# Lidar for Basemaps:

## What to ask for & how to use it

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With minor emendations February 2020 by Barry Hanlon

# LIDAR – What is it

Lidar (also written LIDAR or LiDAR) is a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light

LiDAR = "***Li***"ght + RA "***DAR***"

*Alternatively*

LiDAR = ***Li****ght* ***D****etection* ***a****nd* ***R****anging*

Sometimes called ALS – Airborne Laser Surveying

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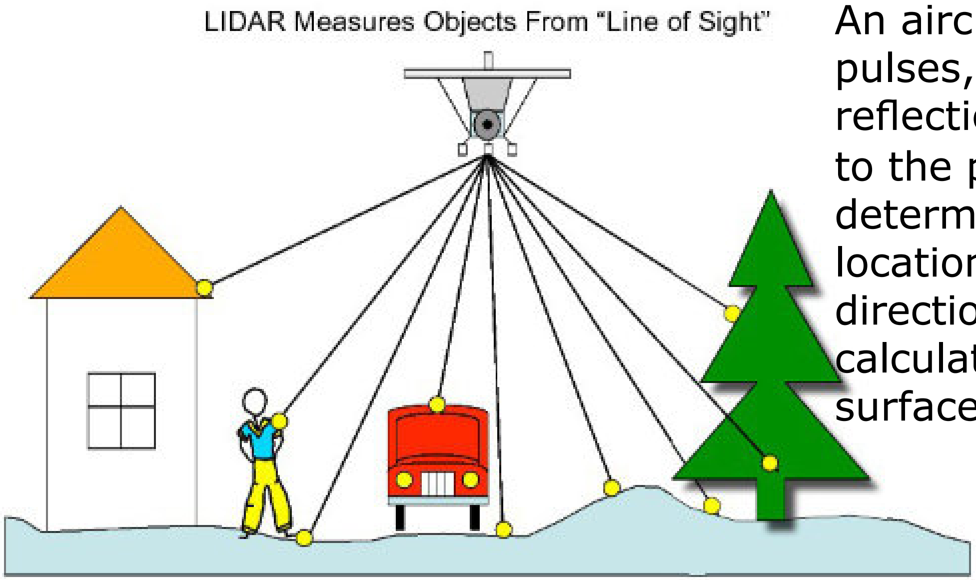
# LIDAR – Who supplies it

The most common source of LiDAR in NSW is Spatial Services a division of the Department of Customer Service, based at Bathurst. Spatial Services is responsible for mapping in NSW

Spatial Services has its own airborne equipment, and has a program to cover much of the state. LiDAR and digital aerial photography have replaced film photography and photogrammetry for routine work.

Commercial contractors include **Fugro** & **AAMI-Hatch**. They work for business and local government clients, as well as some subcontract work with Spatial Services & other government bodies.

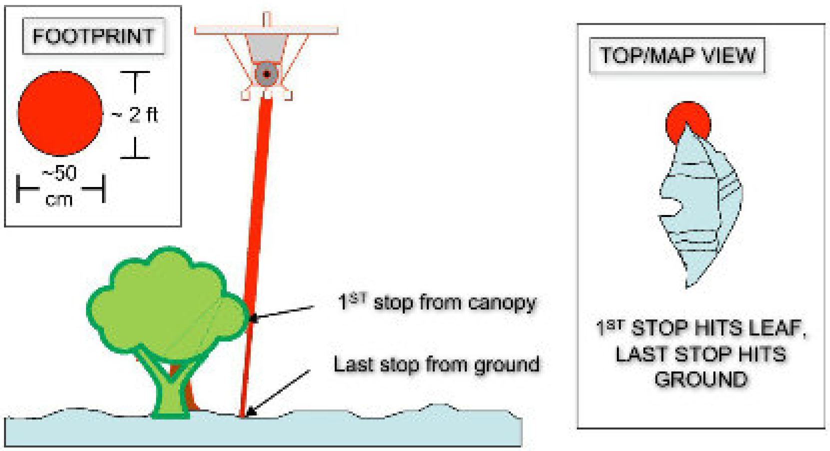
# Lidar Basics Review



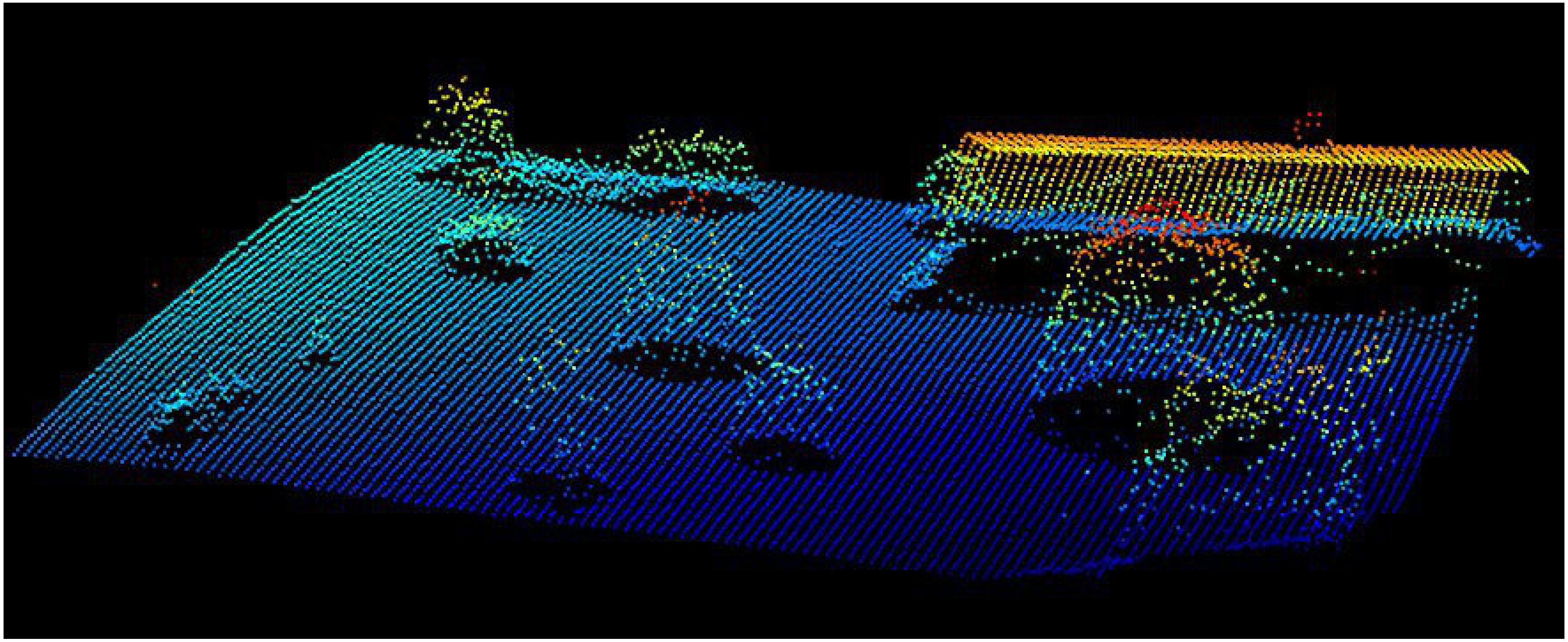

An aircraft flies over the terrain sending out laser pulses, counting the time it takes for the pulse reflections to bounce off of objects and return to the plane. The travel time and speed of light determine the distance to the object, the location of the plane is known via GPS, and the direction the laser was pointing allow for the calculation of the exact location of the reflecting surface.

If only part of the beam hits a surface, there might be enough leftover energy to continue past and bounce off a second or even third object, allowing for multiple returns per-pulse. This depends on the footprint of the pulse and the fraction that is blocked.

Typical data has one or two returns per pulse, and data will often be separated into different files, one for "first-returns" and one for "last-returns"



The raw data from the survey is a cloud of points – some from the ground surface, some from features above the ground level, and some from "noise". To make the data more useful each point is classified, initially by an automated routine, and then checked manually, before the data is released



Classification

The Spatial Services standard classes used in NSW are:

| | | |
|---|---|---|
| 1 | Default | Unclassified |
| 2 | Ground | Bare ground |
| 3 | Low vegetation | 0 – 0.3m (essentially sensor „noise“) |
| 4 | Medium vegetation | 0.3 – 2m |
| 5 | High vegetation | 2m > |
| 6 | Building | Houses, sheds, etc. |
| 7 | Low high points | Spurious high/low point returns (not useable) |
| 8 | Model key points | Reserved for „Model Key Points“ |
| 9 | Water | Any point in water |
| 10 | Bridge | Any bridge or overpass |

In NSW Spatial Services does not release the data until this classification has been done, and checked. (There are exceptions)

## *LPMA Classification Levels*

**Level 0, Undefined**
All points allocated classes 0 (unclassified) or 1 (default) by LiDAR processing software with no classification algorithms applied.

**Level 1, Automated Classification**
Data is subjected to automated algorithms which, as a minimum, will classify the points into classes 2 (ground), 3-5 (vegetation), 6 (building/structures), 7 (low/high points & noise) and where required 12 (overlap).

**Level 2, Ground Anomaly Removal**
Level 1 classified data is further enhanced by the removal of significant anomalies which remain in the ground class (2). Typically, this editing will re-classify points into class 7 (low/high points & noise).

**Level 3, Manual Ground Correction**
Significant (usually manual) effort is required here to ensure that only actual ground points are assigned class 2. Typically, this editing will both remove and add points to the ground class derived using the automated algorithms. Any points observed in water are to be re-classified into class 9, and other features which may require special attention include dense or low vegetation, rocky outcrops/boulders, contour/levee banks, wood/rubbish piles and islands.

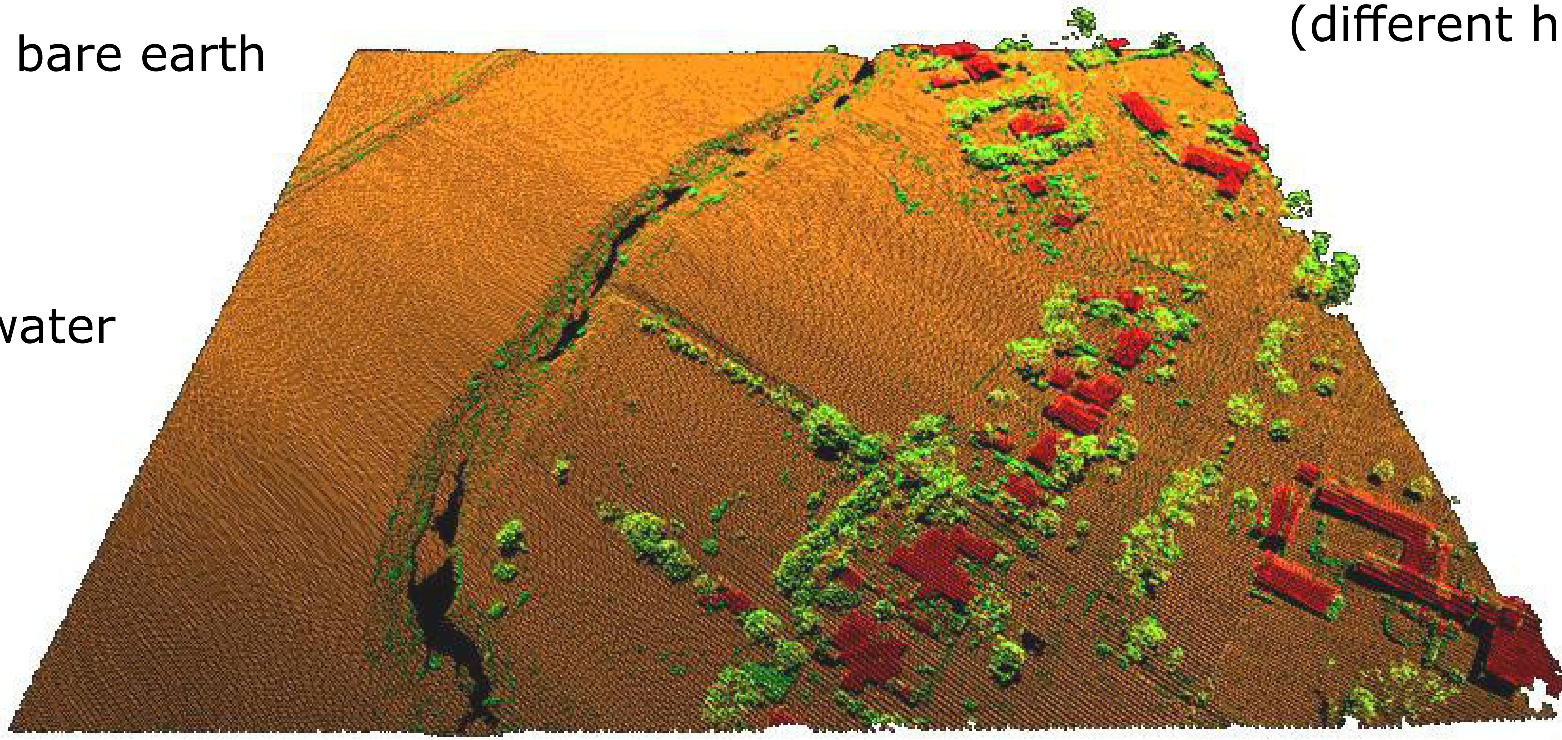
*C3 - This is standard Spatial Services release level of classification*

A classified point cloud

2 bare earth

3, 4, 5 vegetation
(different heights)

9 water



'striping' from
survey scans

6 building

# Classified Point Cloud

The **intensity** of the reflected pulse relative to the intensity of the transmitted pulse is a measure of the reflectivity of the surface at the wavelength of the laser being used (usully red to IR). This reflectivity measure can be used as an image, as if it were a rectified aerial photo with no terrain-induced distortions.

**dark features** (roads,water, buildings, vegetation)
**= low return intensity**, because laser energy absorbed or reflected away

'striping' from survey scans

wet ground - darker because water absorbs laser energy

**Intensity**

In NSW Spatial Services usually also takes digital photography during the LIDAR flights. This is useful in the data processing, to identify anomalous results. The digital photographs may not satisfy Spatial Services' criteria for stand-alone photography because of cloud, shadow, etc.

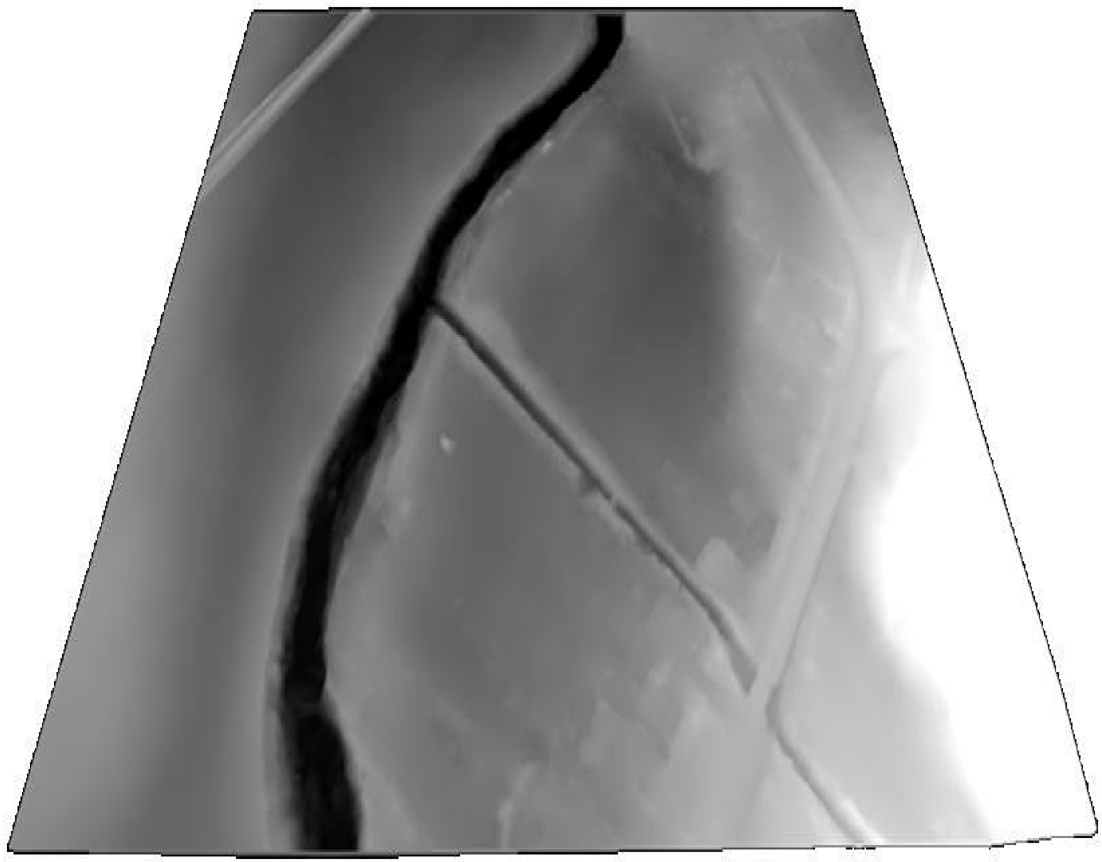
compare photo with intensity image

wet ground - darker

**Digital Photography**

The “bare earth” points are used to create a **Digital Elevation Model (DEM).**

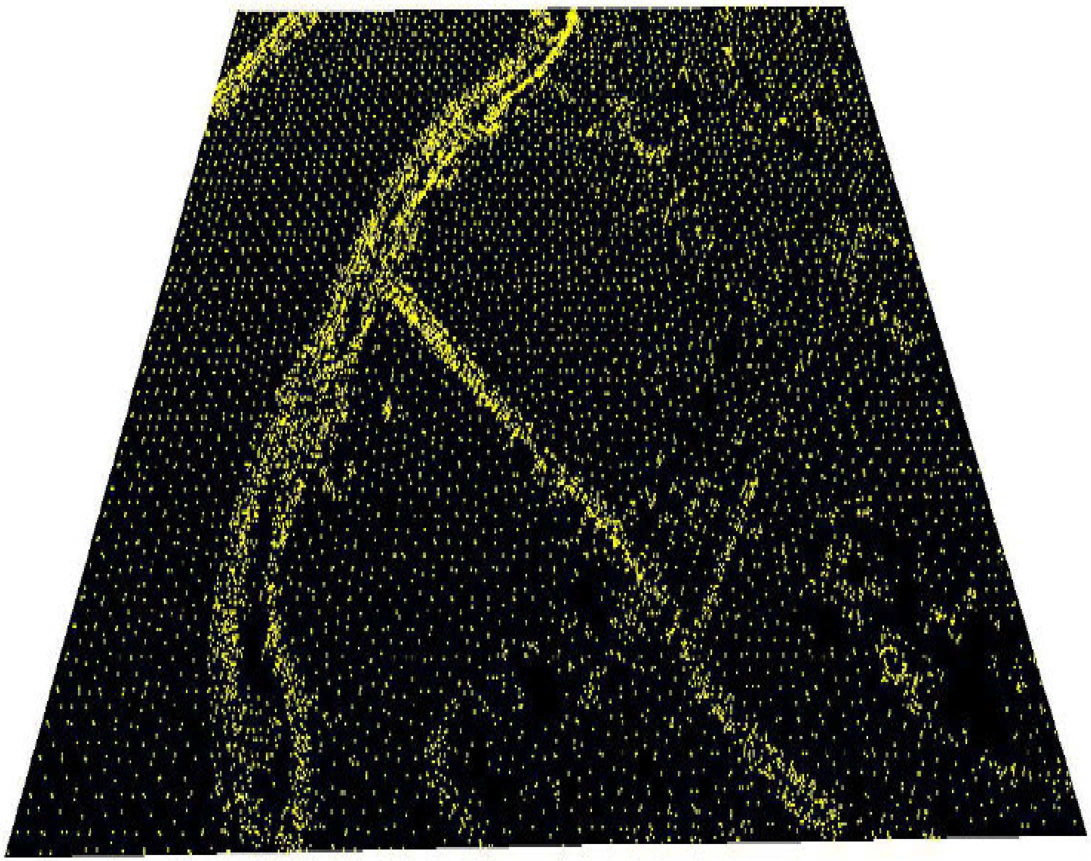
The points in the DEM are sampled onto a regular grid mesh (eg 1,2 or 5 m grid), for use in some mapping and information systems.



**Digital Elevation Model**

The “bare earth” points are also used to create a data set of **thinned points.**

The thinning algorithm recognises the simple and complex areas and removes redundant points. This reduces the density of data points and file size, for use in some mapping and information systems.



**Thinned Points**

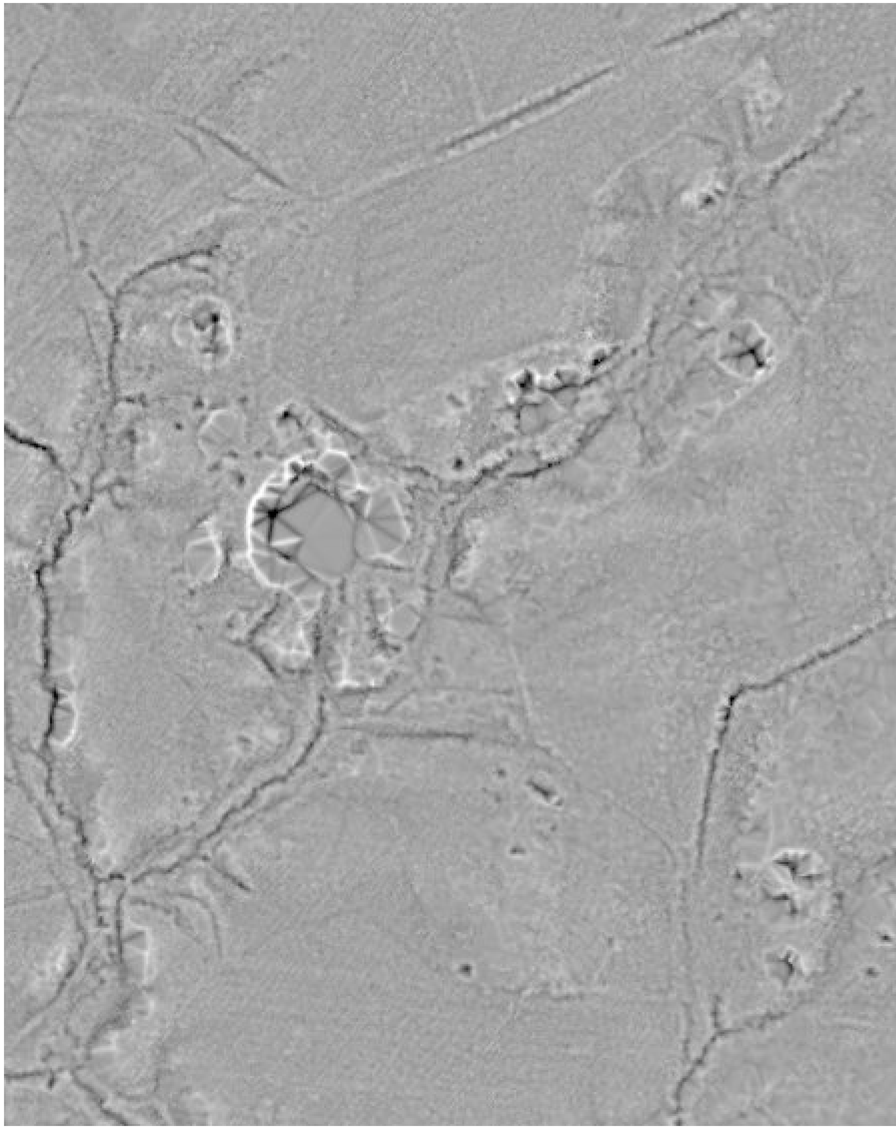
# Accuracy and Resolution - 1

*Individual* lidar points typically have an accuracy in the 10-30cm range.

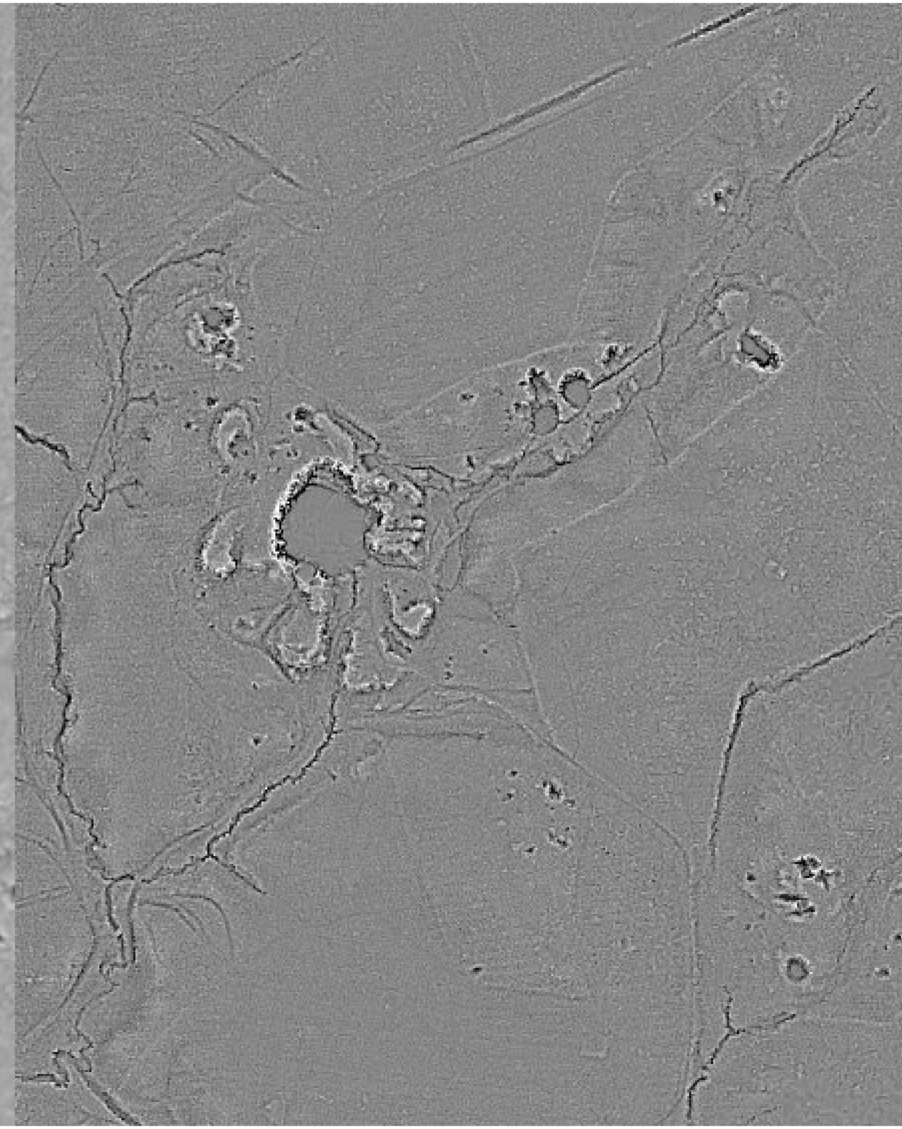
The density of the collected points (number of points per unit surface area) affects the level of detail that can be seen on the ground surface. Lidar is typically collected with an average point spacing of 0.5 to 4 meters. Collecting more samples costs more and results in a larger data volume.

Sampling theory requires at least two samples per resolution element.
To be able to “see” a feature in the terrain, it must be sampled by at least two lidar samples. For example, seeing a 2m wide pit in the bare earth lidar requires average point spacing of 1 sample every meter.

# Bare-Earth Lidar Small-Scale Detail Comparison



2-meter average point spacing



1-meter average point spacing

# Accuracy and Resolution - 2

The density and condition of the vegetation covering an area also has an effect, since some of the samples will be intercepted by vegetation and not reach the ground. Leaf-on data at 1m average sampling won't be as good as leaf-off. It effectively has a lower average point spacing.

Lidar is typically better than classical photogrammetry for determining the shape of the bare-earth surface below evergreen canopy, since it can penetrate to the surface (even though more of the returns would be intercepted than for leaf-off deciduous vegetation, so a higher sampling density might be required to achieve this).

Spatial Services' coverage in NSW aims to have "bare earth" coverage of 1 point per square metre.

# LIDAR in NSW

There are several sources of LIDAR in NSW.

Spatial Services - 2km square tiles can be downloaded free of charge from ELVIS* - widest coverage & growing

Other government agencies

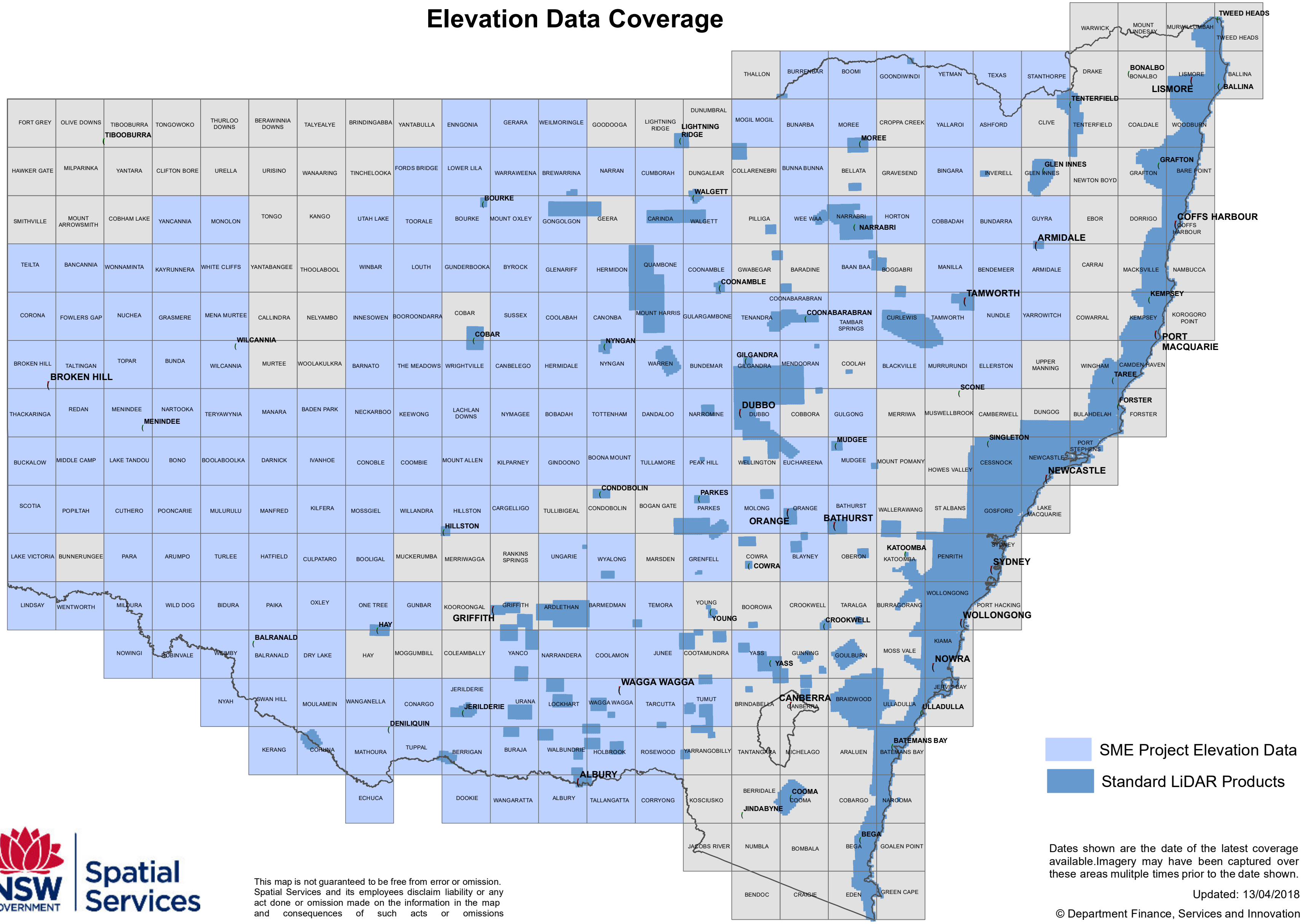
Local Government - older surveys (2005-2010) conducted for individual LGA by contractor
- also sub-licence of data (free?)

Mining Companies – case by case if available

*ELVIS - https://elevation.fsdf.org.au/

# LIDAR in NSW

## Elevation Data Coverage






Dates shown are the date of the latest coverage available.Imagery may have been captured over these areas mulitple times prior to the date shown.

Updated: 13/04/2018

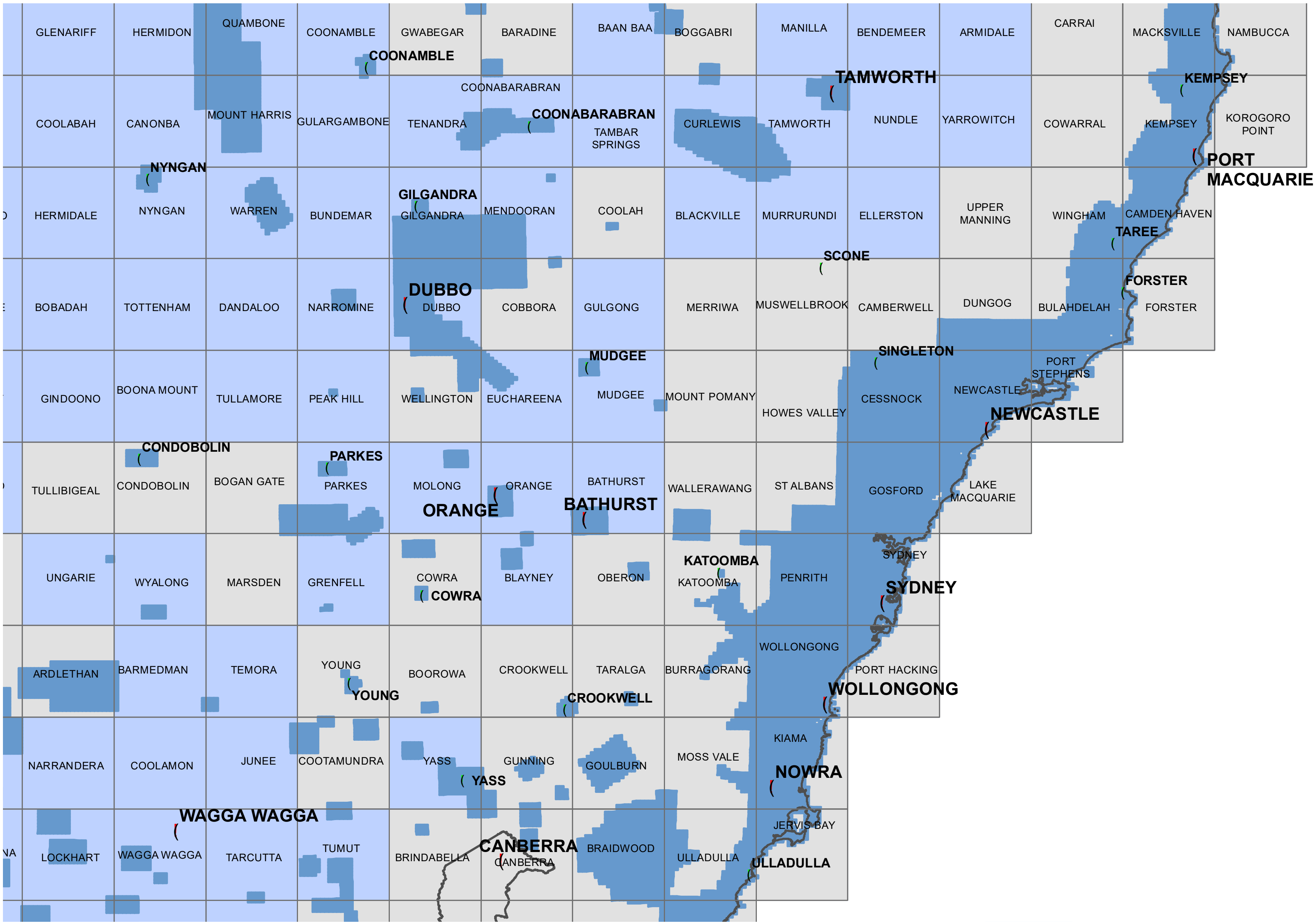


NSW GOVERNMENT Spatial Services

For current version:

https://www.spatial.nsw.gov.au/__data/assets/pdf_file/0004/218992/Elevation_Products_Specification_and_Desciption_LiDAR.pdf

# LIDAR in NSW



GLENARIFF
HERMIDON
QUAMBONE
COONAMBLE
GWABEGAR
BARADINE
BAAN BAA
BOGGABRI
MANILLA
BENDEMEER
ARMIDALE
CARRAI
MACKSVILLE
NAMBUCCA
COONAMBLE
TAMWORTH
KEMPSEY
COONABARABRAN
COOLABAH
CANONBA
MOUNT HARRIS
GULARGAMBONE
TENANDRA
COONABARABRAN
TAMBAR SPRINGS
CURLEWIS
TAMWORTH
NUNDLE
YARROWITCH
COWARRAL
KEMPSEY
KOROGORO POINT
PORT MACQUARIE
NYNGAN
HERMIDALE
NYNGAN
WARREN
BUNDEMAR
GILGANDRA
GILGANDRA
MENDOORAN
COOLAH
BLACKVILLE
MURRURUNDI
ELLERSTON
UPPER MANNING
WINGHAM
CAMDEN HAVEN
TAREE
SCONE
BOBADAH
TOTTENHAM
DANDALOO
NARROMINE
DUBBO
DUBBO
COBBORA
GULGONG
MERRIWA
MUSWELLBROOK
CAMBERWELL
DUNGOG
BULAHDELAH
FORSTER
FORSTER
SINGLETON
MUDGEE
PORT STEPHENS
GINDOONO
BOONA MOUNT
TULLAMORE
PEAK HILL
WELLINGTON
EUCHAREENA
MUDGEE
MOUNT POMANY
HOWES VALLEY
CESSNOCK
NEWCASTLE
NEWCASTLE
CONDOBOLIN
PARKES
TULLIBIGEAL
CONDOBOLIN
BOGAN GATE
PARKES
MOLONG
ORANGE
ORANGE
BATHURST
BATHURST
WALLERAWANG
ST ALBANS
GOSFORD
LAKE MACQUARIE
SYDNEY
KATOOMBA
UNGARIE
WYALONG
MARSDEN
GRENFELL
COWRA
COWRA
BLAYNEY
OBERON
KATOOMBA
PENRITH
SYDNEY
WOLLONGONG
ARDLETHAN
BARMEDMAN
TEMORA
YOUNG
YOUNG
BOOROWA
CROOKWELL
TARALGA
BURRAGORANG
PORT HACKING
CROOKWELL
WOLLONGONG
KIAMA
NARRANDERA
COOLAMON
JUNEE
COOTAMUNDRA
YASS
YASS
GUNNING
GOULBURN
MOSS VALE
NOWRA
WAGGA WAGGA
JERVIS BAY
LOCKHART
WAGGA WAGGA
TARCUTTA
TUMUT
BRINDABELLA
CANBERRA
CANBERRA
BRAIDWOOD
ULLADULLA
ULLADULLA

# SPATIAL SERVICES
# LiDAR Products

[The main items of interest to O-mappers are items 1 and 3]

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| | Product | File format | Description |
|---|---|---|---|
| 1 | **Classified point cloud** | **LAS 1.2** | **(2km x 2km tiles)** |
| | Attributed in accordance with designated classification level. | | |
| 2 | Model key points | LAS 1.2 | (2km x 2km tiles) |
| | "Thinned" ground points. | | |
| 3 | DEM | ESRI ASCII Grid | (2km x 2km tiles) |
| | 1 metre resolution "bare earth" (artefact free) DEM. | | |
| 4 | **Intensity image** | **Compressed ECW** | **1m resolution image**. |
| | (Single file mosaic - tiles combined) | | |
| 6 | **RGB image** | **Compressed ECW (5:1)** 20cm res RGB orthorectified photo mosaic. (Single file mosaic - tiles combined) | |
| 7 | Key diagram | ESRI Shapefile | |
| | Depicting tile layout & naming. Includes „no data area" polygons. | | |
| 8 | Metadata | XML | ANZLIC Metadata profile version 1.1 |
| 9 | Project report | PDF | |
| | As required, detailing methodology and quality assurance details. | | |

# What to ask for

The best data set to get is the **Classified Point Cloud**. This can be used to generate contours and pseudo O-maps using readily available free software.

The **Intensity** image and **Orthophoto** help with the interpretation of the data and supply additional information for mapping.

**DEM, thinned data** and **contour** data sets are less preferable than the point cloud, as the interpretation and thinning that is done in the preparation of this data removes much useful information – still usable, and a lot better than nothing.

Always try to get contour data at a smaller interval than your final map interval eg 1 or 2.5m data for a 5m final map. It is easy to remove the excess, and a lot easier than having to field map where that shallow water course goes between the contours.

The latest version of OCAD does an excellent job processing Point Clouds

# Using the Point Cloud - Karttapullautin

**Karttapullautin –** ("map machine") is a software package developed by Jarrko Ryyppo, of Routegadget fame. It is an alternative point cloud processor if OCAD is not available.

Free for non-commercial use

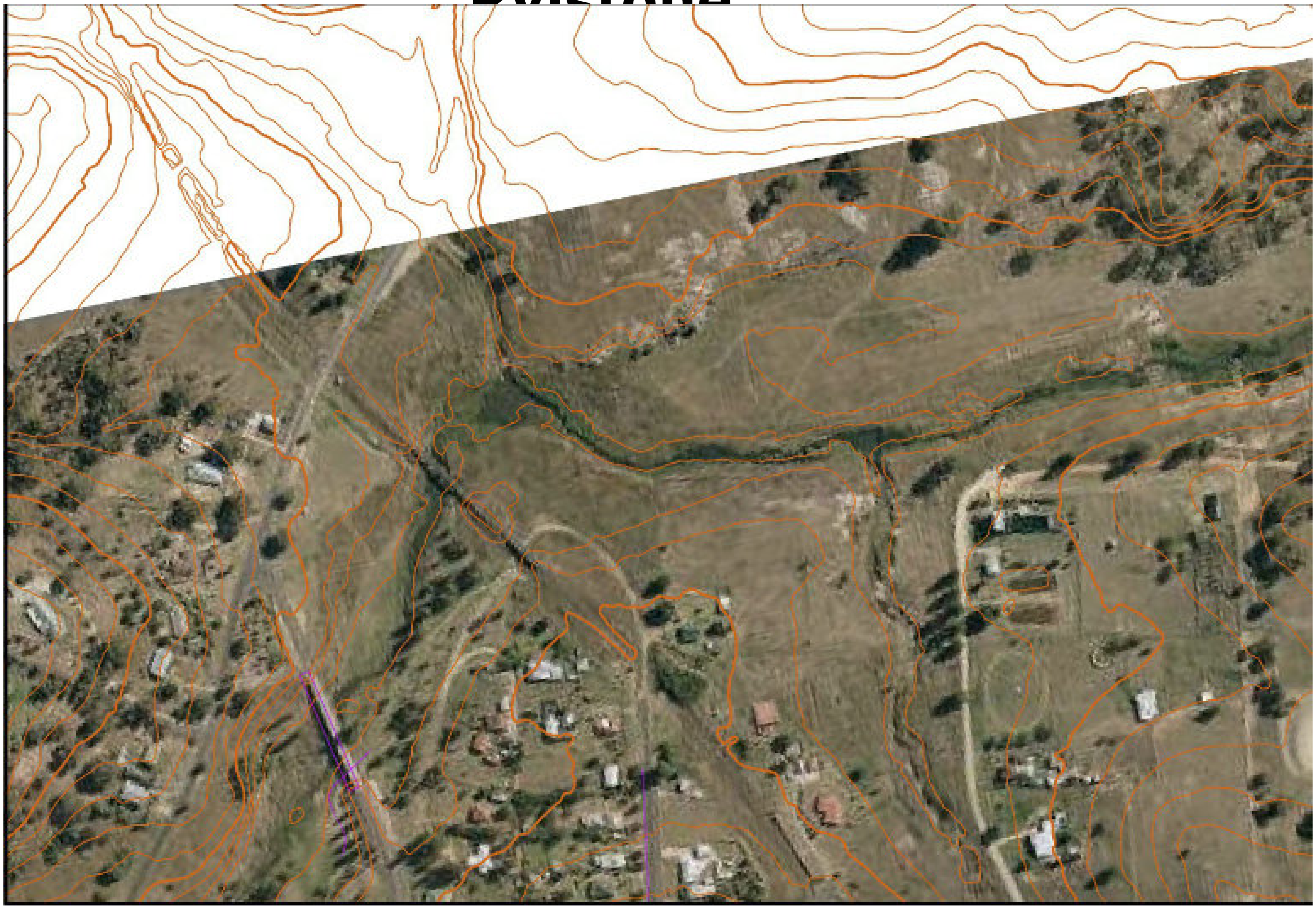
Takes the classified point cloud file & "crunches" it (LAS files may be hundreds on megabytes – plenty of time for a coffee or a 10km run)

You set up a parameter file with:
map area, final scale, magnetic declination, contour interval, vegetation density parameters, slope parameters, etc

Output:
Pseudo O-map (png raster image/s – georeferenced)

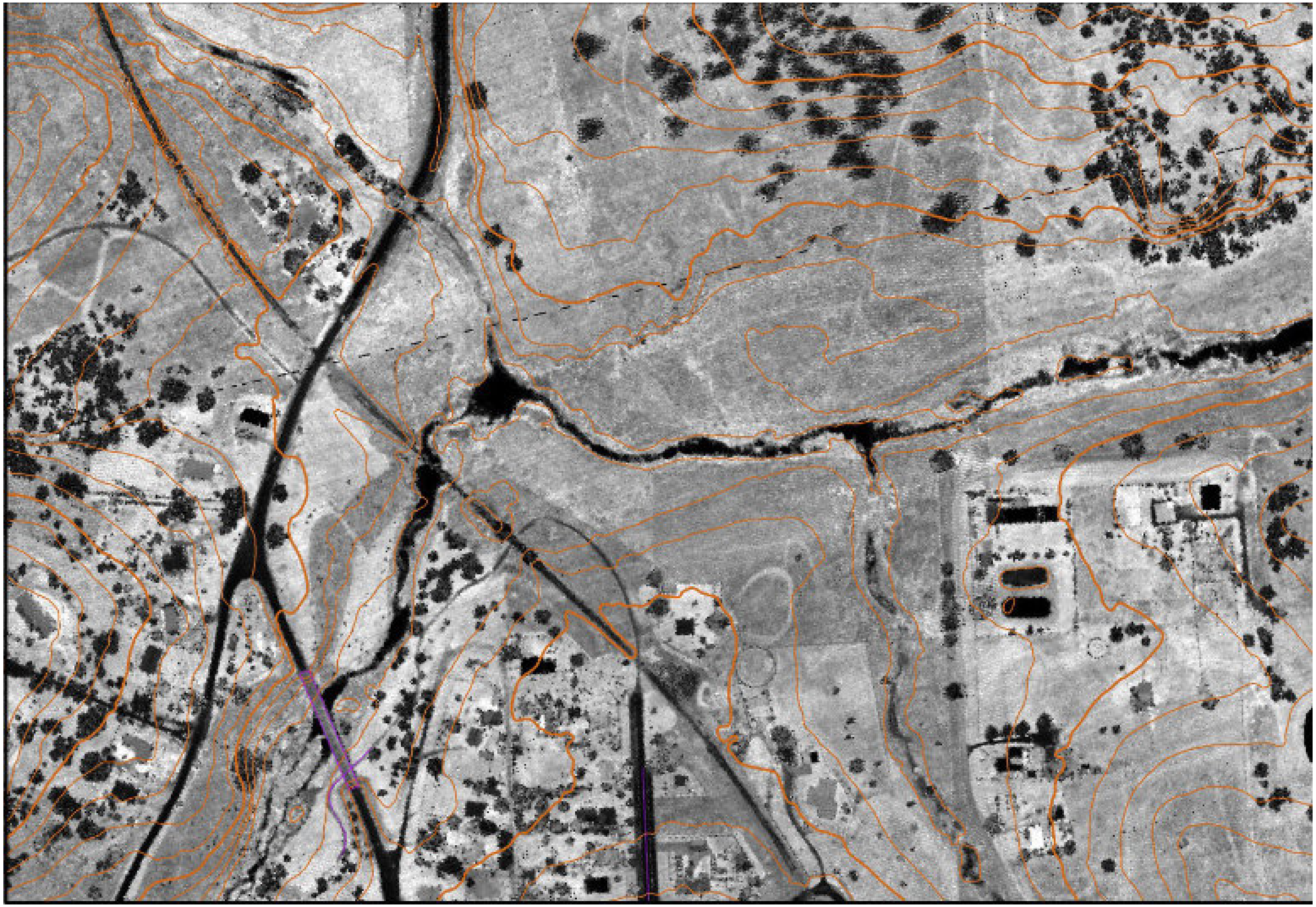
Vector (dxf) files ready for OCAD:
contours, estimated vegetation boundaries, steep slope and likely rock faces, depressions and knolls

# Karttapullautin example - Rylstone



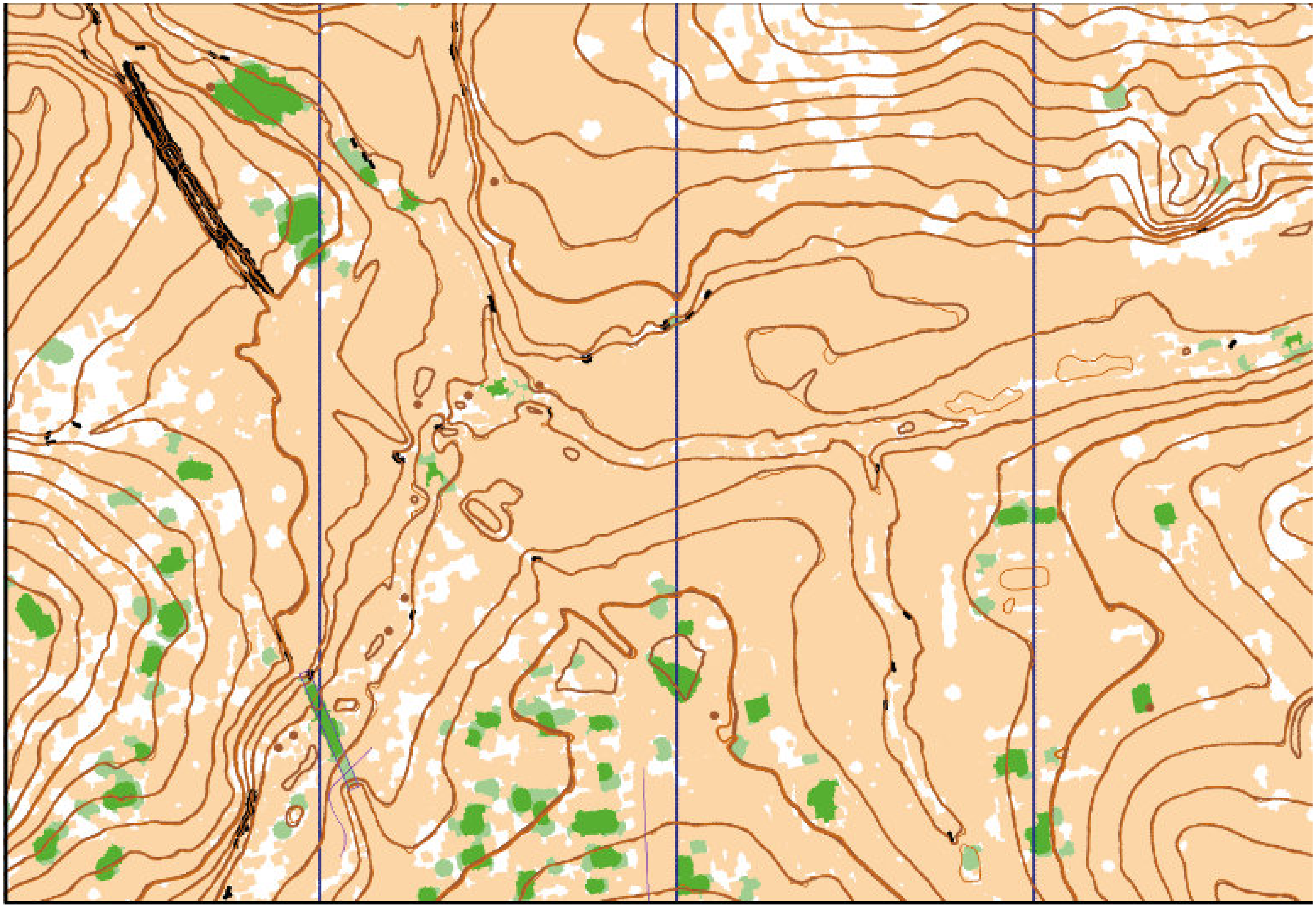
Aerial photo base (SIX) with 5m contours

# Karttapullautin example - Rylstone



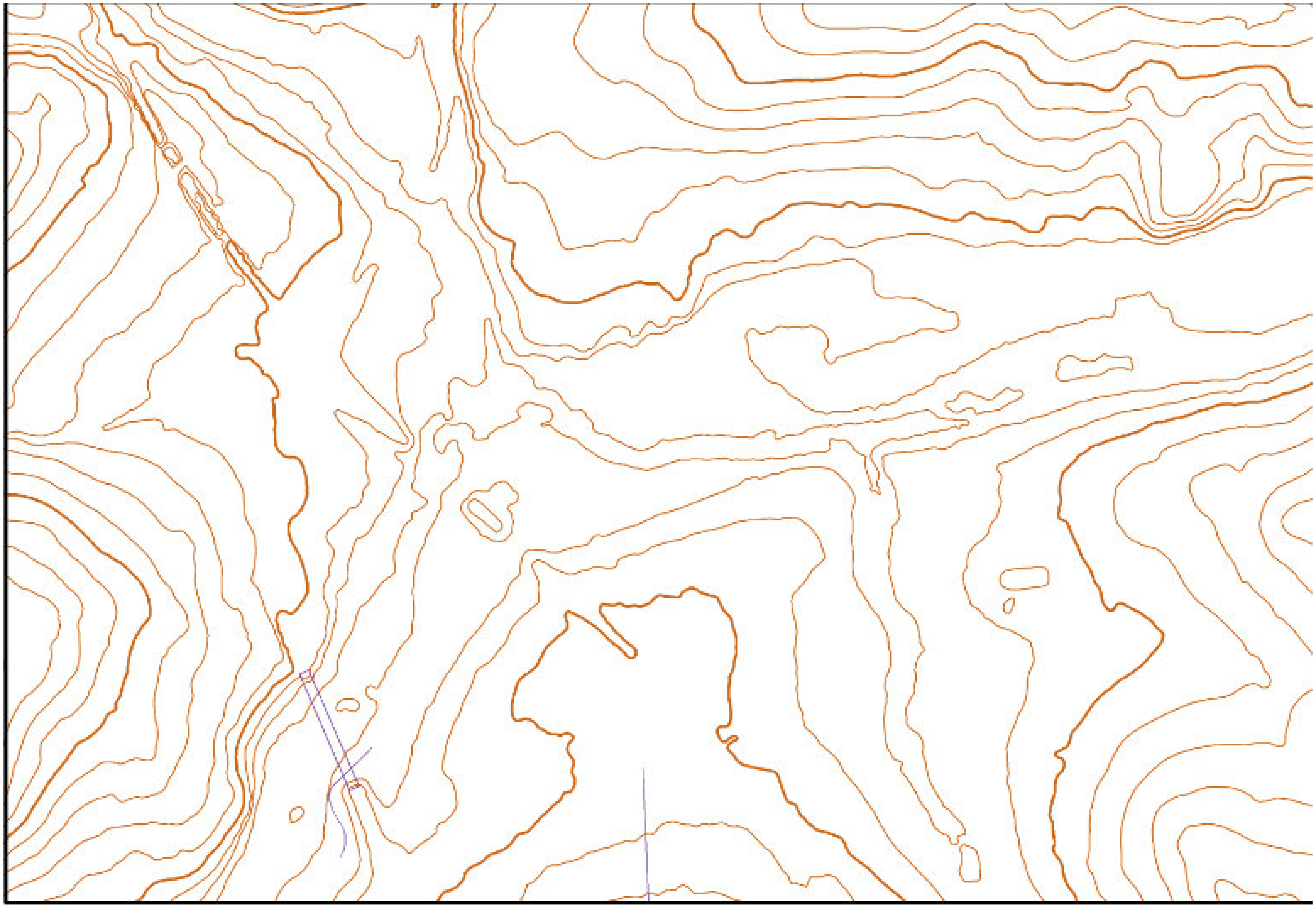
LIDAR intensity

# Karttapullautin example - Rylstone



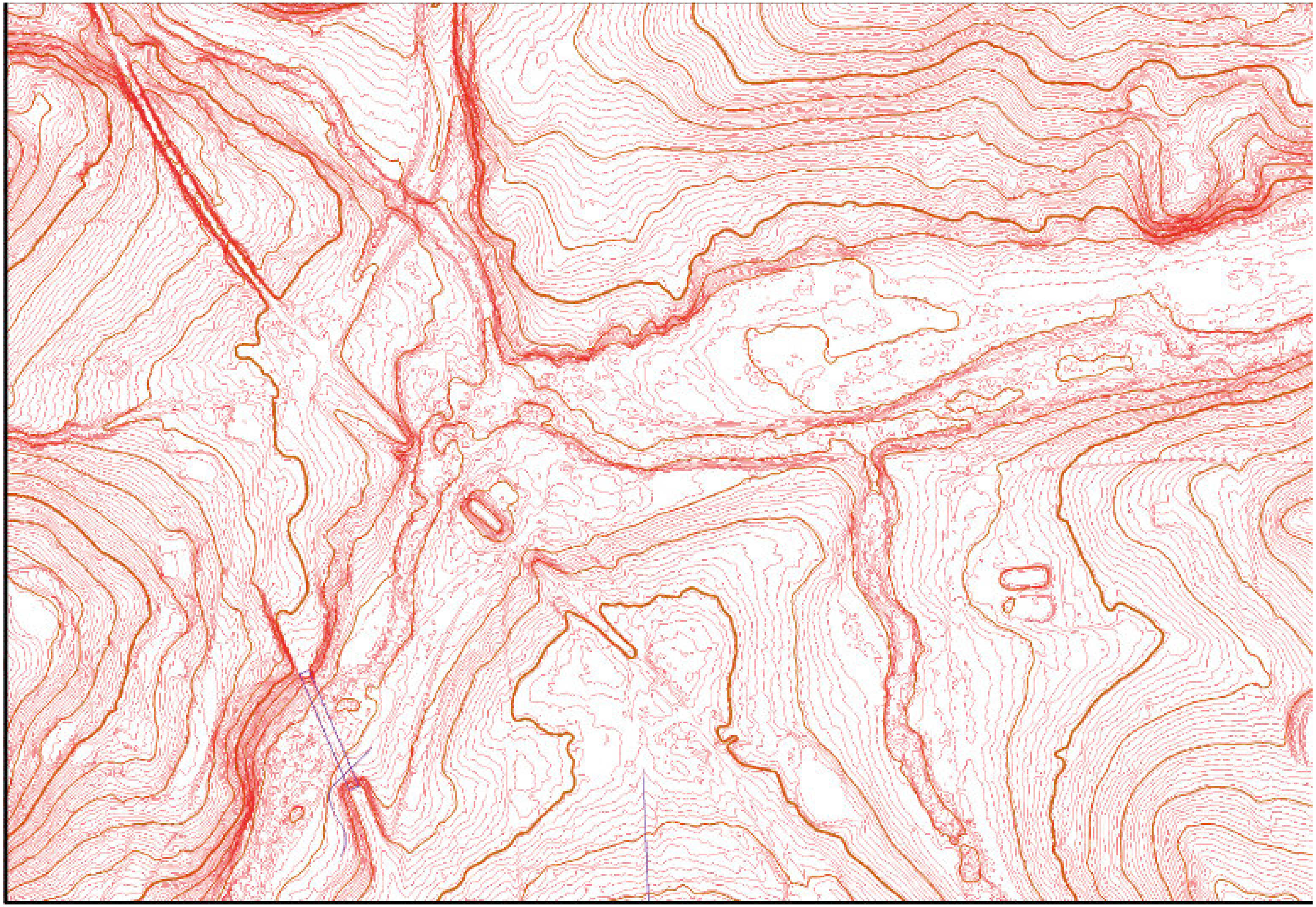
Karttapullautin raster
(note: older data – buildings & bridge not classified, so interpreted as thick vegetation)

# Kartapullautin example - Rylstone



5m contours from Karrtapullautin

# Karrtapullautin example - Rylstone



0.5m & 5m contours from Karrtapullautin

The result from Karttapullautin, or a basemap created using any combination of data,  is by **NO MEANS** a completed orienteering map! This basemap *must* be taken into the field by a fieldchecker, who can then correct features that have been mis-identified.

The features have been drawn in the correct locations with the correct shape, but the fieldchecker must make the decision of what should and should not remain on the final map. Also contour shapes, while physically correct, may need to be adjusted to better represent the terrain to an orienteer running a course.