Session 5 – Paper 18

Prioritising sewer flooding incident reduction using a risk based approach

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Background

Prior to 2015 there was a requirement for all sewerage companies to maintain a register of properties/areas which had reported flooding due to capacity overloading of the public sewerage system during heavy rainfall. This was known as the DG5 register.

The reporting requirements for the DG5 register were set out in annual reporting criteria but the principal aim of the register was to record properties that had reported flooded from sewers and so will continue to be at risk of sewer flooding until the underlying capacity deficiencies are resolved. There were separate registers for internal and external flooding with each register split showing to the risk of flooding twice in ten years (2:10) and once in ten years (1:10). From 2005 an additional category was added to record risk of once in twenty years (1:20). Properties that flooded due to severe weather in excess of a once in twenty year return period were also recorded by the water companies but these were not reportable.

When it came to investment, this was targeted at reducing the number of entries on each flooding register (i.e. a 'net reduction' taking into account discovery of new problems and removals due to capacity upgrades) and/or a target to remove a specific number of properties from the register. Companies targeted investment to remove properties from the registers principally based on a unit cost per problem but this often varied depending on area affected, register type and mix of problems.

Since privatisation all companies made a big reduction in reducing the legacy of problems on the DG5 registers with advances in sewerage planning and hydraulic modelling helping to better understand sewer capacity. In the Severn Trent region the last three investment periods alleviated flood risk to around 3,400 properties plus associated external areas. However what we were left with was a greater number of complex high cost solutions which were continuing to have issues to our customers.

Challenges

Whilst the DG5 register had made a big improvement in alleviating flood risk there were a few challenges which Severn Trent were looking to address as we developed our AMP6 plan covering 2015-2020:

- The register was only based on historic reported incidents which could be verified as set out in regulatory reporting requirements.
- The 2:10, 1:10 and 1:20 register categories were based on frequency between reported incidents not rainfall intensity or return period probability.

- The risk reduction benefits of installing property level protection or mitigation measures (e.g. flood gates and non-return valves) were discounted even though they may be successfully managing incident risk.
- Incident severity was only categorised by affected area, split simply into internal and external flooding.
- External flooding comprised of all areas, irrespective of flooding to curtilages, highways, open spaces or fields.

As part of our AMP6 plans we decided to review our approach to prioritising sewer flooding investment by moving to a risk based approach. This was supported by the 2011 UKWIR study entitled “A Risk Based Approach to Flooding (11/WM/17/2)” which sought to develop a better means of setting priorities for investment to alleviate the risk of sewer flooding caused by hydraulic overloading.

The principles of our Risk Based Approach

One of the main constraints with the DG5 register was all incidents being deemed to have the same severity, with the only distinction being whether the incident was internal or external. To try to address this, back in 2003 Severn Trent made internal enhancements to the DG5 register to start recording further details about each register entry by recording details relating to the area affected, the impact on customers and flooding likelihood to support DG5 investment prioritisation. Through the use of customer research derived weighting factors this additional information help prioritisation using a prioritisation score, known as a “P Score”. This score was calculated for every entry on the DG5 register, albeit was not part of the regulatory reporting submission. Although DG5 investment was still based on a unit cost approach the use of the “P Score” enabled DG5 investment to be prioritised more effectively using a simplified cost benefit approach. In effect the use of the “P Score” a predecessor to the Risk Based Approach eventually adopted in our PR14 Plan.

With the regulatory framework for 2015-2020 moving to ODI incident based performance measures the requirement to maintain a DG5 register was no longer needed. It was therefore left to each water company to decide how they wanted to prioritise sewer flooding investment and so the transition from “P Score” to “Risk Based Approach” was ideal timing to reduce incident risk and optimise customer benefit.

The new approach was built on the principles of a risk triangle as set out below, whereby incident risks which pose greater impact on customers could be prioritised over lesser flood risks, but more importantly allowed funding allocations to vary depending on risk.

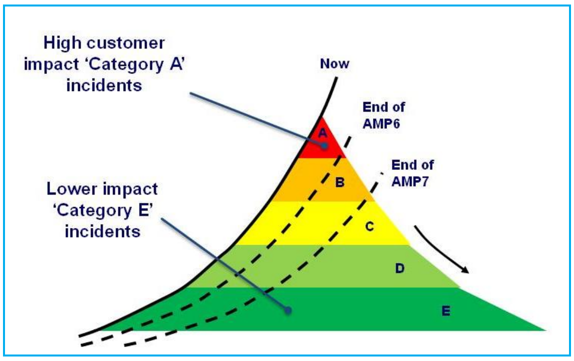

Figure 1: The AMP6 Risk Based Triangle

A scale of five severity bands were created (one set for internal and one for external risks) whereby Internal Category A incidents include basement flooding which results in a property being uninhabitable whilst plaster and brickwork dries out, whereas at the other end of the scale minor flooding to an attached garage which causes negligible damage would be an Internal Category E incidents. For external incidents External Category A would be where the depth/extent of flood water restricts access/egress from a property, with External Category E's being minor flooding to a highway. In terms of risk this approach allows the rarer yet severe incidents to be balanced against the more frequent less severe incidents.

Another key change was to incorporate the success (or failure!) of property level protection (PLP) or mitigation measures which can reduce flood risk. This was not part of the original "P Score" calculation principally because the DG5 register criteria excluded PLP benefits. As we moved to a risk based approach targeted at incident reduction it was vital that the benefits of using PLP were taken into account to ensure risks which could not be managed through use of PLP (and so left customers at incident risk) were given give more priority over risks that PLP could manage. However the approach also needed to factor in that there are different types of PLP, some of which intercept overland flood paths and required external intervention (and so leave a residual risk) whilst others were more automatic passive measures.

To inform the PLP risk reduction benefit a residual matrix was developed. This considered the type of mitigation installed and its likely effectiveness at managing the level of risk identified through the risk based triangle. For example using a flood gate to manage an Internal Category A risk was considered less resilient than installing a non-return value to manage this high consequence impact due to flood gates potentially being left open. However a flood gate failure would be less impactful if failure resulted in an External Category E incident. The residual risk matrix adjusts the risk score to balance likelihood of mitigation measure failure and the risk it was managing.

The final change was to how the underlying incident likelihood was calculated. The former DG5 register relied on verified historic incidents and where customers told us they had previously suffered reporting these incidents were not considered as part of the DG5 approach. For AMP6 we used all available information, whether it be gleaned from operational incident response, customer correspondence or information from other flood risk stakeholders. The principle purpose being to prioritise risk which could then be validated using detailed Type III modelling prior to committing investment improvements. The risk register was therefore amended to allow all incidents to be recorded, not just those which met the verified incident criteria.

Using a Common Risk Currency

For AMP6 the DG5 categories for hydraulic flood risk were replaced with a unit of measure known as an 'Equivalent Flooding Index' or 'EFI'. An EFI is intended to take account of incident risk by evaluating the potential severity of a flooding incident, its likelihood and the potential effectiveness of any mitigation. For example, a property at risk of an 'average' flooding incident once every year would have an EFI value of 1, because it is at risk of 1 average incident per year. If the same property were at risk of two incidents per year it would have an EFI of 2 (i.e. equivalent to 2 average incidents per year) or if the severity was 3 times worse than an average incident every year then the EFI would be 3 (i.e. equivalent to 3 average incidents per year). By assessing all risks using this structured approach it is possible to prioritise investment based on a risk based approach. Adjustments are also made to take account of whether mitigation is installed and therefore expected to reduce incident frequency.

This approach allocates funding based on level of annual risk as per the risk based triangle (see above); whereby the more severe problems get more funding, less severe problems get less funding. Unlike in AMP5 where all DG5 internal and external incidents were deemed to have the same customer impact, the AMP6 risk based approach splits incident severity into 10 severity categories; internal A to E and external A to E. Category ‘C’ incidents are considered to be to have an ‘average’ impact with severe ‘A’ incidents having a higher weighting and ‘E’ incidents a lower weighting.

The level of EFI weighting applied to each category is derived from relative weightings based on previous customer research which considered affected area and impact on customer. The calculation of EFI is based as follows:

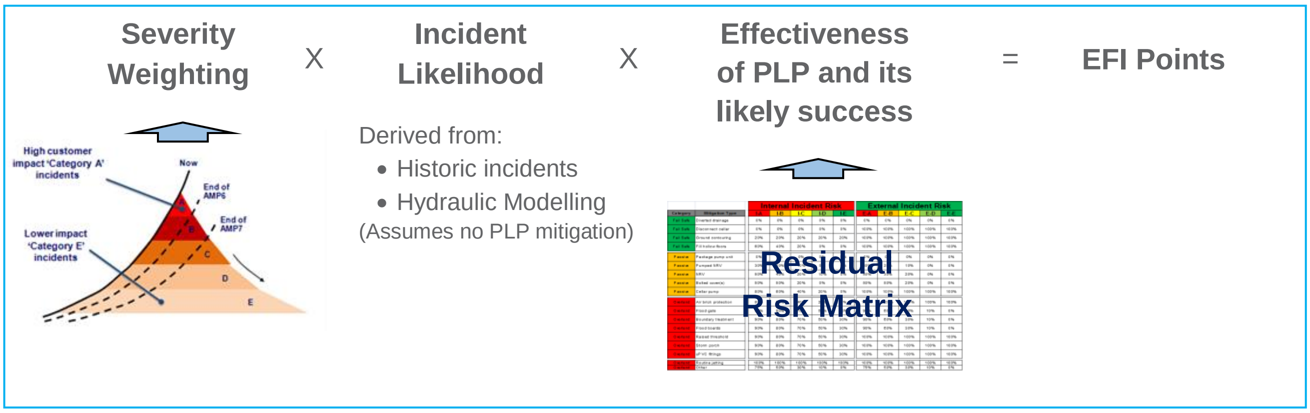

Figure 2: Summary of Equivalent Flooding Index (EFI) Calculation

EFI Points are calculated at an individual risk level and then collated together at a project level. A unit cost per EFI point is then applied based on our PR14 customer willingness to pay. This gives a notional affordability value for each project risk and allows risks to be prioritised.

<u>The Hydraulic Flood Risk Register</u>

All risks on the old DG5 register were transferred over to the Hydraulic Flood Risk Register (HFRR), with the old ‘P Scores’ used to translate historic incidents into the new A-E risk categories. The HFRR was developed on an Excel spreadsheet with Visual Basic functionality. This allowed easy development of enhancements and report development with the long term aim being to develop a corporate IT system once embedded.

Each location known to be at risk has its own individual entry with a dashboard showing the areas at risk, details of historic incidents with a timeline, whether the risk is mitigated and if so what measures are installed and when were they installed, together with details of project and what the detailed hydraulic model indicates in terms of risk (see Figure 3). This information is then used to calculate the EFI score for that individual risk, together with an ODI incident risk score (i.e. the EFI score without the incident severity weightings). These individual risks are then collated at a project/ risk level to allow risks to be prioritised.

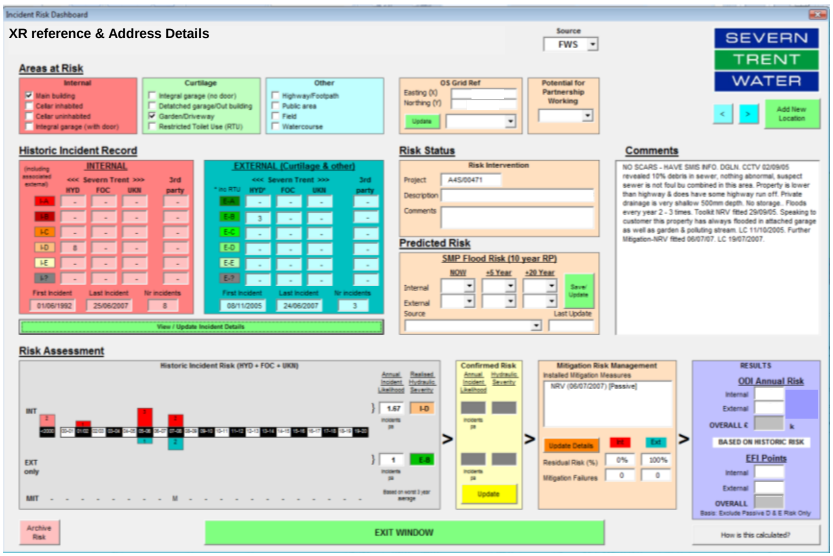

Figure 3: Screenshot from Hydraulic Flooding Risk Register (HFRR) – Risk Dashboard

Implementation of the HFRR in AMP6

Following development in AMP5 the risk based approach was used to support the development of the PR14 plan with the HFRR launched in 2014-15 as the risk management system used to manage the AMP6 hydraulic flooding investment programme. It is now one of four core risk systems, along with the Drinking Water Safety Plan (DWSP), the Operational Risk Management system (ORM/ST-ORM), all of which feed up into STW's Enterprise Risk Management system (ERM).

Through use of the HFRR it is possible for all risks to be ranked and prioritised along a risk curve. Our AMP6 strategy to managing Hydraulic Flooding risk is shown in Figure 4 and involves complex investment delivering capacity improvements for 'high' risks, further investigation to understand 'medium' risks, and to rely on PLP measures for properties at lower risks of flooding.

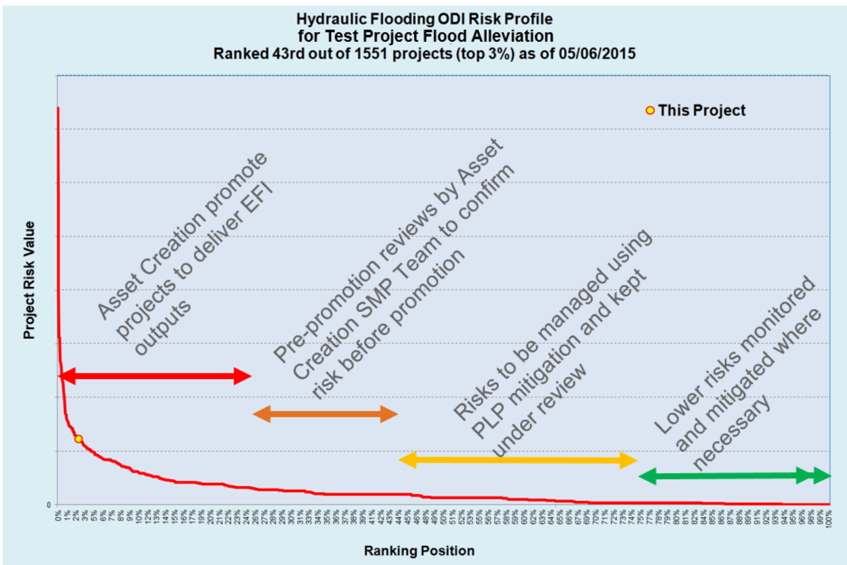

Figure 4: Interventions based on risk level

A number of processes feed into and out of the HFRR, and need to run smoothly for the system to function effectively. These are described in more detail below:

1. Operational reactive incidents standard procedures include an assessment of whether a flooding incident is due to hydraulic or 'other causes'. Back office checks to validate flooding incidents identified as hydraulic include a review of existing HFRR records, rainfall at the

time of the incident, post-incident CCTV and sometimes post-incident questionnaires or interviews with customers and results in a validated hydraulic incident with an assessed severity level.

2. Regular extracts (monthly) of hydraulic incident flooding records are pulled through into the HFRR, along with key data such as the assessed incident severity. This results either in new properties added to the HFRR, or new incidents at existing properties. The risk level is then automatically recalculated both at property level, and at groups of properties considered for capital projects (called ‘grouping reference’).
3. Snapshots of the HFRR are extracted monthly, with details from ongoing capital projects populated including contact names and delivery dates from SAP (used to manage the capital programme). This is published in list and GIS form, so Engineering, Operational and Asset Management teams all have visibility of which risks have interventions planned and when they are due. An example is shown below in Figure 5.

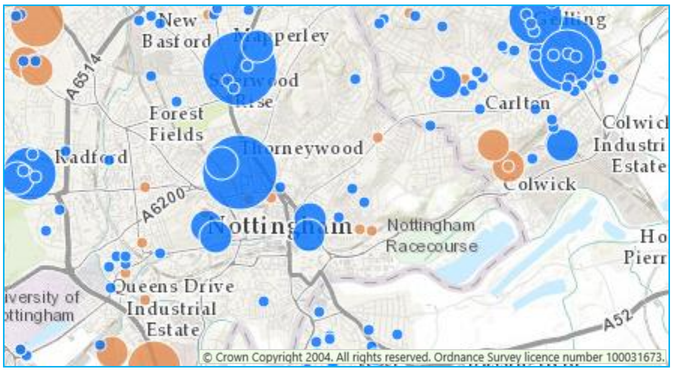

Figure 5 – HFRR – Map Output

4. The HFRR snapshot is used to drive the PLP programme as the HFRR keeps a record of which properties have had PLP measures fitted (resulting in a reduction in the risk level as described above). A record is also kept where PLP has been assessed as ‘not feasible’ and so may impact of our AMP6 Performance Commitments to reduce the number of both internal and external flooding incidents. The reduce the number of repeat hydraulic flooding incidents, the PLP was accelerated in AMP6 and it is expected that all cost-effective properties will have PLP either installed, or assessed as ‘not feasible’ by the end of March 2019.
5. As part of the publishing process (#3 above), any grouping ref risks (groups of properties) that exceed a defined threshold trigger a further investigation in the form of a ‘Pre-Promotion Procedure’ or PPP. The threshold is set such that the volume of PPP and consequence Capital Projects, sustain the value of work required by the AMP6 Sewer Flooding Programme.
6. Completion of a PPP involves a detailed review of a flooding issue, by the Sewerage Management Plan (SMP) Consultant for the catchment, which includes:
   a. A review of the existing hydraulic model.
   b. Confirmation of the zone of interest, including LIDAR and other historic incidents.
   c. A site visit to appreciate the local area and potential flood mechanisms, and sometimes includes targeted customer interviews
   d. Evaluation of potential operational issues such as low self-cleansing velocities, structural issues and FOG history.
   e. From the resulting investigations, targeted customer questionnaires are issued to confirm potential under reporting.
   f. An evaluation is made where PLP solutions may help reduce risk in the short term as well as other sources of flooding and opportunities to partner with other stakeholders.
   g. A final review with internal stakeholders prior to a capital project being initiated or PLP being commissioned where appropriate.

7. Where a capital project is initiated, further surveys and development and verification/validation of the Type III Hydraulic Model results in a greater understanding of the frequency and severity of the flood risk to customers. This is fed back into the HFRR at key project milestones, resulting in a revised risk score which can be used to inform investment priorities. The Affordability value is used to set the target price for batches of projects (note the affordability is set without reference to a solution).
8. Following 3 years of HFRR use, the operational, PPP and Capital Intervention processes are well established and stable. This has allowed the development focus to shift to the generation of standardised Management Information and targeted improvements to the completeness and accuracy of specific data fields.

Benefits and Successes

The use of Affordability based on the monetised sum of internal and external EFI values is a lead, rather than lag measure. Consistent severity bandings, and regular updates of incidents from operational reactive incidents as well as the mitigation effects of PLP and capacity interventions all the total risk value to be monitored over time (Figure 6).

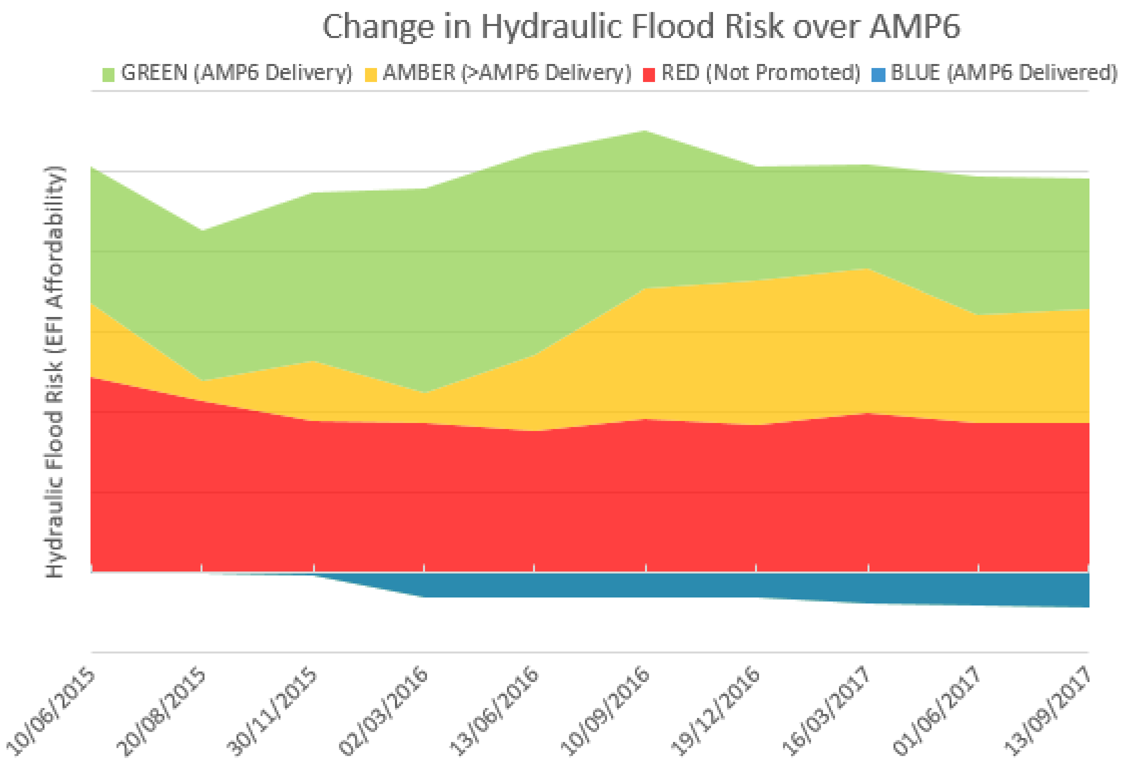

Figure 6: Trend of Hydraulic Flood Risk Over AMP6

This does not correlate directly with a reduction in hydraulic incidents due to the variations in rainfall location, frequency, intensity and spatial distribution, but it does allow a consistent measurement. In the case of Severn Trent, the overall risk level has remained broadly stable over AMP6, despite investment removing risk (BLUE). The current forecast is that Severn Trent's hydraulic risk level will be reduced by ~35% at the end of AMP6 compared to the start (GREEN). This is a high level summary that can be shared with senior management to articulate whether investment levels to resolve Hydraulic Flooding issues are sufficient to achieve the desired reductions.

The number of new hydraulic flooding incidents over AMP6 has been relatively low and the largely stable position from the HFRR is as a result of additional properties and incidents identified through

PPP and capacity investigations which may not have been reported at the time of the incident. For example, a village in Staffordshire experiences sewer flooding to the high street, with photos in local newspapers, but no incidents have been reported to Severn Trent – it is thought due to fear of increased insurance premiums. A PPP is currently ongoing which is likely to result in initiation of investment to improve capacity. This is an example of the partial move the current process is making towards a truly proactive approach.

A number of the core business processes feeding into and out of the HFRR are functioning well, and are achieving their objectives of maintaining a populated and prioritised PLP and capacity investment programmes. This leads to the feeling that the system 'runs itself' and that the focus can now move to optimisation and enhancement of the HFRR in preparation for PR19 and AMP7.

There are some common data changes that result from PPP investigations, for example correction of property x-y coordinates. This was identified and company wide analysis undertaken to ensure x-y data in the HFRR matched property address coordinates within an allowable tolerance. The follow-on from this is ongoing, where properties and their associated grouping references are compared to the risk zone polygon which has been a standard output from SMP activity since AMP5. These changes contribute to greater data integrity and increase the accuracy of risk prioritisation within the HFRR, and reduce error corrections and inefficiency in the following PPP and capacity investment processes.

The five bands of A-E severity are simple to explain and understand, and have incorporated and accepted by both Operational and Engineering colleagues as a common language. This gives the Asset Management team confidence that the AMP6 change to a risk based approach is secure. Some borderline cases have been posted to company discussion forums and have generated interesting and collaborative debate. Such examples have been collated to form a library of worked examples to help improve the consistently of future severity assessments.

The current EFI and Affordability values derived from this have been structured so they can be adjusted without affecting the existing well established definitions. This will allow them to be adjusted to align with the results of willingness to pay results conducted for AMP7 via PR19 work. Such changes can be easily implemented and the HFRR will automatically recalculate the risk level at property, grouping ref and company wide level.

<u>Improvements Identified & Proposed Future Developments</u>

As part of continual improvement the following enhancements are being developed:

1. Improvements to PPP process to ensure risks are grouped appropriately
2. Use of rainfall data to understand risks and support intervention effectiveness.
3. Development of HFRR to include predictive risk based on 'Source > Pathway > Receptor' to validate risks.

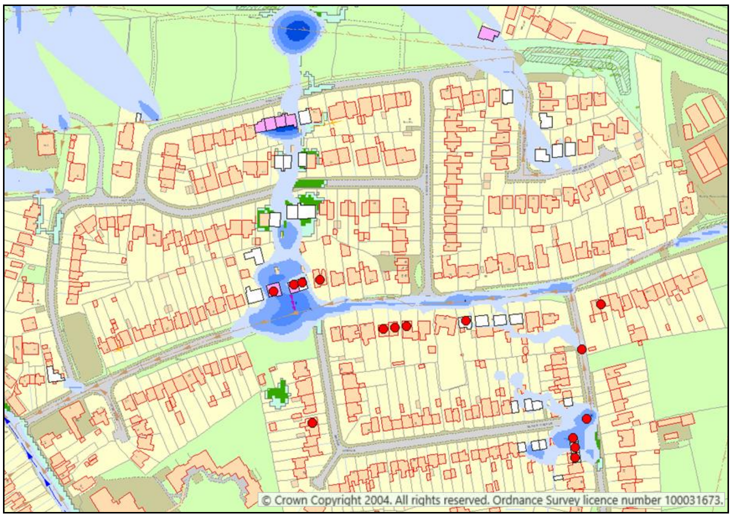

Figure 7: Example of predicted risk of sewer flooding. Red dots indicate properties that have experienced flooding on the HFRR and the blue areas are the extent and depths of predicted flooding from sewer.

4. Development of HFRR to include future risks to align with our existing Sewerage Management Planning approach of using the current model horizon plus future five and twenty-five year look ahead horizons. This also aligns with the 21st Century Drainage Capacity Workstream
5. Identification of locations where 'Complex Mitigation' may be needed.

Conclusions

Severn Trent has successfully moved in AMP6 to a risk-based approach in line with recommendations from UKWIR report 11/WM/17/2 to prioritise interventions to reduce the risk of Hydraulic Sewer Flooding to customers. Having a simple approach with five severity bands A-E is easily understood and by embedding it into Operational and Engineering standard processes Severn Trent has ensured consistent adoption and implementation across the company.

The use of an Equivalent Flooding Index (EFI) to combine the effect of A-E Internal and External incidents, and monetising the EFI to a single 'Affordability' value has enabled simple ranking and prioritisation, as well as making it easy to communicate the relative flood risk of a problem to many internal stakeholders.

A number of developments in the first half of AMP6 have resulted in defined triggers, processes and outputs which ensure the investment programme is sufficiently populated, with confidence that as new risks emerge they will be incorporated and prioritised appropriately.

We are now moving the development focus for the Hydraulic Flooding Risk Register (HFRR) into targeted improvements to address weak areas of both data and process, while continuing to test the additional of a predictive component ready for AMP7 and beyond.