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EFFECTS OF CLIMATE CHANGE ON TRANSPORT FOR WALES' CORE VALLEY LINES (CVL)

Alan has 33 years railway experience having worked for British Rail on Paddington Station and Fenchurch Street Station remodelling, Heathrow Express & Crossrail, Channel Tunnel Rail link (Now HS1), Railtrack in S&C Renewals, Cross Country Route Modernisation, re-opening of the Portishead branch, Network Rail on Great Western Electrification Project, London Underground in Design and Asset Management. Alan has also worked in consultancies carrying out Permanent Way and Drainage designs for Network Rail, London Underground, DLR, Manchester Metrolink, Translink, Dublin Metro, Doha Metro, HS2, Crossrail, Crossrail 2. Engineering management for London Underground – Track Partnership track and drainage renewals. Asset Management for Transport for Wales.

This is the first part of a two-part paper looking at the effects of climate change on railway drainage assets.

BACKGROUND

The Core Valley Lines (CVL), consists of all rail lines running north from Cardiff Queen Street station, south to Cardiff Bay, and south from Radyr towards Ninian Park station. **(Figure 1)**. There are boundaries with Network Rail (NR) owned lines just north of Ninian Park station on the city lines, and east of Cardiff Central for all other lines. All rail lines are located within river valleys, as shown in **Figure 2**.

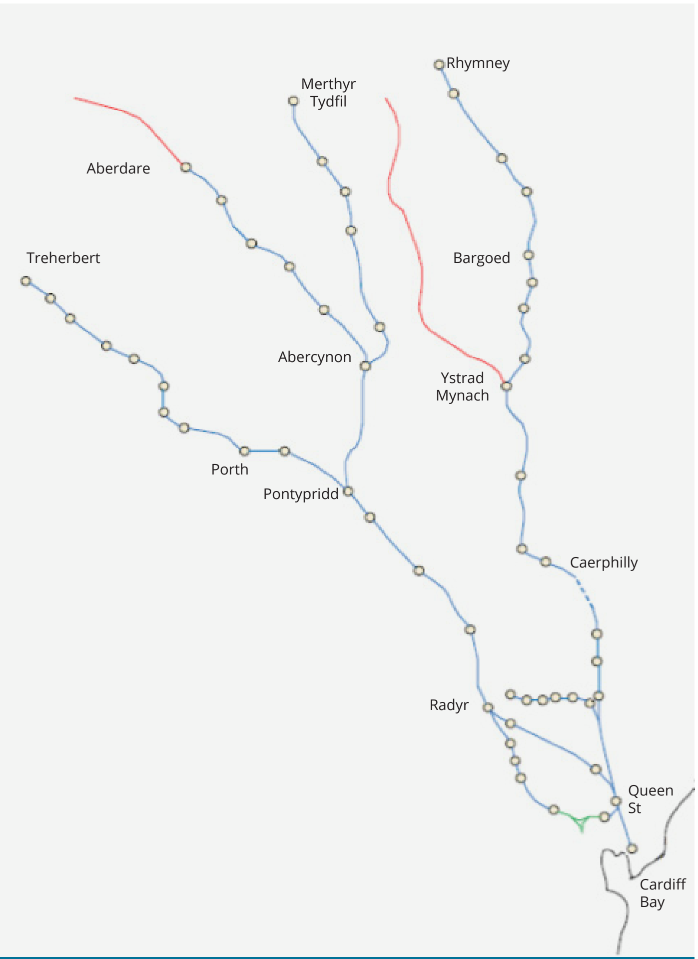

Figure 1: Map of Core Valley Lines (CVL)

Transport for Wales (TfW), took ownership of the CVL on 28 March 2020 from NR, shortly after the major storm events of February 2020, which had resulted in several major flood events on the CVL. This caused massive disruption and damage to assets. The locations of this damage are shown in **Figure 3**, represented by red circles.

Flooding affected Mountain Ash station and Cwmbach on the Aberdare Branch, Trehafod, Britannia Bridge and Llwynipia on the Treherbert branch, Lisvane and Ystrad Mynach on the Rhymney branch, and Llwydcoed on the Aberdare to Hirwaun section. There were also landslips related to the adverse weather at Hirwaun, Mountain Ash, Quakers Yard and Trelewis.

The above events highlighted to TfW the vulnerability of the CVL to climate change due to the lines all being located within river valleys either running along the river valley floor close to the rivers, or located part way up the valley side on sidelong ground. The CVL either cross or run adjacent to one of the main rivers 56 times, in some locations only two metres above mean river level.

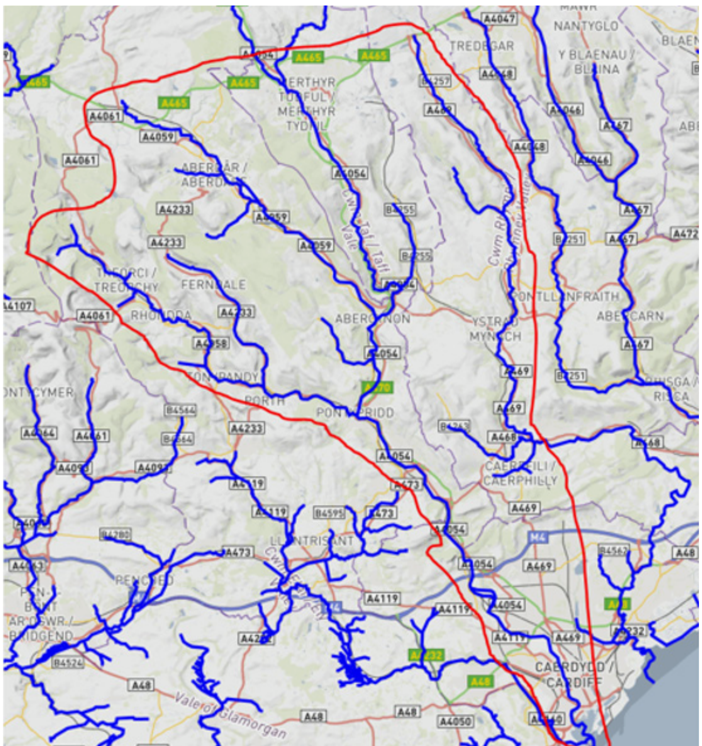

Figure 2: Major Rivers located within CVL area

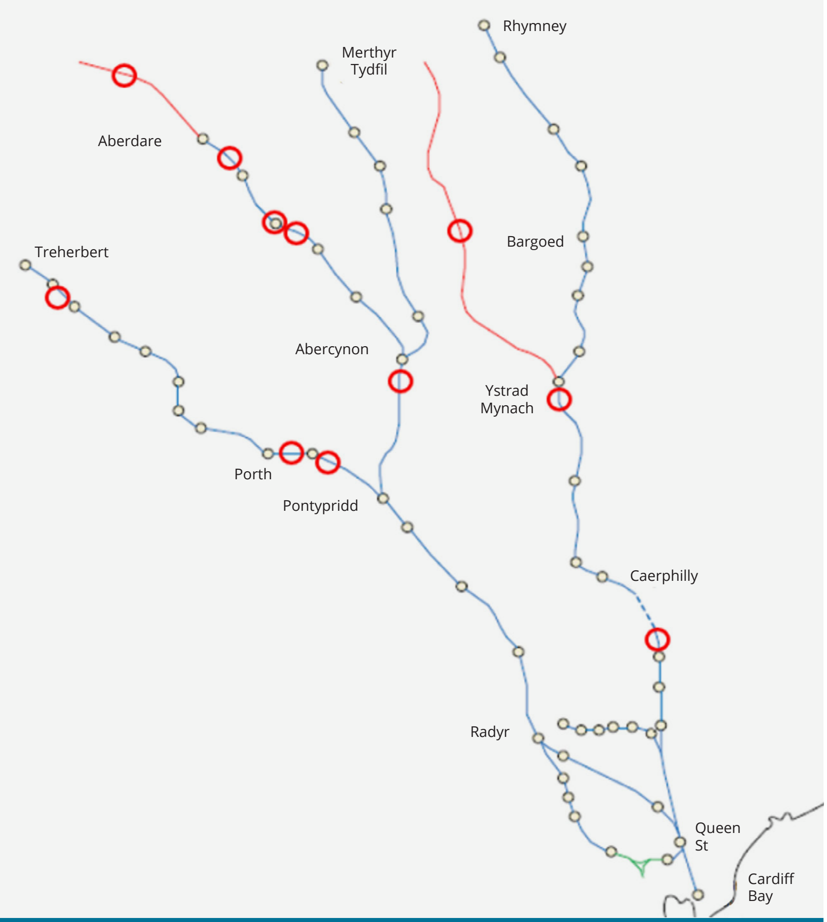

Figure 3: Map of CVL showing flooding and landslip locations during February storms of 2020

ASSUMED PROBLEMS WITH DRAINAGE AND DRAINAGE CAPACITY ON THE CVL

There are 506 culverts crossing under the CVL, the majority are 18 inches (450mm) to 3 feet (915mm) diameter, many carrying water from steep hillsides, and constructed during the 19th Century. Whilst constructed for the flow of water prevalent at the time, in the last 180 years, adjacent land use has changed and climate change has caused more intense convective rainfall, often overwhelming the capacity of culverts or blocking them with debris.

In many locations, outfalls are located just above mean river level, which results in backflow through the outfall when river levels rise during storm events.

Where track drainage exists, it is predominantly a mixture of collector pipe and catchpits and/or unlined ditches: many of these drainage runs are more than 50 years old, and do not have the capacity for the flows experienced during storm events.

Due to historic under investment in drainage assets, over time culvert locations have been lost, drainage ditches have silted up either from lack of maintenance, vegetation ingress, or silting up of outfalls / downstream watercourses. This has dramatically affected the capacity of the drainage system on the CVL.

When reviewing culvert inspection records, approximately 20% are unlocated or have not been inspected since at least 2008. Of the other 80%, there is evidence of silting and debris reducing capacity, or in some cases secondary use for passage of utilities.

Figure 4: Flooding at Mountain Ash station February 2020

Figure 5: Flooding at Cwmbach, a regular occurrence after adverse weather

Some areas prone to flooding showed no drainage present within the NR asset database when supplied to TfW before transfer.

Adjacent land usage has changed over time either affecting surface water runoff, or in some cases, where development has taken place, removed flood plain capacity, or increased flow downstream of railway drainage, reducing the flow rate through the system.

The watercourses that often take the outfalls from railway drainage can also change due to silting and change of flow and direction, which can also have a detrimental effect on the ability to remove water from the railway.

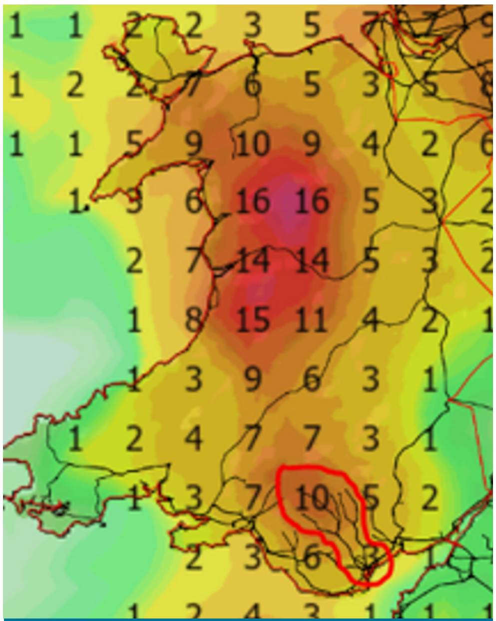

Figure 6: EWAT coverage for Wales

Currently TfW's Infrastructure Maintainer receives notice of potential adverse weather through NR's EWAT process. For Wales, these are split into three areas, North, Mid and South Wales. The CVL is situated on the Eastern Side of the South Wales section, but the elevation of the route changes by 372m between Cardiff and the highest point at Cwmbargoed.

As can be seen in **Figure 6**, only 2 readings cover the CVL, located around Treherbert/Aberdare and Cardiff Bay. As the CVL is formed of five river valleys running in a Southeast to northwest direction, it is assumed as the weather prevails from west to east, that the western valleys would receive more precipitation than the east, and that the differences in elevation would also have an impact..

It would also be useful to know what type of precipitation event causes the most problems on the CVL, i.e. short sharp rainfall events or longer periods of less intense rainfall.

AIM – TO IMPROVE THE KNOWLEDGE OF THE CVL DRAINAGE ASSET AND THE EFFECTS OF CLIMATE CHANGE ON THE SYSTEM

Post-transfer of the CVL to TfW, a review was carried out of the drainage asset database. It quickly became apparent that the knowledge of drainage assets was deficient. All drainage assets are shown as individual assets, with no interconnectivity between the head of the run and the outfall, therefore it is very easy to miss assets that form part of the system, without going to site to trace them. Also, when reviewing the asset database, there is no reference within the data on the capacity of the system in relation to water volume and flow. The only scoring for the asset is the structural condition and its serviceability, i.e. how clear it is from debris.

This led to the realisation that TfW needed to gain a better understanding of the drainage assets and fill any gaps that became apparent. We needed to understand the capacity of the existing drainage system to determine its suitability for existing as well as future climate predictions, as this will drive maintenance, renewal and enhancement policy.

We also needed to understand any potential micro-climates that exist on the CVL. As mentioned previously, it was thought that as the prevailing weather ran west to east, that more precipitation would likely fall on the westernmost valleys, compared to the eastern. When looking at Met Office current climate data and future climate predictions the resolution appeared to be too low, placing several of the valleys under the same data block.

DRAINAGE INVESTIGATION

To gain a better understanding of the track and off-track drainage assets on the CVL, an initial desk-top study was carried out. Each Engineers Line Reference (ELR), of the CVL had the drainage asset data reviewed that had been supplied by NR before transfer. This data came from Ellipse, Dambuster, Orbis, CARRs and CIV/065 inspection reports. These were then checked against data that had been input into TfW's GIS system and AIW's asset management software, MAXIMO. Automated intelligent Video Recording (AiVR) supplied by One Big Circle was also used as a visual aid, as the Intelligent video logs mileage as it progresses and can be used to verify locations of catchpits and culverts, (specifically handrails etc). **(Figure 7)**.

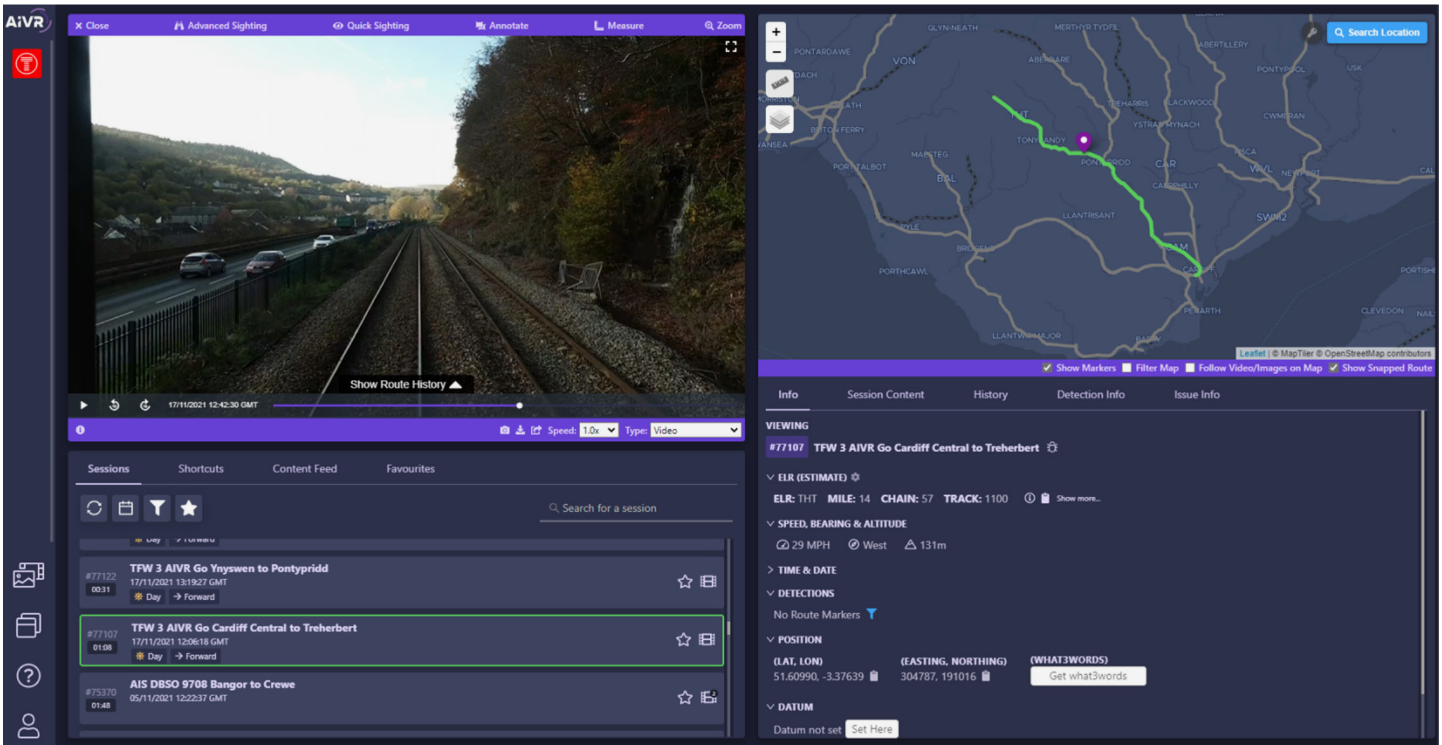

Figure 7: example of AiVR showing a waterfall over a rock cutting dropping into a buried culvert

Figure 8: Adverse weather debris flow blocking flume to culvert, resulting in overtopping of headwall causing silt contamination of ballast and line closure

Whenever site visits are undertaken, Track Locator is used to photograph drainage assets that are visible so these can be checked against records. If the site visit is to look at drainage flooding issues, then every effort is made to ensure that the wider picture is understood, i.e. what is causing the problem: deficient drainage, blocked drainage, lack of drainage, change of land usage etc? **(Figure 8)**.

Pros of site visits

- Gives opportunity to review a specific problem at the site and the surrounding area to build up a detailed picture.
- Data collected informs a review of existing drainage asset data, inspection records, fault logs etc.

Figure 9: Davis Vantage pro 2 plus weather station in Cardiff Bay

Cons of site visits

- Site visit normally takes place after flooding event so no 'real time' live view of the build-up and actual flooding event.
- Not always possible to visit site during daytime due to no red zone working, therefore higher risk of missing problems.

Where previously unknown drainage assets are found, the infrastructure maintainer is informed to ensure those assets are added to Maximo so that they will be visible ready for the next inspection cycle. At the same time TfW's data manager is informed so that the assets can also be added to the GIS system, this will allow TfW's data team to ensure new or newly discovered assets have been inserted into Maximo correctly.

SOLUTION

To improve the knowledge of the drainage asset, a section of the initial drainage review data was supplied to an external consultancy, AtkinsRéalis, to complete a sense check and develop the data into linear drainage runs that could be uploaded into GIS. This would help visualise any gaps between the head of the run and the outfall. This work package is currently underway on a 3-mile section of the CVL between Porth and Pontypridd North Junction. Any noticeable gaps in data will drive targeted site inspections to locate missing assets over the next 12 months.

As previously shown in **Figure 6**, EWAT weather warnings are relatively low resolution, with two sites covering the whole of the CVL area. As weather in the UK is predominantly west to east, it generally follows that a higher proportion of precipitation should fall in the western-most valleys compared to the east, and also on the higher ground. Due to a lack of local weather forecasting stations, this remained an unknown. It was decided to install seven weather stations across the CVL to determine if this thinking was correct. A review of possible locations was carried out, and suitable weather station specifications were reviewed. We needed a system which could operate without mains power and had minimal requirements for attendance to take readings or maintenance. A fully automatic weather station from Davis Instruments, called the Vantage Pro 2 Plus, was chosen for its small footprint, solar powered operation, the ability to upload data to the cloud at 5-minute intervals, and provision of a cloud-based dashboard for the weather stations as part of the package. **(Figure 9)**. The Davis Vantage Pro 2 plus measures wind speed and direction, precipitation, humidity, barometric pressure, evapotranspiration, temperature, UV and solar radiation. This information is uploaded to the cloud via a 4G Gateway located in the solar panel box. Being fully automatic means that staff attendance is only required when there is a fault, or otherwise monthly to ensure the rain gauge is clear of debris. Battery charge can be checked remotely through the web portal. The system could also be set up with alarm trigger levels, to warn of high precipitation rates, high and low temperatures, high wind speeds etc. **(Figure 10)**.

Figure 11 shows the dashboard for the weather station in Treherbert: the benefit of this system is that dashboards from 3rd party weather stations can also be viewed through the portal, (if made public by weather station owners), which gives a live view of developing weather patterns. A mobile app is also available, which shows identical information plus an hourly and weekly forecast.

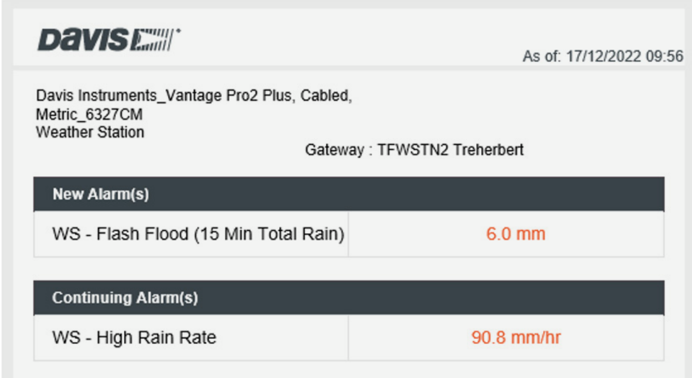

Figure 10: Email alerts, when alarm triggers are reached

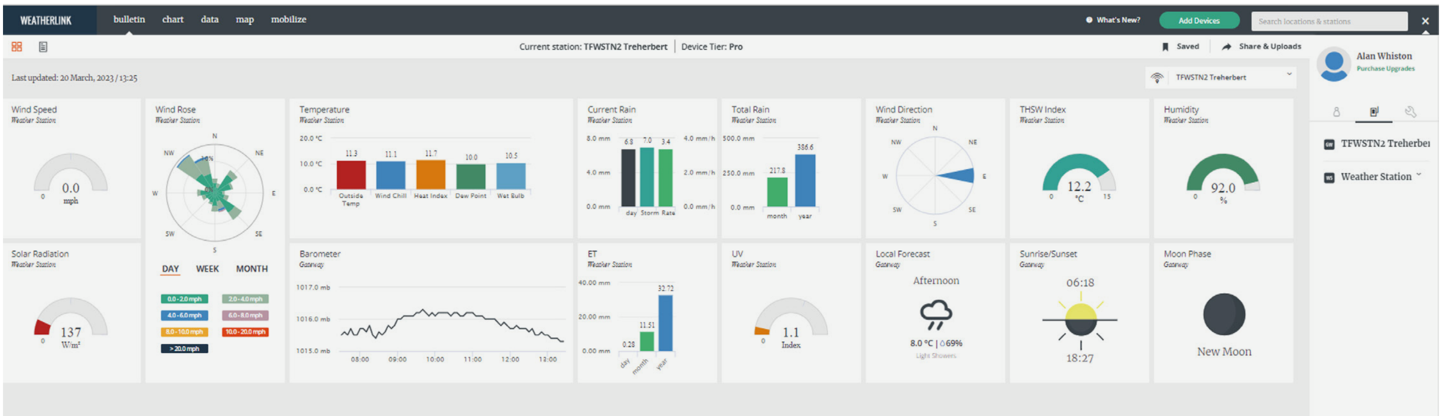

Figure 11: Davis Instruments, Weatherlink Dashboard for weather stations

As can be seen from **Figure 12,** during December daily precipitation values were predominantly higher in the western valleys than the eastern or in Cardiff Bay, which broadly supported our initial thinking. As more data is received, we will be able to confirm our initial assumptions. Readings have been taken at all seven weather stations since 5 October 2022: a snapshot of total precipitation values is shown in **Figure 13**.

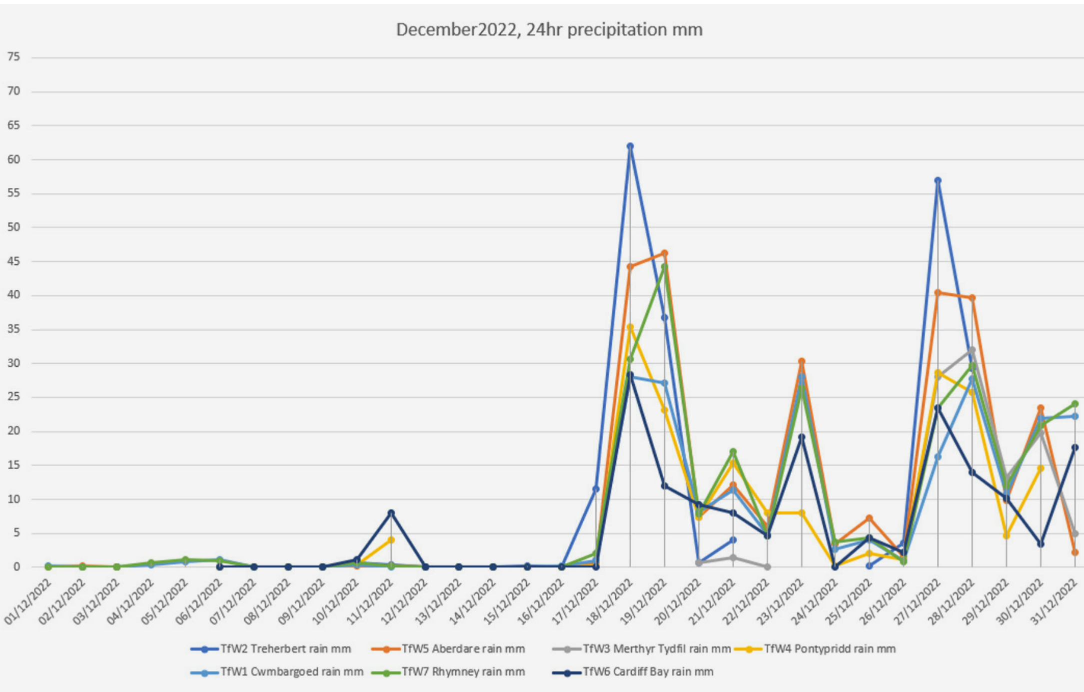

Figure 12: 24 hour precipitation values for December 2022 taken from the 7 TfW Weather Stations

ADDITIONAL WORKSTREAMS

NR are carrying out extensive work in relation to the Mair and Slingo reports, as a result of the Carmont disaster. Costain have worked closely with NR in their initial work streams and are now working with TfW to review the Mair and Slingo recommendations and see how we can work collaboratively with NR and other Infrastructure Managers.

We are just about to start a six-month pilot study with Cardiff University's Hydro-environmental research centre, looking at river flooding modelling and the development of early warning systems. This will enable TfW to prepare for river flooding affecting low lying railway lines on the CVL, especially where the lines are no more than two metres above mean river level.

It is proposed to write a second paper next year to review assumptions against twelve months of hard data, to look at what has worked, what hasn't worked so well, and problems and lessons learned.

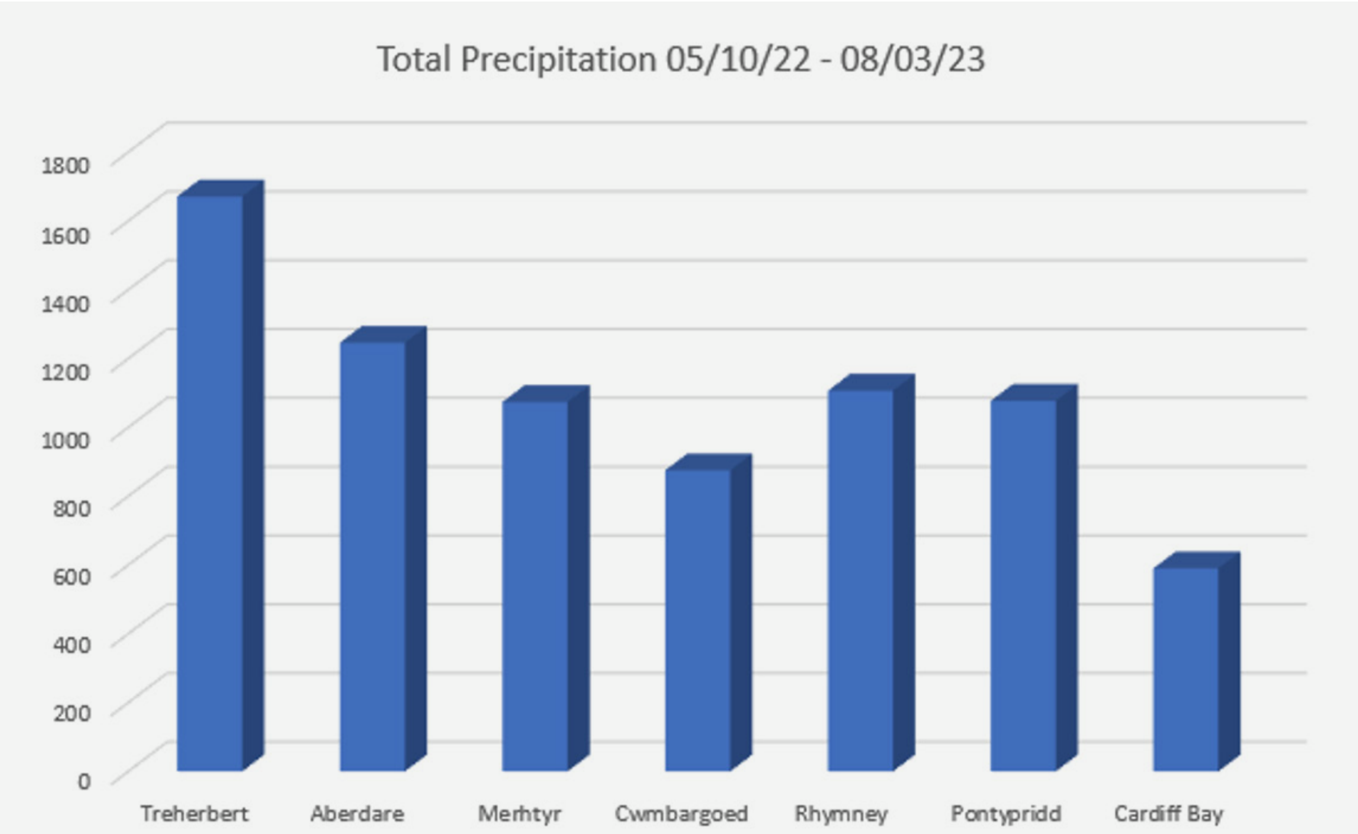

Figure 13: Total precipitation values between 05/10/22 and 08/03/23

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