HV Pilot

WP1 D3 Area Selection Report

Version 0.2

13th August 2025

Prepared by:

Andrew Urquhart and Murray Thomson

CREST, Loughborough University

Prepared for:

David Penfold

National Grid Electricity Distribution

Confidential © Loughborough University

This report describes work in progress and must not be circulated beyond the Project Partners as set out in the Collaboration Agreement.

Contents

1. Introduction 3
1.1 Project overview 3
1.2 Document purpose 3
2. Sample feeder selection process 4
3. Selected HV feeders 7
4. Selected feeder topologies 9
4.1 Primary 600017 Haverfordwest, feeder 0031 9
4.2 Primary 600017 Haverfordwest, feeder 0034 10
4.3 Primary 670113 St Weonards, feeder 0002 11
4.4 Primary 670113 St Weonards, feeder 0006 12
4.5 Primary 417560 Probus, feeder 0041 13
4.6 Primary 770003 Quatt, feeder 0001 14
4.7 Primary 770003 Quatt, feeder 0009 15
5. Conclusions 16

1. Introduction

1.1 Project overview

The HV Pilot aims to identify the phases to which two-wire sections of HV overhead line are connected. This will enable more accurate power-flow modelling of the HV feeders and may ultimately lead to changes in the phase connections to minimise phase unbalance. Two techniques will be used. Smart meter voltage data will be used, building on the learning of the SMITN project. The other technique will use helicopter survey data to build a virtual model of the network to enable the connection of wires to be physically traced. These techniques will be developed and tested to determine accuracy and cost effectiveness compared to site inspections.

1.2 Document purpose

This document specifies a sample set of HV feeders that will be used as study test case for the HV Pillot project. Once these feeders have been identified, NGED can obtain smart meter data and visual survey data to support the development of the phase identification methods.

The selection of this sample set of HV feeders described here builds on two preceding documents:

i) WP1 D1 Network Data Assessment Report, identifying an initial candidate list of HV feeders and assessing the availability of smart meter data and other monitoring data that could support the phase identification methods
ii) WP1 D2 Visual Data Assessment Report, reviewing the visual survey data for the candidate list of HV feeders identified in WP1 D1

This document brings the results from these two reports together to finalise the selection of a set of HV feeders for the project study.

2. Sample feeder selection process

It had originally been expected that the area selection work would identify a set of around five primary substations for use in the project study, and that several HV feeders from each primary would be included in the analysis.

However, while preparing the WP1 D2 Visual Data Assessment Report it became apparent that very few of the candidate list of HV feeders have suitable aerial survey data. The candidate list of HV feeders prepared in the WP1 D1 Network Data Assessment Report already targeted those with the most recent aerial survey data (cycle 7 or cycle 6) but this was found not to be sufficient to ensure that the image quality would be suitable.

The WP1 D2 Visual Data Assessment Report from CGI contains initial results of the visual data assessment but this assessment work has continued since the report was issued. The full set of assessment results provided by CGI are contained in Table 1. Results for each feeder include a manual score based on a subjective assessment by the CGI project team, as described in section 2.3.1 of WP1 D2, and a model assessment score from the machine vision method, as described in section 2.3.2. The model assessment scores are shown here using the raw output data but were normalised as a percentage relative to the best-case results in WP1 D2.

From this list of 36 candidate HV feeders, only 7 feeders, those in the top rows, have been found to have suitable visual survey data. Of these 7, three feeders have more marginally acceptable survey data, but these will be included in the analysis regardless.

> Two of the seven feeders are not included in the candidate list from WP2 D1 but had been identified previously as having good image quality. These two feeders are from primary 670113 St Weonards, feeders 0002 and 0006.

If the visual survey data for the 36 feeders assessed is representative of survey data for all HV feeders, then this would suggest that the machine vision approach can, at best, be applicable to only 20% of feeders. However, future surveys will use higher specification cameras, and the survey method can take account of recommendations from this project. The project team do not expect that the 20% success rate indicated by the existing visual data will be a limiting factor for future surveys.

As only a few feeders have been found to be usable, it has been decided to separate the feeder selection into two sets:

Set 1 will use the 7 feeders identified in Table 1, on the basis that the aerial survey images appear to be of a high quality and there is a reasonable expectation that the phase identification method will provide useful results. The analysis in WP1 D1 Network Data Assessment Report has already indicated that these feeders are expected to have suitable numbers of single-phase substations with smart meters, and that the characteristics of these feeders are of interest to HV planners.

Set 2 feeders will be selected later and will use the most recent aerial survey data. If possible, the aerial surveys will be conducted with lower helicopter altitudes, taking account of feedback from the visual data assessment. There will likely be a similar number of feeders in set 2 to those in set 1. A further feeder selection process may be needed if data is available for many more feeders, but the intention will be to use to consider the surveys as representative of ‘best available practice’ and not to select again based on the visual imagery.

A future Business-As-Usual (BAU) phase identification method may use either the smart meter data approach or the machine vision approach, both of which will be investigated in this project. It may be found that one of these methods gives more reliable results, or possibly that these two approaches are suitable for different types of HV feeder. It will not necessarily be a requirement that both the smart meter data and the visual survey data are needed together for every feeder. However, for the

purposes of this project, there is a need to compare the results from both methods and so, for now, the selection process aims to find feeders for which both the smart meter data and the visual survey are adequate to enable the phase identification methods to have a reasonable chance of success.

This raises the question of whether the candidate list of feeders selected on the basis of smart meter and substation monitoring availability has introduced a bias such that these feeders are less likely (than feeders on average) to have suitable visual survey data. The project team are not aware of any reasons to suggest that these criteria are not independent, and so the 20% probability that the visual data for the feeders with sufficient smart meter can be considered as a reasonable estimate for feeders in general with cycle 7 survey data.

The candidate list of feeders has also selected feeders that have been prioritised for the project by the HV planners, and these feeders are much longer than typical feeders. Potentially, it could be less likely that long feeders would have usable visual survey data if the increased length meant that there is a higher probability of one or more junctions being unclear in the images. However, the CGI method uses an average image quality along the feeder, reducing the risk that one unclear junction could invalidate the visual survey data for the entire feeder. It has also been found that the image quality is highly dependent on the helicopter altitude and that this tends to remain the same for the flight along the feeder. There is therefore no reason to suggest that the estimate of mean visual data quality for long feeders is systematically different to the image quality for feeders with more typical lengths.

Table 1: Visual data assessment for long-list HV feeders

HV feeder	Manual assessment score	Model assessment score	Number of images assessed	Selected
600017/0031	8.4	1668.45	20	Yes
770003/0001	8.13	699.48	8	Yes
600017/0034	7.3	1812.35	29	Yes
670113/0006	7.14	378.49	29	Yes
670113/0002	7	503.91	24	Yes
417560/0041	7	482.36	20	Yes
770003/0009	6.57	1700.31	19	Yes
310056/0024	6.86	565.71	7	No
610077/0003	6.85	460.37	13	No
530177/0070	6.78	388.35	9	No
610077/0069	6.72	451.35	18	No
590020/0038	6.61	302.37	38	No
417680/0045	6.5	469.00	2	No
530001/0051	6.36	411.76	22	No
610092/0068	6.33	427.40	9	No
417780/0043	6.3	232.00	3	No
250310/0288	6.14	679.22	7	No
600200/0051	6.09	282.08	11	No
530001/0084	6	345.37	12	No
310015/0018	6	256.77	7	No
260260/0094	5.74	222.12	19	No
417560/0042	5.6	193.08	12	No
610092/0020	5.57	290.32	42	No
610077/0015	5.53	454.17	17	No
590020/0039	5.44	478.56	16	No
210020/0866	5.33	296.93	3	No
260260/0095	5.31	196.79	16	No
260260/0096	5.29	269.82	17	No
417680/0043	5.18	772.21	11	No
350015/4067	5.1	868.92	18	No
530252/0928	5	358.23	9	No
670113/0008	4.53	272.47	15	No
310056/0022	4.33	437.12	6	No
310015/0023	3.67	289.32	3	No
350015/4066	3.6	563.27	23	No
600085/0009	3.2	544.21	8	No

3. Selected HV feeders

The selected set 1 feeders are listed in Table 2.

All the set 1 selected feeders have either cycle 6 or cycle 7 visual survey data

Two of the feeders were from previously identified candidate list of HV feeders and have been included here as few other feeders were found to have suitable visual survey data. These two feeders would have met the criteria for inclusion in the candidate list with the exception that they do not include a substation with monitoring installed. This monitoring is expected to be used mostly for validation purposes and not necessarily within the phase identification method itself. A method suitable for BAU would ideally not require that feeders have substation monitoring data, although this data would be used if it is available.

Four of the feeders are included in the priority list identified by HV planners.

All have at least 6 single-phase substations at which there are at least 3 customers with a smart meter, and at least 2 three-phase substations at which there are at least 12 customers with smart meters.

However, there are many more substations on each feeder than these minimums, and many will also have smart meters that can be utilised for phase identification.

The selected set includes feeders with a roughly 3:1 range in total circuit length, from 25 km to 75 km.

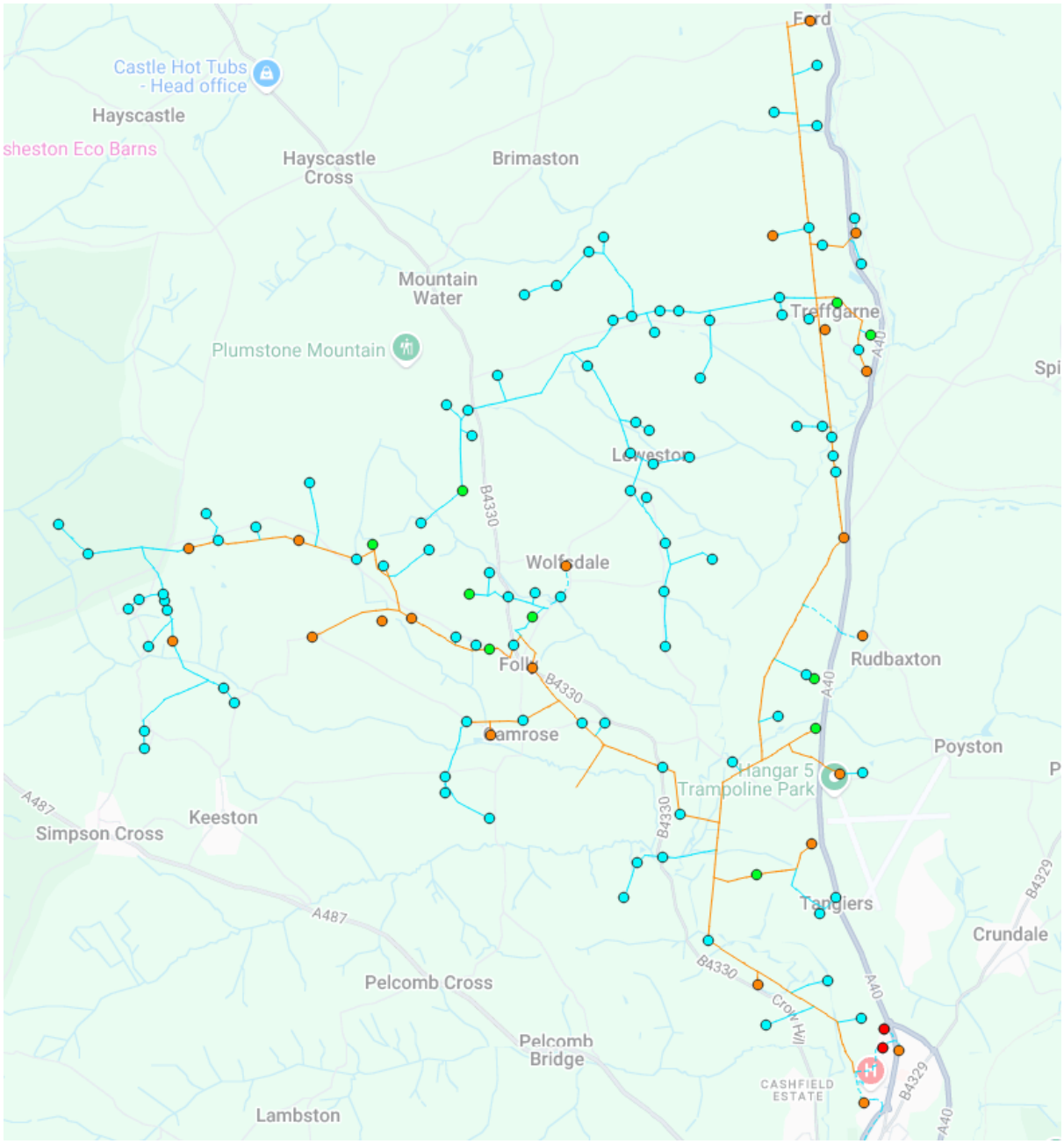
The feeders are longer than is typical, with distances between the primary and the furthest substation ranging from 6 km to nearly 11 km.

Table 2: Set 1 selected HV feeders

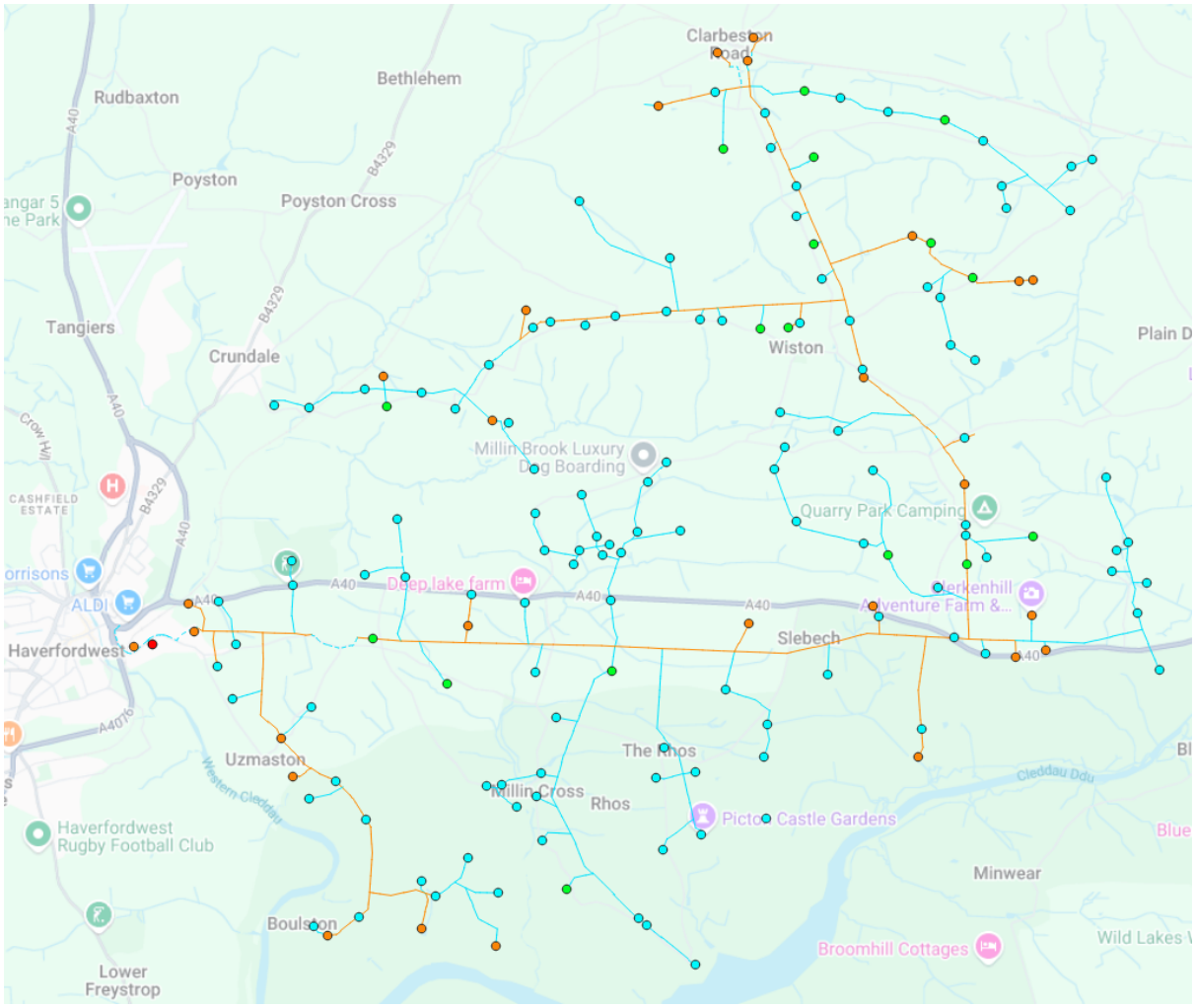
Feeder	**600017 /0031**	**600017 /0034**	**670113 /0002**	**670113 /0006**	**417560 /0041**	**770003 /0001**	**770003 /0009**
Substations	126	164	197	160	101	62	161
Three-phase substations	23	28	65	41	29	30	59
Single-phase substations	103	136	132	119	72	32	102
Single-phase substations with SMETS	15	18	39	21	13	9	26
Three-phase substations with SMETS	5	7	10	6	13	9	21
Three-phase substations with monitoring	2	1	0	0	1	1	2
Cycle	6	6	7	7	6	6	6
Candidate list	Yes	Yes	No	No	Yes	Yes	Yes
Priority list	Yes	Yes	Yes	Yes	No	No	No
Total circuit length, km	53.0	75.4	62.4	62.7	48.5	26.4	74.4
Further substation distance, km	10.6	10.1	8.4	8.1	9.1	6.2	10.8
Furthest single-phase substation distance, km	10.2	10.1	7.6	8.1	9.1	6.2	10.8

4. Selected feeder topologies

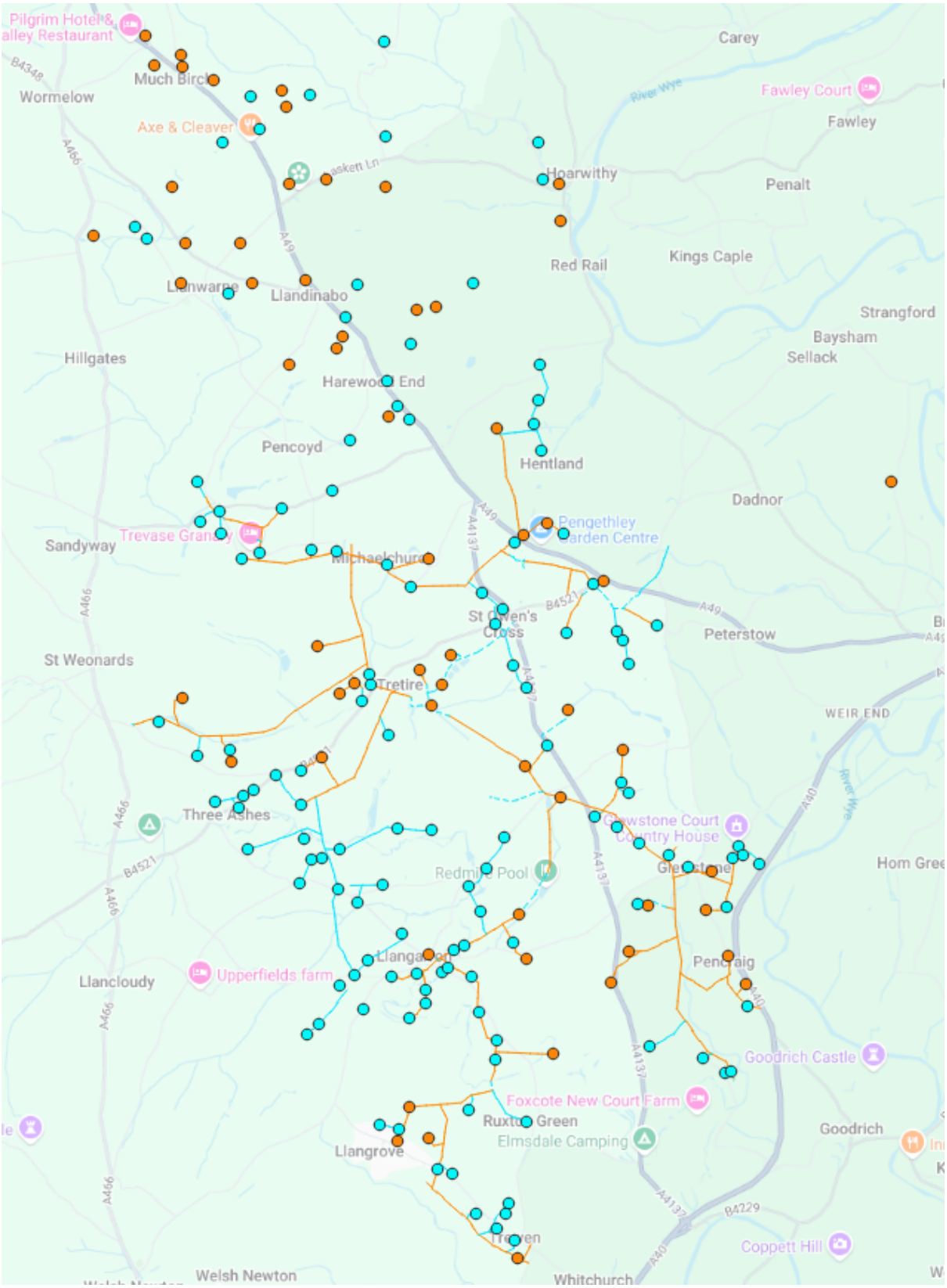
4.1 Primary 600017 Haverfordwest, feeder 0031



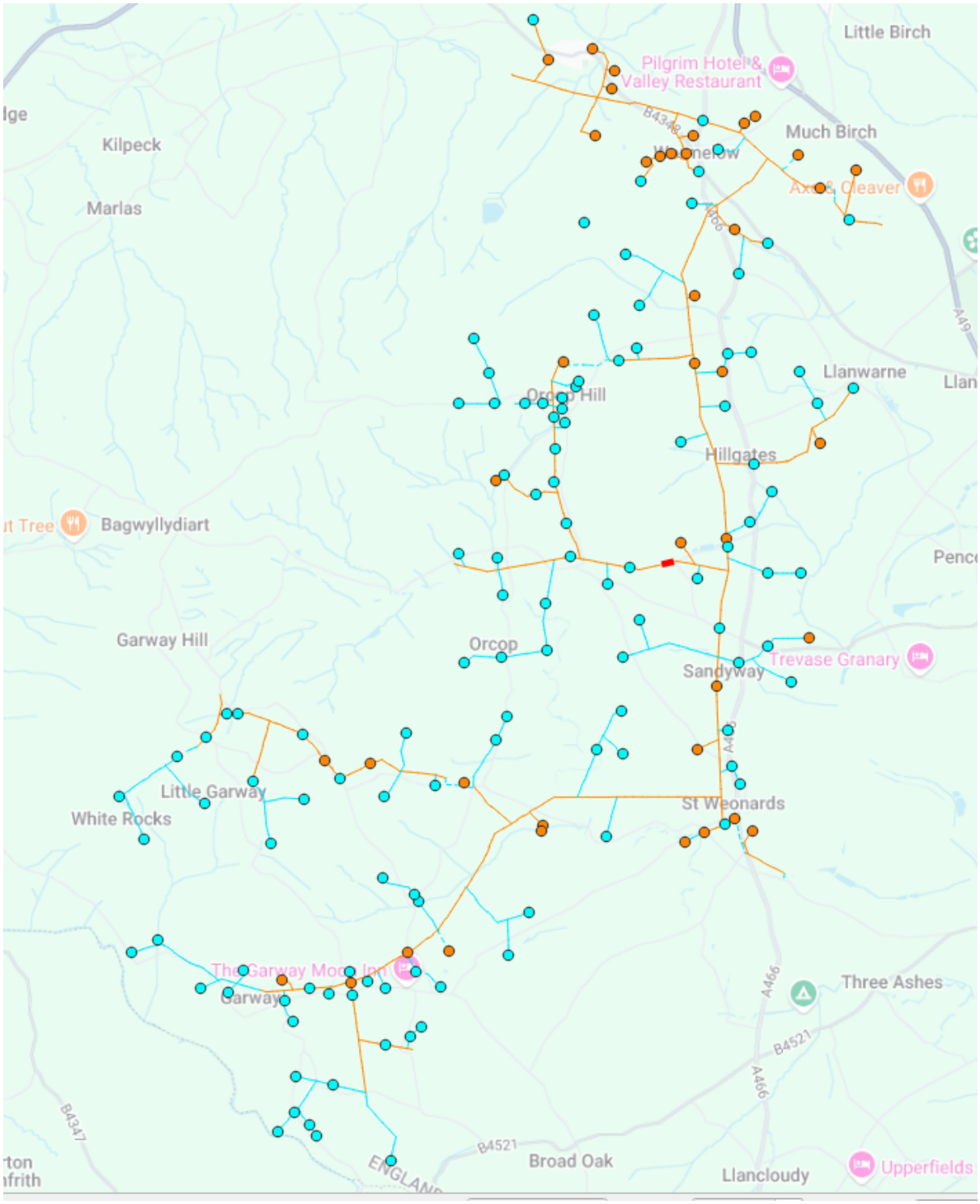
4.2 Primary 600017 Haverfordwest, feeder 0034



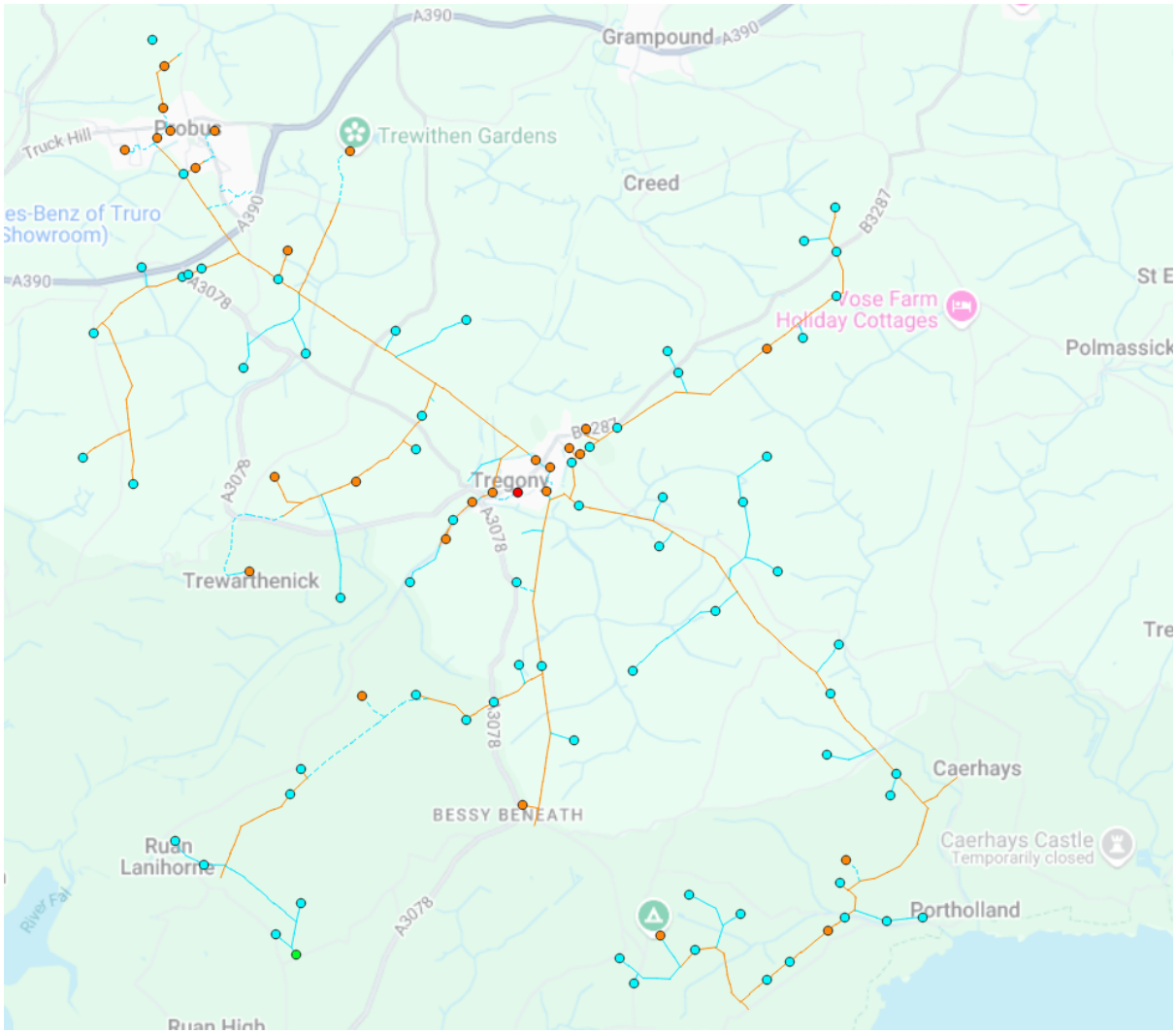
4.3 Primary 670113 St Weonards, feeder 0002



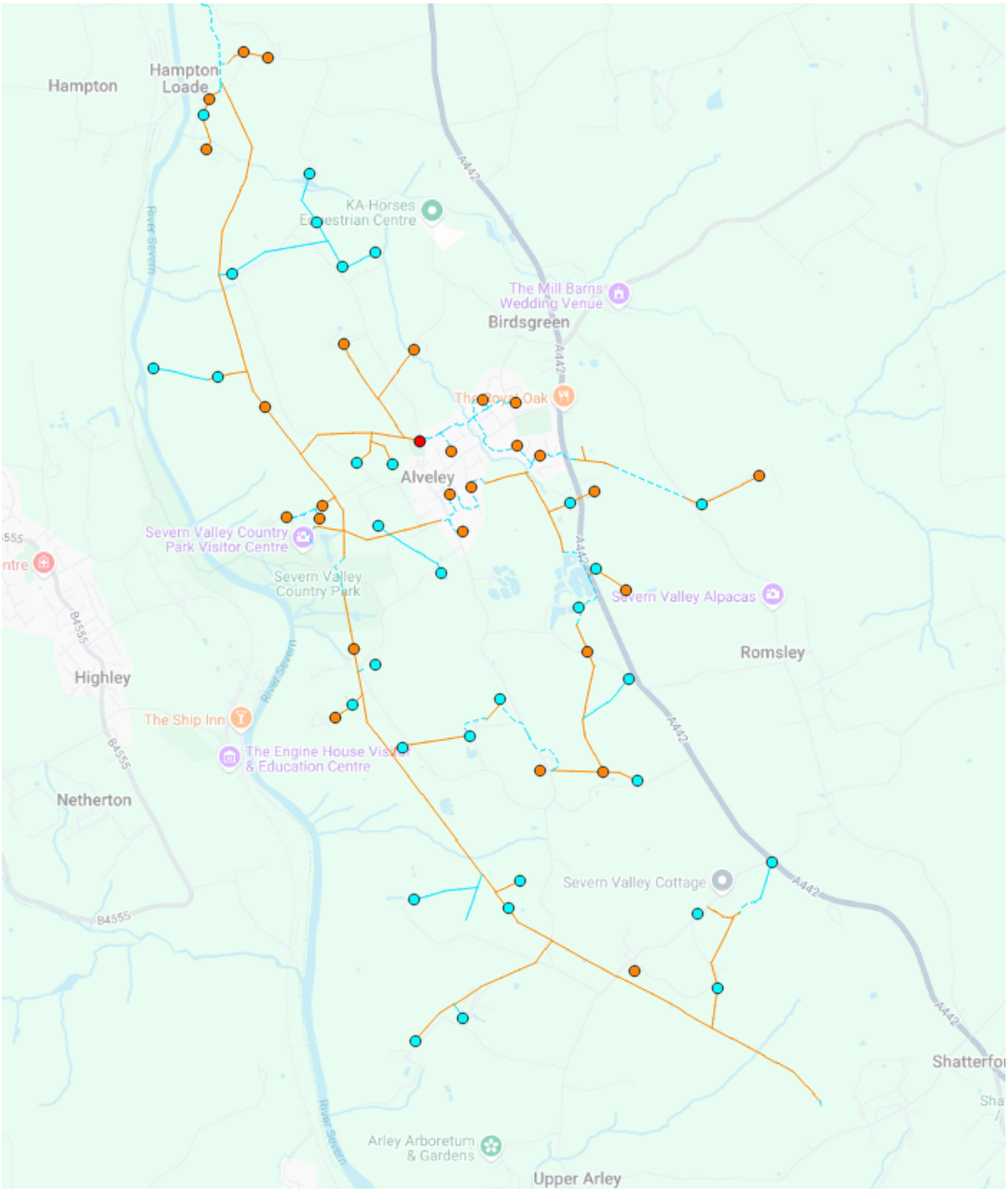
4.4 Primary 670113 St Weonards, feeder 0006



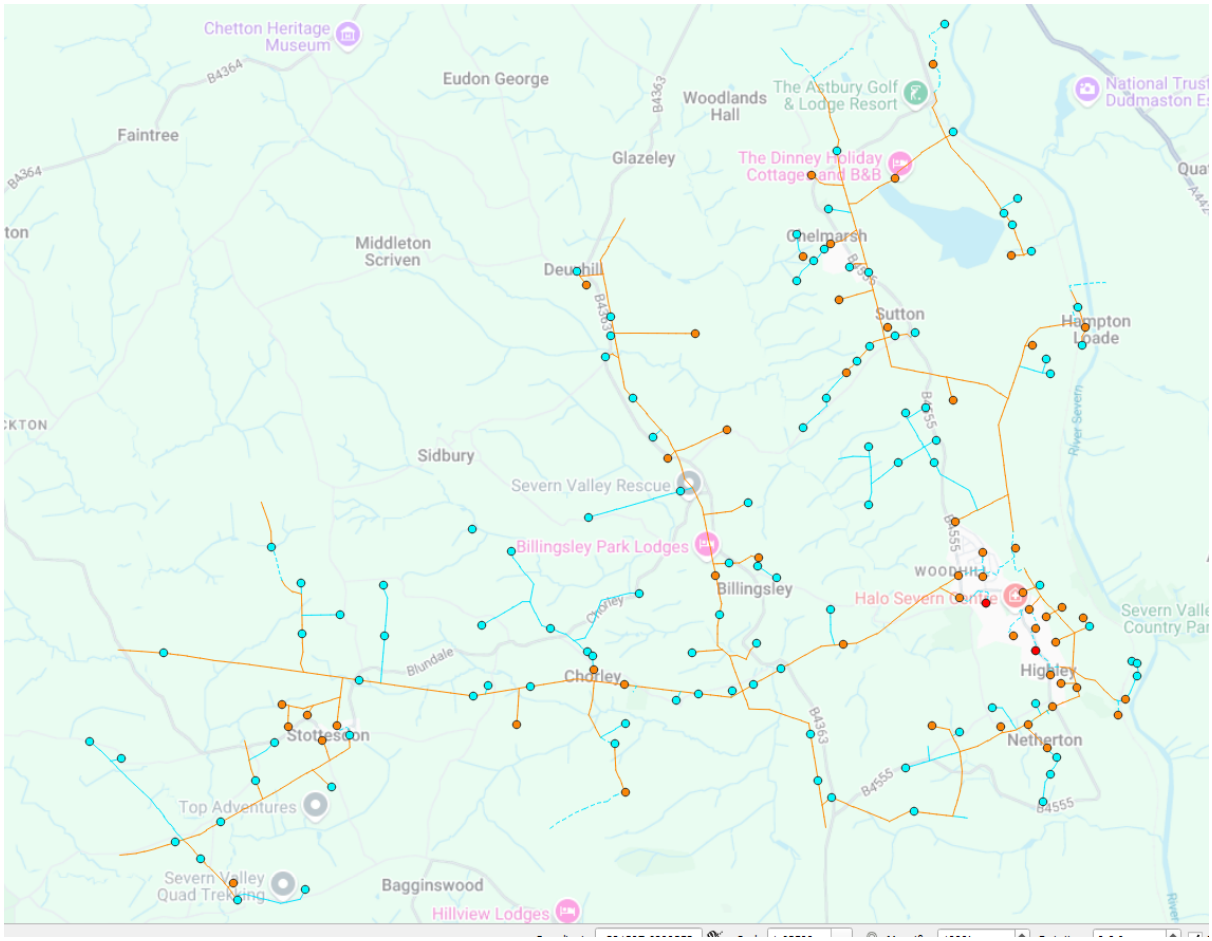
4.5 Primary 417560 Probus, feeder 0041



4.6 Primary 770003 Quatt, feeder 0001



4.7 Primary 770003 Quatt, feeder 0009



5. Conclusions

This report summarises the current development of the sample area selection work, and recommends a first set of HV feeders for use in the analysis.

Smart meter data has now been requested for these feeders from the NGED metering data team.

While many feeders have been found to have sufficient numbers of smart meters such that phase identification appears feasible (although this is as yet unproven), very few have been found to have suitable visual survey data. Only 20% of the feeders assessed, picked from a candidate list of feeders with the most recent cycle 7 or cycle 6 survey data, appear suitable for the phase connections of single-phase branches to be determined.

Although this would appear to limit the effectiveness of the phase identification approach using visual survey data, the cameras and flight altitudes can likely be improved and so this result is not considered to indicate that the machine vision method is infeasible.

A further set of HV feeders will be selected from the ongoing helicopter survey flights, using higher resolution cameras and, if possible, with the flight plan taking account of the results of the visual survey data assessment.