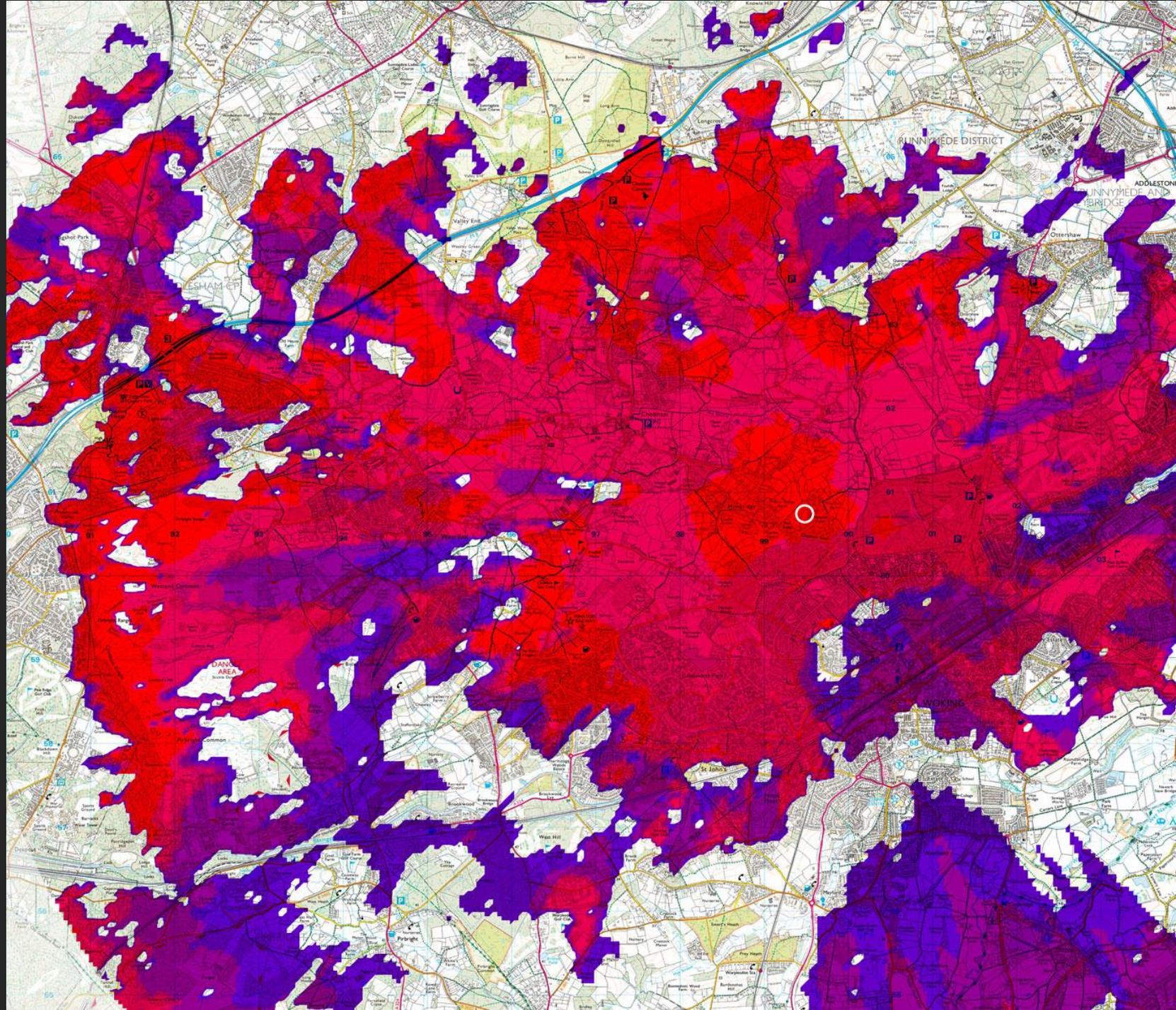


# Zone of Theoretical Visibility

options, analysis  
and outputs

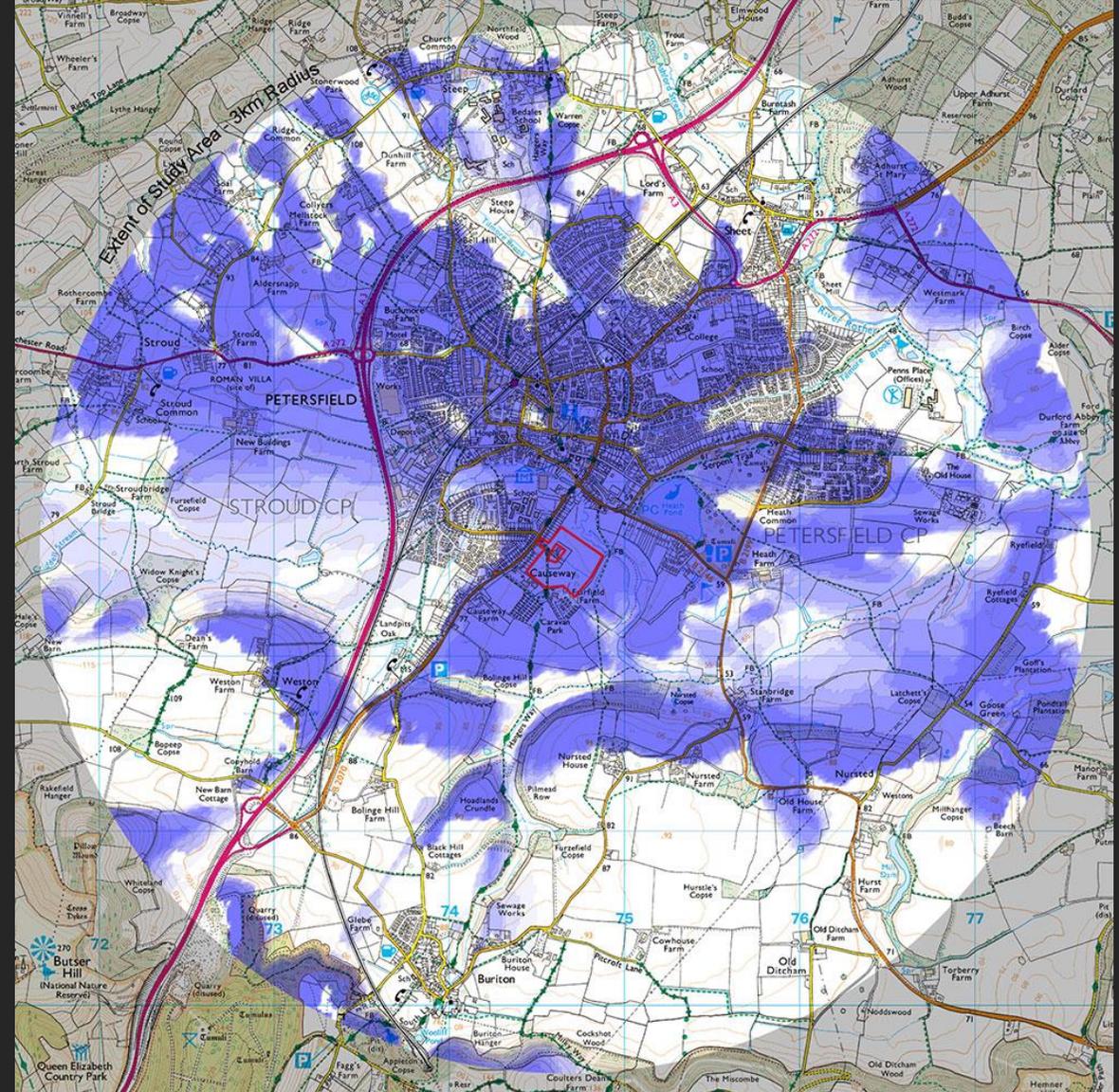
David Watson CMLI  
@springfishblue



# Commonly mistaken



Spin Painting by Damien Hirst



ZTV Analysis

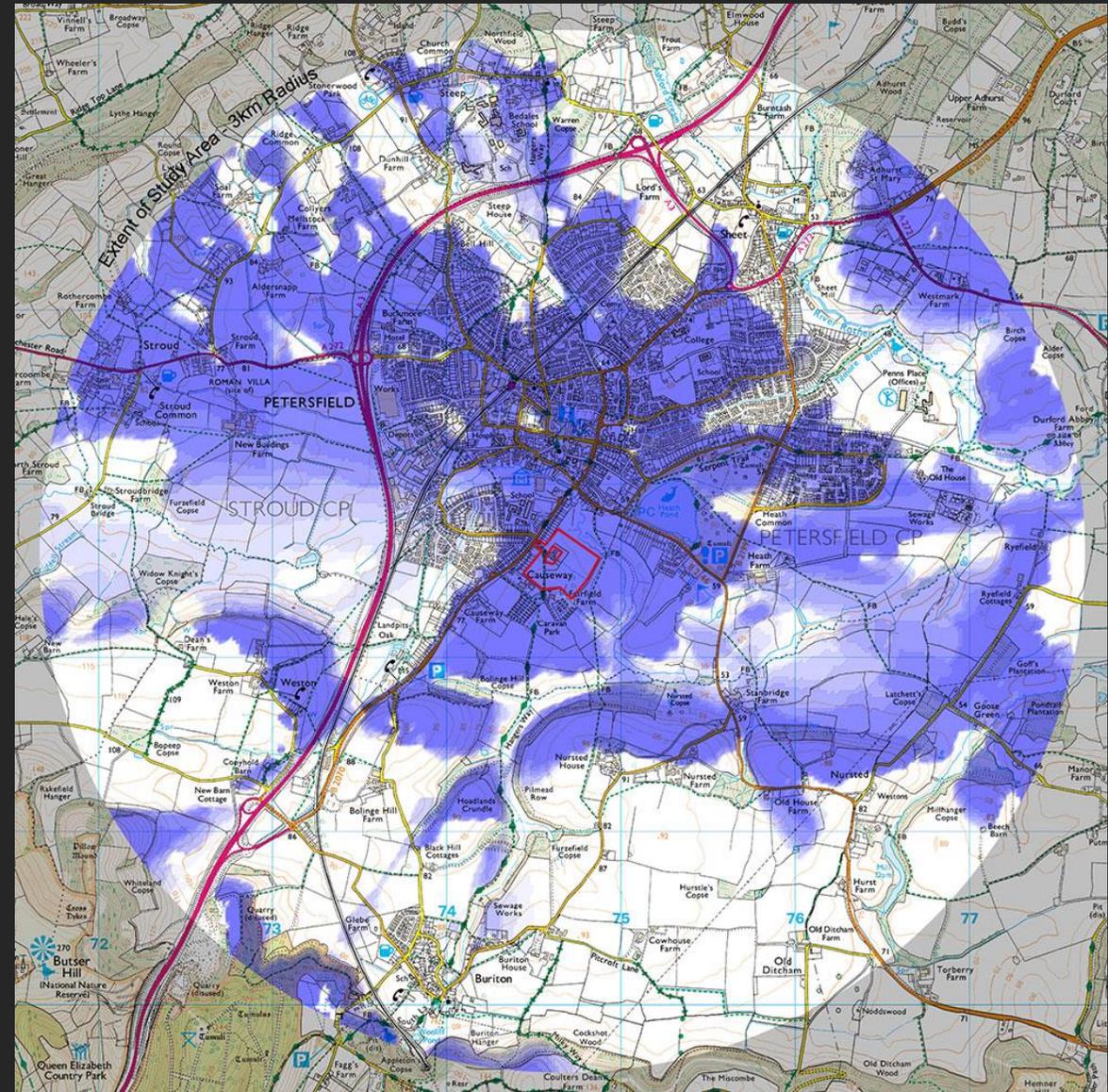
# ZTV Overview

1. What is ZTV analysis?
2. References
3. Terminology
4. Principles
5. Height Data
6. Software
7. Analysis Design
8. Presentation

# What is ZTV Analysis?

ZTV Analysis is the process of determining the non-visibility and the theoretical visibility of an object in the landscape.

It is an objective process where the results are determined by computer software which uses an algorithm to analyse digital height data.



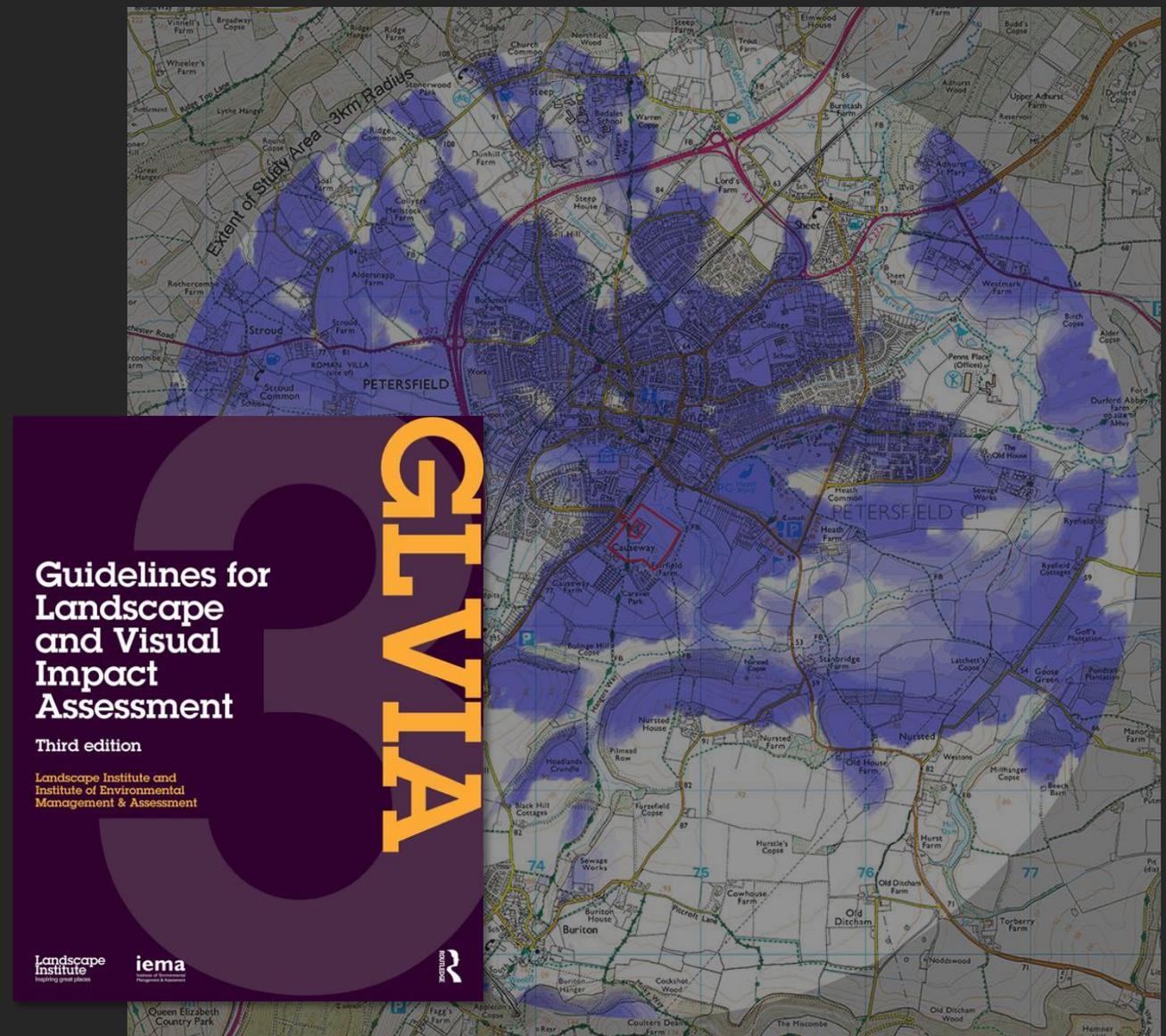
8-point study for a proposed residential development

# References

There are two key references that you should be aware of:

- Guidelines for Landscape and Visual Impact Assessment, 3<sup>rd</sup> Edition (2013) by LI and IEMA.
- Visual Representation of Windfarms, Version 2.2 (February 2017) by Scottish Natural Heritage.

<https://www.landscapeinstitute.org/technical/glvia3-panel/>  
<https://www.nature.scot/visual-representation-wind-farms-guidance>

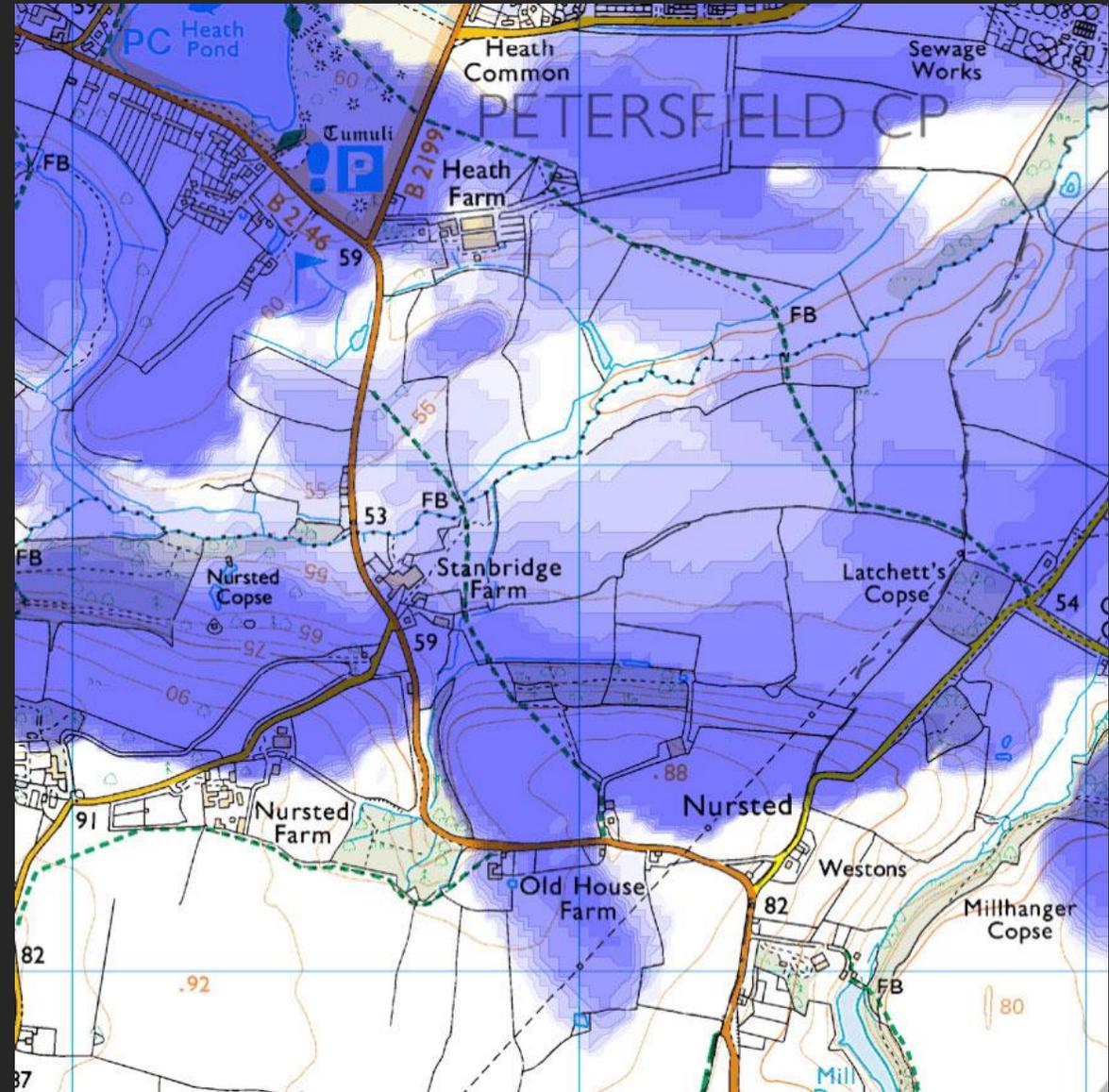


8-point study for a proposed residential development

# Terminology

There is a deal of confusion over the terms used to describe this type of analysis.

Globally, the term “viewshed” is used e.g. in Google Earth. In the UK, we use the term *Zone of Theoretical Visibility* (ZTV).

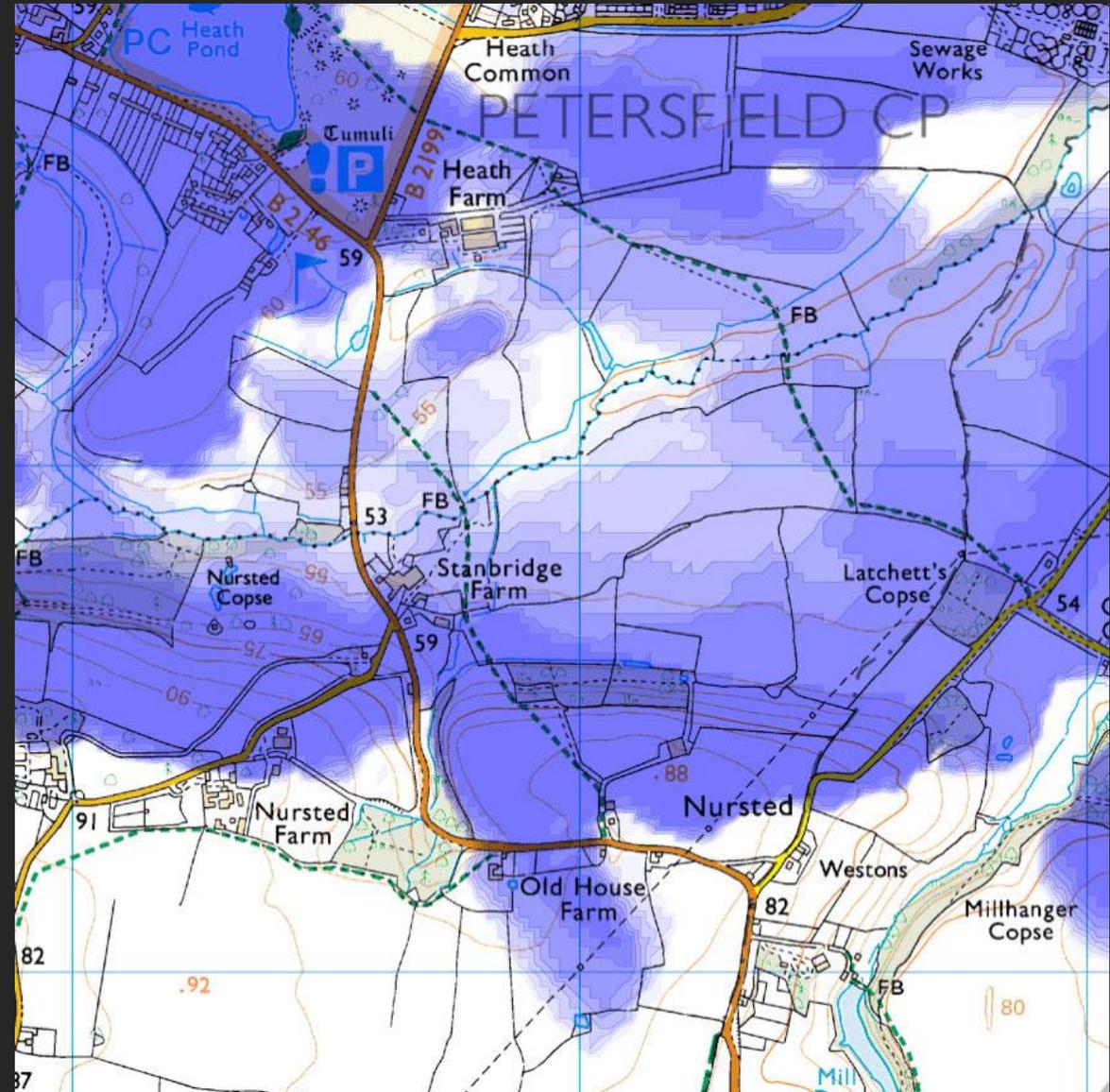


8-point study for a proposed residential development

# ZTV or ZVI?

ZTV was formerly known as ZVI, Zone of Visual Influence (or sometimes “Impact”). The term ZVI should no longer be used. “ZTV” is preferred because:

- The maps indicate *theoretical* visibility only.
- They do not convey the *nature* or *magnitude* of visual effects.  
(GLVIA 6.8 and SNH 2.20)

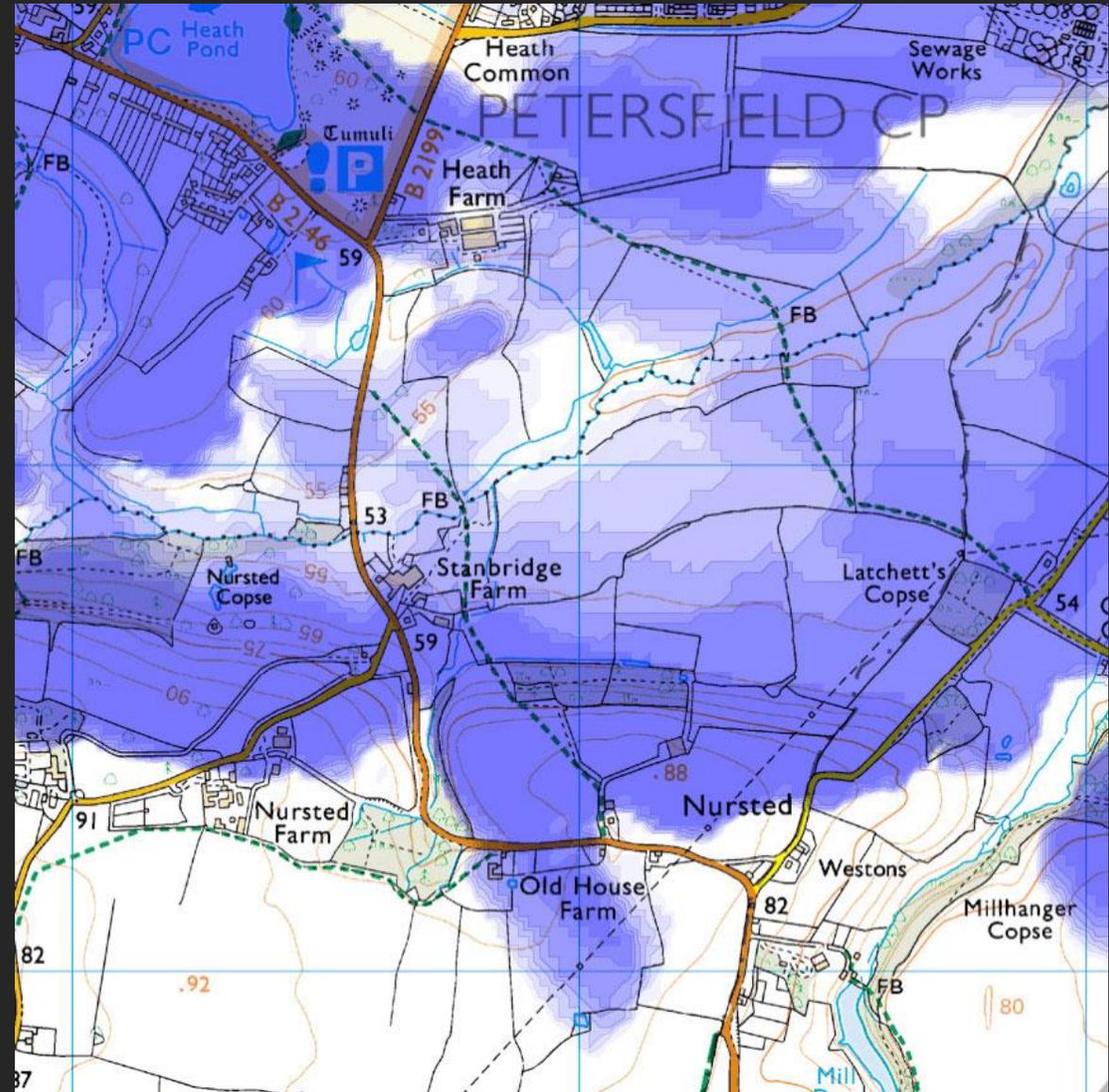


8-point study for a proposed residential development

# There's more?

Other terms also exist, e.g. Visual Envelope Mapping (VEM). Strictly speaking, this refers to a pre-computer methodology of visual survey, looking out from the site of proposed development.

Essentially, all these terms mean the same thing, a map of the visibility of an object in the landscape.



8-point study for a proposed residential development

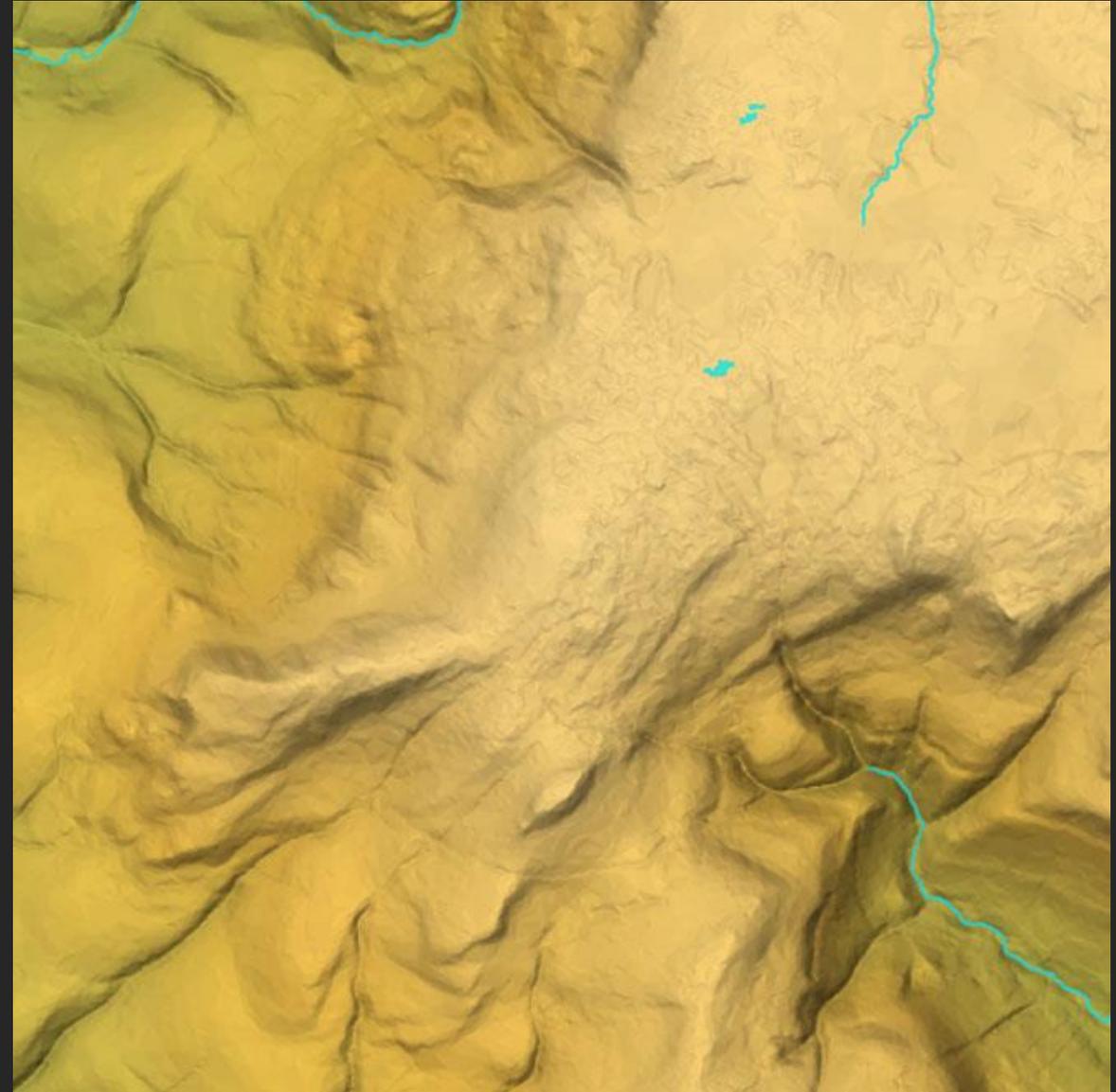
# ZTV Principles

1. Bare Earth
2. The Digital Terrain Model (DTM)
3. Visual barriers
4. Radial line analysis (single point)
5. Intervisibility analysis (multi-point)
6. When should ZTV be used?

# Bare Earth

The Bare Earth principle refers to the height data used for the analysis; this should represent only the terrain surface (i.e. excluding landscape features such as woodland and hedges etc.)

This principle ensures that the resulting map demonstrates a *worst-case scenario* and it allows us to determine exactly where the proposal *cannot* be seen from.



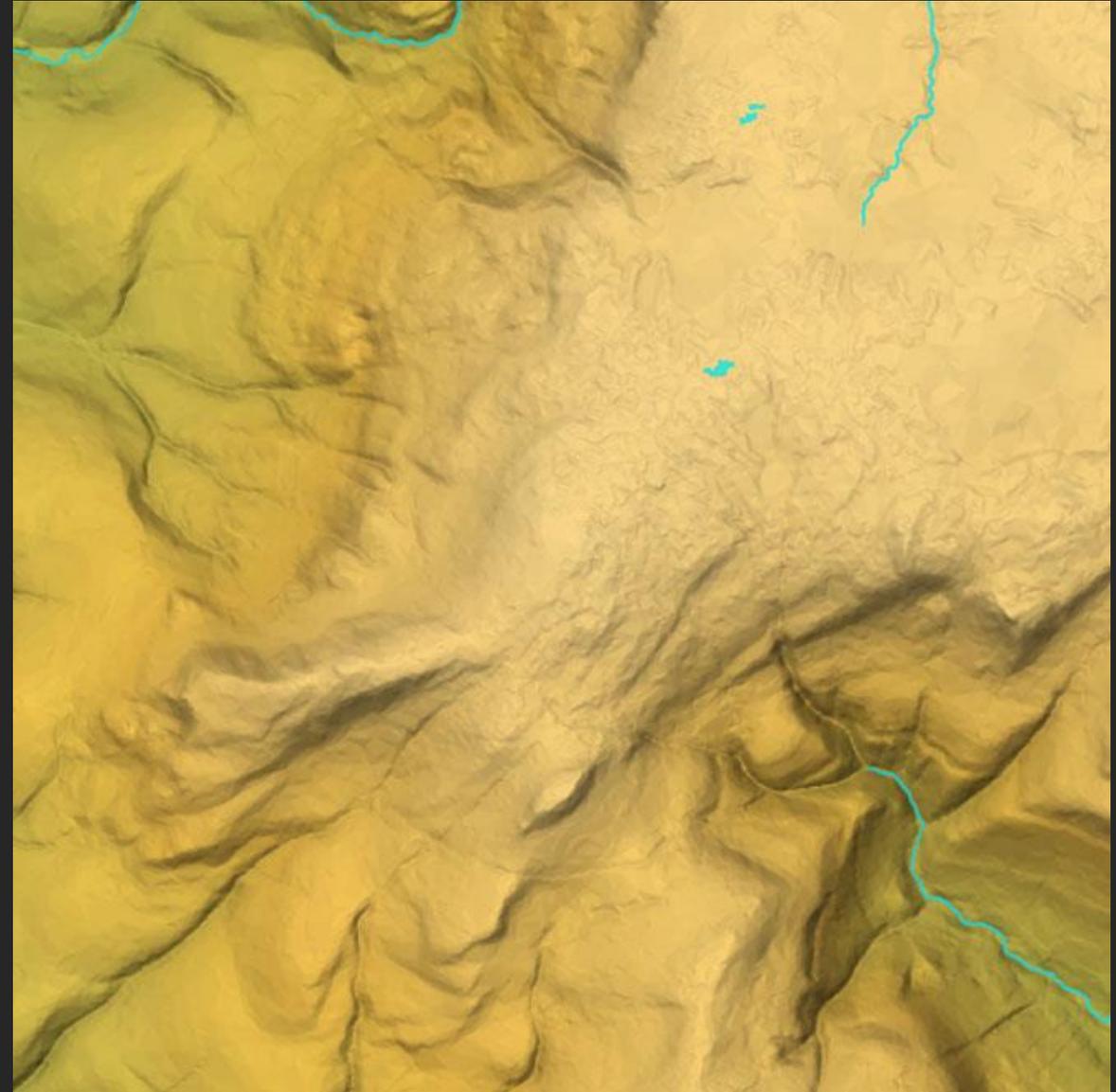
A bare earth digital terrain model (OS Terrain 5 data)

# Theoretical visibility

It's important to understand that the ZTV is *not* used to determine actual visibility, only theoretical visibility. We will not make it more accurate by adding more detail because this may be subjective.

A Bare Earth ZTV objectively shows:

- a. areas where the study point *cannot* be seen.
- b. areas where the study point *may* be seen.

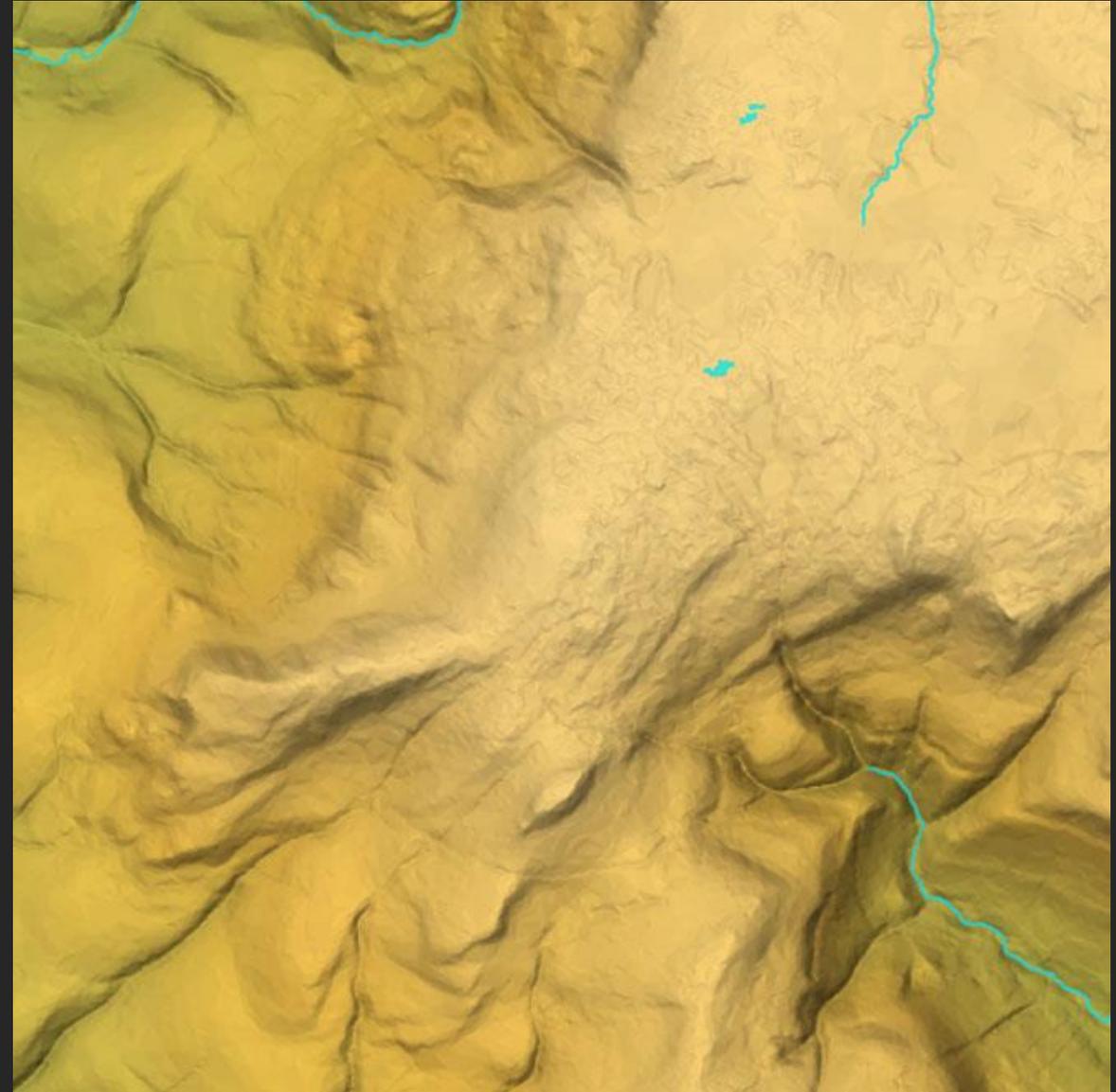


A bare earth digital terrain model (OS Terrain 5 data)

# Actual visibility

Actual visibility can only be determined on site. However, a ZTV analysis prior to the site visit can help to determine those areas that do not need further investigation.

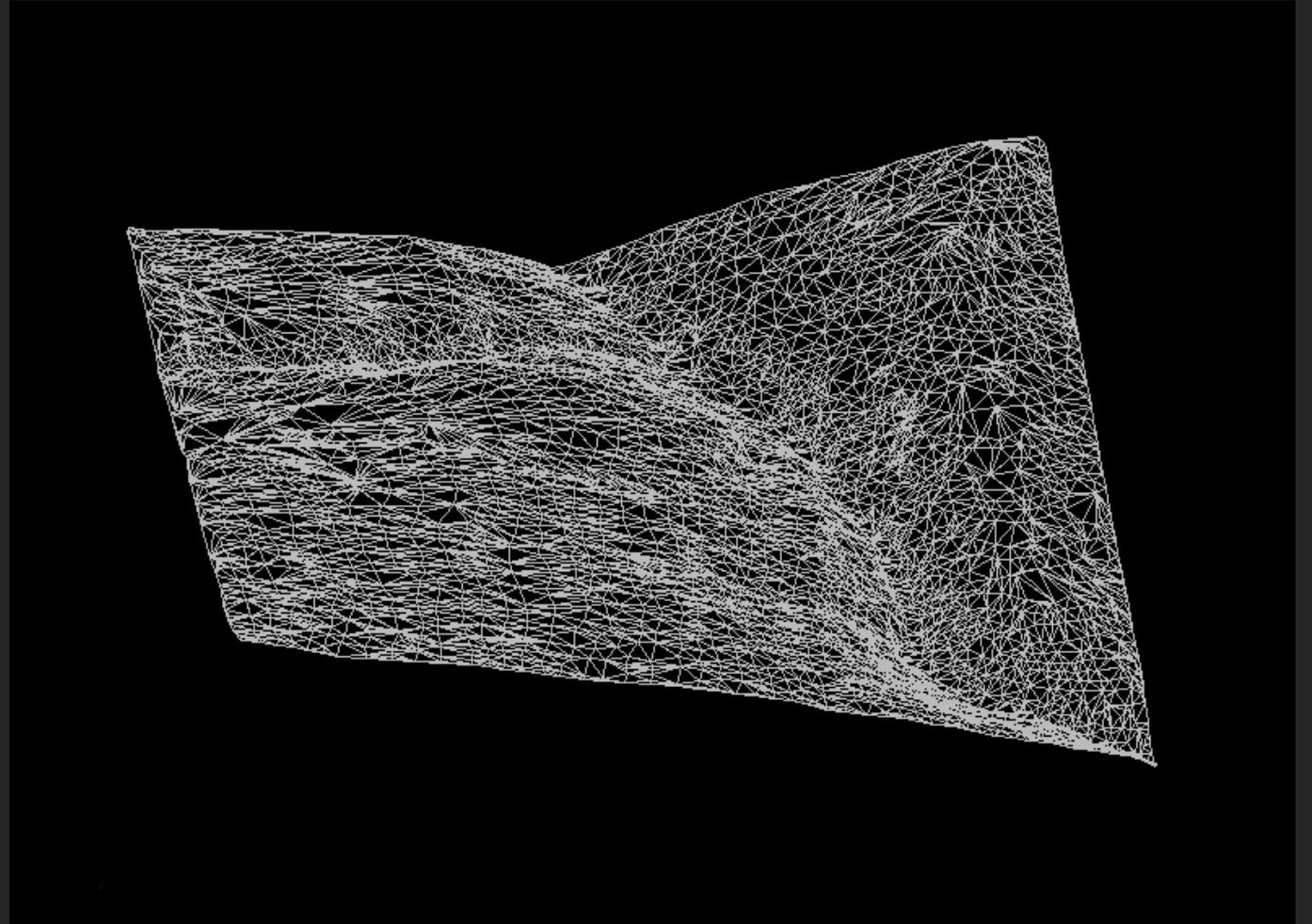
Site surveys are used to “ground truth” those areas shown on the ZTV as theoretically visible.



A bare earth digital terrain model (OS Terrain 5 data)

# Digital Terrain Model

All ZTV analyses require a digital terrain model. This is a mathematical surface that represents the terrain we want to analyse. It is created from 3D point data, which is triangulated. Triangulation creates the most accurate representation of a surface from the given height data.



3D contour data is triangulated, creating a digital terrain model

# Visual barriers

Sometimes it is desirable to include visual barriers such as woodland in the analysis. There are usually two reasons why you may want to do this:

- a. The landscape is characterised by a certain feature type and the analysis needs to reflect the scale of variance from Bare Earth.
- b. You may want to test the effectiveness of visual screening.



Meindert Hobbema - The Avenue at Middelharnis (1689)

# Woodland

Woodland across the study area should be added with caution. Effectively, this changes an objective analysis to a subjective one. To some extent, this can be mitigated by using a standard dataset such as the National Forest Inventory.

<https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/>

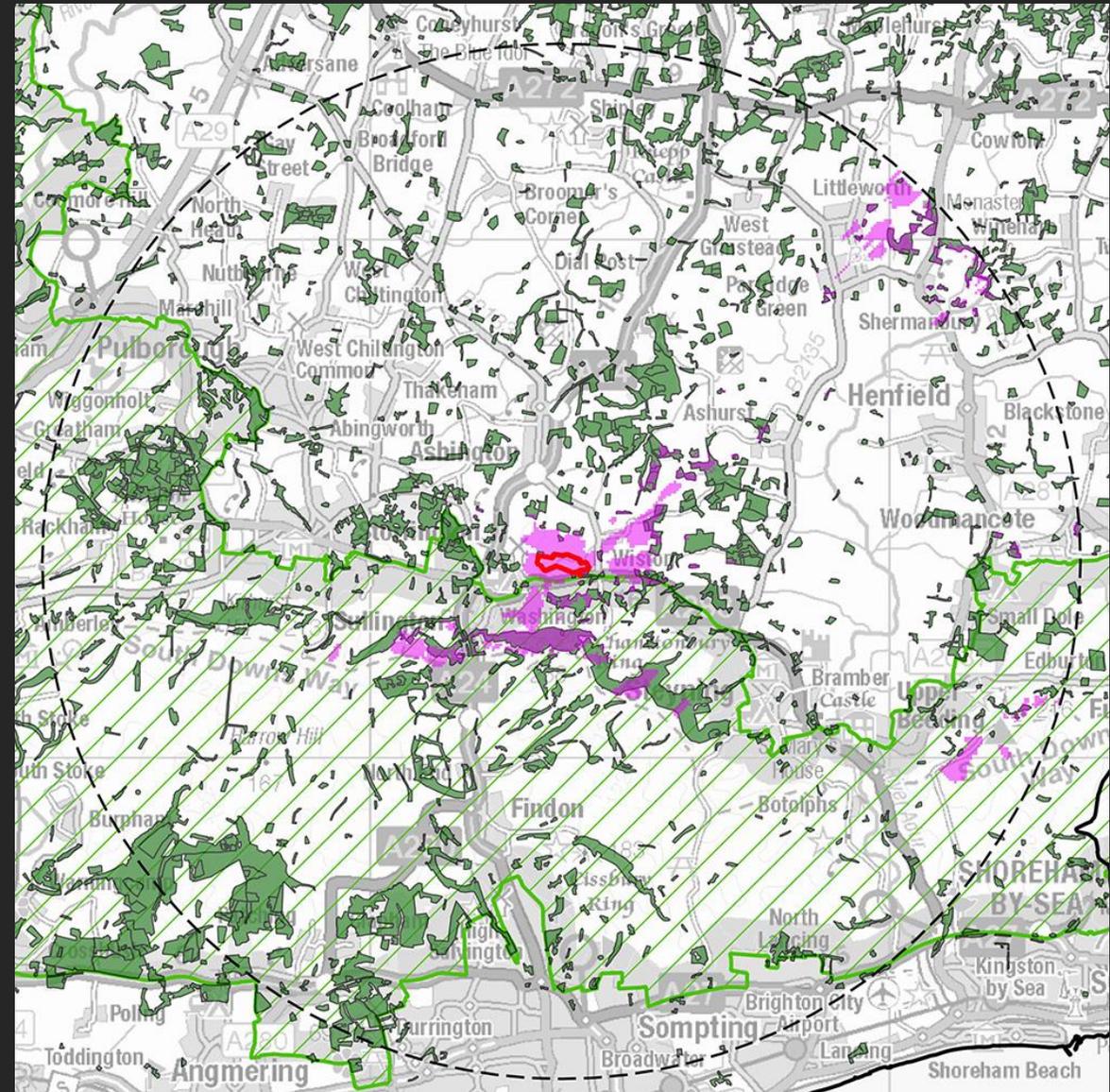


Meindert Hobbema - The Avenue at Middelharnis (1689)

# Considerations

Woodland height must be estimated or surveyed, summer/winter differences in effective screening and potential future removal must all be factored into any study.

If you create a ZTV with visual barriers, you should also create a bare earth version for comparison so that the screening effect can be understood.

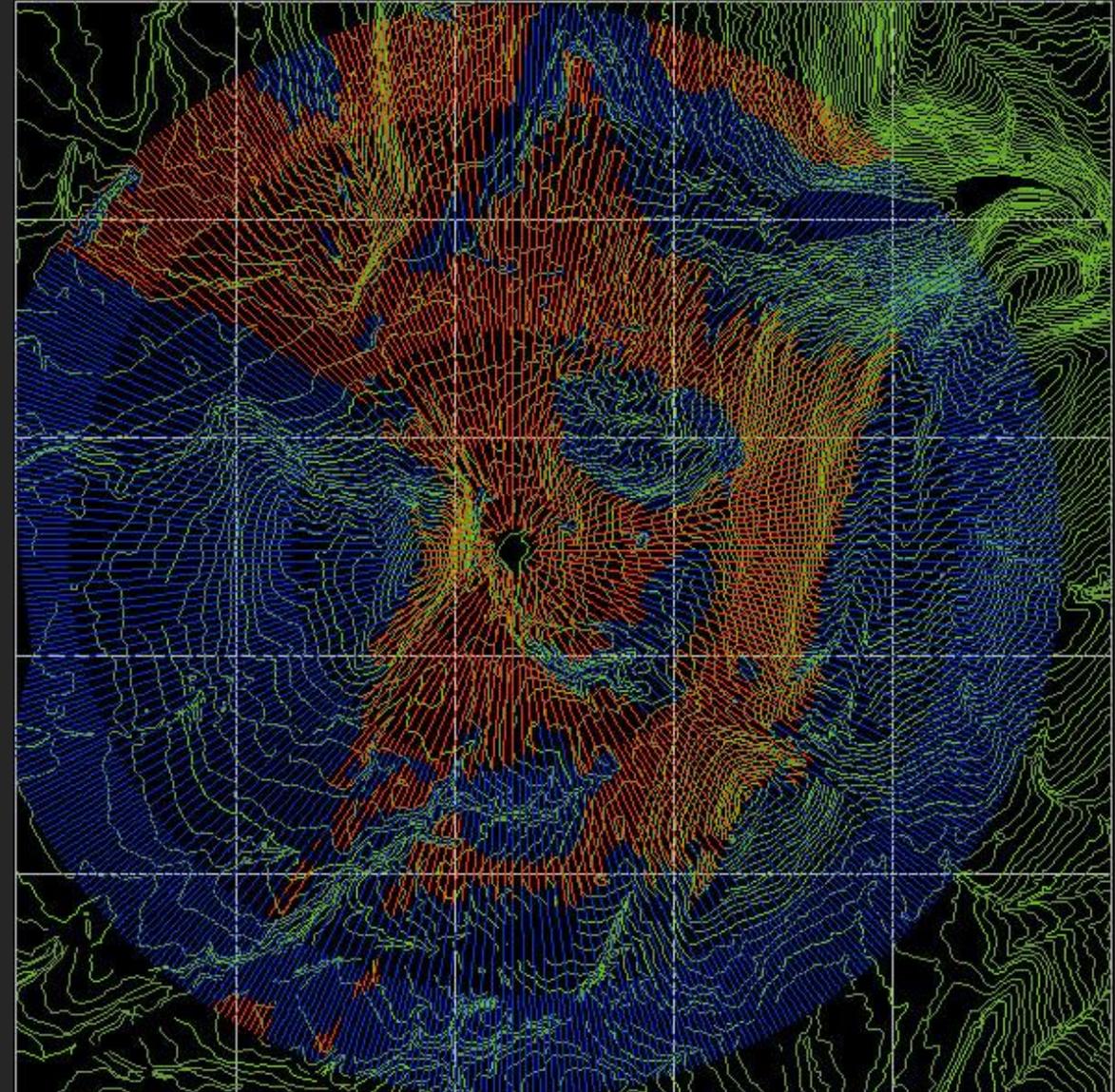


ZTV with woodland included (The terra firma consultancy)

# Analysis methods

Typically, two different analysis methods are used, depending on the number of points analysed and the software used.

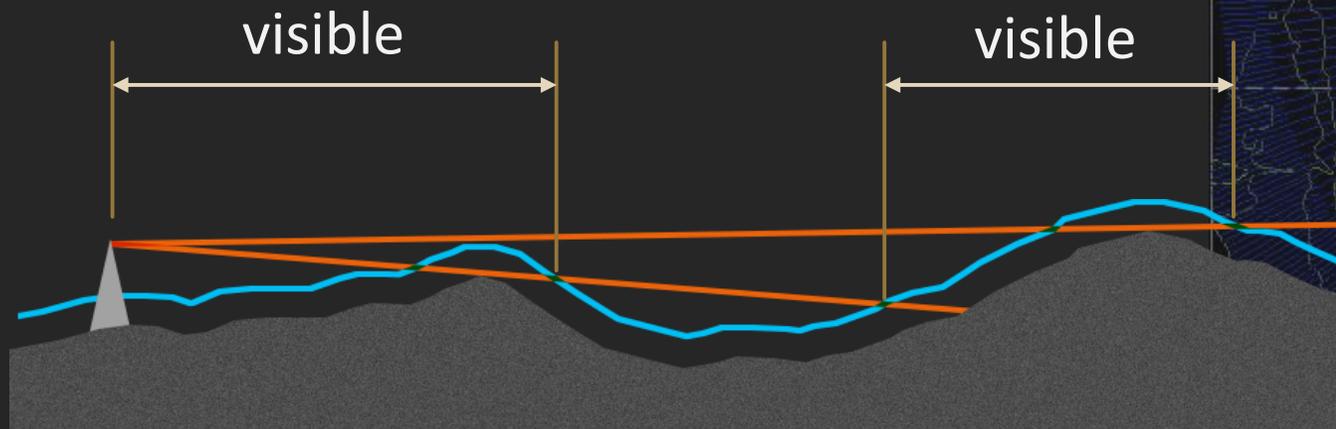
- a. The radial line or line of sight method.
- b. The intervisibility (point-to-point) or viewshed method.



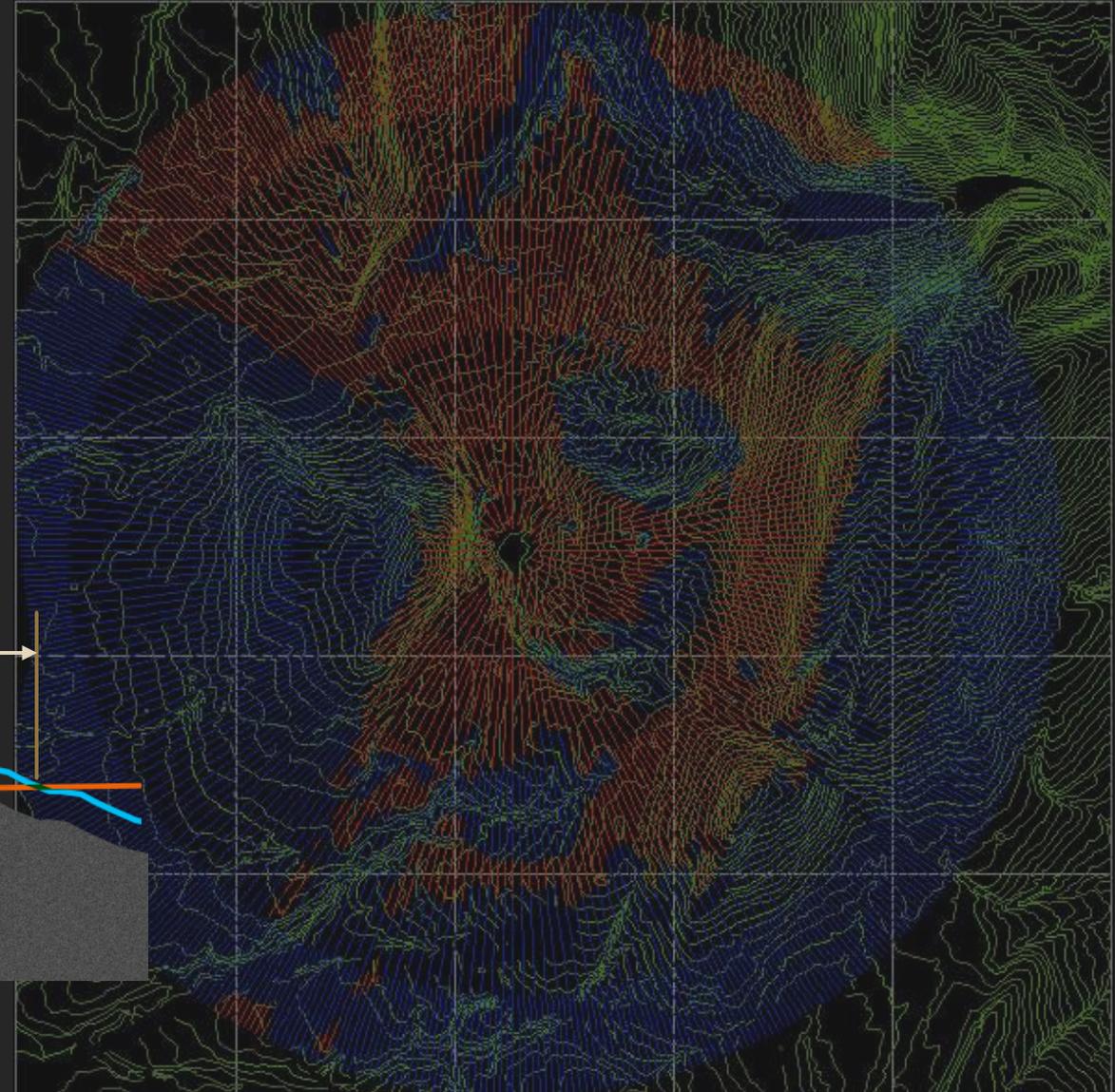
Radial line output on OS contour base

# Radial line

In the radial line method, a line of sight is analysed along a radial section from the object location to the perimeter of the study area.



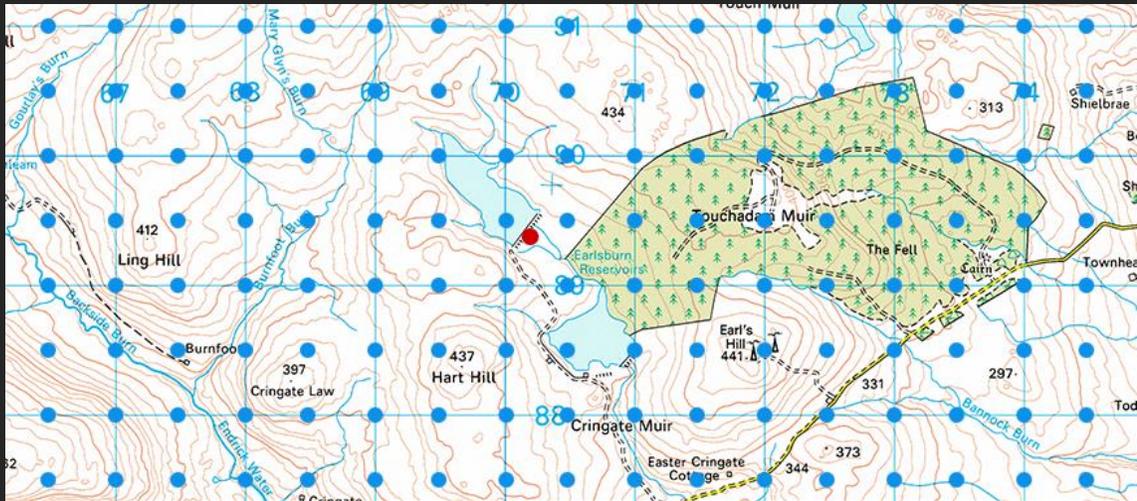
- Viewer eye height (2m)
- Line of sight



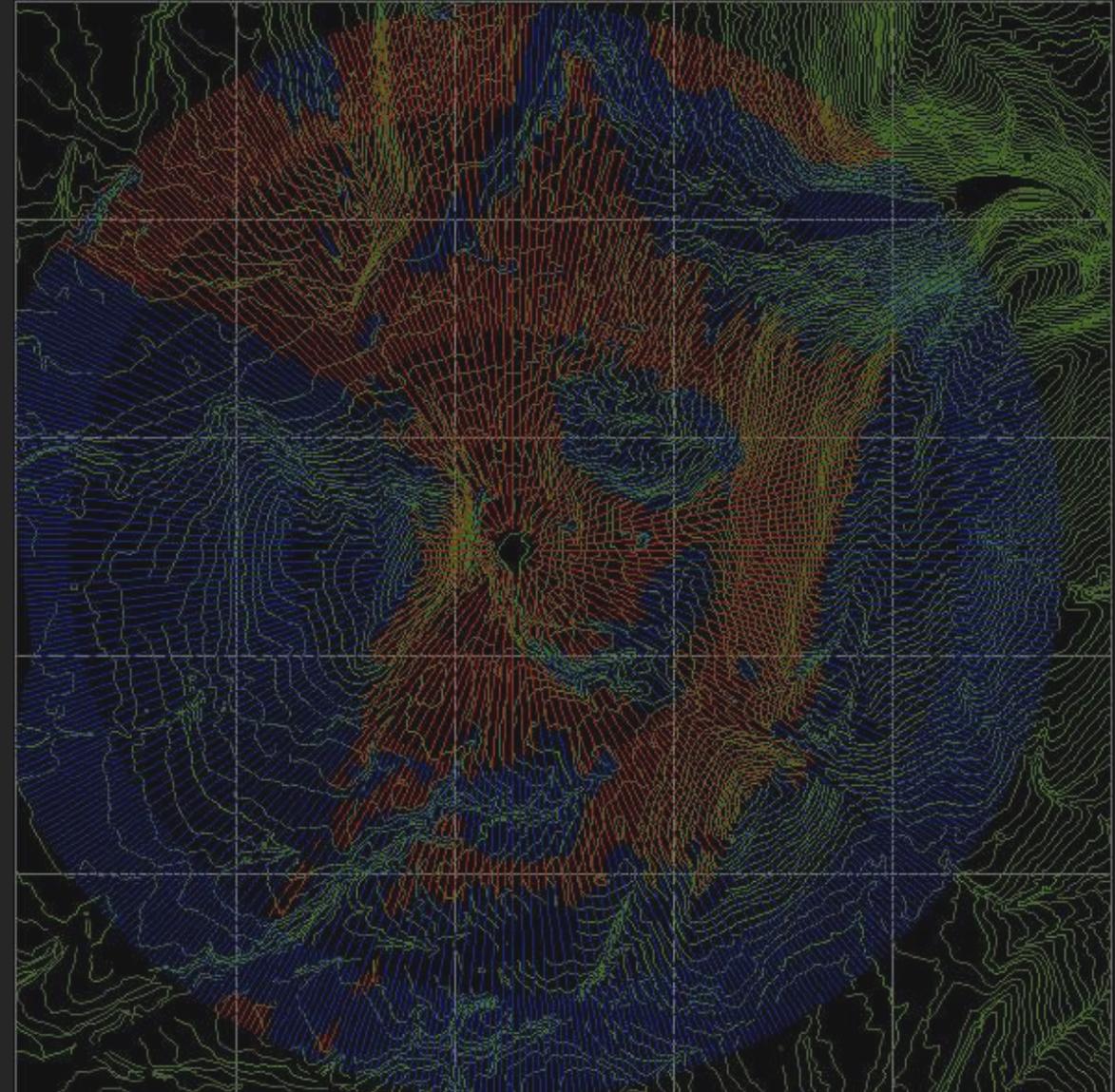
Radial line output on contour base

# Intervisibility

In the intervisibility method, the visibility (or not) of a study point from a regular matrix of observer points across the study area is mapped.



- Study point
- Observer point



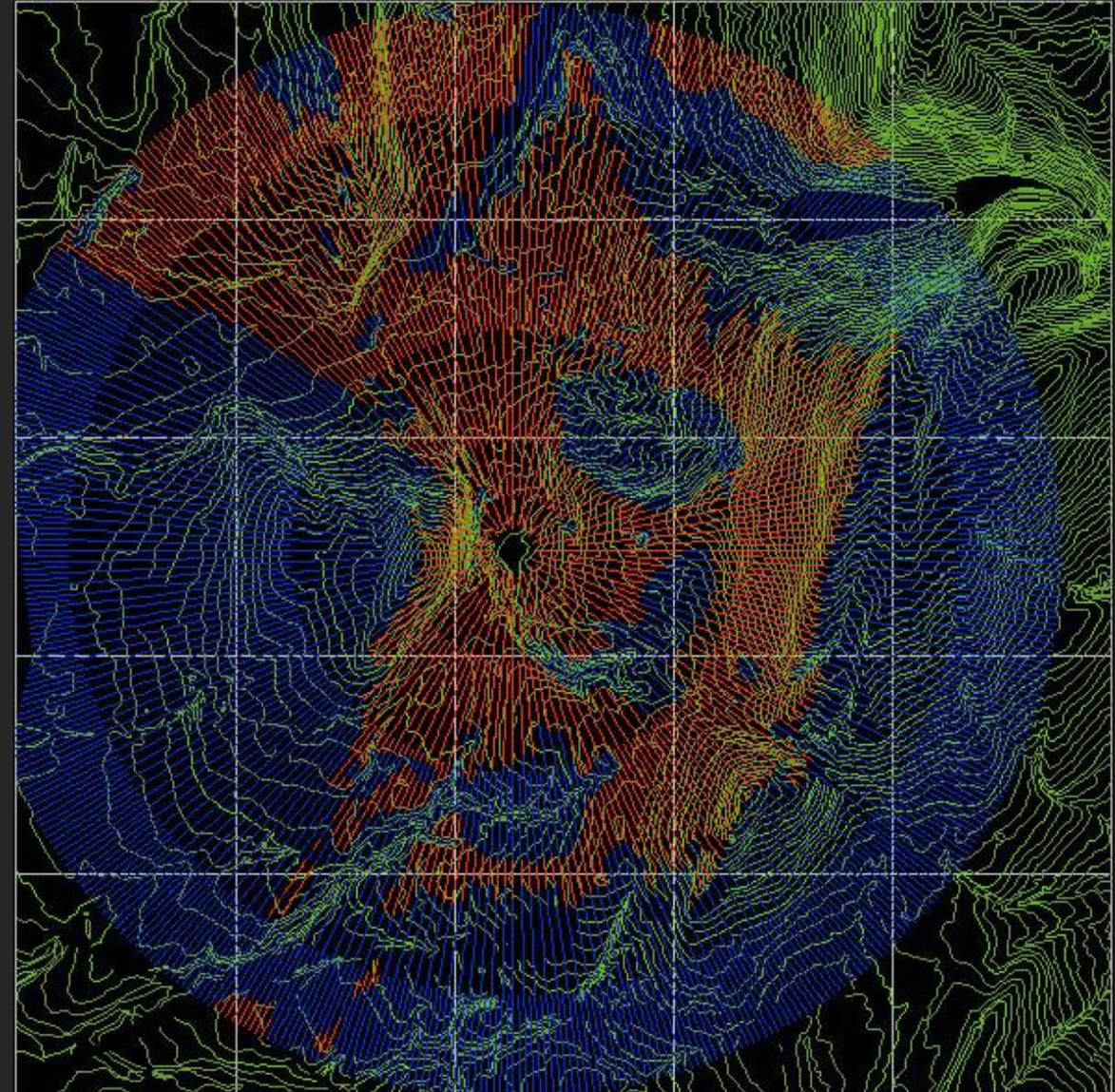
Radial line output on contour base

# Corrections

For both methods, corrections are made for the curvature of the Earth and for atmospheric refraction.

For a 15km radius study, the surface of the Earth curves by approximately 17.6m from the study point to the perimeter of the study.

<http://earthcurvature.com/>  
<https://britastro.org/node/17066>



Radial line output on OS contour base

# When should ZTV be used?

## Scoping

ZTV can be used as a quick way to inform the site survey process and to get an overview of the nature of visibility of a landscape.

## Inform the design process

ZTV is often used only to illustrate the visibility of a development proposal at the end of the design process but this is to miss one of its most valuable applications.

## LVIA supporting evidence

ZTV is most commonly used to provide supporting evidence (in conjunction with site photographs and photomontages) as part of a visual impact assessment (VIA).

When used for LVIA, the quality and accuracy of the analysis are paramount.

# Height data used for the digital terrain model

1. OS Terrain 50
2. OS Terrain 5
3. LiDAR

# OS Terrain 50

The OS Terrain 50 digital data set is derived from the 10m contours shown on the OS 1:50,000 sheet series. The DTM has a resolution of 50m, hence “Terrain 50”. It is provided in 10km x 10km tiles with full GB coverage and is available as contours or grid points.

This dataset is free and published through OS OpenData. Recommended for scoping.

<https://www.ordnancesurvey.co.uk/business-government/products/terrain-50>



Example of OS Terrain 50 height data (Ordnance Survey)

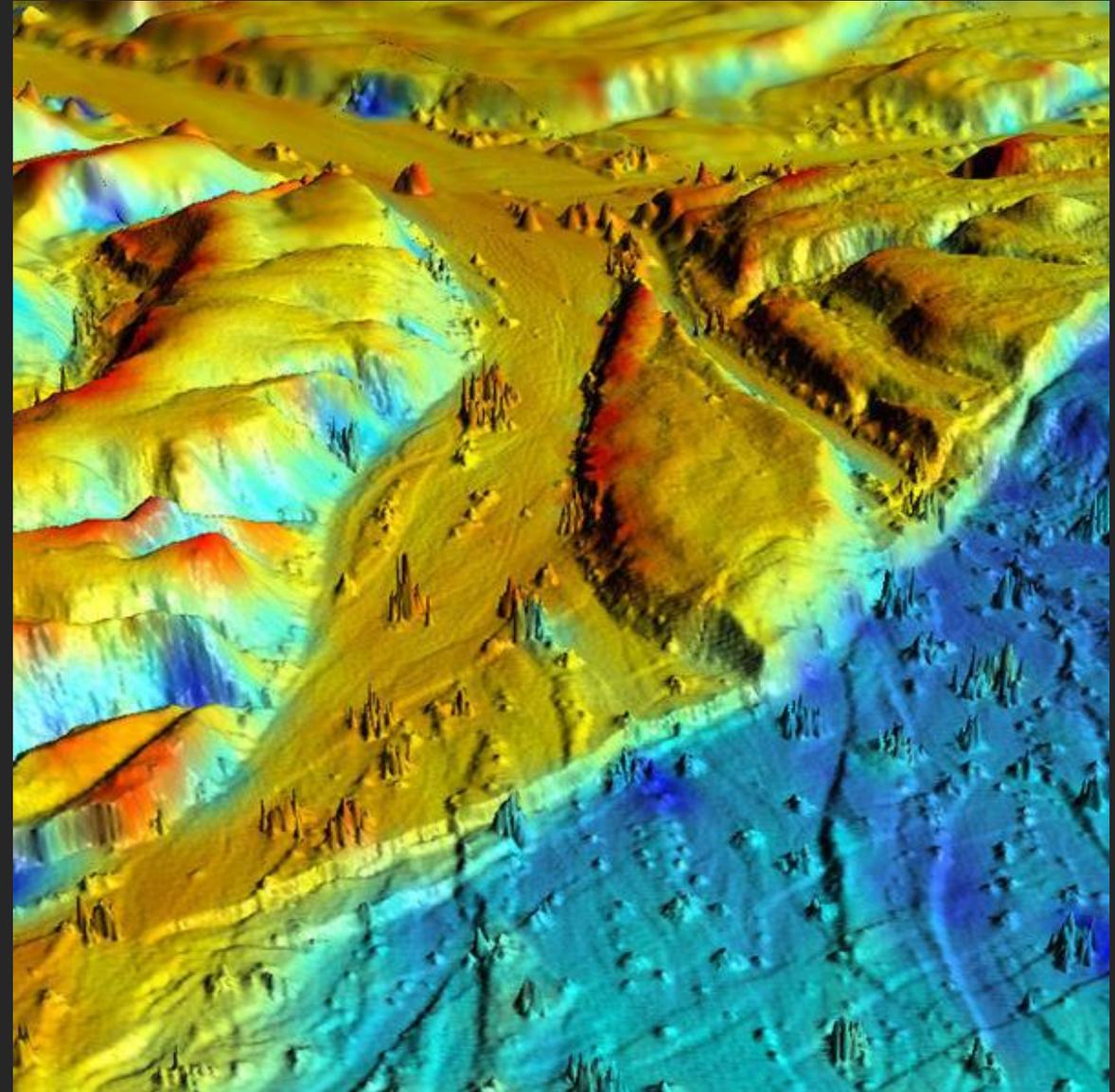


# LiDAR

LiDAR data, often at sub-1m resolution is becoming widely available through the same 3<sup>rd</sup> party suppliers as for OS data but is relatively expensive. The Environment Agency has recently released their LiDAR dataset under the Government Open Licence (effectively free).

LiDAR may be too detailed for regional ZTV studies.

<https://data.gov.uk/dataset/fba12e80-519f-4be2-806f-41be9e26ab96/lidar-composite-dsm-2m>



Visualisation of LiDAR data (University of California, Davis)

# What factors influence height data choice?

## Output type

In general, the dataset used should be appropriate to the results required (e.g. high resolution for high accuracy).

## Dataset size

Very high accuracy datasets (e.g. LiDAR) will result in very large datasets. This will slow down processing and handling so should be avoided for regional studies.

## Resolution/accuracy

In most cases, ZTVs created for LVIA should use the OS Terrain 5 data set. This provides enough accuracy to illustrate local variations while maintaining a manageable dataset size. OS Terrain 50 is a good option for scoping or crude exploratory work. LiDAR may be useful for limited local studies but is too detailed for general use.

# Software

1. Google Earth Pro
2. QGIS
3. LSS
4. Key TERRA-FIRMA
5. ArcMap

# Google Earth Pro

Google Earth Pro provides a quick, easy and free way to create a ZTV Analysis.

Horizontal resolution of the DTM is approximately 90m. The analysis extent is fixed at 10km. Only single-point analysis is possible. Output styling is fixed.

However, it can be a useful tool.

[https://www.google.co.uk/intl/en\\_uk/earth/versions/](https://www.google.co.uk/intl/en_uk/earth/versions/)  
<https://www.youtube.com/watch?v=9SP1O8q2Lng>



Viewshed output from Google Earth Pro

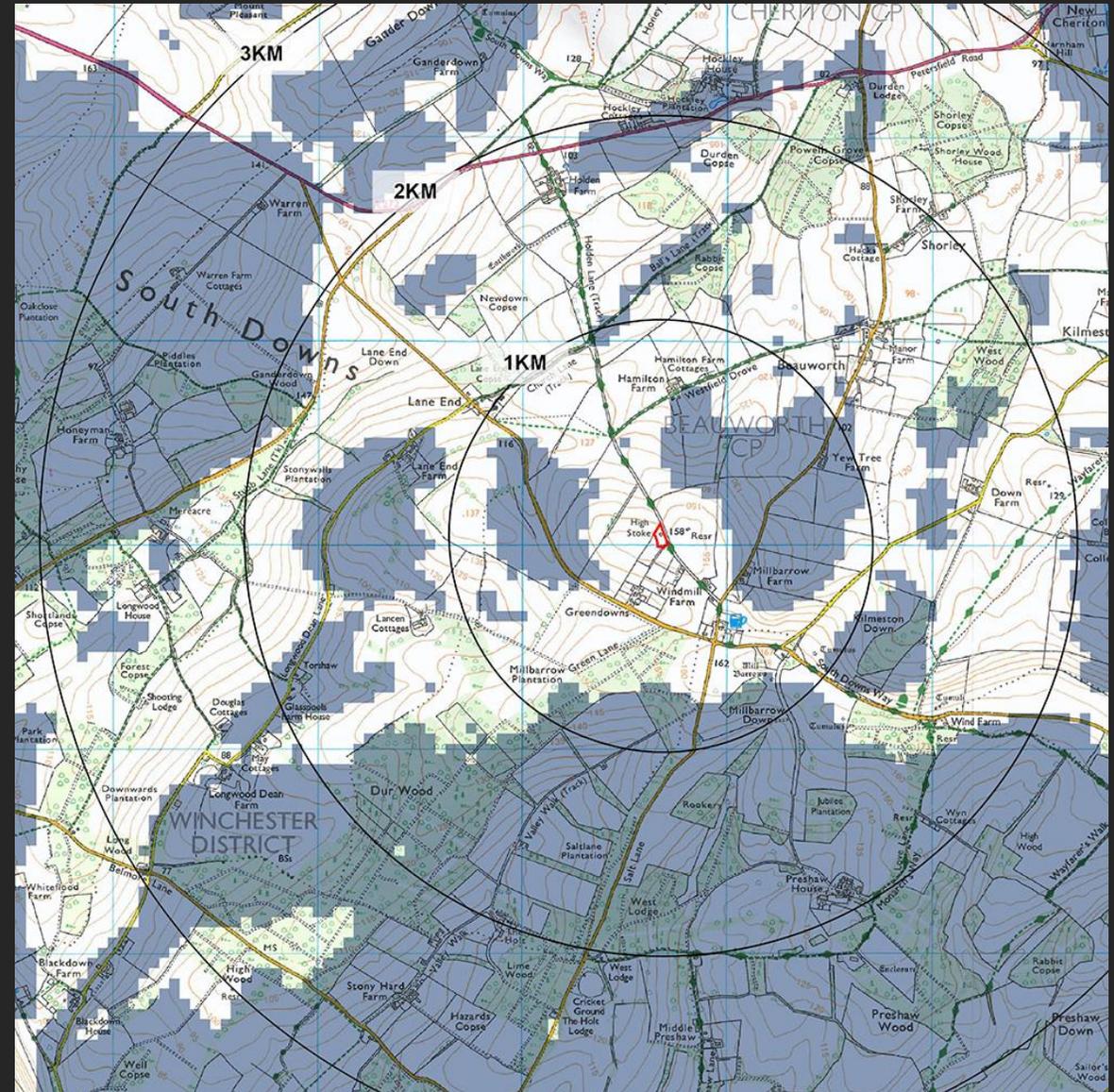
# QGIS

QGIS is a complete GIS package. It is an open source project, so the software is free to install and use. There's no dedicated support but there are 3<sup>rd</sup> party partners.

Any height data can be used. The output shown uses OS Terrain 50, which is free, open data.

<https://www.qgis.org/en/site/>

<https://thinkwhere.com/viewsheds-and-visibility-analysis-in-qgis/>



Example output from QGIS (The terra firma Consultancy)

# LSS Elite

LSS Elite provides a comprehensive range of visual analysis tools. It's a stand-alone application (e.g. no AutoCAD required). Cost is £750 per year, including support.

Single and multi-point ZTV and good support for visual barrier analysis.



Visualisation created in LSS by draping areal photography over the DTM.

[https://www.dtmsoftware.com/our\\_products/LSS-Elite](https://www.dtmsoftware.com/our_products/LSS-Elite)  
[https://www.dtmsoftware.com/for\\_business/by-task/Visual-Impact](https://www.dtmsoftware.com/for_business/by-task/Visual-Impact)

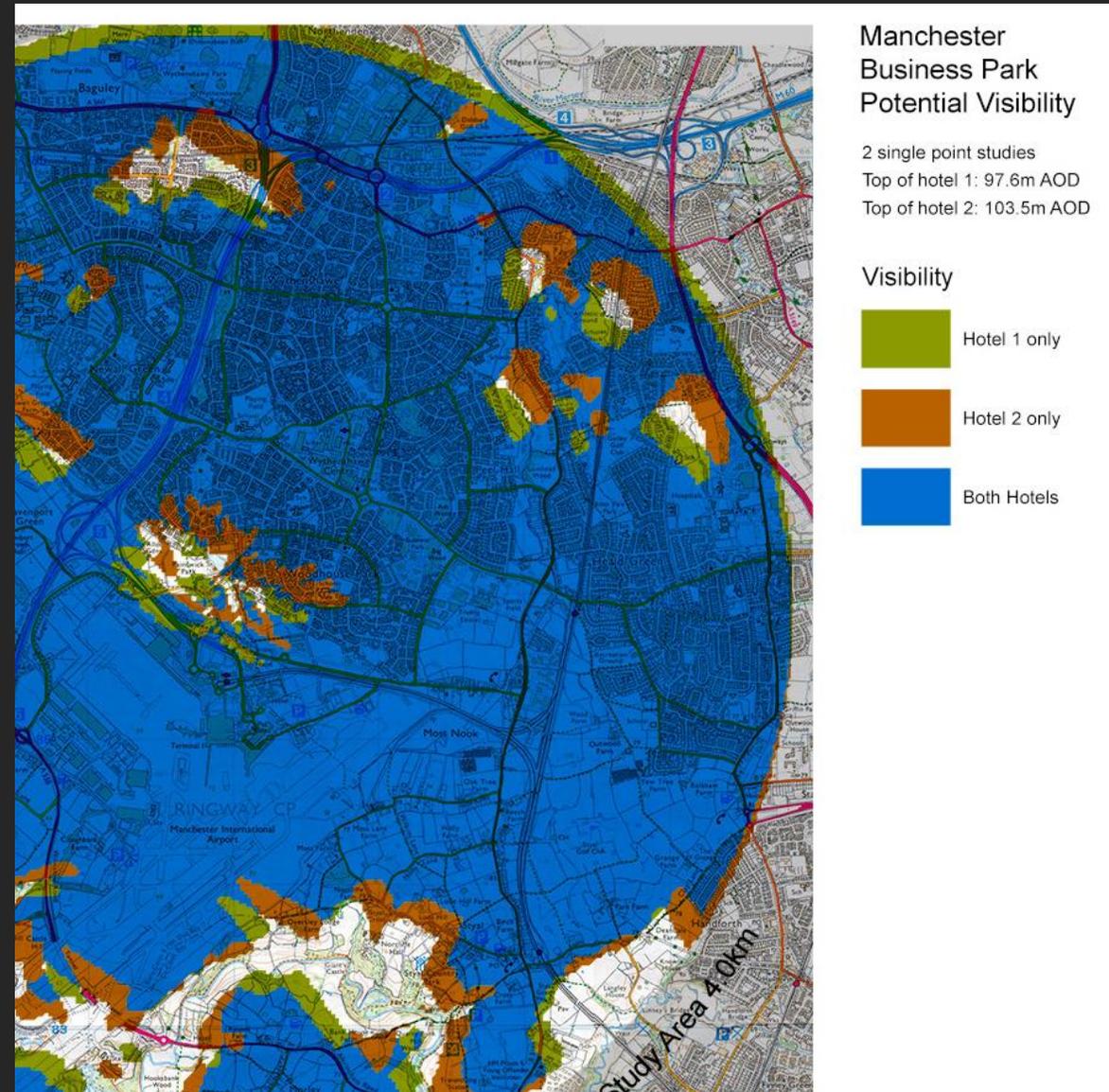
# KeyTERRA-FIRMA

KeyTERRA-FIRMA provides a dedicated module for visual analysis. The software is an add-on for either AutoCAD or BricsCAD. It costs £1,750 for the core application plus £500 for the ZTV module. Annual maintenance is £600.

This may be a more costly option but is extremely flexible and may integrate well with your workflow.

<https://www.ktfsoftware.com>

<https://www.ktfsoftware.com/products/zvi.shtml>



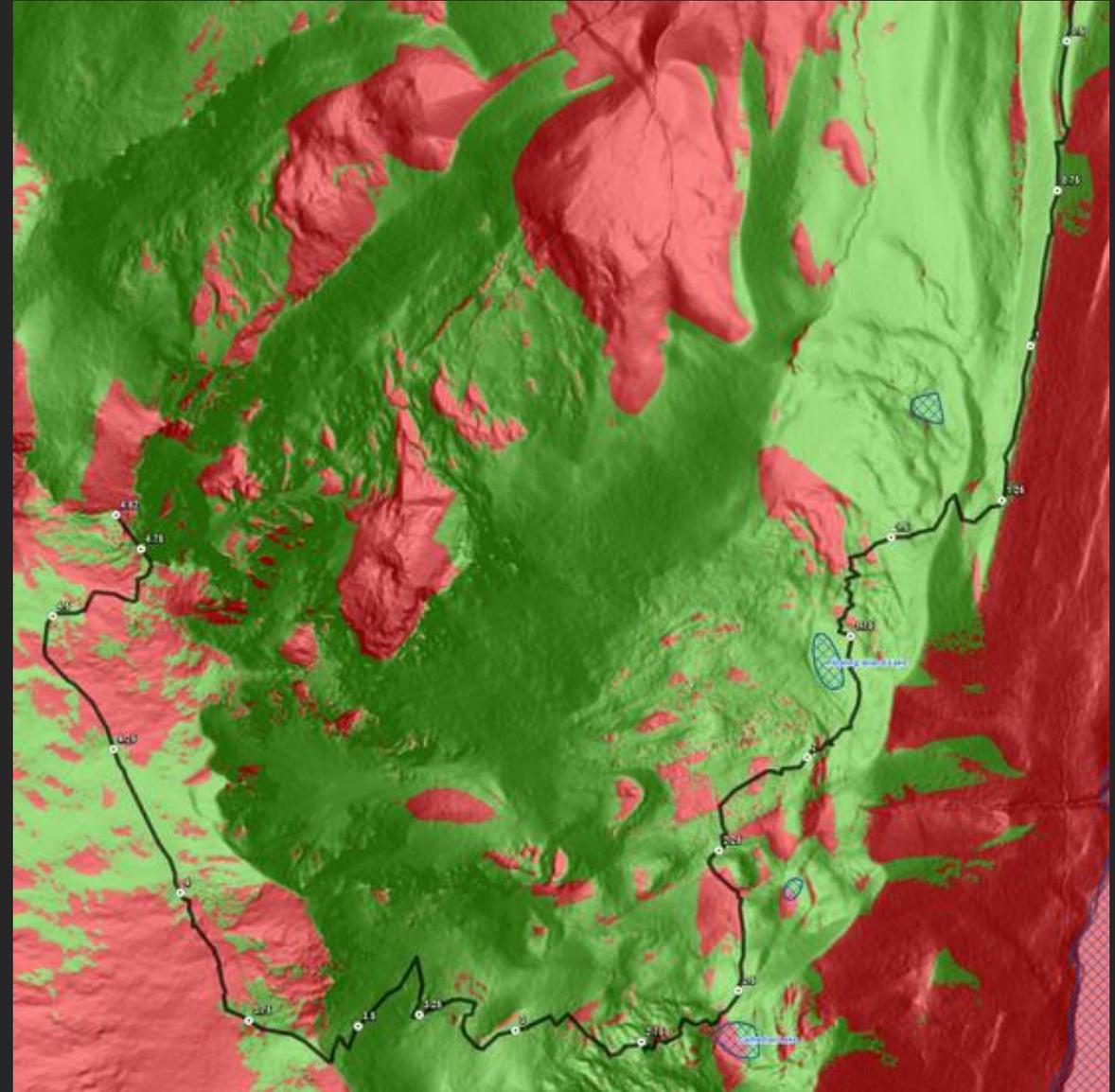
Composite ZTV produced with Key TERRA-FIRMA

# ArcMap

ArcMap is a heavy-duty GIS application, commonly used by larger organisations such as local authorities. The “viewshed” tools are included in the Spatial Analysis extension and included as standard with ArcGIS Pro.

Costs start at £1,500 for the core application.

<https://desktop.arcgis.com/en/arcmap/>  
<https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/how-viewshed-2-works.htm>



Viewshed (ZTV) created with ArcMap

# What factors influence software choice?

## Budget

Although some of the available options are free, it may be worth paying for an application that is well supported with an active development cycle.

## Type/quality of output

Some of the options are not as flexible as others and functionality varies greatly from simple, one-point analysis to comprehensive suites of tools.

## Workflow

Workflow is an important consideration. Ideally, choose an option that can easily fit your current workflow. For example, if you are already using AutoCAD for your 3D visualisation work, Key TERRA-FIRMA may be a good choice. If you're not tied to any specific application, consider how each option could best work for you.

# Analysis design

1. Single-point studies
2. Multi-point studies
3. Modelling the development

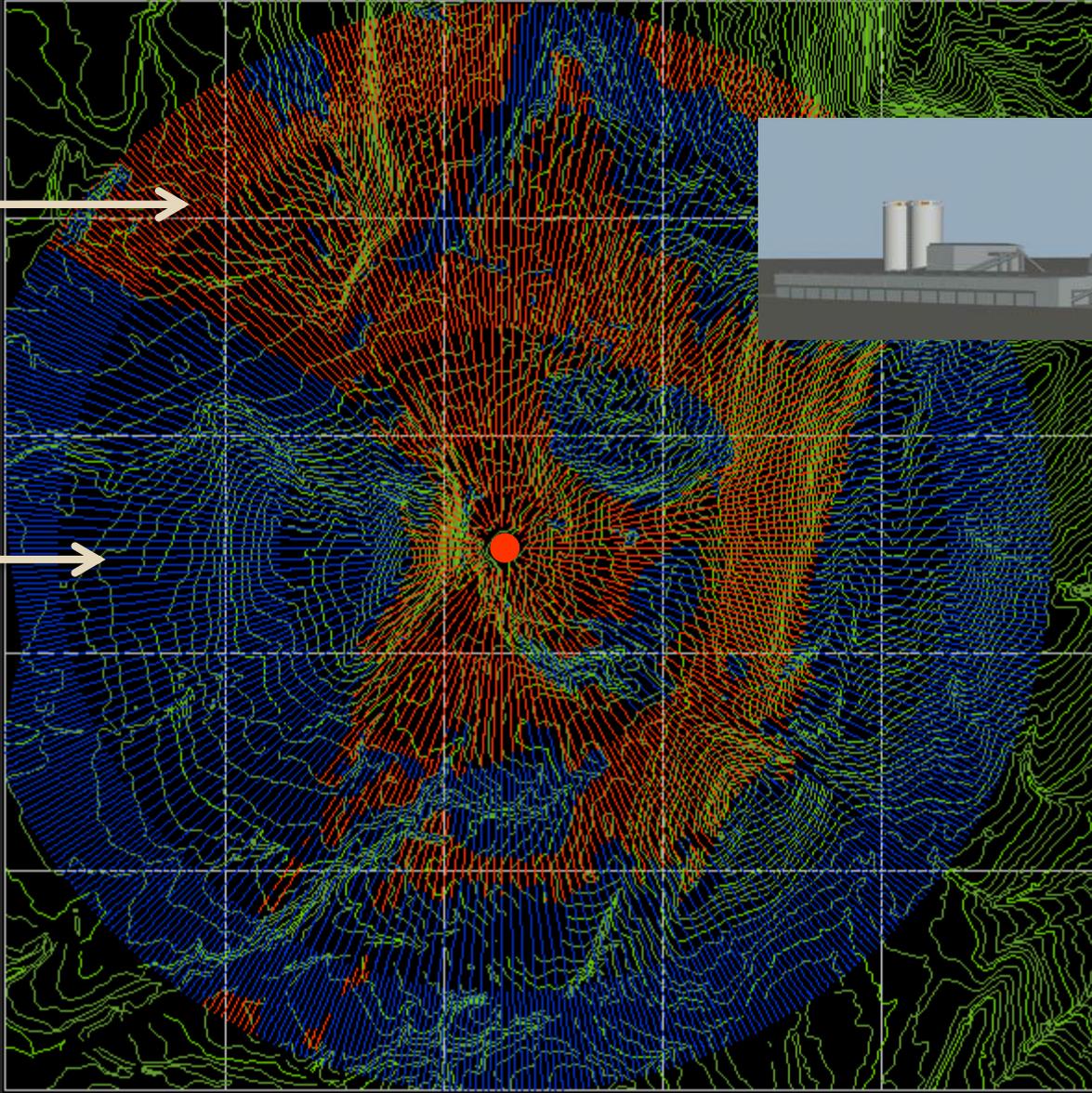
# Single-point ZTV

For single-point analysis studies, the point is usually located at the highest point of the proposed development. The resulting ZTV will show where any part of the proposal may be seen.

Theoretically visible



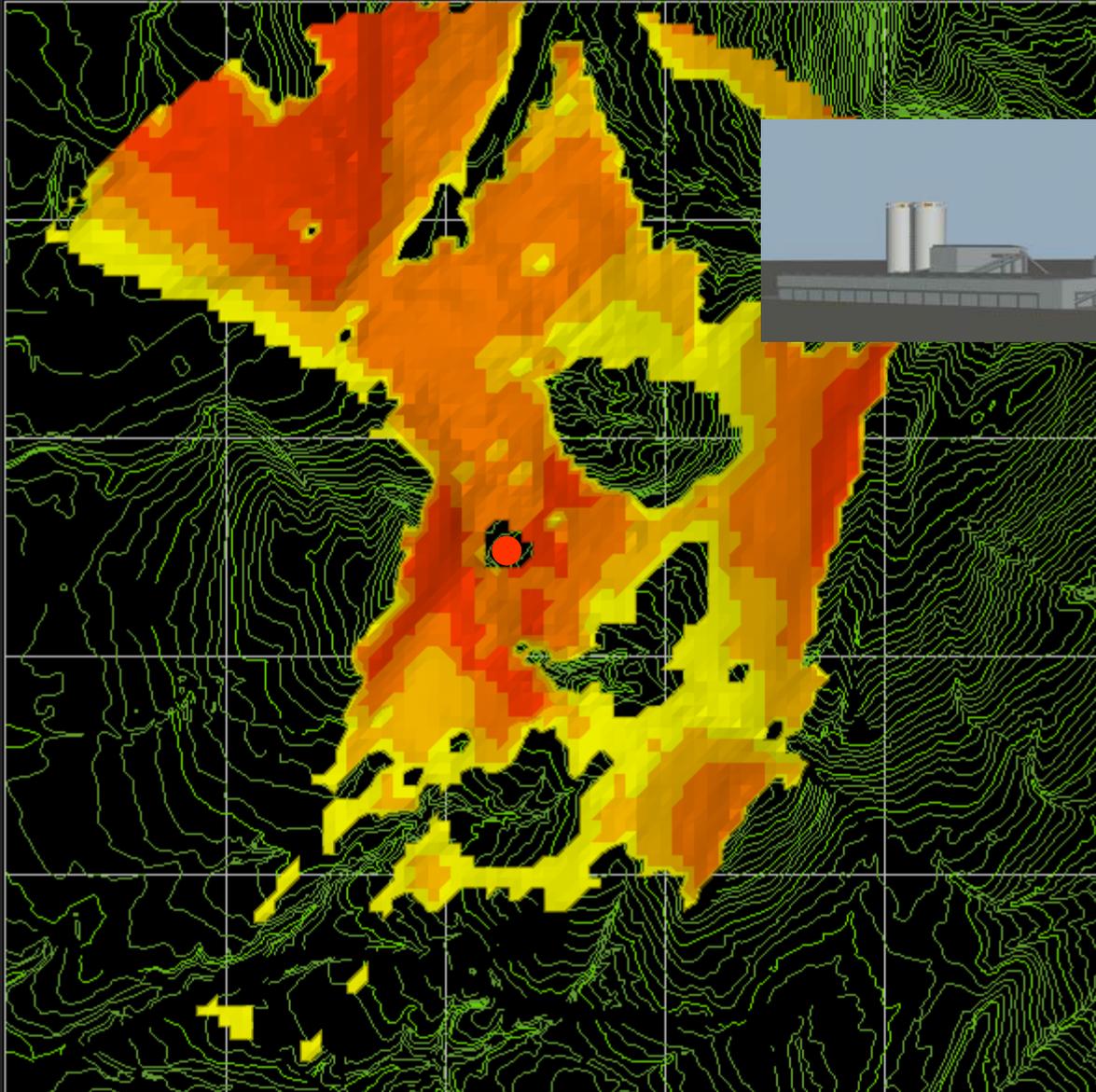
Not visible



# Multi-point ZTV

For multi-point analysis studies, the points should be located so that they allow us to answer any questions we may have. In this example we can show where only the chimney can be seen (1 point).

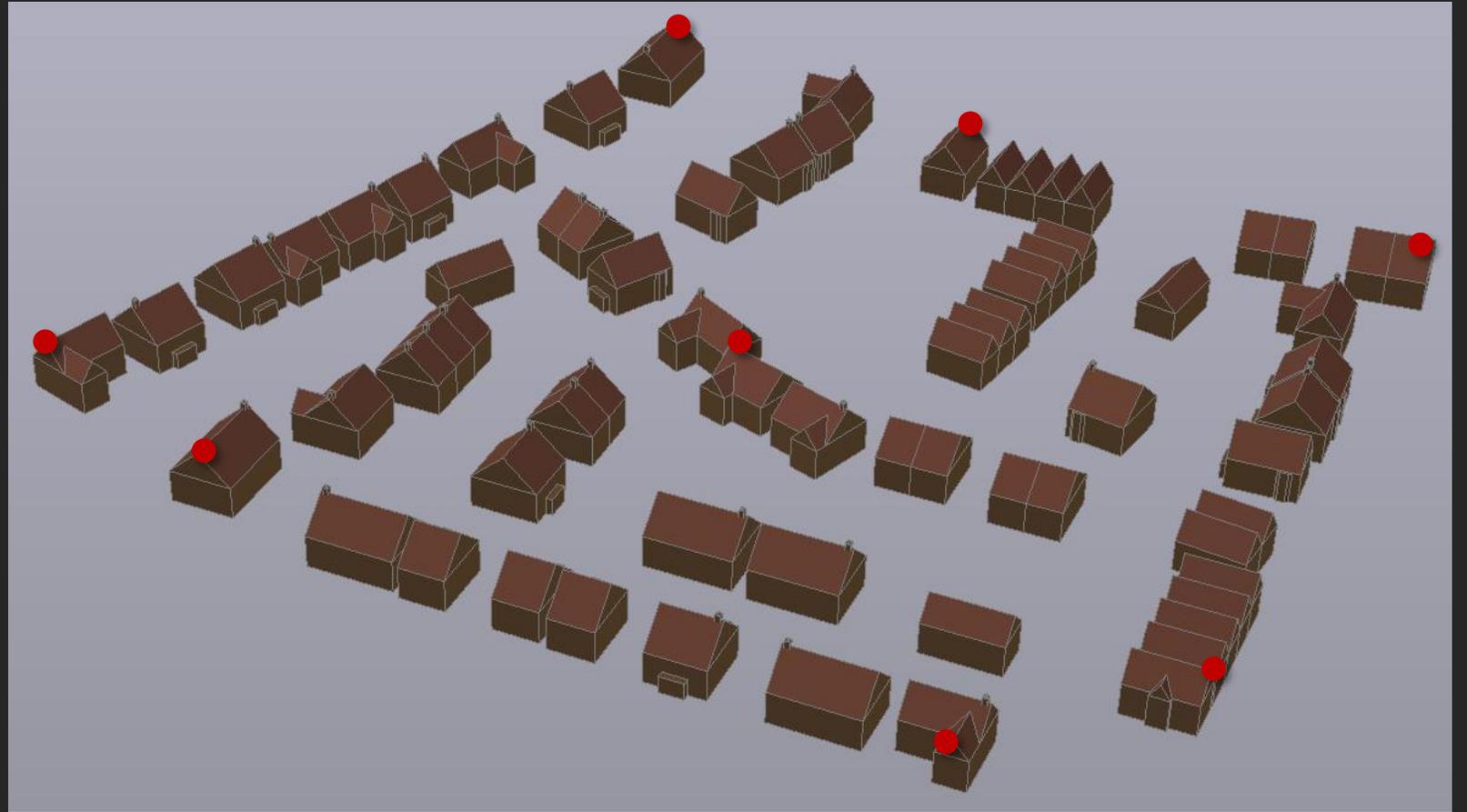
## Visibility



# Modelling the development

Any development can be modelled with an appropriate number of strategically located study points.

Roads/railways can be modelled with a linear arrangement, towers a vertical arrangement and quarry faces a regular matrix of points.



Residential development represented by 8 points on ridgelines

# Presentation

1. Base mapping
2. Overlay colour
3. Overlay blend mode
4. Good examples

# Base mapping

All ZTVs should be sown on a suitably detailed base map. Most usually, this is a digital raster image. As with height data, various datasets exist:

- OS 1:250,000 = free OS OpenData
- OS 1:50,000 = £40 for 15km study
- OS 1:25,000 = £300 for 15km study
- OS 1:25,000 is best for LVIA studies.

<https://www.ordnancesurvey.co.uk/business-government/products/25k-raster>



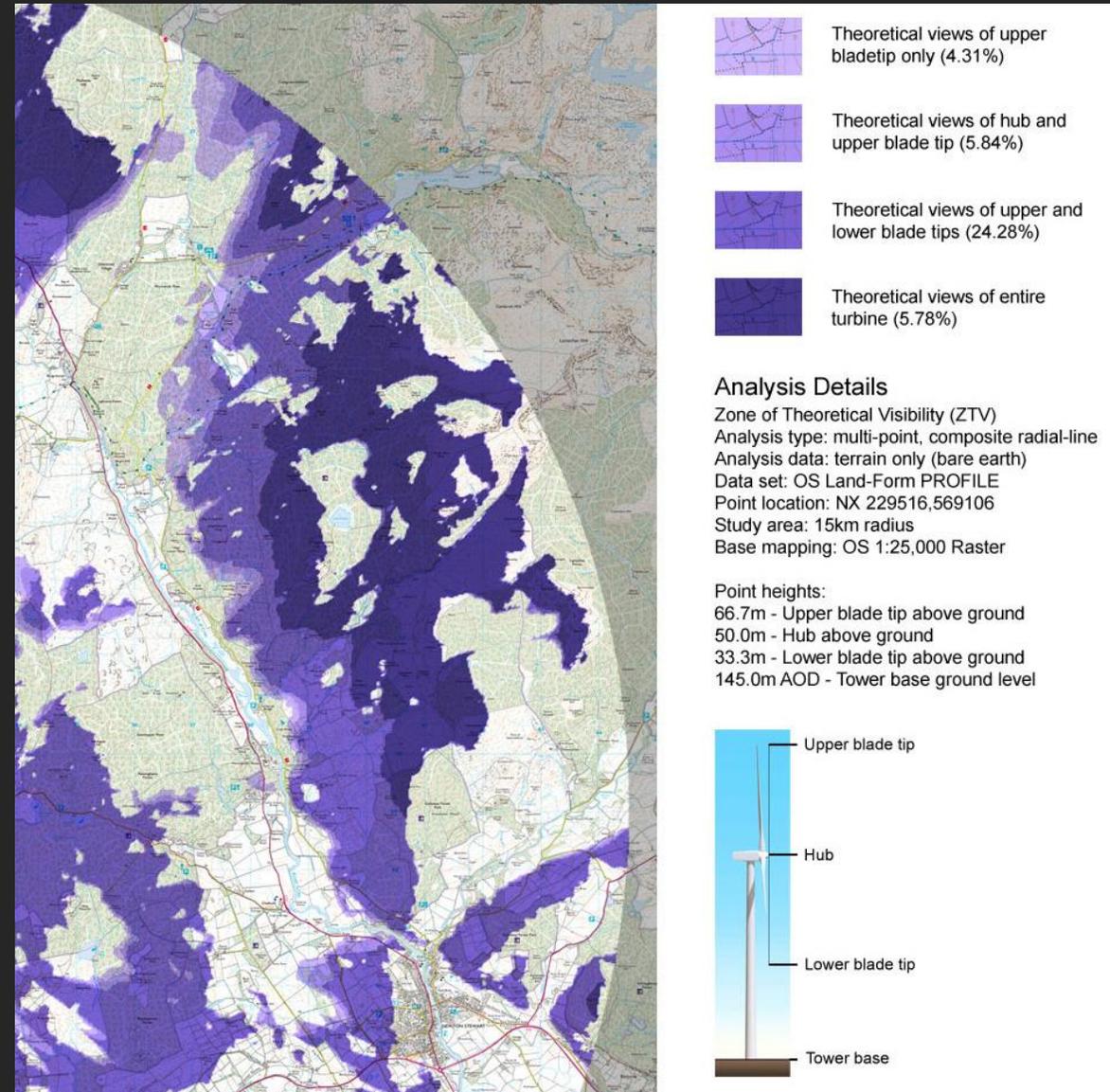
OS 1:25,000 raster map (Ordnance Survey)

# Overlay colour

When selecting colours for presentation, avoid using colours that are common on map bases e.g. ensure that greens and blues cannot be confused with woodland and water.

Ensure that a colour key is clear and that the boundary between colour bands is obvious. Include all relevant analysis details.

Check for colour blindness issues.



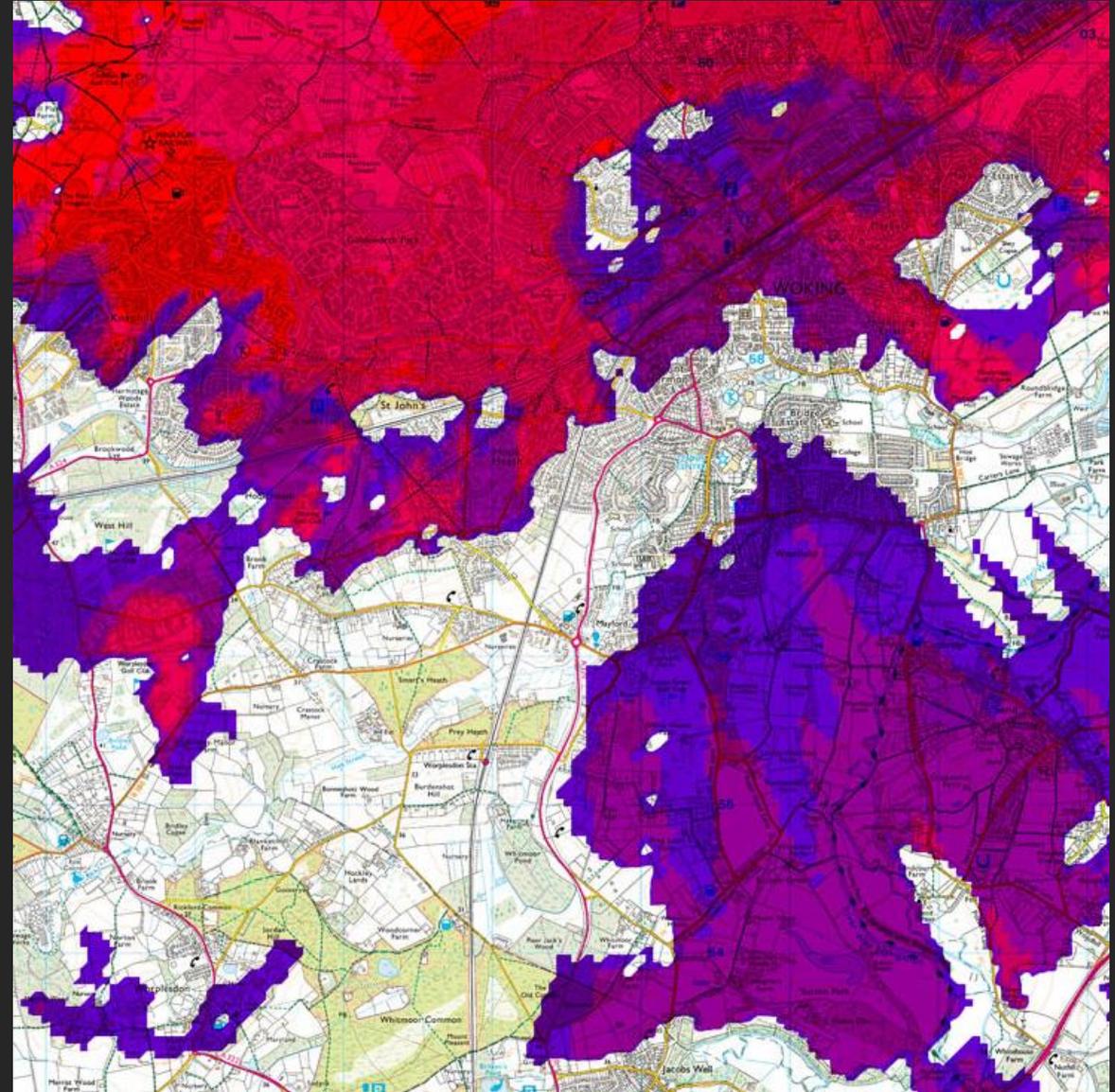
ZTV for a wind turbine with study point interpretation

# Blend mode/opacity

Ensure that base map detail can clearly be seen on the final presentation maps. This can best be achieved using the *Multiply* blend mode. This is preferred to using opacity because it retains the original colour of the overlay whilst allowing the underlying map to be seen.

Always include a method statement that clearly describes how the analysis was done and how it is presented.

<https://helpx.adobe.com/uk/photoshop/using/blending-modes.html>

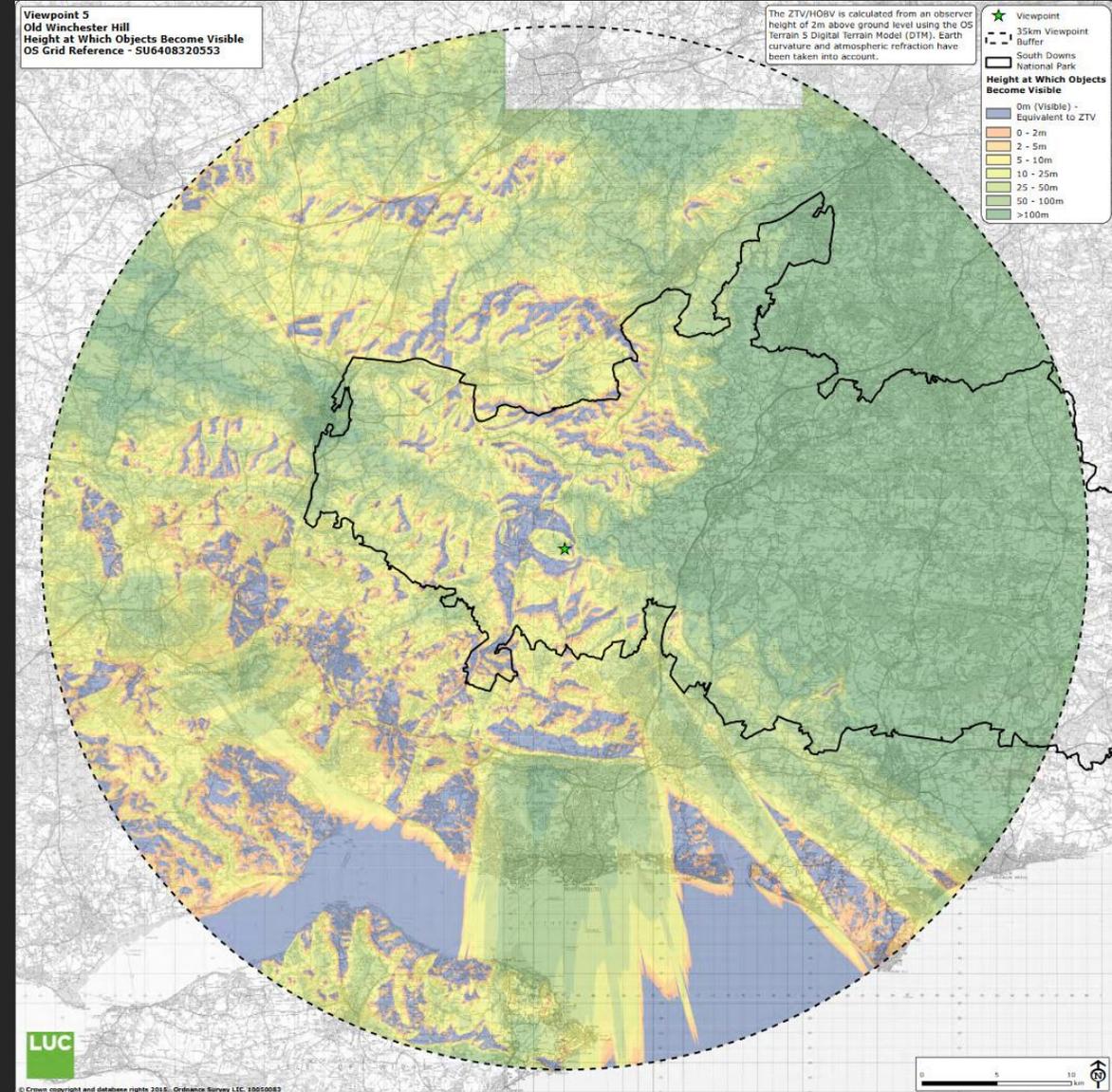


ZTV overlay using the Multiply blend mode in Adobe Photoshop

# Good examples

LUC's work for South Downs National Park is impressive. SDNP identified that, "Breathtaking views and diverse, inspirational landscapes" were one of the seven special qualities of the national park. LUC were asked to produce a set of viewshed analyses covering 77 key viewpoints. The image on the right is the view from Old Winchester Hill.

[https://www.southdowns.gov.uk/planning/south-downs-local-plan-2019/inspector-modifications\\_trashed/evidence-and-supporting-documents/viewshed-analysis/](https://www.southdowns.gov.uk/planning/south-downs-local-plan-2019/inspector-modifications_trashed/evidence-and-supporting-documents/viewshed-analysis/)



Analysis of viewpoints in the South Downs National Park by LUC

# Questions

