When is a DMA not a DMA?

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Abstract

How many times do we think that we have considered all the dependencies necessary to demonstrate to various regulatory bodies that all our data is validated and proved to be correct only to find that a reported burst main does not appear to manifest on the Daily Measured Flow (DMF) or even worse, that the burst when repaired does not significantly reduce or impact on Minimum Night Flow (MNF).

This paper aims at making engineers think of "When is a DMA not a DMA" and the associated improvements that should be considered in an attempt to demonstrate that 100% of all DMFs into an area are captured effectively and more importantly if the MNF does not reduce after a burst has been repaired within a District Metered Area (DMA) then what maybe the cause.

Introduction

Modern leakage detection strategies are based around the need for the capture of accurately derived infrastructure data sets. To most water companies concise information on network performance is essential in the effective management of leakage detection activity and repair functions, which directly impacts upon the company's annual Operational Performance Assessment (OPA) score and subsequent regulatory standing.

Several instances have already been gathered from various countries around the world where a DMA is reported as such and yet burst water mains have been repaired and not had any effect to the incoming flow data at the time of repair or the MNF.

Water companies should not continue to promote and report their losses without some form of verification process that recorded DMFs are correct.

Under current mechanisms, high night time flows are identified from metered flows by the register of the intervention or trigger level. Leakage detection is then mobilised in order to establish where the losses occur and subsequent repairs completed, often without any apparent significant improvement in MNF characteristics.

This paper explores a significant component part in the effective measurement of network performance from metered flow data captured within the field and how this may be interpreted in order to identify the robustness of leakage strategy.

Principles of a DMA

As mentioned the key principle behind DMA management is the use of flow to determine the level of leakage within a defined area of the water network. The establishment of DMAs will enable the current levels of leakage to be determined and to consequently prioritise the leakage location activities. By monitoring flows in the DMAs it will be possible to identify the presence of new bursts so that leakage can be maintained at the optimum level. Leakage is dynamic and whilst initially significant reductions can be made, levels over a period of time will tend to rise unless on-going leakage control is carried out. DMA management should therefore be considered as a method to reduce and subsequently maintain a low leakage level in a water distribution network.

The key to DMA management is the correct analysis of the flow to determine whether there is excess leakage and identify the presence of new leaks.

The extent of leakage can be gauged by assessing the 24-hour flow pattern of a network. A limited variation between the minimum and peak flow, particularly in a network with little industrial night use, is indicative of a leaky network. However this approach does not allow the leakage level to be directly quantified.

Leakage is most accurately determined when the customer consumption is a minimum, which normally occurs at night. This is the principle of minimum night flow originally recommended in the UK document Report 26 (1980).

Figure 1.1 shows the typical variation of minimum night flow in a valid and proven DMA in which there is little seasonal variation in night consumption and all flows are measure accurately. In this instance the presence of reported and unreported bursts can be identified and results of the savings made can be measured after any leakage have been repaired

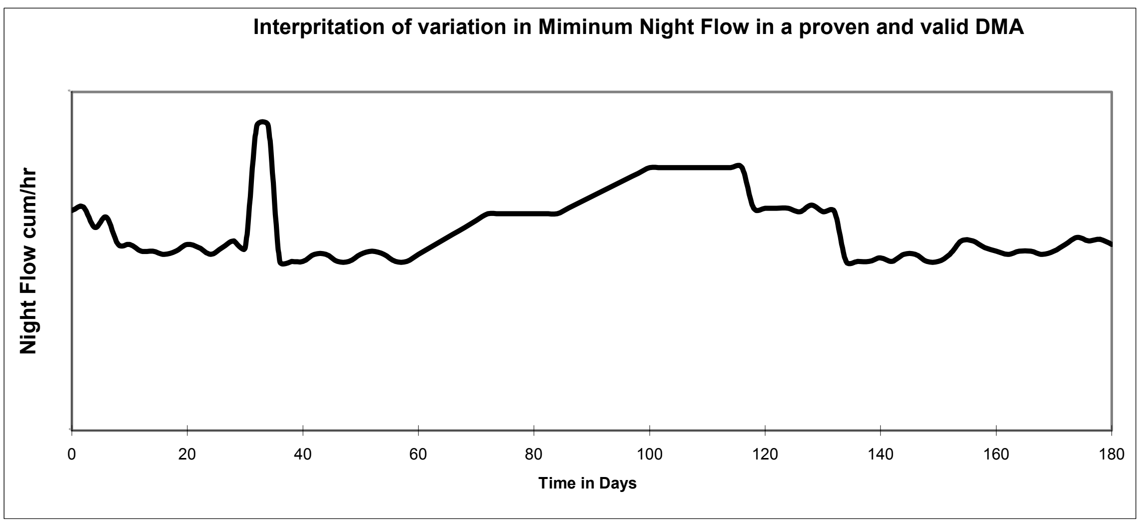


Figure 1.1 Variation in minimum night flow over time

DMA Verification

After the design of the DMA boundaries, trial closure of the valves should be undertaken to verify their efficiency and identify those valves which need to be replaced. The importance of tight boundaries should not be underestimated, as one inefficient valve can compromise the leakage estimate of two DMAs. In fact, an important reason for locating a boundary valve as close as possible to the natural hydraulic balance point is to limit the pressure drop, and hence any flow, across the valve. Once the efficiency of the valves has been verified, they should be closed and the pressure inside each DMA monitored to ensure that the operational pressure is as designed.

Once the DMA has been created, a zero pressure test should be carried out.

Historically this can be completed in various ways, two of which are mentioned below.

Method 1

A brief procedure for a pressure zero test is as follows:

1. Indicate boundary valves by marking valve covers (e.g. often by painting the valve cover).
2. Set up pressure loggers or gauges at key locations throughout the DMA.
3. Close the DMA inlet to isolate the DMA.
4. Monitor pressure

This method is initiated by isolating the in-coming flow into a given area with all identified BVs in the closed position whilst monitoring the reduction in pressure at the highest elevated point in order to establish if this pressure falls to zero, thus indicating that no other inflows into the area are apparent.

However, in attempting to PZT the whole DMA and achieving a zero pressure this can also be misleading due to the following reasons:

- A previously unidentified significant loss may be occurring within the area that is sufficiently large enough to be consuming the incoming water at a lower elevation from an unknown connection hence an imitation ZPT occurs.
  Or
- The legitimate night time use from commercial and domestic properties is comparable to that of the unknown connection, which consumes the incoming water.

Method 2

This method is where the BVs are individually tested to achieve a local PZT where the mains into a diminutive area are independently isolated and to achieve a zero pressure reduction.

The test is carried out on a shorter pipe length to substantiate that the BV is watertight and thus will not allow any water to pass through into the adjoining DMA. This method is often considered as the preferred option for DMAs which have a history of poor water quality or where iron deposits are prevalent and subject to impact directly by any changes in flow or pressure. So in assessing each identified BV it is considered sufficient to say that the DMA has been proven.

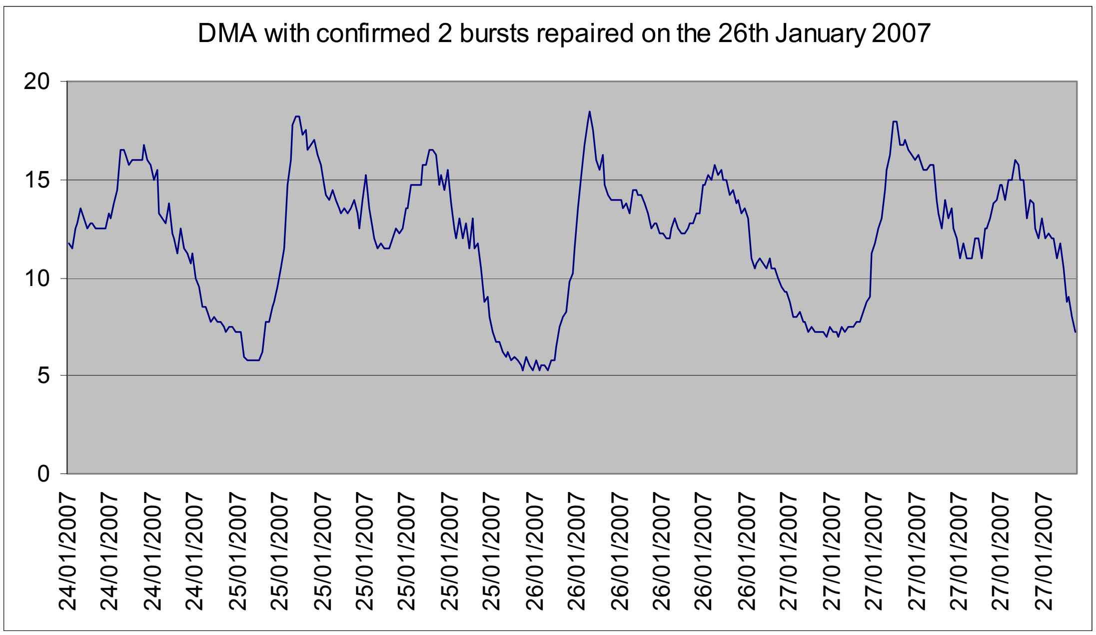
The problem with this method is that only known BVs are tested, what happens to those connections that have not effectively been captured on record drawings or situated within private sites?

These continue to supply water into the area, which is not captured through the flow meter provisions and subsequently presenting false or misleading data to the end user inevitably wasting valuable survey resource time and unsuccessful loss abatement or that any leaks that are identified and repaired cannot be measured with the anticipated savings realised.

World Case Studies

Several countries have supplied data from DMAs that did not reduce in flow upon the completion of confirmed repairs.

The following data sets are representative of these areas.

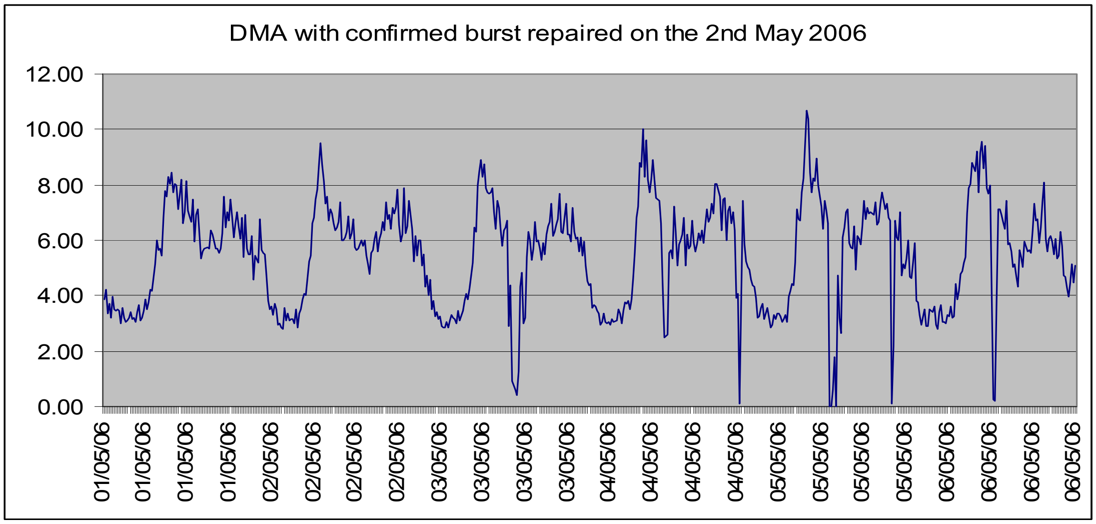


Graph 1.1 – 2 Bursts repaired 16/01/2007

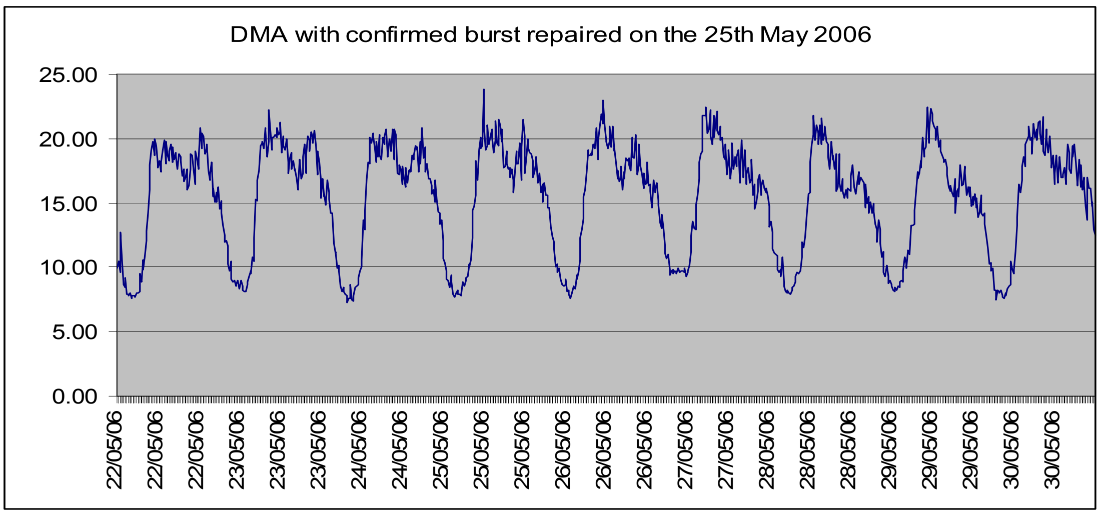
It was confirmed that during the day of the 26th January 2007 two burst water mains were repaired. One of these was confirmed as a 6" PVC water main that had a split along the pipe wall and a section had to be removed to complete the repair.

The second was a confirmed circumferential fracture on a 4" cast iron main that also required the pipe section to be isolated whilst the repair clamp was fitted. Both isolations were completed during the working day. Upon examining the flow data it is evident that no reduction in flow is captured during the isolation periods and that the MNF on the morning of the 27th had in fact increased by some 2 litres per second whilst the daytime flow remains largely unchanged.

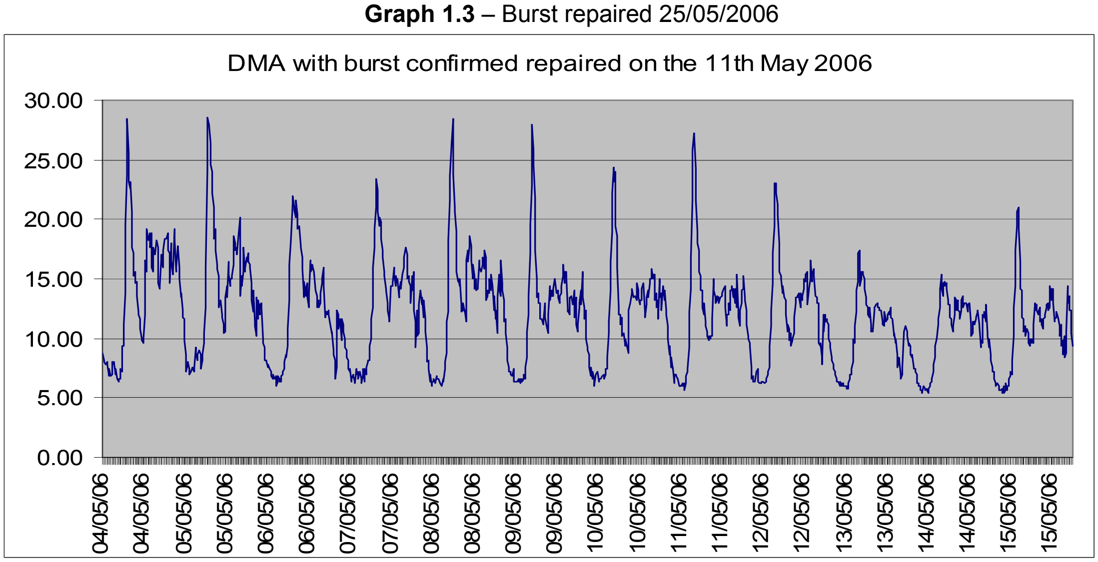
This DMA is considered as being "proven" and is being reported upon as legitimate by the water company in their annual "bottom up" water balance calculation.



Graph 1.2 – Burst repaired on 02/05/2006



Graph 1.3 – Burst repaired 25/05/2006



Graph 1.4 – Burst repaired 11/05/2006

Note the daytime peak flow actually increases during the weekdays Mon – Fri (no industrial usage in this DMA)

On the above graphs flow changes remain relatively unaffected during the period of repair with any anticipated reduction in MNFs not reflected.

In a recent meeting with one water company it was stated that in over 40% of DMAs subject to recent mains repair recorded no apparent reduction in day or night time flows was achieved and yet these DMAs are routinely being reported.

Incidentally, the purpose for intervention was not excessive MNL but that the water company strategy incorporated the survey of all areas annually.

It is recognised that the reduction is however reflected within distribution input and captured within the "top down" water balance calculation.

Photo 1.1 – Typical example of an unknown connection

Photo 1.1 shows an unknown boundary valve that was located after many months of investigation work after continuous problems with pressure management, the DMA was depicted as proven within GIS plans and all known boundary valves closed. The area was supposed to be supplied by two PRVs and the flow measured through a singular bulk meter.

Extract from email No 1 reference photo 1.1

"On the GIS it showed 2 closed valves on the boundary of the zone to make this a discreet DMA.

When the PRV entering the zone was logged it was found that the PRV downstream pressure at night is higher than in the day. This suggested that pressure is entering into the zone at night pushing back against the PRV.

Unfortunately the meter for the zone was not working at the time of logging the PRV and it was requested that the council should replace the meter. After two attempts from the council to replace the meter it was finally installed. The field guys told me that one thing that was strange that the meter was turning forward when the PRV was totally closed during this exercise and when no water should have been entering the zone.

After further investigation and excavations the consultant and the council found 2 T-pieces between the PRV and meter that was not shown on the drawings and that was covered with soil. This was obviously the reason why the meter did not stop while it was being replaced and water was continuously running during the meter change.

The council now has to decide to either meter those two valves or to close them.

The council also discovered that the 2 boundary valves that was showed as closed on the GIS – was in fact not closed.

Attached is a photo (photo1.1) of the 2 valves found between the PRV and the bulk meter".

As shown in the email, although the GIS plans show that the boundary valves are in the closed position they should be checked regardless. The flow into the area was being measured however the pressure was not being controlled by the PRV at night and the two unknown connections were allowing the area at minimum flow periods to receive an uncontrolled and unmanaged pressure.

Extract from email No 2

"It was found that after repairing unreported bursts, the night flow didn't reduce in some DMAs, but it did in others. Simple solution - in the DMAs with direct pumping at night, no-one thought to tell the guys at the pumping station to cut back on the rate of pumping after the bursts were repaired. So the system average pressure would simply have risen, to accommodate (by increased leakage and new bursts) the same amount of water being pumped in. This reinforces, to me at least, the importance of measuring not only inflows but also Average Zone Pressures when interpreting night flows in DMAs, and not only in pumped-systems".

An alternative method of checking if boundary valves are passing (inside or outside of the DMA) was identified from a special version of the 'N1' test software, where inlet pressure is reduced in steps, and the corresponding pairs of points for leakage (= inflow minus estimated night consumption) and Average Zone Night Pressure (AZNP) is analysed.

By calculating the effective area of each of the leakage values (as if it was one hole) on the Y-axis against AZNP on the X-axis, and fitting a straight line to the data, it is possible to identify if water is entering the DMA (this gives a negative intercept on the Y-axis). If you have an all-plastic system, and you see a large positive intercept on the Y-axis, it is likely that water is flowing out through a boundary valve (this was proved for sure in an N1 test in Florida which gave a low N1 value for an all-plastic system).

ALC project UK 2003

Evidence of the comments mentioned in ''email no 2'' are confirmed by the results taken from an ALC project completed within the UK during 2003. See figure 2.1 results from ALC project 2003. This ALC project was completed within an unusually large DMA (properties exceeded 20,000) known as a District Zone or Super DMA. Although the

MNF could not be significantly reduced after all identified leaks were repaired the AZNP within the area was increased by some 4 metres head.

Compliance Zone	All Areas	Name	
DMA		Date	
No of Properties		Sheet No	:

Distance Km	Mains Fittings	Property Fittings	Properties	MAINS	SERVICE	SUPPLY	F/H	S/V	S/C	MAINT.
0	0	0	0	212	445	236	160	100	603	0

Leakage rate start (l/s)	0
Leakage rate end (l/s)	0
Water Saved (l/s)	0
Total Cost of Survey	£
Cost of Repairs	£
Total hours	13635
Total noise logging hours	3220
Total hours Leak Detection	10415
Total leaks	1756
Props per leak	0.00
Man hours per leak	5.93
Fittings per man hour	0.00
Fittings per Leak	0.00
Kilometers per leak	0.00

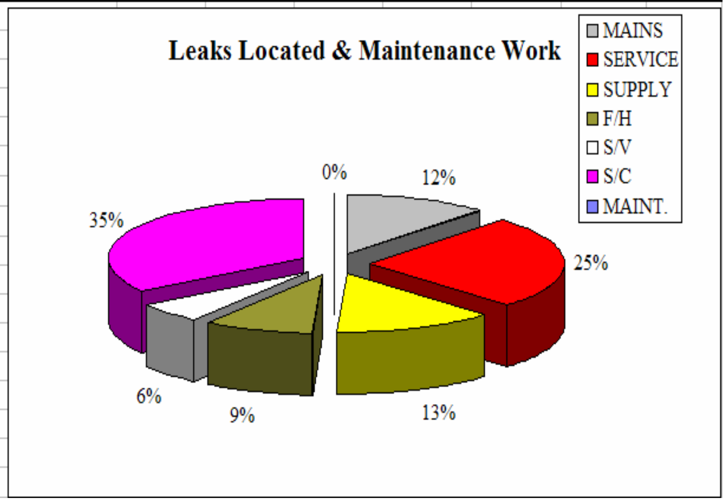


Figure2.1 Results from ALC project UK 2003

Solutions

As presented within this paper a proven DMA is not always a functional DMA, an assessment of previous repairs and comparable flow data sets should be routinely completed and a % confidence factor given for each when reporting losses.

For example a DMA with reported losses of 'X' is reported with a 90% confidence factor.

Some solutions of how to measure this are as follows:

As technology progresses engineering companies have developed a robust measurement process for capturing legitimate operational discharge from a standard standpipe facility by the incorporation of an electromagnetic flow meter situated within the design of the device.

By utilising this technology it can be proven that the DMA is in fact a DMA by the following principle:

A flow should be induced at a strategic point within the DMA similar to that of an average burst during the period of historic MNF in order to reduce the risk of potential water quality issues from increased velocities in excess of known day time flows.

The induced flow would be incrementally attained from the operation of a fire hydrant with the metered standpipe fitted and when achieved held for a minimum of 20 minutes before closure which for accountability reasons can also be logged.

This process should then be replicated at several points throughout a cross sectional area of the DMA and the data obtained checked to correspond with the incoming permanently installed meter flow. Any discrepancy or failure in the comparable data sets can then be assigned a weighted % confidence factor.

Example confidence factors:

Below 5% error = 100% confidence factor in DMA data

Between 5% - 10% error = 95% confidence factor In DMA data

Between 10% – 15% error = 90% confidence factor in DMA data

Between 15% – 20% error = 75% confidence factor in DMA data

Between 20% – 25% error = 60% confidence factor in DMA data

Between 25% – 30% error = 50% confidence factor in DMA data

The principle behind this is that if an unknown connection is apparent then flows will be incoming from this adjoining system and will not be comparably captured upon the permanent flow meter.

A further test should always be carried out as a matter of routine and should be used as evidence that the DMA is recording all known flows.

Each and every time a burst is completed within a water company then the flow data from within the DMA that this repair was carried should be examined to for the following.

Time of day mains turn off was initialised

Time of day main was returned to full pressure

Confirmation of type of repair completed

Estimation of flow from leak

Check against materials booked out the repair to confirm what was carried out

On all DMAs that are considered to be operational then a flow reduction must be seen during these operational procedures. On any DMA that does not show any reduction in flow during a turn off procedure for the repair of a burst then this should be deemed as “NOT a DMA”

Hence the title of this paper “When is a DMA not a DMA” = when recorded flows do not replicate a reduction in flow when certified repairs are completed regardless of the zero pressure test of the boundary valves be completed be it as individual valves or as a complete area.

Conclusions

- Engineers should not fall into a false sense of security that because all the Boundary Valves have been checked that a DMA is validated by this method alone.

- A flow should be induced into the DMA at strategic points and that this induced flow can be measured and quantified on the incoming water meter.

- A DMA should not only be reported with the Performance Indicator of choice but to match this with a % confidence factor that is an indicator the DMA is recording all flows correctly

- After each and every repair the flow data should be analysed so to prove that the reduction in flow has been measured and that the DMA can be reported as working to a satisfactory level for reporting purposes.

- Investigate a rule of thumb rough guide that acts as an immediate indicator where the Maximum Day Flow is divided by the Minimum Night Flow thus giving a ratio. This ratio could be used after investigating the parameters as an indicator of is the DMA is performing to a satisfactory level and within operational parameters.

- Pressure management should be monitored and in situ within all DMA's to prevent pressure increase from occurring thus feeding the bursts after mains leak repairs

- How this idea will work with cascading DMA's needs to be investigated

- The method of how software reports on level of leakage within companies may need to be investigated of how this information is gathered – does this report on data that was applicable when a DMA was **not** a DMA hence reporting on a level of leakage that is below or above that, that is genuine.

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