CIWEM Chartered Institution of Water and Environmental Management

Urban Drainage Group

EVENT DURATION MONITORING

GOOD PRACTICE GUIDE

Developed specifically for use in England and Wales to address the need in those countries, others may find the information of interest and of use.

Version 2.2: January 2016

Revision History

Version	Issued	Status	Reasons for revision	Revised by
1a	*June 2013*		*Original documentation*	
1b	*June 2013*	*Draft*	*Revisions following feedback from T&F group*	*EAB*
1c	*October 2013*	*Draft*	*Revisions following issue of risk based approach;* *Revised to address what constitutes a spill, significance, spill reporting*	*EAB*
2.0	*February 2015*	*Draft*	*Inclusion of significance matrix and monitoring requirements*	*EAB*
2.1	*April 2015*	*Final*	*Incorporates comments from Environment Agency and NRW, and also covers any differences in requirements in England and Wales*	*EAB*
2.2	*December 2016*	*Final CIWEM*	*Incorporates text to allow CIWEM UDG adoption*	*PRH / EAB*

Contents

1 Overview

This guide collates current good practice on CSO monitoring from across the industry and regulators, and systematically covers each of the relevant components. Some of the components are technical, whilst others are about having reliable procedures in place and consistently following them.

The contents of this document will be reviewed from time to time, in the light of experience.

The document is published for wider public and water industry benefit by CIWEM Urban Drainage Group and made available through its website. Subsequent updates will be curated by CIWEM Urban Drainage Group in collaboration with the industry.

2 Rationale for monitoring

The Water Industry is setting out to improve the visibility of the performance of its sewerage networks to third parties including regulators and the public, specifically around Combined Sewer Overflow (CSO) discharges to the environment. To achieve this, Companies are looking to promote more extensive implementation of Event Duration Monitoring (EDM), as part of their five yearly business plans.

For the majority of sites, this would take the form of logging the timing and duration of CSO spills, to enable summarised reports to be consistently produced, generally on an annual basis. Where such monitoring is not already in place, it is intended that further sites would be included on a prioritised basis, focussed on environmental sensitivity.

Where locations are of a particularly sensitive nature, such as designated bathing waters, Companies may seek to notify appropriate parties about spills, as they are happening or soon after. Ideally this would be on a near real-time basis, to allow potential impacts to be pro-actively managed. As examples, there are already several internet and mobile phone systems in operation around the UK by water companies and other third parties that help bathing water users make informed choices. Note that near real-time warnings are not a regulatory requirement placed on Companies.

To provide this capability may require a commensurately higher level of technology and associated support systems than logging alone. Work is being done by water companies in partnership with the shellfish industry to ascertain whether similar systems would be beneficial for shellfish harvesters, so there is potential for real-time warning systems to be used at many more sites.

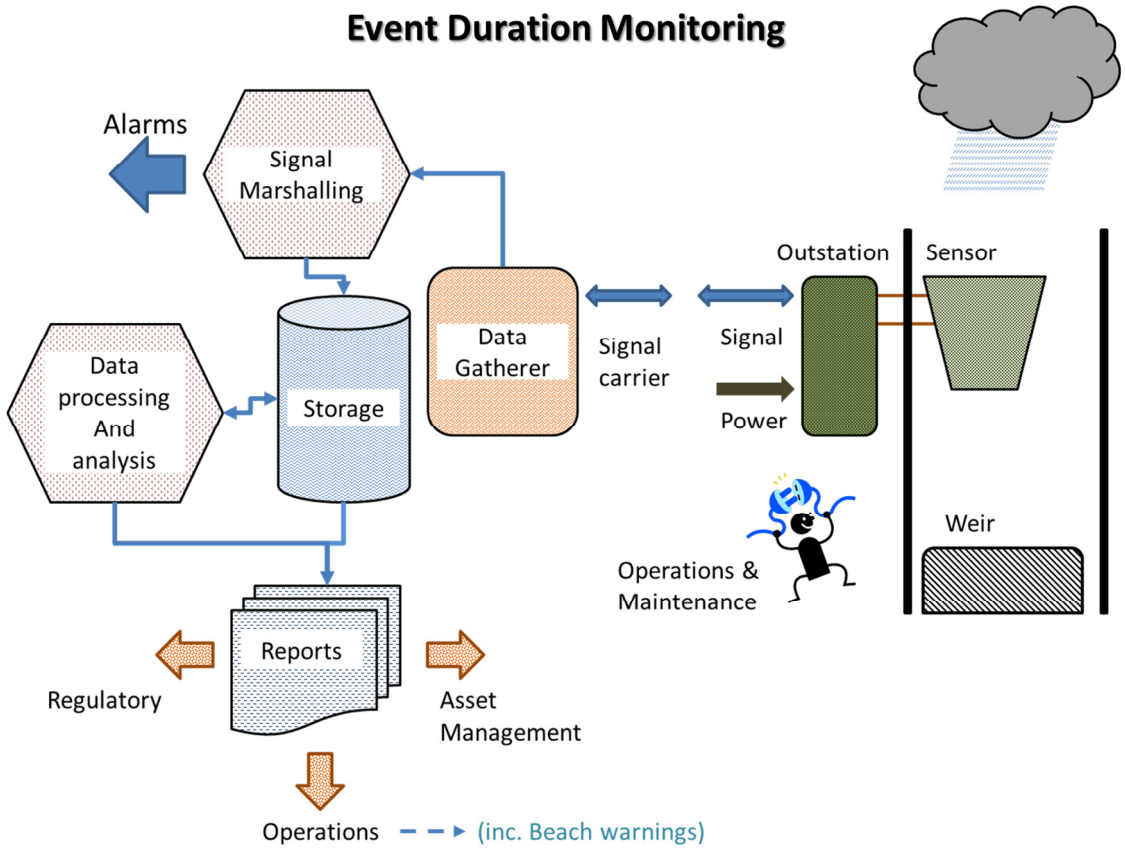
For recipients to be able to trust this information, it is key that reliable and consistent information is produced.

3 The monitoring environment

The extent of the information chain involved in CSO monitoring is illustrated below. To achieve consistent and reliable monitoring of CSO performance requires the adoption and consistent implementation of good practice across the whole information chain, including:

- Selection of monitor location
- Quality of installation
- Inherent reliability of equipment
- Operation and maintenance of sites
- Ongoing quality control of information

- How finalised reports are produced.



4 Overall monitoring location

4.1 Selection of sites to be monitored

Beyond locations where there is already a regulatory requirement for monitoring, the selection of additional sites for CSO monitoring should be based on environmental sensitivity.

For **England**, the Environment Agency has produced the following matrix[1] to define the EDM requirements for a site.

Amenity Class	No. of spills per annum		
	<1	>=1 to <20	20 or more
High	No EDM required	EDM, plus telemetry warning (Monitoring at 2 minute intervals*)	
Medium		EDM (Monitoring at 15 minute intervals)	
Low			

** Unless a lower frequency of monitoring agreed locally*

In **Wales**, EDM requirements[2] have been defined following environmental sensitivity criteria, with a standard requirement to monitor the spill at 15 min intervals.

Where sites requirements are a function of spill frequency, where there is no pre-existing information then Drainage Strategies are often the fundamental source of information, and are likely to contain useful relevant data for individual CSOs, including the expected frequency of discharge, and potential environmental impact.

4.2 Type(s) of monitoring to be provided

Where monitoring is additionally required for the purposes of warning (including notifications), rather than just logging spills, then this is likely to dictate the approach to power and signals at the monitoring sites. For sites requiring warnings, and hence near immediate reporting, the current best practice favours use of mains power supply and land line for signal transmitting. This will be covered in detail in subsequent sections.

At some sites, surrogate spill monitoring may already exist as part of systems for identifying CSO blockages. Such dual use of technologies can offer efficiency of scale. Care is required however to confirm that the blockage monitoring technology is effectively monitoring discharges to watercourse and that the equipment has suitable level alarm settings accordingly.

4.3 Services availability

Once the type(s) of monitoring have been decided upon, then the availability of power and phone line can be considered, as appropriate. Where a mobile phone network (either GSM or GPRS) is to be used for transmitting data, then an initial assessment of the coverage can be made from maps available from network providers. This initial assessment should be confirmed on site by measurement of signal strength as near to the intended location of the antenna as possible.

4.4 Accessibility

All access to monitoring equipment needs to place health and safety considerations as paramount.

Wherever feasible, it should be ensured that there is ready access to both the sensor and outstation equipment, particularly to allow routine maintenance of equipment. If this is not possible, for example, where an overflow is situated in the middle of a highway, then consideration should be given to at least siting the sensor processor and outstation away from the highway. In some circumstances, it may be possible to set up a surrogate measurement point at a different point on the sewerage network that is not subject to the same access restrictions.

In addition, there should be a clear right of access to equipment at all times.

4.5 Sensor location

The default location for a sensor, particularly the sensor head, is in the CSO chamber, measuring water levels on a smooth water surface, on the sewer (wet) side of the CSO structure.

It is important to consider the hydraulics at and upstream of the CSO structure, so that a representative location for level measurement can be selected. This should include:

- Assessing the potential impact of other equipment installed at the overflow, for example screens, on representativeness of the sensor location.
- Initial survey of weir to check that there are no significant leaks, and that the weir is level.

- Whether there are other influences, such as a propensity for Fat, Oil and Grease build up, or other blockage causes, that can interfere with reliable and consistent measurement.
- Assessing the expected range of levels in the system, both for selecting the appropriate device, and for ensuring that the device is less likely to be subject to inundation.

For some locations, such as those affected by saline or other intrusion, backflow, surcharging, flap valves and pumped overflows, it may be possible to set up secondary measurements that help to confirm whether changes in level are due to the overflow operating, or other causes. Where bespoke solutions are required, the proposed approach should be shared with the Environment Agency / NRW.

4.6 Other location considerations

It should be checked whether the environment that the sensor is to be placed in is particularly aggressive, where this may affect the performance or life span of the equipment.

The installation location needs to be appropriately earthed, to prevent either electrical damage to equipment or false signals being recorded.

It is advisable to protect sensors from accidental contact when accessing a chamber, to prevent misalignment.

The equipment selected should meet appropriate intrinsic safety requirements.

5 Sensor

5.1 General

When considering the type of equipment, its underlying life span should be taken into account. For many types of Instrumentation Control Automation (ICA) equipment which includes sensors, this is considered of the order of 7 to 15 years.

5.2 Sensor types

There are three main types of sensor:

- Ultrasonic
- Pressure
- Float

For each type of sensor, there are specific locational considerations to be made.

- For ultrasonic devices, misting & condensation can be an issue. The effects of this can be minimised by fitting a drip shield. Similarly where equipment could be subject to inundation, it may also be possible to fit a submergence shield.
- Float systems need locations that are free from risk of fouling.
- Pressure transducer systems need to avoid locations that are susceptible to siltation.

For all types of sensor, the following needs to be assessed:

- Span range (beyond range),
- Blanking distance (minimum distance to head).

Establishing this information will also impact on the resolution of the device when installed.

5.3 Reference point

Given that many CSO monitoring devices need routine maintenance and sensors may need to be replaced and structures are not perfectly level, it is important to decide what will

constitute the reference point for measurement. Where it is not practicable or representative to use first spill as the reference point, such instances should be discussed with the Agency / NRW.

To allow the sensor to be configured, validated or reinstated following maintenance, a reference plate or datum point should be set up. Reference plates offer a distinct and defined reference datum and should be installed where practical. Where there is a risk of the reference plate becoming misaligned, then a datum point can be used instead.

5.4 Data Capture

The other basic decision is whether the monitoring will only provide event data relating to changes of state (i.e. spilling or not spilling, along with the associated date & time stamp), or whether the sensor will monitor other analogue data such as levels at a fixed frequency, to produce a trended data set. The former is most common where the overflow itself is pumped.

The advantage of the former is the compactness of the data set, whilst the latter is more useful for understanding trends in levels, which can then be used in more sophisticated validation of the monitoring.

Note that alarm generation (for high priority overflows) is generally derived at site through instrument and outstation settings.

5.5 Signal\Data processing considerations

Within any monitoring system, there are several factors that affect reporting and processing of signals. The first issue arises at the sensor itself. The issues fall into the following categories:

- Frequency/Periodicity of monitor polling.
- Local monitoring configuration signal damping (persistence) in instrument or outstation.
- Logging interval
- Data retransmission – the choice is either direct or storing and subsequent forwarding.

6 Outstation

6.1 Signal

There are two main options for transmitting signals from the outstation – Mobile phone, or land line.

As covered in a previous section, where warnings are required from the device, then land line is generally the favoured option, due to reliability of signal transmission. Data passed back to the parent station using land line may be achieved in two ways, either as dial up, or via a broad band network connection. The latter is particularly useful when considering large volumes of data traffic but is generally only available at large sites.

The other main method for transferring signals from the outstation to the parent station is via a mobile phone network. Where this is the only option and is being used for transmission of warning information, rather than just logging, then there ideally needs to be a reliable signal at all times. As mentioned earlier, it is important to carry out a mobile signal survey at the height of the proposed antenna, to check reliability of signal. Several factors can interfere with signal transmission, including parked cars and severe weather conditions. With the mobile phone approach, where the device is used for logging only, then subject to local data storage (considered as part the site risk assessment), if the network signal is temporarily

lost, then data can be (re)transmitted once communications become re- established. Data is transmitted either as single items (GSM) or as blocks of data (GPRS).

A methodology sometimes used for signal transmission is radio communications, using packet data communication. This is more commonly used on large complex sites but can also be used in a local area to collect information from several devices over a private (FM) radio network. In optimal circumstances the devices can be up to several miles apart.

In extreme and rare circumstances signal transmission may be achieved using satellites in Low Earth Orbit (LEO). As this mode of signal transmission is not in common use, no further details are provided here.

6.2 Power

As covered in earlier sections, whether a mains power system is adopted or not is principally a function of how frequently a site is polled. For real-time warnings and notifications, or any other site where the polling frequency needs to be two minutes or less, mains power is the most viable option in the majority of these circumstances. If a battery option is proposed, there needs to be careful examination of the impact of frequency of outstation polling (as opposed to event logging) on battery life, and the frequency that batteries will need to be exchanged at.

The viability of battery based solutions increases when the polling frequency is 5 minutes or less often. As an example, by monitoring at a 15 minute interval, a battery life of five years or more is achievable with the most recent lithium encapsulated technology. In addition, such systems are also equipped with power management alarms, so low battery levels can be monitored remotely. More frequent polling can be achieved with battery powered systems, but this then increases the frequency of battery changing to yearly, and also places more emphasis on the ability to regularly access sites that may involve RASWA permissions, which may then require re-engineering of the outstation installation.

7 Displays

Displays for the outstation are not always necessary but where available serve several useful purposes, including:

- General installation and initial setting up of the device
- Rapid visual cross checking that the equipment has remained set to the datum, and adjusting if necessary
- False overflow alarm avoidance when maintaining
- Self diagnosis

Whilst instruments can have inbuilt display panels, it is common practice to have a portable plug in intelligent display device, which can then also be used for configuring, testing and maintaining the outstation (and sensor).

7.1 Kiosks / Bollards

There are no specific issues around kiosks or bollards used for housing outstation and / or antenna equipment.

7.2 Antennae

Where mobile phone technology is used, wherever possible the antenna should be sited in a safe and handy location, where it is less likely to have the signal interrupted by parked cars. The antenna is generally sited either close to the ground, or within a CSO manhole, provided there is not the risk of submergence. See earlier sections for signal tests.

7.3 Outstation processing

Processing of signals can be potentially be carried out at several points in the signal chain.

It is common to configure device sensitivity at the outstation, to smooth out spikes and noise a persistence setting can be set in the monitoring device or the outstation. This is the time that a signal needs to be above a critical level, before it is treated as a valid signal. (1second is typical in this situation.)

8 Data Gatherer

Data can be relayed back to the parent station using a number of systems. What is key for the parent station is the amount of traffic that will be transmitting signals at any one time.

Where telephone lines are used, a number of options are available:

- Direct dial back – These feature most commonly in SCADA systems
- Multiplexing – This allows number of phone lines into the parent station, increasing capacity, and also allowing traffic to be prioritised
- Hub stations with broadband capabilities are now becoming more common.

Where there is significant data traffic, then as well as increasing the capacity of signal transmission, managing the timing of device polling and data transfer can balance the loading on both the signal transmission systems, and the associated onward data processing.

9 Signal Marshalling

Once signals have arrived at the parent station, they are then marshalled into data storage. This is analogous to putting the information into the correct pigeon holes.
This is the stage at which alarms will be generated from incoming signals and passed to control rooms.
Given the volume of signal traffic involved at this stage, it is important that routine data processing is scheduled to allow this to take place.

10 Storage

Assessing the volume of data to be stored is the critical aspect of data storage. Factors affecting the volume of storage required include:

- The number of sites
- The data retention period
- Whether raw incoming data is retained as well as validated data
- The extent of regulatory audit trail required
- Whether processed data is only generated ‘on the fly’, or is also permanently stored.

11 Information validation

This stage centres on data checking that is not already covered at the outstation (which should filter majority of suspect readings).

This stage can be an alternative point at which alarms are generated by the system.

In deciding upon the degree of checking that data is subject to, there is a balance to be struck, particularly when information is used for warning purposes. Even in these circumstances, depending on the number of sites and the degree of checking employed, checking times can vary from minutes to hours. It is also important to note that many of these checks are carried out manually by companies, so are resource intensive. Note that where warnings are provided, checking is not generally carried out until after the warnings have been issued. Depending on the numbers of warnings being generated, this validation stage can take from minutes to hours, and can involve the need to send people to site.

To avoid the risk of long records containing no data, it is advisable to check the events recorded at all sites at least quarterly, to see whether events have been recorded. Where no events are recorded, the long term event trend for the site should be checked to see if this is likely to be due to real circumstances, or an equipment malfunction.

Checks carried out on data used for warning purposes include detection of sudden rise and fall of level (square wave), as opposed to a ramping up of flows before spillage, and whether the levels tie in with the time that an overflow is recorded as a change of state.

More sophisticated analyses, such as cusums are more likely to be carried out manually, and are unlikely to be used in the context of generating warnings.

It should also be borne in mind that no system is likely to have 100% reliability in spill recording, when viewed over the long term. No criteria have been defined to date for recording reliability, or time to recover once a recording system is known to be inoperable. It is recommended that through use, the reliability of recording for individual overflows is established, so that ultimately reliability criteria can be defined.

12 Reports

Reporting can take three basic forms:-

- Routine reporting of logged spill information
- Near real time warnings of CSO operation
- Ad hoc reporting of logged spill information.

12.1 Routine reporting

Detailed reporting requirements and formats are currently being produced by the SWQWPG Intermittents T&F group, and this section will be revised once that work has been completed.

For routine summary reporting of spills, the DEFRA 12 /24 hour spill calculator should be used. Returns should be made to the regulator on an annual basis, in an agreed form.

The summary reporting should not exclude any spills on the basis of their significance.

For these returns, initial work is involved in setting up and testing equivalent algorithms on the host computer. When this has been completed, it is then straightforward to produce routine reports. These can often be pre scheduled.

Whilst routine reporting will consolidate the amount of data supplied to the regulator, it is recommended that the raw data is retained for a period of at least six years, to allow further analysis or investigation at a later date, should this be required.

12.2 Near real-time warnings

This reporting facility is focussed on generating warnings that a CSO has either started or stopped spilling, or that the data has not been verified, and is being recalled.

The key focus on this type of reporting is the pre-work to the report, to ensure, as far as is reasonably practicable in the time available, that a real spill is being reported.

To ensure these warnings are produced expeditiously, the associated signals may be tagged in such a way that ensures priority in the processing of information.

Where companies are checking for blockages, this can be achieved with a system that is polling less frequently (eg 15 minutes), as the detection of potential blockages is based on information on trends across groups of overflows over a number of days. Here the time interval of returning data is more important than the polling frequency.

Currently, work on near real-time notification in relation to the revised Bathing Water Directive is well advanced in a number of Companies. In relation to shellfish protected areas, a similar capability is being trialled in several areas.

12.3 Ad hoc reporting

Whilst such reports use the same basic information as the routine reports, as they are not actioned as part of a batch process, then they can be time consuming to produce.

As learning develops in relation to the information provided for bathing water and possibly in the future shellfish protected areas, it is recommended that the need for other ad hoc warnings should be reviewed.

Where new reporting requirements come about in the future, then they need to be considered in terms of ease of production of the reports, as well as usefulness to the end user.

13 Operations & Maintenance activities

Operations and maintenance procedures for sites should be suitably developed and documented.

Those procedures should include:

- Testing of equipment and settings
- Visual inspection of equipment for any damage or misalignment
- Whether devices used for regulatory reporting will be specifically physically tagged
- Clarity over use of information where sites supply information for more than one purpose.

14 Monitoring costs

It is not the intent of this best practice guide to provide detailed costs of monitoring as these are significantly dependent on both the individual site, and the current cost of each item of monitoring equipment.

As an indication however, provision of near real-time warning systems, necessitating use of mains power and telephone land line, are likely to be up to 10 times as expensive as locations where logging is carried out using battery powered equipment, transmitting signals over the mobile phone network. Where sites are complex and involve the checking of more than one device to establish that a CSO spill has occurred, then this cost will rise significantly.

15 Defining a spill

Definition of a spill can be divided into two activities:

- Ensuring that a reliable and persistent signal of a spill has been generated
- Where data is being used for warning purposes, potential filtering of the raw information, to decide that the spill is significant enough to be acted upon.

15.1 Instrument

These issues have all been covered previously, but are also summarised here for clarity.

- Ensure that the instrument is not susceptible to false readings, particularly misting of ultrasonic devices.
- On and off tolerances over the weir structure should be suitably set at, say, ± 5mm, to allow for the practicalities of weirs not being level and the inability to level within the sewer environment to very fine tolerances.
- The persistence of the signal should be set to at least 1 second (normally set at sensor), to reduce spiking and signal noise.
- The siting of the sensor should take account of other external influences on the measurement eg pumped overflows, tides, infiltration.
- Where such external influences cannot be avoided, then the use of double measurement or alternative measurement points should be considered, to identify real CSO spills.

15.2 Data filtering

This is only applicable to near real time warnings. As set out in section12.1, filtering should not be carried out on data used for routine reporting.

Data filtering is carried out to exclude very minor spills from overflows from warnings issued. Where data filtering is carried out, it is recommended that the unfiltered data should be retained, so that it is available for inspection should it be required, or the filtering criteria changed.

In relation to filtering data, there is currently no consistency across companies. Depending on the type of use made of the data, values between 5 and 15 minutes duration are currently used across the UK. Feedback from current receivers of warnings has indicated that they would rather be notified of fewer spills and that those are significant for beach usage.

Where there is a requirement to notify either the Agency or users of a discharge, such notifications should initially be sent out as a presumptive spill (based on all data, before validation). This can then either be withdrawn if found to be an insignificant or erroneous spill, or confirmed when the spill has ceased.
There is a separate Task and Finish group that is focussed on the questions associated with warnings and predictions of bathing beach quality, and these issues will be progressed by that group, in consultation with this team.

16 Interpretation of spill information

At present, the focus of spill monitoring is to establish a consistent and reliable spill monitoring regime across the majority of intermittent discharges in the UK.

As awareness and interest in this information grows, it is likely that requests for that information will increase, followed by calls to interpret the information, particularly about whether the frequency of operation aligns with what was expected for the asset. It is therefore recommended that as a follow on from this work, methodologies are developed for

comparing modelled and actual overflow performance, understanding why differences occur, and understanding how this information could be used as part of an on-going asset management cycle.

References

1. Environment Agency 2013; Risk Based Approach to the Monitoring of Storm Discharges (Version5.0) 30/09/13.
2. Natural Resources Wales. Policy for Monitoring Storm Discharges in Wales. WQSP_0001_01 version1. 09/07/14.