Hydrological Applications of Weather Radar

Summary of Findings and Conclusions from Survey distributed by the Inter-Agency Committee on the Hydrological Use of Weather Radar

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Contents

Introduction

The Inter-Agency Committee on the Hydrological Use of Weather Radar conducted a survey into the usage of weather radar during the Seventh Session Reporting period 2008 to 2010. This survey was targeted at key users such as the Environment Agency, the UK Meteorological Office, Scottish Environment Protection Agency and leading research institutes and bodies. The survey aimed to gauge opinions into the positive and negative aspects of weather radar and to highlight any issues and potential improvements that would benefit the global users of such data. The questions and results are detailed in the Seventh Session Report.

The original survey was targeted very much towards an established user base with an existing wealth of knowledge of current hydrological radar technology. However, there is an emerging interest in radar technologies from within the UK water industry as water companies explore smarter ways to manage the performance of assets and deliver a better service to customers. It was therefore decided that a second survey should be designed to target the small, but growing number of users within the water companies and their supporting engineering consultants to understand their applications, their perception of radar data and to learn more about future development needs within this growing sector.

The survey was distributed to over 120 people and although the number of responses was very low, 35 in total, it is felt that this number represents a significant proportion of 'pilot study' users within the 10 UK Water and Sewerage Companies. These 'pilot study' users are very much at the forefront of this technology within the water industry and will play a key role in setting future business plans and future water company investment in radar products. It is therefore believed that despite the low response rate, the answers and comments provided are extremely valuable to the aims of the Inter-Agency Committee on the Hydrological Use of Weather Radar and our thanks are extended to all those who participated. The following report details the survey responses and aims to draw some conclusions from them.

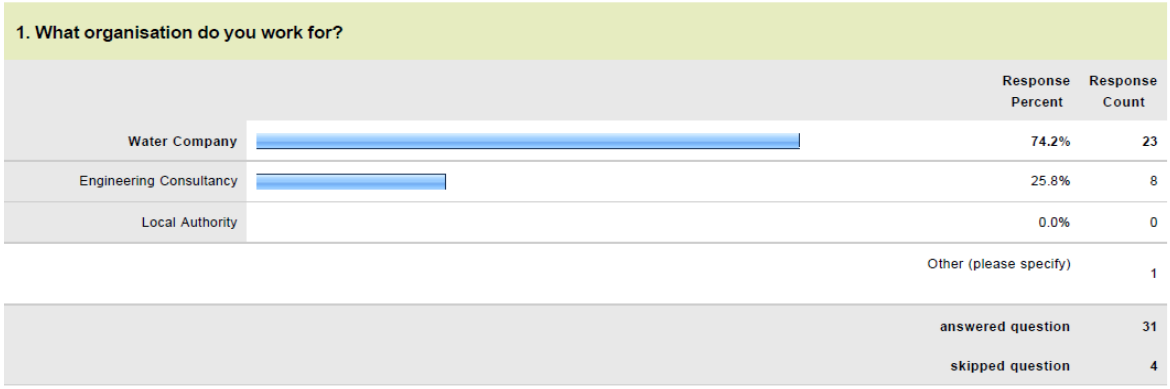
1. Organisational Background

1.1 Question 1 - What organisation do you work for?

Out of the 35 responses for this question 23 (74.2%) worked for Water Companies, 8 (25.8%) worked for Engineering Consultants and 1 response was from the Navigation Authority.

This shows that much of the work involving radar products is largely conducted 'In –House' at the Water Companies as they explore new and more efficient ways to manage and understand the performance of their assets while delivering savings to their capital investment programmes. The response from the Engineering Consultants is probably based on those who are actively engaged on water company pilot studies or those who are provided with radar data to understand historic flooding problems.

Figure 1 Question 1 results



1. What organisation do you work for?

	Response Percent	Response Count
Water Company	74.2%	23
Engineering Consultancy	25.8%	8
Local Authority	0.0%	0
Other (please specify)		1
answered question		31
skipped question		4

2. Organisational Area

2.1 Question 2 - Where are you based?

This question was intended to give an indication of the geographical spread across the UK of radar usage. This is important to try and understand regional perspectives that could be related to local topographical features and also to make sure that the responses are not all from one area.

As expected, the survey results do show slightly larger responses from the regions where radar data is known to be more widely used. These are 28% from the UK South East, which is likely to be the Thames Water region, 12.5% from the UK East Anglia, which is likely to be the Anglian Water region and 15.6% from the UK North West, which is probably the United Utilities region.

There is also at least one response from all the other regions of the UK including Northern Ireland, which indicates that there is an awareness of radar products across the UK water industry.

Figure 2 Question 2 results

2. Where are you based?

	Response Percent	Response Count
UK- South East	28.1%	9
UK- South West	6.3%	2
UK-South	6.3%	2
UK- Midlands	9.4%	3
UK- East Anglia	12.5%	4
UK- North East	6.3%	2
UK- North West	15.6%	5
UK- Wales	9.4%	3
UK- Scotland	3.1%	1
UK- Northern Ireland	3.1%	1
Europe	0.0%	0
	Other (please specify)	1
	answered question	32
	skipped question	3

3. Scientific Discipline

3.1 Question 3 - Which discipline best describes your area of work?

There are several radar products available on the market and different working disciplines will have differing requirements. This question aimed to understand the make up of the working disciplines so that the current and future needs of the water industry can be understood and hopefully met.

The large majority of responses (56.3%) came from the Hydraulic/Hydrological modelling discipline which reflects the water company regulatory requirements to reduce the size of their sewer flooding registers. Understanding historic rainfall events and how assets performed enables the design of future flood alleviation schemes.

The second highest response (21.9%) came from Asset Planners. This reflects the reorganisations that have taken place within water companies, with specific Asset Management teams / divisions taking more strategic long term views on the life cycle of key company assets. Again understanding rainfall past, present and future plays its part in the asset planning process.

The joint third highest response was from Network Operations and 'Other'. Network Operations are likely to require the forecasting products available so they can manage the sewerage networks on a day to day basis. It is also important in terms of Health and Safety and when it may or may not be safe to enter the networks to carry out maintenance.

The 'Other' category did have a response from Control Room Operations, which is similar to the Network Operations field, but interestingly there was a response from an IT development team. There are no radar rainfall database/analysis packages available on the market specifically for the water industry user, which is why many have developed their own company bespoke packages. This is probably why there is a response from an IT development team. See survey Question 6.*If you use radar data, how do you view/analyse the data?*

Figure 3 Question 3 results

3. Which discipline best describes your area work?

	Response Percent	Response Count
Hydraulic / Hydrological modelling	56.3%	18
Asset Planning	21.9%	7
Environment	3.1%	1
Network Operations	9.4%	3
Customer liaison	0.0%	0
Engineering consultant	6.3%	2
Other	9.4%	3
Other (please specify)		4
answered question		32
skipped question		3

4. Use of Radar Data

4.1 Question 4 - What radar based products do you use?

This question is an extension to question 3 in that after discussing the work discipline we can explore which radar products are used.

The largest response (81.5%) was for radar actuals which reflects the use of live data feeds and use of data stored on company databases for future historic rainfall analysis work. Interestingly, almost half (44.4%) of respondents use radar forecast data reflecting the industry's developing interest in real time control of assets and flood (Sewerage and pluvial) forecasting.

The use of Hazard Manager and the Flood Forecast Centre Guidance Statements are products used by the survey respondents, but are 'visual only' products that can be used to raise general awareness of forth coming rainfall events. However, these are not linked to

live telemetry or network models and the water company response to such information remains at a strategic catchment wide level.

22.8% of people answering the survey skipped this question. One possible conclusion for this is that there is a lack of knowledge of what products are available, what they are called and how their company uses them. One respondent stated that 'these products are not currently used consistently across the business'.

Figure 4 Question 4 results

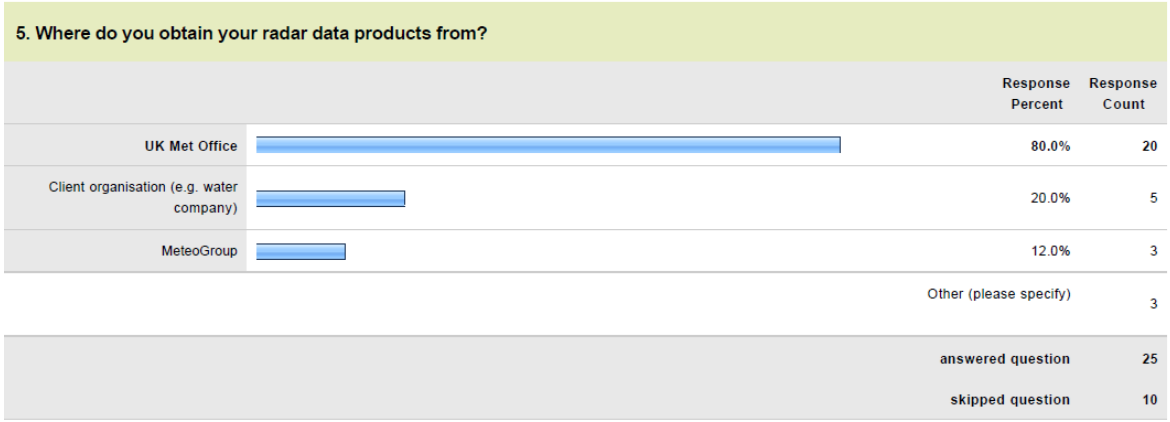
4. What radar based products do you use?

	Response Percent	Response Count
Radar actuals	81.5%	22
Radar forecast	44.4%	12
Hydrocast	11.1%	3
Hazard Manager	18.5%	5
Flood Forecasting Centre Guidance Statements	22.2%	6
Storm analysis reports (from Met Office)	37.0%	10
Other (please specify)		2
answered question		27
skipped question		8

4.2 Question 5 - Where do you obtain your data products from?

Many of the radar products originate from the UK Meteorological Office and so it is not surprising that 80% of respondents confirm that they use the UK Meteorological Office as their supplier. The 20% who obtain their data from a Client Organisation must be the Engineering Consultants engaged on water company capital programmes or research/pilot studies.

Figure 5 Question 5 results



5. Where do you obtain your radar data products from?

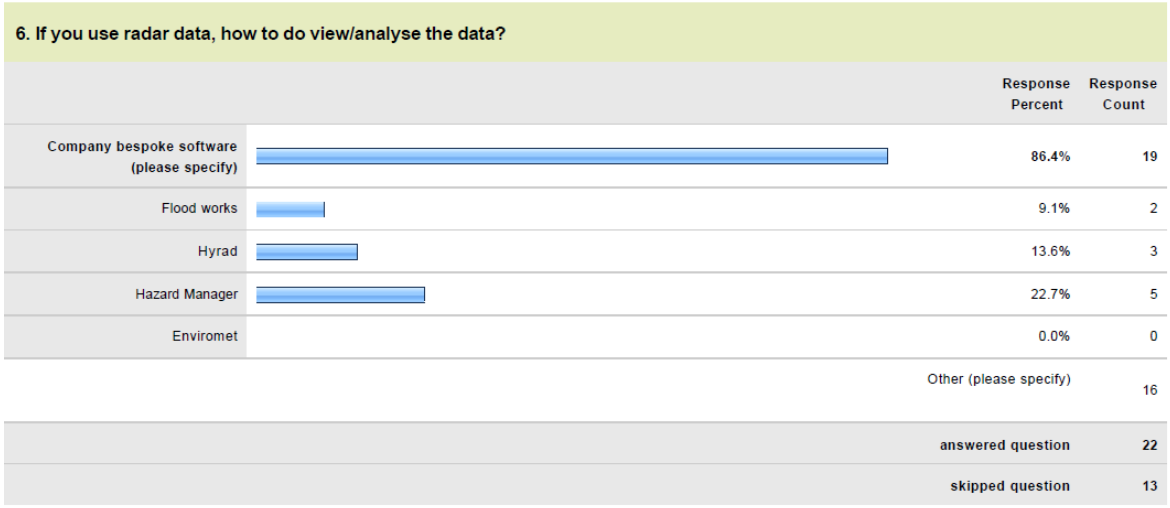
	Response Percent	Response Count
UK Met Office	80.0%	20
Client organisation (e.g. water company)	20.0%	5
MeteoGroup	12.0%	3
Other (please specify)		3
answered question		25
skipped question		10

4.3 Question 6 - If you use radar data, how do you view/analyse the data?

This question aimed to understand how users view and analyse the data they purchase. Of the 22 people who answered this question 19 (86.4%) said they use a company bespoke piece of software. 16 people also entered a comment in the 'Other' section, which indicates that there is a wide spectrum of methods to import, view and analyse data. 3 responses referenced the Thames Water RaRA system, while a further 3 mentioned InfoWorks, which is the standard sewerage network modelling software used in the water industry. Other responses refer to GIS mapping packages and MS Excel.

These results demonstrate that unlike a standard modelling software package, there is no single radar viewing/analysis/database system available to users. This prevents a uniform and consistent approach to using radar data from being adopted. It also makes it difficult for new users to enter the market as although the data is readily available, people are not aware of the best software products on the market with which to collect, store and analyse the data.

Figure 6 Question 6 results



6. If you use radar data, how to do view/analyse the data?		
	Response Percent	Response Count
Company bespoke software (please specify)	86.4%	19
Flood works	9.1%	2
Hyrad	13.6%	3
Hazard Manager	22.7%	5
Enviromet	0.0%	0
	Other (please specify)	16
	answered question	22
	skipped question	13

4.4 Question 7 - What do you use radar data for?

This question was intended to capture the uses of radar data within the water industry so that existing and future needs can be understood and planned for.

Historically the post rainfall/flooding event analysis has been the largest requirement for radar data. This is confirmed by the largest response of 21 (84%) people stating this as one of their uses.

The second highest response (52%) was for using radar data to verify hydraulic models. This reflects the need to make sure that a thorough historic verification is undertaken and that models are not just verified to WaPUG (Wastewater Planning User Group) compliant storm events. The ability to build larger, more detailed models brings with it the need to have a greater understanding of the rainfall falling on the catchment. This includes the spatial variability of rainfall, which is often represented more accurately with radar data, especially as permanent rain gauges offering a similar historic record of rainfall are often widely spread and don't offer the same level of detail.

As expected, flood warning is a significant activity (44%) and the Flood Forecast Centre Guidance Statements and Hazard Manager provide much of this information. The response rate for Continuous model calibration and network optimisation (32%) is a good indication that the industry is moving towards continuous model simulations using a combination of radar actuals and forecast data.

Figure 7 Question 7 results

7. What do you use radar data for?

	Response Percent	Response Count
Verification of hydraulic models	52.0%	13
Continuous model calibration and network optimisation	32.0%	8
Post rainfall/flooding event analysis	**84.0%**	**21**
Flood warning	44.0%	11
Other (please specify)		3
answered question		**25**
skipped question		**10**

4.5 Question 8 - How often do you use radar data? If project specific, please state usage during the project?

It appears that radar usage is varied with quite a wide spread of responses. There are more responses for Monthly with 9 (36%), but there are 8 responses for daily or sub-daily. This is probably a reflection of the mixed uses and when a user would actually receive and view information. For example, if you were responsible to issuing alerts to the business based on the Flood Forecast Centre Guidance Statements, then you are only going to receive this information when weather warnings are issued. This will be on a much lower frequency then someone who administers a bespoke company system that is receiving and processing data requests daily.

Figure 8 Question 8 results

8. How often do you use radar data? If project specific, please state usage during the project?

	Response Percent	Response Count
Sub-daily	12.0%	3
Daily	20.0%	5
Weekly	24.0%	6
Monthly	36.0%	9
Quarterly	24.0%	6
answered question		25
skipped question		10

4.6 Question 9 - What role does radar data have in your field of work?

This question was also trying to understand more details about the usage of radar data and is a continuation from Question 7. Rather than specifying key areas, the question allowed the respondents to elaborate a bit more about the specific uses within their organisation.

Of the 35 people who responded to the questionnaire, only 17 (49%) answered this question. This is possibly a reflection on people wanting to get through the questionnaire quickly and the departure away from tick boxes and selectable options to a written response resulted in fewer responses.

From the responses given there are clearly some general trends. These are

- Understanding rainfall in more detail, such as identifying discrete rainfall events, determining rainfall return periods and knowing more about the size and spatial variation or rainfall events.
- Informing Network Operations and decision making. This includes reviewing predicted and actual alarm levels with respect to pumping station performance and levels of flow in sewers. Radar data is used to manage network performance and to make informed management decisions on a day by day basis.
- Network modelling. These references refer to verifying hydraulic models to historic rainfall events and to verifying new models using radar data, which is a new development away from the standard WaPUG guidance using rain gauges. There are also some references to continuous model calibration, which will allow models to be seasonably adjusted and kept up to date at all times.
- Understanding flooding and supporting DG5 evidence. These references relate to the rainfall analysis discussed above, but are specifically about understanding a flooding mechanism and therefore supporting the development of appropriate capital solutions to address DG5 flooding.

4.7 Question 10 - How important do you rate the following data sources for your line of work?

The responses to this question mirror the uses of data. We know that there is still a strong reliance on raingauge data and so it is not surprising that this was rated as 'Extremely Important' by 14 (51.9%) of respondents.

Radar actual also play an important role in the work undertaken by the water industry as discussed in Question 9. Radar actual also received 14 (51.9%) for 'Extremely Important'.

Other sources of data that rated extremely important were Sewer level and flow data which received 17 (63%) responses. This is also not surprising as there is significant work carried out to verify/calibrate network models and this is one of the key sources of data with which to do this by.

Site telemetry is becoming more widely used as remote sensing and telecommunication technologies improve and so an even split of 12(46.2%) for being both 'Extremely Important' and 'Very Important' is to be expected.

Numerical Weather Prediction and Radar forecast were only rated as 'Fairly Important' 9(42.9%) and 9(34.6%) respectively. This reflects the fact that this data is only just starting to be used in small development/pilot studies and the full benefits and wider uses have not been determined yet. As this field develops and usage increases, a greater understanding will be developed and the importance of these data sets to the industry will be demonstrated.

Figure 9 Question 10 results

10. How important do you rate the following data sources for your line of work

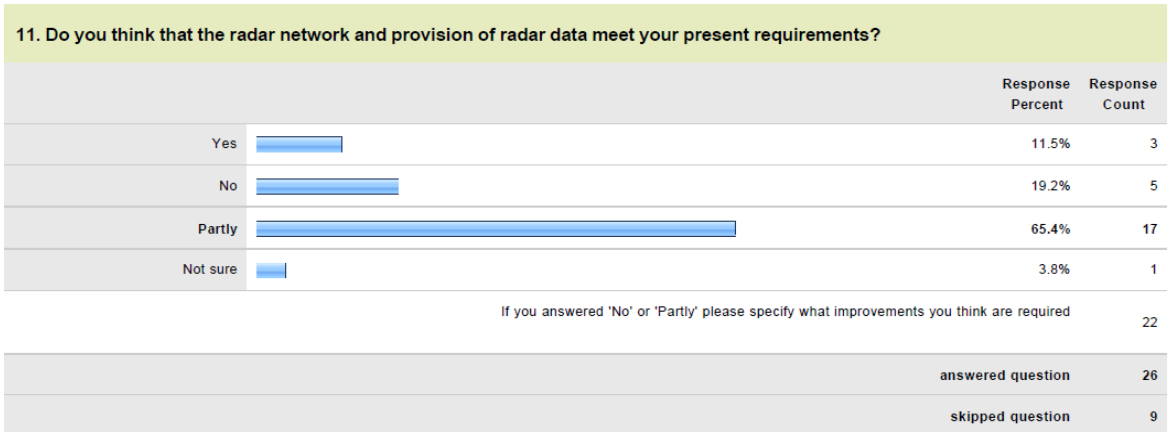
	Extremely important	Very important	Fairly important	Slightly important	No importance	Rating Average	Response Count
Radar actuals	**51.9% (14)**	25.9% (7)	22.2% (6)	0.0% (0)	0.0% (0)	1.00	27
Raingauge	**51.9% (14)**	33.3% (9)	11.1% (3)	3.7% (1)	0.0% (0)	1.00	27
Numerical Weather Prediction	9.5% (2)	14.3% (3)	**42.9% (9)**	19.0% (4)	14.3% (3)	1.00	21
Radar forecast	15.4% (4)	23.1% (6)	**34.6% (9)**	19.2% (5)	7.7% (2)	1.00	26
River level and flow data	25.0% (6)	16.7% (4)	**37.5% (9)**	20.8% (5)	0.0% (0)	1.00	24
Sewer level and flow data	**63.0% (17)**	22.2% (6)	11.1% (3)	3.7% (1)	0.0% (0)	1.00	27
Site specific telemetry data	**46.2% (12)**	**46.2% (12)**	7.7% (2)	0.0% (0)	0.0% (0)	1.00	26
						answered question	**27**
						skipped question	**8**

4.8 Question 11 - Do you think that the radar network and provision of radar data meet your present requirements?

This question starts to explore peoples' perception of radar data. It is also aimed at highlighting where people think there are weaknesses that the Inter-Agency Committee on the Hydrological Use of Weather Radar can try to address during future sessions.

The large majority of responses felt that the provision of radar data only partly met their requirements with 17 (65.4%) of the 26 highlighting this option. From the comments people entered it is clear that many of the concerns are related to country wide coverage particularly in Wales and Orkney & Shetland. However, the underlying theme in the comments relates to accuracy. Some suggesting that this deteriorates when there are significant events and others wanting 'some kind of confidence grading' for the data. At the time of the survey the people responding to this question would have been unaware of the huge work being undertaken on the UK radar network as detailed in section 4.2 and on the development of quality indicators/quantified errors in section 4.3 of the Eighth session report. Hopefully this will go a long way to addressing these concerns, but this message must be communicated to the Water Industry users.

Figure 10 Question 11 results



11. Do you think that the radar network and provision of radar data meet your present requirements?

	Response Percent	Response Count
Yes	11.5%	3
No	19.2%	5
Partly	65.4%	17
Not sure	3.8%	1
If you answered 'No' or 'Partly' please specify what improvements you think are required		22
answered question		26
skipped question		9

4.9 Question 12 - If radar data were available for your project work, would you use them?

This question required a simple Yes or No response although 8 (23%) of people undertaking the survey skipped this question. Perhaps this was because the question referred to 'project work', rather than saying 'for your field of work'. All 27 (77%) respondents to this question said that they would use radar data on project work if it was available to them.

This shows that there is willingness within the water industry to explore and try new technologies which is encouraging for the future use of radar products.

Figure 11 Question 12 results

12. If radar data were available for your project work, would you use them?

	Response Percent	Response Count
Yes	100.0%	27
No	0.0%	0
answered question		27
skipped question		8

4.10 Question 13 - If radar data were available for your project work, would you know how to use them and what the differences were between radar and raingauge data?

This question asks whether or not 'new' users of radar data understand the differences between the raingauge data they have always used and the new radar products becoming available to them. 25 (71%) of survey participants said that they did know the difference with one person saying that they didn't. There was a comment entered for this question which said that they knew the two products are different but that more training is probably required in this area. This is a key point and is one brought out in question 19 which aimed to gauge interest in future training courses.

Figure 12 Question 13 results

13. If radar data were available for your project work, would you know how to use them and what the differences were between radar and raingauge data?

	Response Percent	Response Count
Yes	96.2%	25
No	3.8%	1
Comment		1
answered question		26
skipped question		9

5. Radar Limitations

5.1 Question 14 - When comparing radar rainfall to raingauge rainfall data, how do you think the radar data fairs in terms of accuracy?

Although the next set of questions were designed to gauge peoples' perception of radar limitations and the limitations to its use, questions 14 and 15 build on the direct question asked in question 13 regarding peoples' understanding of the differences between raingauge and radar data.

When answering the first part of the question regarding the accuracy of radar peak intensities, 10 (47.6%) respondents 'neither agreed or disagreed', however there was a larger proportion of people 'disagreeing' than 'agreeing' with the statement which reflects the general impression that radar data isn't always as accurate as users would like.

The second part of the question regarding the spatial variation of radar data has a more positive response in that there is an even split of 9 (42.9%) responses for both 'Agree' and 'Neither agree or disagree'. This indicates that people are aware of how radar data is generated and that the more common 1km resolution grid provides a much better spatial distribution of rainfall than could be achieved using the UK network of permanent raingauges or even using a WaPUG compliant distribution of raingauges for network modelling. (1 per 2km^2 + 1 for average terrain, from A Guide to short term flow surveys of sewer systems)

The third part of the question regarding accuracy levels meeting your requirements shows a reasonably even split between agreement and disagreement with a slight bias towards agreement.

Figure 13 Question 14 results

14. When comparing radar rainfall to raingauge rainfall data, how do you think the radar data fairs in terms of accuracy?

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly Disagree	Rating Average	Response Count
Radar peak rainfall intensities are accurate	0.0% (0)	19.0% (4)	**47.6% (10)**	33.3% (7)	0.0% (0)	1.00	21
Radar spatial variations are accurate	4.8% (1)	**42.9% (9)**	**42.9% (9)**	9.5% (2)	0.0% (0)	1.00	21
Radar data meets your accuracy requirements	0.0% (0)	33.3% (7)	**42.9% (9)**	23.8% (5)	0.0% (0)	1.00	21
					answered question		**21**
					skipped question		**14**

5.2 Question 15 - When comparing radar rainfall to raingauge rainfall data, how do you think the radar data fairs in terms of total depth and peak intensities?

The general perception is that Radar peak intensities are generally lower than those recorded by raingauges with 8 (53.3%) of the 15 responses ticking this option which is a fair assessment when you consider that radar is an average value over a 1km by 1km square and raingauge data is observed data collected at one point.

The second and third parts to this question relate to the use of radar data in hydraulic models. Models have historically been calibrated to raingauge data and the relationship between rainfall and observed catchment runoff entering the sewerage system has been set during this calibration exercise. With this rainfall/runoff relationship set, applying historic and Nowcast radar rainfall should generate accurate responses within the sewerage networks. Part two asked how predicted runoff from small catchments fairs when compared to raingauge data. The greatest individual response is 7 (46.7%) for 'about the same', but there are also a total of 7 responses for 'almost always lower' and 'generally lower' indicating that radar data produces a general under prediction in runoff volumes.

When the same question was asked for large catchments the greatest individual response is again 7 (46.7%) for 'about the same'. However there is then an even split of responses for 'generally lower' and 'generally higher' with 4 (26.7%) responses each. This is perhaps down to spatial variation being more pronounced over the larger catchments and using radar data can improve model calibration in some circumstances.

It is probably important to note that no definition of 'small' or 'large' catchment was given and peoples' perception of this will differ greatly depending on the type of catchment they are most familiar with.

Figure 14 Question 15 results

15. Again, when comparing radar rainfall to raingauge rainfall data, how do you think the radar data fairs in terms of total depth and peak intensities?

	Radar almost always lower than raingauge	Radar generally lower than raingauge	About the same	Radar generally higher than raingauge	Radar almost always higher than raingauge	Rating Average	Response Count
Radar peak rainfall intensities	6.7% (1)	**53.3% (8)**	33.3% (5)	6.7% (1)	0.0% (0)	1.00	15
Small catchments: predicted model runoff generated from radar data	13.3% (2)	33.3% (5)	**46.7% (7)**	6.7% (1)	0.0% (0)	1.00	15
Large catchments: predicted model runoff generated from radar data	0.0% (0)	26.7% (4)	**46.7% (7)**	26.7% (4)	0.0% (0)	1.00	15
					answered question		15
					skipped question		20

5.3 Question 16 - What limits the use of radar data within your organisation?

This question is quite wide ranging and gave the participant nine options to rate from 'Extremely important' to 'No importance'. The overall findings can be seen in Figure 15 below. Seven of the nine questions received a peak rating of 'Very Important' with only delivery time and cost achieving a peak for the 'Fairly important' score.

The higher percentages for the 'Very Important' rating were given to data accuracy, data resolution and network coverage, which correlates well with answers given earlier in the survey.

The fact that the development of hydraulic or hydrological models is a limiting factor in the use of radar data is interesting. This is probably due to the fact that there is very little in the way of industry guidance in the form of evaluation studies and an up to date WaPUG user note that the modeller can follow and be audited against. The modeller will understandably revert back to standard industry practise and use raingauge data. Radar data tends to be used as a 'check' to support work rather than be the benchmark with which to develop network models. This is probably an area where the Committee could encourage CIWEM (WaPUG) members to update the current radar User Note 39 and offer more evaluation studies as practical examples to follow. See question 18.

Figure 15 Question 16 results

16. What limits the use of radar data within your organisation?

	Extremely important	Very important	Fairly important	Slightly important	No importance	Rating Average	Response Count
Awareness of available products	5.6% (1)	**38.9% (7)**	33.3% (6)	11.1% (2)	11.1% (2)	1.00	18
Data resolution	27.8% (5)	**44.4% (8)**	16.7% (3)	5.6% (1)	5.6% (1)	1.00	18
Data accuracy	35.0% (7)	**50.0% (10)**	15.0% (3)	0.0% (0)	0.0% (0)	1.00	20
Network coverage	23.5% (4)	**58.8% (10)**	11.8% (2)	5.9% (1)	0.0% (0)	1.00	17
Delivery time	11.1% (2)	22.2% (4)	**44.4% (8)**	11.1% (2)	11.1% (2)	1.00	18
Data availability	15.8% (3)	**36.8% (7)**	**36.8% (7)**	0.0% (0)	10.5% (2)	1.00	19
Hydraulic / Hydrological model developments	0.0% (0)	**33.3% (6)**	**33.3% (6)**	16.7% (3)	16.7% (3)	1.00	18
Software/Hardware	11.1% (2)	**27.8% (5)**	22.2% (4)	**27.8% (5)**	11.1% (2)	1.00	18
Cost	15.0% (3)	30.0% (6)	**40.0% (8)**	10.0% (2)	5.0% (1)	1.00	20
					Other (please specify)		6
					answered question		**21**
					skipped question		**14**

5.4 Question 17 - What do you feel needs to change in order for your organisation to make more use of radar data?

This question follows on from question 16 and makes use of the same nine options and scoring mechanism. Once again data accuracy and network coverage come out on top and it is clear that confidence in these areas needs to be improved before radar data are more widely adopted by the end users within the water industry.

Figure 16 Question 17 results

17. What do you feel needs to change in order for your organisation to make more use of radar data?

	Extremely important	Very important	Fairly important	Slightly important	No importance	Rating Average	Response Count
Awareness of available products	5.6% (1)	**50.0% (9)**	33.3% (6)	11.1% (2)	0.0% (0)	1.00	18
Data resolution	36.8% (7)	**42.1% (8)**	10.5% (2)	10.5% (2)	0.0% (0)	1.00	19
Data accuracy	**50.0% (9)**	33.3% (6)	11.1% (2)	5.6% (1)	0.0% (0)	1.00	18
Network coverage	**38.9% (7)**	27.8% (5)	22.2% (4)	11.1% (2)	0.0% (0)	1.00	18
Delivery time	17.6% (3)	**35.3% (6)**	29.4% (5)	5.9% (1)	11.8% (2)	1.00	17
Data availability	16.7% (3)	**44.4% (8)**	22.2% (4)	5.6% (1)	11.1% (2)	1.00	18
Hydraulic / Hydrological model developments	5.9% (1)	**41.2% (7)**	23.5% (4)	23.5% (4)	5.9% (1)	1.00	17
Software/Hardware	11.8% (2)	**35.3% (6)**	**35.3% (6)**	17.6% (3)	0.0% (0)	1.00	17
Cost	22.2% (4)	**33.3% (6)**	**33.3% (6)**	11.1% (2)	0.0% (0)	1.00	18
					Other (please specify)		2
					answered question		**21**
					skipped question		**14**

6. Research and Development

6.1 Question 18 - What areas of research and development do you think are needed for your organisation to make more use of radar data?

This question offered the participant seven areas of research and development to rate from 'Extremely important' to 'No importance'. The overall findings can be seen in Figure 17 below.

Interestingly the three areas that would provide guidance and assurance in data quality scored highly. These were the CIWEM/WaPUG user guidance notes, development of quality data flags/indicators and evaluation studies.

Improved rain rate estimation and finer resolutions of data also scored highly which is a further link to peoples' desire to see greater network coverage and more confidence in the data provided.

Figure 17 Question 18 results

18. What areas of research and development do you think are needed for your organisation to make more use of radar data?

	Extremely important	Very important	Fairly important	Slightly important	No importance	Rating Average	Response Count
Improved rain rate estimation	31.8% (7)	**45.5% (10)**	22.7% (5)	0.0% (0)	0.0% (0)	1.00	22
Evaluation studies	15.8% (3)	**36.8% (7)**	31.6% (6)	15.8% (3)	0.0% (0)	1.00	19
CIWEM/WaPUG user guidance notes	**30.0% (6)**	15.0% (3)	**30.0% (6)**	25.0% (5)	0.0% (0)	1.00	20
Development of quality data flags/indicators	33.3% (7)	**38.1% (8)**	23.8% (5)	4.8% (1)	0.0% (0)	1.00	21
Improvement in hydraulic / hydrological models	4.8% (1)	19.0% (4)	**57.1% (12)**	9.5% (2)	9.5% (2)	1.00	21
Finer resolutions <1km2	**38.1% (8)**	23.8% (5)	19.0% (4)	9.5% (2)	9.5% (2)	1.00	21
Training	22.2% (4)	**38.9% (7)**	27.8% (5)	11.1% (2)	0.0% (0)	1.00	18
					Other (please specify)		0
					answered question		**23**
					skipped question		**12**

7. Training and future interest

7.1 Question 19 - Would you be interested in future training courses on the use of weather radar within the water industry?

Training was scored as a 'Very important' area of research and development in question 18. This is confirmed by the result from this question which found that 17 (77%) of the responses said that they would be interested in future training courses.

Those that answered 'Yes' were then asked to specify the type of course content they would be interested in. The thirteen responses request a similar theme to future training. It appears that a general overview/awareness of how radar actually works and the products available to the end user is required. An understanding of how data quality is affected by various meteorological conditions relates back to the work on quality data flags/indicators and so this could form a separate training course. The final area relates to the practical use of radar data in sewerage modelling which could potentially be covered by future evaluation studies and an update of the current WaPUG user note 39 – Use of rainfall data from radar.

Figure 18 Question 19 results

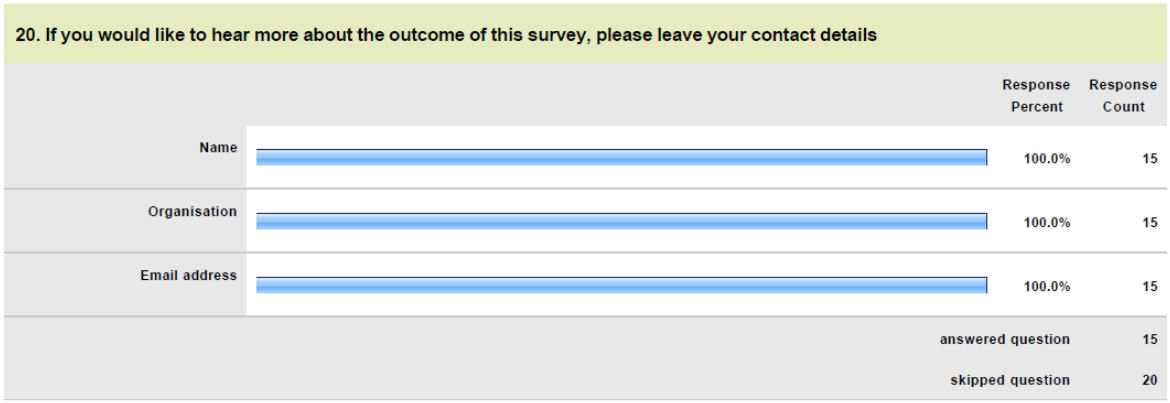
19. Would you be interested in future training courses on the use of weather radar within the water industry?

	Response Percent	Response Count
Yes	77.3%	17
No	22.7%	5
If yes, please specify the type of course content you would be interested to learn more about.		13
answered question		22
skipped question		13

7.2 Question 20 - If you would like to hear more about the outcome of this survey, please leave your contact details?

The survey was completed by 35 people of which 15 decided to leave contact details so that they could hear more about the outcome of this survey. The survey results and a link to the Eighth session report from the IACHUWR will be sent to all those who have expressed a wish to be contacted.

Figure 19 Question 20 results



20. If you would like to hear more about the outcome of this survey, please leave your contact details

	Response Percent	Response Count
Name	100.0%	15
Organisation	100.0%	15
Email address	100.0%	15
answered question		15
skipped question		20

8. Survey Conclusions

The overall response to the questionnaire was low, but there are relatively few users of radar data within the water industry and so the number of participants is perhaps not too surprising. The questions relating to organisational background show that there was at least one response from each of the main geographical regions of the UK. This indicates that the awareness and use of radar products is not just concentrated in a few regions and there is a reasonable spread across the country.

The survey shows that the largest use of radar data is in the field of Hydraulic / Hydrological modelling investigating past rainfall and flooding events. As expected, flood warning is a significant activity and the Flood Forecast Centre Guidance Statements and Hazard Manager provide much of this information. The response rate for Continuous model calibration and network optimisation is a good indication that the industry is moving towards continuous model simulations using a combination of radar actuals and forecast data. Numerical Weather Prediction and Radar forecast were only rated as 'Fairly Important' by those that responded to the survey. This reflects the fact that this data is only just starting to be used in small development/pilot studies and the full benefits and wider uses have not been determined yet. As this field develops and usage increases, a greater understanding will be developed and the importance of these data sets to the industry will increase.

At the moment radar actuals are the most widely used of the products available. The UK Meteorological Office is the primary supplier of data with a few responses stating that they obtain their data from the MeteoGroup.

Question 6 demonstrated that unlike modelling software, there is no industry standard viewing/analysis/database system available to water industry users that could provide a link into the current modelling packages. Many users have developed their own bespoke software packages and data manipulation techniques using Microsoft Excel and GIS mapping packages. This prevents a uniform and consistent approach to using radar data from being adopted. It also makes it difficult for new users to enter the market as although the data is readily available, people are not aware of the best software products on the market with which to collect, store and analyse the data. There is probably a need for the committee to summarise the various packages available such as Hyrad and communicate the salient features that would benefit water industry users. This would aid their future investment decisions for those wishing to invest in radar products.

The large majority of responses felt that the provision of radar data only partly met their requirements. From the comments people entered it is clear that many of the concerns are related to country wide coverage particularly in Wales and Orkney & Shetland. However, the underlying theme in the comments relates to accuracy. Some suggesting that this

deteriorates when there are significant events and others wanting ‘some kind of confidence grading’ for the data. At the time of the survey the people responding to this question would have been unaware of the huge work being undertaken on the UK radar network as detailed in section 4.2 and on the development of quality indicators/quantified errors in section 4.3 of the Eighth session report. Hopefully this will go a long way to addressing these concerns, but this message must be clearly communicated to the Water Industry users to improve confidence.

One such way of improving confidence in the accuracy of the data would be to demonstrate the improvements through evaluation studies and to provide a common guidance note on how to interpret and use the radar products currently available. This is further highlighted by question 16, (what limits the use of radar data within your organisation?) The fact that the development of hydraulic or hydrological models is a limiting factor in the use of radar data is interesting. This is probably due to the fact that there is very little in the way of industry guidance past evaluation studies and an up to date CIWEM / WaPUG user note that the modeller can follow and be audited against. The modeller will understandably revert back to standard industry practise and use raingauge data when uncertain on how to use radar data. Radar data tends to be used as a ‘check’ to support work rather than be the benchmark with which to develop network models. This is probably an area where the Committee could encourage CIWEM (WaPUG) members to update the current radar User note, (User note 39 – Use of rainfall data from radar) and offer more evaluation studies that can be used as industry best practice and good examples to follow.

Only when confidence has been increased and there are clear benefits that the water industry can rely upon, will radar data become more widely adopted and used by within the water industry.