDou (COMPASS): B1, B2
- CenterPoint RTX, OmniSTAR HP, XP, G2, VBS positioning
- QZSS, WAAS, EGNOS, GAGAN
- Positioning Rates: 1 Hz, 2 Hz, 5 Hz, 10 Hz, and 20 Hz

POSITIONING PERFORMANCE¹

Code differential GNSS positioning

Horizontal	0.25 m + 1 ppm RMS
Vertical	0.50 m + 1 ppm RMS
SBAS differential positioning accuracy ²	typically <5 m 3DRMS

Static GNSS surveying

High-Precision Static	
Horizontal	.3 mm + 0.1 ppm RMS
Vertical	3.5 mm + 0.4 ppm RMS
Static and Fast Static	
Horizontal	.3 mm + 0.5 ppm RMS
Vertical	.5 mm + 0.5 ppm RMS

Real Time Kinematic surveying

Single Baseline <30 km	
Horizontal	8 mm + 1 ppm RMS
Vertical	15 mm + 1 ppm RMS
Network RTK ³	
Horizontal	.8 mm + 0.5 ppm RMS
Vertical	15 mm + 0.5 ppm RMS
RTK start-up time for specified precisions ⁴	
Trimble CenterPoint RTX	2 to 8 seconds
Horizontal	
Vertical	.4 cm
RTX convergence time for specified precisions ¹²	
RTX QuickStart convergence time for specified precisions ¹²	5 minutes or less
Trimble xFill ⁵	
Horizontal	.RTK ⁶ + 10 mm/minute RMS
Vertical	.RTK ⁶ + 20 mm/minute RMS

1 Precision and reliability may be subject to anomalies due to multipath, obstructions, satellite geometry, and atmospheric conditions. The specifications stated recommend the use of stable mounts in an open sky view, EMI and multipath clean environment, optimal GNSS constellation configurations, along with the use of survey practices that are generally accepted for performing the highest-order surveys for the applicable application including occupation times appropriate for baseline length. Baselines longer than 30 km require precise ephemeris and occupations up to 24 hours may be required to achieve the high precision static specification.

2 Depends on WAAS/EGNOS system performance.

3 Network RTK PPM values are referenced to the closest physical base station.

4 May be affected by atmospheric conditions, signal multipath, obstructions and satellite geometry. Initialization reliability is continuously monitored to ensure highest quality.

5 Precisions are dependent on GNSS satellite availability, xFill positioning without a RTX subscription ends after 5 minutes of radio downtime. xFill positioning with a RTX subscription will continue beyond 5 minutes providing RTX has converged, with typical precisions not exceeding 6 cm horizontal, 14 cm vertical. xFill is not available in all regions, check with your local sales representative for more information.

6 RTK refers to the last reported precision before the correction source was lost and xFill started.

7 Receiver will operate normally to -40° C, internal batteries are rated to -20° C.

8 Tracking GPS, GLONASS and SBAS satellites.

9 Varies with temperature and wireless data rate. When using a receiver and internal radio in the transmit mode, it is recommended that an external 6 Ah or higher battery is used.

10 Varies with terrain and operating conditions.

11 Bluetooth type approvals are country specific.

12 Receiver convergence time varies based on GNSS constellation health, level of multipath, and proximity to obstructions such as large trees and buildings. Convergences times decrease significantly when using a "RTX Quickstart" on a previously surveyed point or a known survey control point.

HARDWARE

Physical

Dimensions (WxH)	11.9 cm x 13.6 cm (4.6 in x 5.4 in)
Weight	1.12 kg (2.49 lb) with internal battery, internal radio with UHF antenna, 3.57 kg (7.86 lb) items above plus range pole, controller & bracket
Temperature ⁷	
Operating	-40° C to +65° C (-40° F to +149° F)
Storage	-40° C to +75° C (-40° F to +167° F)
Humidity	100%, condensing
Ingress Protection	IP67 dustproof, protected from temporary immersion to depth of 1 m (3.28 ft)
Shock and vibration	
Tested and meets the following environmental standards:	
Shock	Non-operating: Designed to survive a 2 m (6.6 ft) pole drop onto concrete. Operating: to 40 G, 10 msec, sawtooth
Vibration	MIL-STD-810F, FIG.514.5C-1

Electrical

- Power 11 to 24 V DC external power input with over-voltage protection on Port 1 and Port 2 (7-pin Lemo)
- Rechargeable, removable 7.4 V, 3.7 Ah Lithium-ion smart battery with LED status indicators
- Power consumption is 5.1 W in RTK rover mode with internal radio⁸
- Operating times on internal battery⁹:
 - 450 MHz and 900 MHz receive only option: 5.5 hours
 - 450 MHz and 900 MHz receive/transmit option (0.5 W): 4.5 hours
 - 450 MHz receive/transmit option (2.0 W): 3.7 hours
 - Cellular receive option: 5.0 hours

COMMUNICATIONS AND DATA STORAGE

- Serial: 3-wire serial (7-pin Lemo)
- USB v2.0: supports data download and high speed communications
- Radio Modem: fully Integrated, sealed 450 MHz wide band receiver/transmitter with frequency range of 403 MHz to 473 MHz, support of Trimble, Pacific Crest, and SATEL radio protocols:
 - Transmit power: 2 W
 - Range: 3-5 km typical / 10 km optimal¹⁰
- Cellular: integrated, 3.5 G modem, HSDPA 7.2 Mbps (download), GPRS multi-slot class 12, EDGE multi-slot class 12, UMTS/HSDPA (WCDMA/FDD) 850/1900/2100MHz, Quad-band GSM 850/900/1800/1900 MHz, GSM CSD, 3GPP LTE
- Bluetooth: fully integrated, fully sealed 2.4 GHz communications port (Bluetooth®)¹¹
- WiFi: 802.11 b/g, access point and client mode, WPA/WPA2/WEP64/WEP128 encryption
- External communication devices for corrections supported on – Serial, USB, Ethernet, and Bluetooth ports
- Data storage: 4 GB internal memory; over three years of raw observables (approx. 1.4 MB /day), based on recording every 15 seconds from an average of 14 satellites
- CMR+, CMRx, RTCM 2.1, RTCM 2.3, RTCM 3.0, RTCM 3.1 input and output
- 24 NMEA outputs, GSOFF, RT17 and RT27 outputs

WebUI

- Offers simple configuration, operation, status, and data transfer
- Accessible via WiFi, Serial, USB, and Bluetooth

Supported Trimble Controllers

- Trimble TSC3, Trimble Slate, Trimble CU, Trimble Tablet Rugged PC

CERTIFICATIONS

FCC Part 15 (Class B device), 22, 24; R&TTE CE Mark; C-Tick, A-Tick; PTCRB; WFA

Specifications subject to change without notice.



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MATRICE 600

The Matrice 600 (M600) is DJI's new flying platform designed for professional aerial photography and industrial applications. It is built to closely integrate with a host of powerful DJI technologies, including the A3 flight controller, Lightbridge 2 transmission system, Intelligent Batteries and Battery Management system, for maximum performance and quick setup.



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AIRCRAFT

STRUCTURE

Diagonal Wheelbase	1133 mm
Aircraft Dimensions	<ul style="list-style-type: none">• 1668 mm x 1518 mm x 759 mm (Propellers, frame arms and GPS mount unfolded)• 640 mm x 582 mm x 623 mm (Frame arms and GPS mount folded)
Package Dimensions	620 mm x 320 mm x 505 mm
Intelligent Flight Battery Quantity	6
Weight (with six TB47S batteries)	9.1 kg

PROPULSION SYSTEM

Motor Model	DJI 6010
Propeller Model	DJI 2170

OTHER

Supported DJI Gimbals	Zenmuse X3; Zenmuse X5 series; Zenmuse XT; Ronin-MX; Zenmuse Z15 series HD gimbals: Z15-A7, Z15-BMPCC, Z15-5D III, Z15-GH4
Retractable Landing Gear	Standard
Operating Temperature	14° to 104° F (-10° to 40° C)

CHARGER

Model	A14-100P1A
Voltage Output	26.3 V
Power Rating	100 W

BATTERY (OPTIONAL)

Model	TB48S
Capacity	5700 mAh
Voltage	22.8 V
Type	LiPo 6S
Energy	129.96 Wh
Net Weight	680 g
Operating Temperature	14° to 104° F (-10° to 40° C)
Storage Temperature	<ul style="list-style-type: none"> Less than 3 months: -4° to 113° F (-20° to 45° C) More than 3 months: 72° to 82° F (22° to 28° C)
Charge Temperature	41° to 104° F (5° to 40° C)
Max Charging Power	180 W

PERFORMANCE

Hovering Accuracy (P-Mode, with GPS)	Vertical: ±0.5 m, Horizontal: ±1.5 m
Max Angular Velocity	Pitch: 300°/s, Yaw: 150°/s
Max Pitch Angle	25°
Max Speed of Ascent	5 m/s
Max Speed of Descent	3 m/s
Max Wind Resistance	8 m/s
Max Flight Altitude above Sea Level	2500 m
Max Speed	18 m/s (No wind)
Hovering Time (with six TB47S batteries)*	No payload: 35 min, 6 kg payload: 16 min
Hovering Time (with six TB48S batteries)*	No payload: 40 min, 5.5 kg payload: 18 min

* The hovering time is based on flying at 10 m above sea level in a no-wind environment and landing with 10% battery level.

FLIGHT CONTROL SYSTEM

Model	A3
-------	----

REMOTE CONTROLLER

Operating Frequency	<ul style="list-style-type: none"> 920.6 MHz to 928 MHz (Japan) 5.725 GHz to 5.825 GHz 2.400 GHz to 2.483 GHz
---------------------	--

Matrice 600

EIRP	<ul style="list-style-type: none"> • 10 dBm @ 900 M/ i> • 13 dBm @ 5.8 G • 20 dBm @ 2.4 G
Video Output Port	HDMI, SDI, USB
Dual Users Capability	Master-and-Slave control
Mobile Device Holder	Supports smartphones and tablets
Output Power	9W
Operating Temperature	14° to 104° F (-10° to 40° C)
Storage Temperature	<ul style="list-style-type: none"> • Less than 3 months: -4° to 113° F (-20° to 45° C) • More than 3 months: 72° to 82° F (22° to 28° C)
Charge Temperature	32° to 104° F (0° to 40° C)
Built-in Battery	6000 mAh, 2S LiPo
Max Tablet Width	170 mm

BATTERY (STANDARD)

Model	TB47S
Capacity	4500 mAh
Voltage	22.2V
Type	LiPo 6S
Energy	99.9 Wh
Net Weight	595 g
Operating Temperature	14° to 104° F (-10° to 40° C)
Storage Temperature	<ul style="list-style-type: none"> • Less than 3 months: -4° to 113° F (-20° to 45° C) • More than 3 months: 72° to 82° F (22° to 28° C)
Charge Temperature	41° to 104° F (5° to 40° C)
Max Charging Power	180 W

MATRICE 600 VIDEOS

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SHOWCASE

Velodyne LiDAR[®] HDL-32E

HIGH RESOLUTION REAL-TIME 3D LiDAR SENSOR



HDL-32E



Stylishly small and ruggedly built with an unrivaled field of view, Velodyne's HDL-32E LiDAR sensor was designed to exceed the demands of the most challenging, real-world industrial applications including autonomous vehicle control and operation, mobile terrestrial mapping, aerial 3D mapping and security surveillance.

The HDL-32E measures only 144 mm by 85 mm and weighs 1.0 kg (plus 0.3 kg for cabling). Its compact size and weight makes it for all LiDAR applications, in particular those with constrained form factors and pricing requirements but still demand high performance.

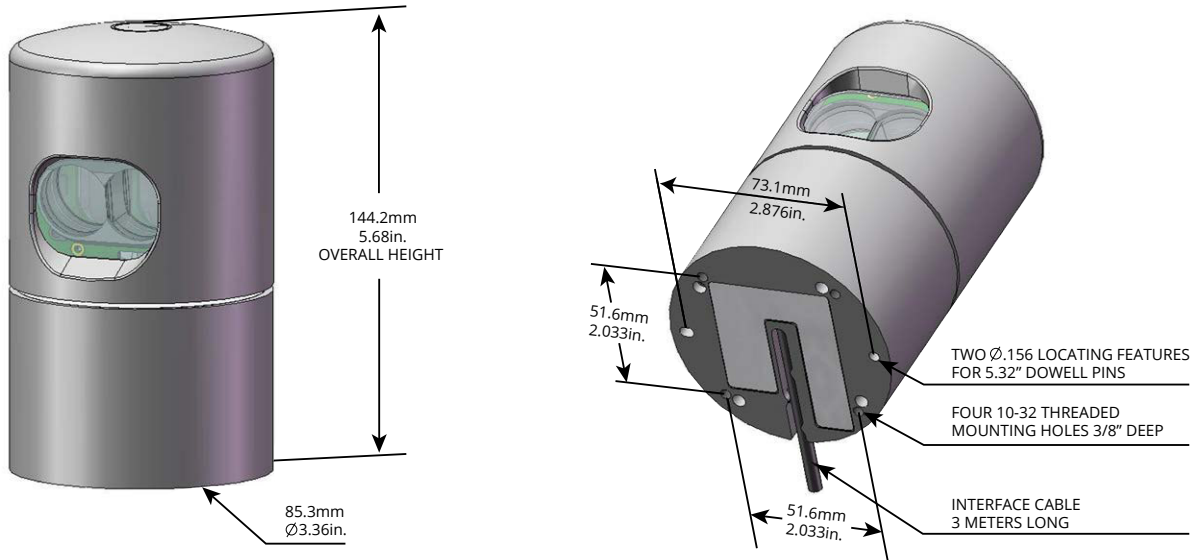
Unprecedented Field of View and Point Density

The HDL-32E's innovative multi-channel array enables navigation and mapping systems to observe more of their environment than any other LiDAR sensor. The HDL-32E utilizes 32 LiDAR channels aligned from +10.67° to -30.67° to provide an unmatched vertical field of view, and its patented rotating head design delivers a real-time 360° horizontal field of view. The HDL-32E generates a point cloud of up to 695,000 points per second with a range of up to 100 m and a typical accuracy of ±2 cm. The resulting comprehensive point cloud coverage within a single data stream makes the HDL-32E an indispensable part of any sensor suite.

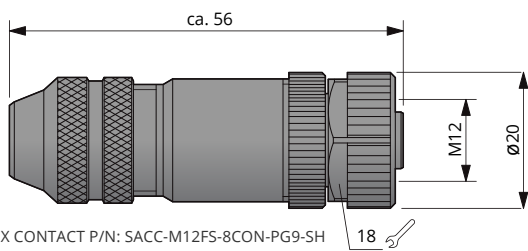


HDL-32E

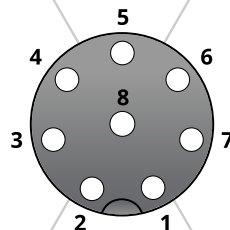
DIMENSIONS



M12 CONNECTOR ON SENSOR SIDE



PHOENIX CONTACT P/N: SACC-M12FS-8CON-PG9-SH



Pin	Wire Color	Function
8	Black	Ground
7	Red	+12 V
6	Yellow	GPS Pulse Per Second (PPS)
5	White	GPS Serial Data
4	Light Orange	Ethernet TX+
3	Orange	Ethernet TX-
2	Light Blue	Ethernet RX+
1	Blue	Ethernet RX-



High Definition Real-Time 3D LiDAR Sensor

The HDL-32E provides high definition 3-dimensional information about the surrounding environment.

Specifications:

Sensor:	<ul style="list-style-type: none"> • Time of Flight Distance Measurement with Calibrated Reflectivities • 32 Channels • Measurement Range: Up to 100 m • Accuracy: ± 2 cm (Typical) • Single and Dual Returns (Strongest, Last) • Field of View (Vertical): $+10.67^\circ$ to -30.67° (41.33°) • Angular Resolution (Vertical): 1.33° • Field of View (Horizontal): 360° • Angular Resolution (Horizontal/Azimuth): $0.1^\circ - 0.4^\circ$ • Rotation Rate: 5 Hz – 20 Hz • Integrated Web Server for Easy Monitoring and Configuration
Laser:	<ul style="list-style-type: none"> • Laser Product Classification: Class 1 Eye-safe per IEC 60825-1:2007 & 2014 • Wavelength: 903 nm • Beam Size @ Screen: 12.7 mm (Horizontal) x 9.5 mm (Vertical) • Beam Divergence Horizontal: 0.18° (3.0 mrad); Vertical: 0.07° (1.2 mrad)
Mechanical/ Electrical/ Operational	<ul style="list-style-type: none"> • Power Consumption: 12 W (Typical) • Operating Voltage: 9 V – 18 V (with Interface Box and Regulated Power Supply) • Weight: 1.0 kg (without Cabling and Interface Box) • Dimensions: 85 mm Diameter x 144 mm Height • Shock: 500 m/s^2 Amplitude, 11 ms Duration • Vibration: 5 Hz to 2,000 Hz, $3 G_{\text{rms}}$ • Environmental Protection: IP67 • Operating Temperature: -10°C to $+60^\circ\text{C}$ • Storage Temperature: -40°C to $+105^\circ\text{C}$
Output:	<ul style="list-style-type: none"> • 3D LiDAR Data Points Generated: <ul style="list-style-type: none"> - Single Return Mode: ~695,000 points per second - Dual Return Mode: ~1,390,000 points per second • 100 Mbps Ethernet Connection • UDP Packets Contain: <ul style="list-style-type: none"> - Time of Flight Distance Measurement - Calibrated Reflectivity Measurement - Rotation Angles - Synchronized Time Stamps (μs resolution) • Orientation: 6DoF Inertial Sensor Measurements • GPS: \$GPRMC NMEA Sentence from GPS Receiver (GPS not included)

97-0038 Rev-K

Product Ordering Information:

Product Name	SKU Ordering Number	Sensor		Interface Box			
		Connector	Cable Length*	Included	Connector to Sensor	Cable Length*	I/O Connectors
HDL-32E	80-HDL-32E	None	3.0 m	Yes	None	-	RJ45, GPS and Power
HDL-32E	80-HDL-32E M12-IFB	M12 Female	0.3 m	Yes	M12 Male	1.6 m	RJ45, GPS and Power
HDL-32E	80-HDL-32E M12-0.3M	M12 Female	0.3 m	No	-	-	-
HDL-32E	80-HDL-32E M12	M12 Female	1.6 m	No	-	-	-

*Cable Length includes the connector.



CLASS 1 LASER PRODUCT

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