

TRIPARTITE GROUP

LEAKAGE PERFORMANCE INDICATORS

March 2002

1
March 2002

SUMMARY

This report presents details of the development of a set of Leakage Performance Indicators (LPIs) that can be used to assess leakage management performance in support of an economic level of leakage (ELL) analysis. A second report; WRc Report UC3914 Best Practice Principles in the Economic Level of Leakage presents details of the ELL analysis. These two reports form the output of a project commissioned by a Tripartite Group comprising Ofwat, the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) to review the approach to leakage target setting for water companies in England and Wales.

The economic level of leakage (ELL) methodology is the method currently used to define a leakage target. This target reflects a balance of costs that takes into account the relative value of water resource development and leakage management. However, it does not allow independent assessment of the efficiency of leakage management processes and the operational conditions that apply in a leakage management area. Thus a higher ELL may be the result of inefficient practices, the supply-demand position or a difficult operating environment. This means that it is not possible to make valid comparisons of targets set by different water companies using the ELL methodology alone.

The LPIs presented in this report have been developed to support a leakage target set by ELL or by some other means.

The final set of LPIs developed is summarised in Table S.1. They are part KPI (measure the efficiency of the leakage detection process) and part explanatory factor (measure the leakage characteristics of the system).

Table S.1 Leakage Performance Indicators

Status	LPIs
Primary	1 Leaks found per property surveyed (by type) 2 Leaks found per inspector (by type) 3 Repair time (by type)
Secondary	4 Flow data age 5 Burst reaction period 6 Prioritisation factor 7 Inspector number (peak week to average) 8 Proportion of dry holes 9 Proportion of repeat repairs
Leakage Management System Descriptors	1 Number of 'district meter' areas in the company 2 Number of 'waste and combined metering' areas in the company 3 Number of PRVs in the company 4 Average Zone Night Pressure (AZNP) target divided by AZNP.

The Primary LPIs provide a measure of the performance of the leakage control process. They are very useful for monitoring trends and hence provide incentives for introducing innovation and best practice. They also provide useful additional information on leakage performance to support the leakage target so, for example, may help to understand a high leakage target, or allow leakage efficiency to be monitored in years when Companies experience difficulties in achieving leakage levels due to extremes in weather. However, due to their dependence on system characteristics they should not be used for direct comparison of area against area or company against company without consideration of differences in operating environments.

The Secondary LPIs provide additional measures of company performance on leakage and should be used to support the primary measure, reported leakage level, to form a more complete view of the company's leakage performance.

The leakage management system descriptors are additional data that should be collected in addition to the data already collected as part of Table 10A of the Ofwat Return. These provide a clearer assessment of the leakage management system in place in the company now that most companies have fully implemented district metering.

The LPIs were developed from an initial set of LPIs and explanatory factors which were then piloted at six water companies. The development of the LPIs has drawn on the experiences of both WRc and the water companies in developing KPIs for leakage management. It is considered that the final LPIs presented in Table S.1 reflect the optimum balance between data availability and provision of robust measures of performance and operating environment. It is recommended that a wider data collection exercise is undertaken, since the companies that provided data for the trial are all considered good performers and so represent a relatively narrow range of efficiency and performance.

It is important that the LPIs are used within the context of attaining leakage targets set through a best practice analysis. The primary objective should be to achieve the leakage target; the LPIs then provide a measure of the efficiency of the leakage processes being used and the operating environment.

There are many factors that can not be collected robustly, such as traffic congestion and the magnitude and variability of night use, that impact of the performance of the leakage control inspectors. For this reason direct comparison of LPIs between companies is not recommended.

The study has focussed on LPIs that provide performance measures rather than cost comparators. This is primarily because cost definitions are difficult to standardise due to differences in data collection methods and allocation of overhead costs. The LPIs are intended to measure the effectiveness of the selected policy. The least cost leakage control policy (including pressure management, DMA size and coverage, use of new technology) is defined as part of the ELL analysis.

It is considered that the LPIs produced have the potential to support the current Ofwat reporting requirements and to assist the regulators in their understanding of water companies ELLs. It is recommended that a wider data collection exercise be undertaken to confirm both the availability of data and the robustness of the indicators.

CONTENTS

SUMMARY

1.	INTRODUCTION	7
1.1	Context	7
1.2	Background	7
1.3	Objectives of LPIS	7
1.4	Review of previous work	8
1.5	Overview of Approach	8
1.6	Stages in the development of LPIS	9
2.	INITIAL SET OF LPIS AND EXPLANATORY FACTORS	10
2.1	Strategic objective	10
2.2	Leakage management processes	10
2.3	Developing activity objectives	10
2.4	Developing measurables for activity objectives	11
2.5	Consideration of available data and KPI metric interpretation	11
2.6	Evaluating whether the LPIS provide appropriate incentives	13
2.7	Initial set of LPIS and explanatory factors	13
3.	TESTING LPIS AND EXPLANATORY FACTORS USING REAL COMPANY DATA	15
3.1	Data requirements and guidance notes	15
3.2	Data Collection	15
3.3	Testing of LPIS and explanatory factors	16
3.4	Conclusions from testing the initial set of LPIS	16
4.	FINAL SET OF LPIS	21
4.1	Key Considerations in the development of the final set of LPIS	21
4.2	Leakage Performance Indicators	21
4.3	Leakage Management System descriptors	26

APPENDICES

APPENDIX A	REVIEW OF IWA UFW TASK FORCE WORK	28
APPENDIX B	REVIEW OF WS ATKINS REPORT	31
APPENDIX C	INITIAL SET OF LPIS AND EXPLANATORY FACTORS	34
APPENDIX D	DATA REQUIREMENTS AND GUIDANCE NOTES FOR FINAL SET OF LPIS	42

LIST OF TABLES

Table 2.1	Summary of primary objectives of leakage management activities	11
Table 2.2	Initial LPIs	13
Table 2.3	Summary of key explanatory factors	14
Table 3.1	Summary of performance of initial LPIs and explanatory factors	17
Table 4.1	Final Leakage Performance Indicators	22

LIST OF FIGURES

Figure 2.1	Dependence of KPI on level of leakage	12
------------	---------------------------------------	----

1. INTRODUCTION

1.1 Context

This report covers the development of Leakage Performance Indicators (LPIs) to assess leakage management performance. This is part of a project commissioned by a Tripartite Group comprising Ofwat, the Environment Agency and the Department for Environment, Food and Rural Affairs (DEFRA) to review the approach to leakage target setting for water companies in England and Wales.

Other tasks in the project considered the development of key principles to be followed when calculating the economic level of leakage (ELL), improving the quality of assumptions and developing a forward looking approach. These tasks are covered in a separate report; WRc Report: UC3914 Best Practice Principles in the Economic Level of Leakage.

1.2 Background

The ELL methodology is currently used to define a leakage target. This target reflects a balance of costs that takes into account the relative value of water resource development and leakage management. However, it does not allow independent assessment of the efficiency of leakage management processes and the operational conditions that apply in a leakage management area. Thus a higher ELL may be the result of inefficient practices or a difficult operating environment.

This means that it is not possible to make valid comparisons of targets set by different water companies using the ELL methodology alone. The development of a set of LPIs that are able to evaluate leakage management performance and variations in performance due to operational conditions will provide a valuable supporting tool to the ELL or any other target setting analysis.

1.3 Objectives of LPIs

The use of properly developed key performance indicators (KPIs) is seen as a powerful management tool. For leakage purposes their objectives are to:

- Allow proper comparison between zones within a company and between companies
- Allow trends to be monitored over time
- Identify leakage management best practice
- Provide incentives for innovation and new technology
- Support and enhance the robustness of leakage target setting calculations

It is important that KPIs do not stifle innovation by limiting thinking regarding best practice. This is achieved by developing measures that reflect the processes of achieving leakage targets and which are 'output based'.

For leakage control it is not possible to develop a set of true KPIs. The efficiency of the leakage control process is dependent on a large number of factors outside the control of company leakage management. In this project a number of LPIs have been developed that measure leakage performance, but are also dependent on the characteristics of the system.

The prime objectives of the LPIs developed in this study are to evaluate leakage management performance and to provide robust assessments of leakage performance in support of a leakage target derived from an ELL or other analysis. They have not been developed to be used as an operational tool to improve productivity of leakage detection, although there is considerable overlap with KPIs developed for this purpose.

1.4 Review of previous work

In considering the approach to be adopted, two previous leakage KPI studies have been assessed. These are:

IWA Task Force on Unaccounted-for Water⁽¹⁾

Primarily focussed on developing a consistent methodology for assessing leakage levels and other components of the water balance in order to make valid comparisons between areas/companies/countries.

WS Atkins' Review of Water Company Submissions on Leakage⁽²⁾

A detailed assessment of all the potential KPIs and explanatory factors for leakage management. The report also presents a structure for grouping the KPIs and explanatory factors.

Critiques of these studies are given in Appendices A & B respectively.

WRc have recently completed a benchmarking study for UKWIR⁽³⁾. Key elements of the methodology together with the reports listed above have been applied in order to develop a standard approach to the development of KPIs.

1.5 Overview of Approach

Initially a set of output based LPIs (primary and secondary) and a set of supporting explanatory factors was developed. The LPIs measured the performance of the leakage management process. The key explanatory factors provided a measure of the current operating environment in which the leakage control is undertaken.

Data requirements were then developed along similar lines to those produced by Ofwat for company reporting. These were then piloted by sending them out to selected water companies. The data received from the companies were then analysed in order to evaluate the initial set of LPIs and explanatory factors. A final set of LPIs were then produced based on the experience of the trial.

The work has focussed on LPIs that provide performance measures rather than cost comparators. This is primarily because cost definitions are difficult to standardise due to differences in data collection (or recording) methods and overhead allocation.

From experience, companies (particularly those currently implementing best practice leakage management) already collect the majority of the data required to calculate the LPIs. It was not the intention of this work to identify a wide range of new data collection items.

1.6 Stages in the development of LPIs

The following stages have been applied to the development of the LPIs:

Develop an initial set of LPIs and explanatory factors

1. Define the strategic objective of the process.
2. Develop a process map of activities.
3. Develop the objectives or deliverables for each activity.
4. Review possible 'measurables' for each activity that satisfy the objective.
5. Determine practical issues, reliability of measurement, data availability and KPI metric interpretation.
6. Evaluate whether the LPIs provide appropriate incentives.
7. Define an initial set of LPIs and explanatory factors.

Test the LPIs and explanatory factors using real company data

8. Develop data requirement and guidance notes for data collection.
9. Collect company data.
10. Test the LPIs and explanatory factors and review their performance using real company data.

Produce final set of LPIs

11. Define a final set of LPIs.
12. Define final data requirement and guidance notes for data collection.

2. INITIAL SET OF LPIS AND EXPLANATORY FACTORS

2.1 Strategic objective

The strategic objective of leakage control is to find and eliminate the greatest volume of leaking water as efficiently as possible within the leakage target defined by the ELL or other analysis.

2.2 Leakage management processes

The ELL methodology defines the least cost leakage policy, including pressure management, DMA size/coverage, etc. The LPIs are intended to measure the effectiveness of the selected policy.

The leakage control process can be split into four main activities:

- **Monitoring**

Collection of system data used for the direction of leakage control inspectors. This includes maintenance of the system (meters, boundary valves, etc)

- **Detection**

Using the system information (flows, pressures, repairs, etc.) to identify areas for leak location. This will include suitable data validation and analysis of the data.

- **Location**

The location of leak(s) within an area using appropriate survey techniques (e.g. step testing, acoustic logging, sound surveys, etc.) and then pinpointing the leak position(s) on the ground.

- **Repair**

Repair of leaks (initiated either through active leakage control or by the customer).

The effectiveness of each of these tasks is interdependent. For example, the effectiveness of leak location will depend on the effectiveness of the detection process as well as the skill, ability and motivation of the leakage inspector. The effectiveness of one activity affects the performance of another.

2.3 Developing activity objectives

The challenge of leakage management is to minimise the volume of water lost through leakage by minimising each of the components: leak numbers, leak flow rates and leak runtimes. The leakage management policy will have a large impact on leak runtimes, a lesser impact on leak flow rates and only a relatively small impact on leak numbers.

Table 2.1 shows the primary objectives of the key activities in the leakage management process.

Table 2.1 Summary of primary objectives of leakage management activities

Activity	Primary Objective
Monitoring & detection	To react quickly to identify bursts. To minimise leak run times efficiently. To direct leakage inspectors to areas of greatest reducible leakage for least effort.
Location	To locate leaks accurately with the least effort.
Repair	To minimise leak repair times and ensure reliable repairs whilst minimising the disturbance on the network.

2.4 Developing measurables for activity objectives

From the activity objectives of the leakage management process a number of LPIs were developed to measure the performance of these objectives or outputs (see Section 2.7). The outputs are reliant on a whole range of inputs, such as data interpretation, working practices, use of appropriate technology, staff training and motivation.

In the development of suitable measures, reference was made to the WS Atkins report⁽²⁾, Companies' submissions to Ofwat, Companies' ELL Reports and discussions with company leakage practitioners.

2.5 Consideration of available data and KPI metric interpretation

2.5.1 Available data

The current availability of company data was carefully considered in the development of the initial LPIs. It is important not to introduce unnecessary data collection yet it is equally important not to restrict the LPIs because the required data are not currently available in all companies. Data definitions have therefore only been used if some companies already collect the data because it has been shown to be useful in the leakage management process.

Where possible the initial LPIs were based on measures that are readily defined and do not require 'interpretation' of the data. One example of this is that ideally, the 'volume of leakage reduction' should be used in the measure of the efficiency of the leakage control process. However, this would require detailed analysis of DMA minimum night flow data to allow the impact of the natural rate of rise (NRR) of leakage to be taken into account. Experience has shown that this can be complex with difficulty in determining the start and end night flows required to calculate the leakage reduction. It also requires all Companies to have DMAs. A surrogate of 'number of leaks found' was therefore used in the development of these LPIs as it can be readily assessed at a leakage management area level. In the future, as more companies pay leakage inspectors on leakage reductions achieved in each DMA, so the

reliability of the information will improve, potentially allowing the 'volume of leakage reduction' to be used in LPIs in the future.

2.5.2 Developing LPIs independent of the level of leakage

The level of leakage, determined by the ELL profile, will have a direct impact on some leakage performance measures, such as 'leaks found per full time inspector'.

Figure 2.1 shows how the relationship of 'leaks found per full time inspector' would be expected to reduce at lower levels of leakage. This is due to the increased number of leakage surveys required at lower leakage levels and the subsequent reduction in the number of leaks found per survey. Figure 2.1 is based on typical data for a study area with policy minimum leakage of 60 l/prop/d. (At the policy minimum level the number of leaks found per inspector per year is theoretically zero.) At an average leakage level of 100 l/prop/d each inspector would be expected to find around 50 leaks per year under good performance, and only around half this number under poor performance. For an average leakage level of 150 l/prop/d the number of leaks found per inspector would be expected to almost double.

The gradient of the performance line can be assumed to be independent of the level of leakage and the steeper the gradient, the better the performance. Therefore, in this case, the gradient of the line has been used as the LPI. Through this approach, where possible, LPIs have been developed which are independent of the level of leakage.

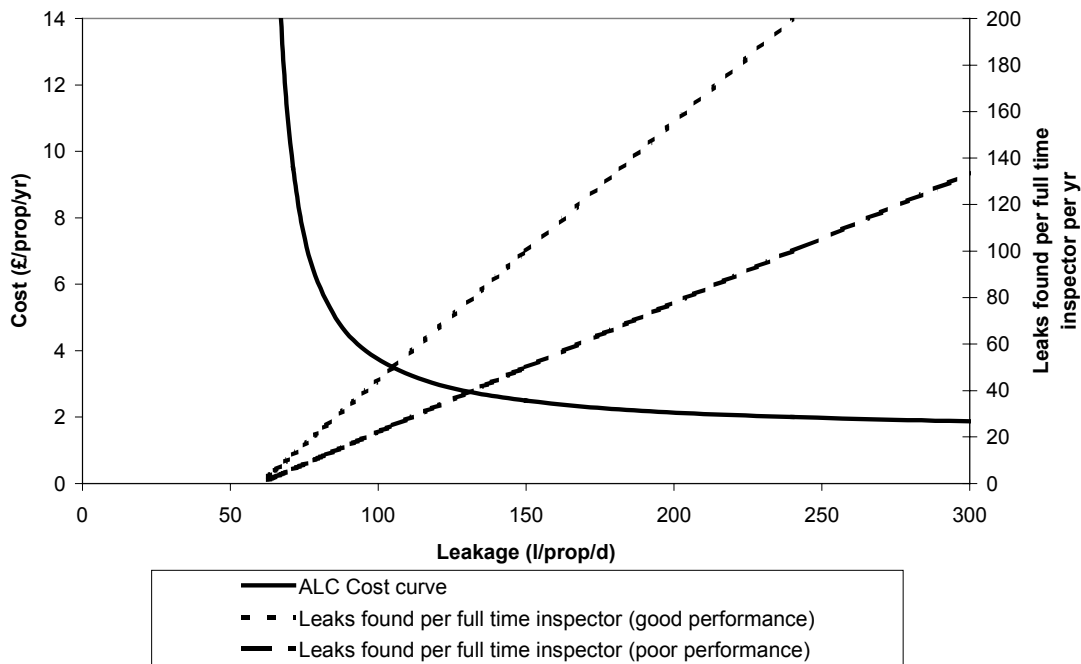


Figure 2.1 Dependence of KPI on level of leakage

This approach is useful for tracking performance year on year in the same areas when leakage is being reduced. By using this approach it also means that the associated LPIs

include a measure of monitoring and detection reaction time. However, the correction will be dependent on an accurate assessment of the policy minimum, the use of a higher policy minimum will give the impression of better performance.

2.6 Evaluating whether the LPIs provide appropriate incentives

Using experience, initial LPIs were developed so that improving LPI score is equivalent to improving performance. This provides an incentive for continuous efficiency gains. However, until these LPIs can be tested on a 'real' dataset, and used in conjunction with the explanatory factors, it is not possible to determine how they will operate in practice.

2.7 Initial set of LPIs and explanatory factors

2.7.1 LPIs

Table 2.2 summarises the LPIs that were developed initially. The LPIs have been separated into:

- 'primary' LPIs - those that directly measure the output of the leakage management process, and
- 'secondary' LPIs - those that measure the output of sub-processes within the leakage management process.

A full explanation of these initial LPIs is given in Appendix C.

Ultimately, the performance of the leakage management process should be measured against the achievement of the leakage target derived as part of the ELL.

Table 2.2 Initial LPIs

Status	LPIs
Primary	1 Leaks found per property surveyed (by type) 2 Leaks found per inspector (by type) 3 Repair time (by type)
Secondary	4 Flow data age 5 Burst reaction period 6 Prioritisation factor 7 Inspector number (peak week to average) 8 Proportion of dry holes 9 Proportion of repeat repairs

2.7.2 Explanatory factors

Factors such as the breakout rate of leaks, the cost of water and mains length per property have a large impact on apparent leakage control performance. Some factors are outside the immediate control of the leakage inspectors. Some factors are outside the control of the

leakage control strategy and associated policies, and some are outside the control of the company.

A number of 'explanatory factors' have therefore been developed. These support the LPIs and should be used when making comparisons of leakage management performance. Key explanatory factors are summarised in Table 2.3 and presented in detail in Appendix C. The table also indicates which factors are:

- influenced by leakage control policy,
- outside the control of the leakage control policy but influenced by company policy (such as customer metering which cannot be justified on leakage grounds alone), and
- are outside the control of the company.

Some factors such as the potential for pressure management are dependent on all three.

Table 2.3 Summary of key explanatory factors

Explanatory Factors	Dependent on Leakage Policy	Dependent on other Company policies	Underlying operating conditions
1 Mains length per property			✓
2 Proportion of external metering		✓	
3 Marginal Cost of Water (Opex & Capex)		✓	✓
4 Leakage repairs/1000 properties (by type)	✓	✓	✓
5 Detected repairs/1000 properties (by type)	✓	✓	✓
6 Policy minimum	✓	✓	✓
7 Leakage above policy minimum	✓		✓
8 Average DMA size	✓		✓
9 Number of meters per DMA	✓		✓
10 Night flow data quality	✓		
11 Extent of pressure management	✓	✓	✓
12 Potential for pressure management	✓	✓	✓

3. TESTING LPIs AND EXPLANATORY FACTORS USING REAL COMPANY DATA

3.1 Data requirements and guidance notes

In order to test the initial LPIs and explanatory factors with real company data it was necessary to first request the data from Companies.

Through discussions between the Tripartite group, Water Company representatives and WRc, six water companies were selected for this process. These companies were selected predominately because they were considered to be at the forefront of leakage management and therefore already collected much of the required data.

A data requirement sheet and guidance notes were produced along similar lines to those currently produced by Ofwat for collecting Companies' Returns data. Ofwat then sent these to Companies for completion and return.

3.2 Data Collection

In general, Companies did not find the data collection too difficult although a few data items were either estimated or could not be provided by some Companies.

The data collection process highlighted differences in the interpretation by the Companies of the data required. For example:

- The definition of "detected" leak. In general a customer reporting loss of pressure which then results in a subsequent leak being found is considered as 'reported' (it would be found if the company was operating a passive leakage control policy). However, one company includes these types of repairs as 'detected' if a leakage inspector is required to locate the leak.
- Confusion over classification of a ferrule. Sometimes a ferrule repair is classed as a "mains repair", sometimes a "communication pipe" repair and sometimes a "mains fitting" repair. The classification of a repair is also normally done when a job is raised on the job management system before the leak is excavated. At this time it is often difficult to determine the exact position of a leak, whether it is on the main or on the ferrule for example. In some Companies the repair would not be re-classified if the repair were later found to be on a ferrule when it was originally raised as a mains repair. One company omitted ferrules altogether in the numbers provided.

Where clarification of the required data was required or suggested by Companies these were built into the revised data collection guidelines (as presented in Appendix D).

3.3 Testing of LPIs and explanatory factors

Once initial LPIs have been established and data have been collected for at least a representative sample of organisations, it is important to establish whether the chosen LPIs and explanatory factors are fulfilling their purpose.

Two main criteria were used in the review process:

- Are the organisations which have a relatively “good” LPI(s) actually performing well for the aspect of performance that is being measured? Inside knowledge about a particular organisation (or organisations) must be relied on to see whether “one’s opinions” about the organisation(s) are borne out by the resultant LPIs. If expectations are met, i.e. the organisation(s) does actually appear to be a relatively good/poorer performer, then this will provide confidence in the LPIs. If not, further investigation may need to be undertaken to decide if it is the expert opinion or the LPI which is incorrect. WRc has a good working knowledge of the leakage management processes and systems for the majority of the Companies in the sample. This detailed knowledge and review has been used in the assessment of the LPIs.
- Are the LPIs consistent, i.e. when a number of different LPIs are all indicating independently that certain organisations are poor performers and certain other organisations are good performers. If one LPI told a different story then further investigation was undertaken to determine whether this LPI was actually being informative about an aspect of performance that the others had not picked up, or whether this LPI was merely a “rogue” LPI. Again, subjective judgement was required.

Practical issues were also considered such as how freely available the required data was and how reliable it was considered to be. Consideration was also given to the variability of LPIs over time. If the LPI only informs about performance in a narrow snapshot an average LPI value over a longer time horizon may be more appropriate.

Following an initial review of the LPIs and explanatory factors, follow-up discussions were carried out with company representatives to understand:

- where there appeared to be inconsistencies in input data,
- how a company had produced particular data where other companies struggled, and
- where data did not agree with data already held by WRc for the company.

Because of the known differences in data provided by the companies (as described in Section 3.2), the difficulty in making the data totally anonymous, and the danger of inaccurate conclusions being drawn from the resulting LPIs it is not appropriate to present the company data collected in this report.

3.4 Conclusions from testing the initial set of LPIs

The testing of the initial LPIs and explanatory factors provided extremely useful feedback on their usefulness and their use. This is summarised in Table 3.1 and was used in the production of the final set of LPIs.

Table 3.1 Summary of performance of initial LPIs and explanatory factors

	Initial LPI	Meets Objectives					Usefulness		
		Area Comparison	Trends	Best Practice	Innovation	Support ELL	Availability of data	Reliability of data	Ease of interpretation
Primary	1 Leaks found per property surveyed (by type)	○	★	★	★	☆	○	☆	★
	2 Leaks found per inspector (by type)	○	★	★	★	☆	★	★	★
	3 Repair time (by type)	★	★	★	☆	★	★	★	★
Secondary	4 Flow data age	☆	○	★	★	★	a	a	★
	5 Burst reaction period	☆	○	★	★	★	a	a	★
	6 Prioritisation factor	○	☆	☆	○	○	○	○	○
	7 Peak week to average inspector number	☆	●	☆	●	○	★	★	b
	8 Proportion of dry holes	★	★	★	☆	☆	●		★
9 Proportion of repeat repairs	★	★	★	☆	☆	●		★	
Explanatory Factors	1 Length per property	★	●	●	●	☆	★	★	★
	2 Proportion of external metering	★	★	●	●	☆	★	★	★
	3 Marginal Cost of Water (Opex & Capex)	★	★	●	●	☆	★	☆	★
	4 Leakage repairs/1000 properties (by type)	★	★	●	●	☆	★	★	★
	5 Detected repairs/1000 properties (by type)	★	★	☆	○	☆	★	★	★
	6 Policy minimum	★	★	☆	☆	☆	★	☆	☆
	7 Leakage above policy minimum	★	★	●	●	●	★	★	○
	8 Average DMA size	★	★	★	●	○	★	★	☆
	9 Number of meters per DMA	★	★	★	●	○	★	★	☆
	10 Night flow data quality	★	★	★	○	○	●		☆
	11 Extent of pressure management	★	★	★	☆	○	★	★	○
	12 Potential for pressure management	★	★	●	●	☆	●		○

Notes:

Poor ← ● ○ - ☆ ★ → Good

a - Cannot be measured but is implied by the DMA monitoring process, although this can be complex.

b - Predominately a function of weather conditions

The LPIs were considered on their ability to meet the objectives set out in Section 1.3 as well as the availability and reliability of data and the ease of interpreting the resulting LPI.

- **Availability of data** - Generally the availability of data was good but the sample of Companies was generally restricted to those that were considered to be good at leakage management. The full range of each LPI was therefore not fully tested.
- **Reliability of data** - Some inconsistencies in the data were identified. During follow-up discussions with companies on how they collected the information it was found that some values, e.g. % dry holes, were estimated by some Companies. This highlights the need for Reporters' comments to accompany the data if it were to be requested on a routine basis in the future. There was also some difficulty in determining values such as burst reaction time where the exact definition is often dependent on the exact leakage control process. It was also implied by the process rather than being a measurable.

It was considered more important to concentrate on the small number of reliable measures than to suggest a large data collection exercise where the quality of the input data could not be assured.

- **Ease of interpretation of the LPI** - for example, the best performing company found a greater proportion of leaks on mains than other companies. Assuming that data were correct it may be concluded that this company is using the most appropriate leak detection techniques. However, it could equally be concluded that in this company a greater proportion of leaks break out on mains and therefore they tend to be easier to locate.

It is important that the LPIs are used for the correct purpose, i.e. within the context of achievement of the ELL. For example, the number of leaks found per full time equivalent (FTE) inspector would not provide the right incentive for the leakage inspector. In order to achieve the ELL the inspector is required to find the optimal mix of leak types as well as the total number. This measure, however, is useful when used along side the leakage level in understanding the leakage performance of the company.

3.4.1 Primary LPIs

The Primary LPIs clearly indicated that companies with lower leakage also appeared to be “most efficient”, even when the adjustment for the level of leakage, as described Section 2.5.2, was removed. This was a surprising result, as theoretically it would be expected that efficiency would reduce at lower levels of leakage. The better performance may in fact partly reflect:

- investment in technology that has been made by these companies in the past to improve their performance, and/or
- easier operating conditions

and highlights the danger when making comparisons between Companies.

However, it was concluded that the Primary LPIs performed well in measuring leakage management performance for a particular area and generally use available and reliable data. The exception to this was LPI 1 for which the number of surveys carried out in a particular DMA was not always readily available. However, many Companies are now starting to collect this information.

LPI 1 is primarily a measure of the effectiveness of directing the leakage inspectors to the correct areas. LPI 2 is primarily a measure of the effectiveness of the inspectors to find leaks. However, they are heavily dependent on each other and should be used in parallel. Repair types were found to complicate the analysis of these LPIs. The overall objective is to find the ‘best’ mix of repair types (as measured by the final Secondary LPIs) with, for example, the greatest number of leaks per inspector.

LPI 1 and LPI 2 are very useful for monitoring trends in leakage control performance and hence provide incentives for introducing innovation and best practice. However, due to their dependence on system characteristics, they should not be used for direct comparison of area against area or company against company without consideration of differences in operating environments. They do provide useful additional information on leakage performance to

support the ELL so, for example, may help to understand a high ELL, or allow leakage efficiency to be monitored in years when Companies experience difficulties in achieving leakage levels due to extremes in weather. In the pilot of the LPIs the level of leakage above policy minimum was not found to be significant and did not change the ranking of companies for LPIs where it was used. However, it is considered theoretically sound and therefore should be included where accuracy assessments of policy minimum can be made.

LPI 3 is a straight forward measure of the speed at which repairs are carried out, reducing the repair time and therefore reducing leakage levels, but normally at an increased repair cost. The optimum repair time needs to be considered as part of the ELL analysis. Repair 'types' were retained in the LPI as they can then be compared across companies for the same repair type, where the mix of repair types will be different from company to company.

3.4.2 Secondary LPIs

The secondary LPIs were not found to adequately measure good performance. There was also some confusion in the interpretation of the required data needed to generate some of these LPIs.

LPI 4 and LPI 5 could not be directly measured but are dependent on the leakage monitoring and detection process. They are therefore derived from the process and not a direct measure of performance. These processes can be complex with sub-processes running in parallel. It means that the measures can not always be derived and assumptions have to be made. For this reason these LPIs are not recommended.

LPI 6, the 'Prioritisation Factor', required data that a number of companies do not currently collect. The interpretation of the LPI was also difficult with the measure not adequately reflecting good or bad performance.

LPI 7, the 'Peak week to average inspector number', was predominately a function of variations in weather, so although the inspector number should depend on weather conditions, the LPI was not a good measure of leakage control performance.

Although LPI 8 and LPI 9 provide good measures of aspects of the leakage control process the data required was generally either not provided by companies in the trial, or estimated. It was therefore concluded that these LPIs should not be requested from Companies for the time being but should be considered in the future.

It is clear that the performance of leakage control is dependent on a wide range of factors, e.g.

- the systems used to monitor leakage and target leakage detection effort,
- the processes involved in using the systems,
- the expertise and motivation of the leakage control staff (both those on the ground that find the leaks and those who direct the leakage detection effort).

It was felt that this was not reliably picked up in the initial set of secondary LPIs.

3.4.3 Key Explanatory Factors

There are many factors which were not picked up through the selected explanatory factors, such as traffic congestion, extent of night use, soil conditions etc. that have a large impact on the performance of the leakage control inspectors.

It was concluded that the explanatory factors were not complete enough to allow the initial LPIs to be meaningfully compared across areas. For this reason, direct comparison of individual LPIs between Companies is not recommended. Instead the explanatory factors have been developed into:

- A set of Secondary LPIs that should be used to develop a “picture” of water company performance on leakage. These Secondary LPIs provide a very good secondary measure of leakage performance and should be used in conjunction with the primary measure, reported leakage level, to form a more complete view of the company’s leakage performance.
- A set of leakage management system descriptors that are in addition to those already collected by Ofwat on Table 10A of the June Return.

Data items such as “extent of reliable data” was not felt to be accurate and could be interrupted in a number of ways and was not normally available.

The only explanatory factor that was significantly correlated with good leakage performance was “proportion of external metering”. However, this measure could not be classed as either a LPI or a leakage management system descriptor.

4. FINAL SET OF LPIS

4.1 Key Considerations in the development of the final set of LPIS

The results from the pilot of the initial LPIS have been used in the development of the final set of LPIS. In this process it was necessary to consider and balance a number of issues:

- Requirement to provide an additional view of the leakage performance of the company, in addition to the reported leakage level and in support of the ELL analysis.
- Accuracy of the LPI in measuring true performance. Emphasis was placed on producing a small number of reliable and significant LPIS rather than a large number of weak LPIS
- The accuracy of the data used in the LPIS and the need to base the data on measurement and not estimates.
- The ease with which the data could be collected. It was considered important not to provide additional data requirements that would not be of use in leakage management.
- Provide the correct incentive and, even more important, not to provide the wrong incentive.
- Encourage companies to develop their systems (where necessary) to collect the right information which will both provide LPI data and also improve their leakage control performance.

4.2 Leakage Performance Indicators

This section provides details of the LPIS that have been developed. They have been split into two categories:

- **Primary LPIS** - provide a measure of the effectiveness of the leakage control process. They are very useful for monitoring trends in leakage control performance and hence provide incentives for introducing innovation and best practice. However, due to their dependence on system characteristics, they should not be used for direct comparison of area against area or company against company without consideration of differences in operating environments. They do provide useful additional information on leakage performance to support the ELL so, for example, may help to understand a high ELL, or allow leakage efficiency to be monitored in years when Companies experience difficulties in achieving leakage levels due to extremes in weather.
- **Secondary LPIS** - provide additional measures of company performance on leakage and should be used to support the reported leakage level achieved. They provide additional information on the effort that a company has applied in achieving the leakage level.
- A set of **leakage management system descriptors** that are in addition to those already collected by Ofwat on Table 10A of the June Return are also provided. These provide a

clearer assessment of the leakage management system in place in the company now that most companies have fully implemented district metering.

It is important that the LPIs are used within the context of attaining leakage targets set through a best practice ELL analysis. The primary objective of the company should be to achieve its leakage target; the LPIs then provide a measure of the efficiency and performance of the leakage processes being used. It is important to consider the LPIs as an integral part of achievement of leakage targets and not to set LPI targets. However, Companies should look to make improvements in the LPIs on a year by year basis in order to demonstrate continuous improvement in leakage management efficiency.

The final LPIs are summarised in Table 4.1, with further details in the following sections.

Table 4.1 Final Leakage Performance Indicators

Status	LPIs
Primary	1 Leaks found per property surveyed (by type) 2 Leaks found per inspector (by type) 3 Repair time (by type)
Secondary	4 Flow data age 5 Burst reaction period 6 Prioritisation factor 7 Inspector number (peak week to average) 8 Proportion of dry holes 9 Proportion of repeat repairs
Leakage Management System Descriptors	1 Number of 'district meter' areas in the company 2 Number of 'waste and combined metering' areas in the company 3 Number of PRVs in the company 4 Average Zone Night Pressure (AZNP) target divided by AZNP.

Guidance notes for collecting the data required for the LPIs are provided in Appendix D.

4.2.1 Primary Leakage Performance Indicators

LPI 1	Leaks found per survey property
Activity Objective	Maximise efficiency of leakage detection and leak location.
Description	This is a measure primarily of the effectiveness of the detection process in sending leakage inspectors to the areas with the greatest number of leaks (surrogate for greatest reducible leakage). This LPI has been normalised for level of leakage above policy minimum.
Measurable	$(LD/PS)/(L-CPM)$ where: LD is the annual number of detected leakage repairs PS is the sum of properties surveyed in the year L is the annual average level of leakage (litres/property/day) CPM is the current policy minimum level of leakage (litres/property/day)
Units	(Leaks/property) per (litres/property/day)

LPI 2	Leaks found per inspector
Activity Objective	Maximise efficiency of leak location.
Description	The measure of the effectiveness of inspectors in finding leaks. It is dependent on many aspects of the leakage control process including monitoring and detection. It is also dependent on the leakage control policy and the technology being used. This LPI has been normalised for level of leakage above policy minimum.
Measurable	$(LD/IH)/(L-CPM)$ where: LD is the annual number of detected leakage repairs IH is the total annual number of leakage inspector hours L is the annual average level of leakage (litres/property/day) CPM is the current policy minimum level of leakage (litres/property/day)
Units	(Leaks/hour) per (litres/property/day)

LPI 3	Repair time (by type)
Activity Objective	Minimise leak run times.
Description	<p>The time (in total elapsed days) between a leak being located by the leakage inspector or reported by a customer and the repair being completed. Repairs should be divided into:</p> <ul style="list-style-type: none"> 3.1 reported mains 3.2 reported mains fittings (including valves, hydrants, etc.), 3.3 reported communication pipes (incl ferrules, stop taps, repair and replace), 3.4 reported supply pipes (repair and replace, and including waste notices), 3.5 detected mains 3.6 detected mains fittings (including valves, hydrants, etc.), 3.7 detected communication pipes (incl ferrules, stop taps, repair and replace), 3.8 detected supply pipes (repair and replace, and including waste notices).
Measurable	Average period between date leak reported/located and date repair completed
Units	Days

4.2.2 Secondary Leakage Performance Indicators

LPI 4	Leakage repairs per 1000 properties (by type)
Comment	<p>Used as an indicator of the breakout rate of leaks. It should include all repairs on the system carried out to rectify a leak. Repairs should be split:</p> <ul style="list-style-type: none"> 4.1 mains 4.2 mains fittings (including valves, hydrants etc.), 4.3 communication pipes (incl ferrules, stop taps, repair and replace), 4.4 supply pipes (repair and replace, and including waste notices).
Measurable	Annual number of repairs / total connected properties (,000)
Units	Repairs / 1000 properties

LPI 5	Detected repairs per 1000 properties (by type)
Comment	Used as an indicator of the breakout rate of leaks that need to be identified through active leakage control. It should include all repairs on the system carried out to rectify a leak which was initiated by the customer (e.g. through reported visible leak or through supply problems). Repairs should be split: 5.1 mains 5.2 mains fittings (including valves, hydrants etc.), 5.3 communication pipes (incl ferrules, stop taps, repair and replace), 5.4 supply pipes (repair and replace, and including waste notices).
Measurable	Annual number of repairs / total connected properties (,000)
Units	Repairs / 1000 properties

LPI 6	Percentage detected leakage repairs
Comment	Used as an indicator of the intensity of activity leakage control. As active leakage control becomes more intensive more leaks are found through active leakage control and less are reported. Note: This LPI is very company dependent and therefore should not be used for inter company comparisons.
Measurable	Annual number of detected repairs / Annual number of leakage repairs
Units	%

LPI 7	Policy Minimum level of leakage
Comment	Used as a measure of how low leakage could theoretically be reduced to given infinite <u>leakage detection</u> resources using the least cost leakage control policy. (Pressure management and mains replacement impacts are considered as part of the ELL analysis) This value is a key input to the ELL analysis.
Measurable	Policy minimum level of leakage (Mld) * 1000000 / total connected properties
Units	Litres / property / day

4.3 Leakage Management System descriptors

In addition to the data already collected as part of Table 10A of the Ofwat Return it is recommended that the following leakage management system descriptors should be collected. These provide a clearer assessment of the leakage management system in place in the company now that most companies have fully implemented district metering:

- Number of 'district meter areas'¹ in the company – used with existing Table 10A data to allow both average DMA size and change in DMA numbers to be monitored.
- Number of 'waste and combined metering areas'² in the company – used with existing Table 10A data to allow both average area size and change in area numbers to be monitored.
- Number of PRVs in the company – allowing progress on PRV installations to be monitored with readily available data, but avoiding the complexity of calculating the coverage of pressure management which can be open to interpretation. For example, PRVs on trunk mains may provide pressure reduction for many properties downstream although further savings may be available through localised downstream pressure management.

It is also considered that reporting 'target AZNP / current AZNP' will provide an indication of progress towards achievement of the economic level of pressure management. The economic level of pressure management, and hence the target AZNP, should be derived as part of the development of the economic level of leakage.

¹ Using current Ofwat JR definitions from Table 10A

REFERENCES

1. *A Review of Performance Indicators for Real Losses from Water Supply Systems*, JWaterSRT. Lambert et al. 1999.
2. *Review of Water Company Submissions on Leakage*. Environment Agency National Water Demand Management Centre. WS Atkins. August 1999.
3. UK Water Industry Research Report RG-04. *International Benchmarking of Water Industry Costs and Performance*. April 2000.

APPENDIX A REVIEW OF IWA UFW TASK FORCE WORK

This appendix reviews the work of the IWA Task Force on Unaccounted for Water, as reported in the J Water SRT paper². The paper draws on data from 27 distribution systems in 20 countries.

Preliminaries and assumptions

The following assumptions are presented within the paper:

The following local factors are assumed to influence the level of losses from the water distribution system:

- soil/ground type
- continuity of supply
- length of mains
- no. of service connections
- location of customer meters
- average operating pressure

The urban or rural nature of a distribution system in England and Wales can be measured by the number of service connections per km of mains.

The number of service connections is the best denominator for measurements of leakage levels, e.g. l/service connection/day.

Leakage has been shown to be proportional to (pressure)^{1.15}, but for the purpose of the IWA study it was found that a linear relationship was adequate.

The paper presents the following key definitions:

Technical Indicator for Real Losses (TIRL)

TIRL = l/service connection/day (when the system is pressurised)

Unavoidable Annual Real Losses (UARL)

UARL (measured in l/service connection/day) represents what could be achieved at current operating pressures assuming the following:

- no financial or economic constraints
- good infrastructure
- intensive state of the art active leakage control (ALC)
- all detectable leaks and bursts are repaired quickly and effectively.

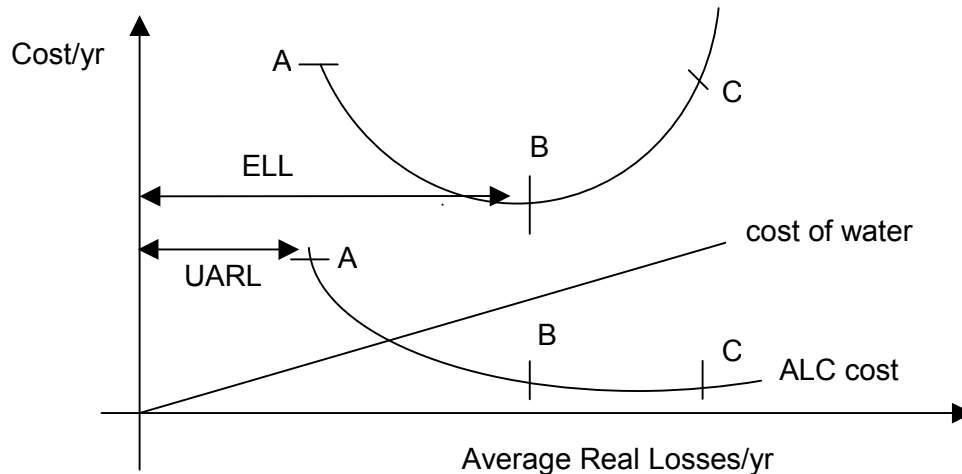
Therefore, UARL does not directly address the scope for reductions in leakage due to pressure control. It is similar in concept to the lowest technically possible policy minimum level of leakage. The UARL calculation takes the existing pressure as given. This is not necessarily the optimum pressure and consequently there is a danger of underestimating potential leakage reductions.

Infrastructure Leakage Index

ILI = TIRL / UARL

- Almost half of the 27 systems included in the study have ILI > 5
- One system in the Netherlands has ILI < 1; a feature of this distribution system is that leaks show rapidly and little ALC is required

The following graph shows the relationship between UARL and ELL.



A component based approach can be taken to calculate UARL, with the following components:

- background losses from undetectable leaks (low flow, long duration)
- losses from reported leaks and bursts (high flow, short duration)
- losses from unreported bursts (flow and duration depend on ALC method and intensity)

No UARL allowance is given for service reservoir leakage and overflows or above ground pipework.

Look-up tables are provided for UARL components – it is claimed that sensitivity analysis shows that local factors have little influence, so little company specific data is required. UARL is calculated as:

$$\text{UARL} = (18 \times L_m + 0.8 \times N_c + 25 \times L_p) \times P$$

Where:

L_m = mains length (km)

N_c = number of service connections

L_p = length of unmetered supply pipe in km

P = average operating pressure (m)

The UARL calculation has an accuracy of $\pm 20\%$, which, it is claimed, is well within the likely range of error in assessing real losses from water balances on systems with low leakage.

Comments

- UARL provides an indication of the potential for leakage reductions. Although its scope is limited, in that it relies on a modelled relationship, it could provide Regulators a benchmark

against which to compare company leakage levels. Differences between companies would be due to a range of factors including asset condition and current leakage control policy.

- UARL has limitations when used to compare individual water companies. There is too much variation to use it directly within ELL calculations since the ELL is very sensitive to local estimates of base levels of leakage (or equivalent concepts).
- A major limitation is that scope for pressure management is ignored.
- Many assumptions about local conditions are made and the argument that sensitivity analysis shows that local conditions are not important is not convincing. Neither system condition nor factors such as soil type are considered as an input for UARL.
- ILI, which is the ratio of actual losses to UARL is not considered to provide useful additional information on leakage performance. A high ILI could, for example result from poor quality infrastructure that was uneconomic to replace or from a company with a high ELL due to its supply-demand situation.

The work is good for its purpose, i.e. international comparisons of systems in very different situations, and of limited value for use in comparing water company performance without additional information. The calculations are considered too complex, and include too many factors to provide robust measures of performance. Additionally, the approach may provide regulators with an indication of leakage reductions that are technically achievable without reference to the economics of these reduction.

It is considered, however, that the approach, could form the basis of an alternative target setting approach and is discussed further in Section 5.2 of the Best Practice Report.

APPENDIX B REVIEW OF WS ATKINS REPORT

This appendix reviews the report on leakage submissions undertaken by WS Atkins for the Environment Agency¹, focusing particularly on Section 6 of the report, entitled “Future approaches to leakage assessment”. Section 6 “discusses how existing differences in the overall approach to leakage assessment by the different companies can be brought together into a set of meaningful performance indices”.

Main drivers of leakage

Factors that influence current leakage levels have been categorised into:

- Fixed Physical – no management control possible
- Fixed Inherited – some management control possible
- Variable Physical
- Variable Policy
- Variable Status

Future leakage levels

Sensitivity analysis has been undertaken to determine the effect of the following factors on the Economic Level of Leakage (ELL). It is acknowledged that results are indicative only due to inter-relationships between the factors.

- LI_e – exit level of leakage
- LI_m – level of leakage with more intensive activity
- Unit cost of leakage activity
- Marginal cost of water
- Average zonal night pressure (AZNP)

Benchmarking of leakage performance

The following performance indicators (PIs) are suggested:

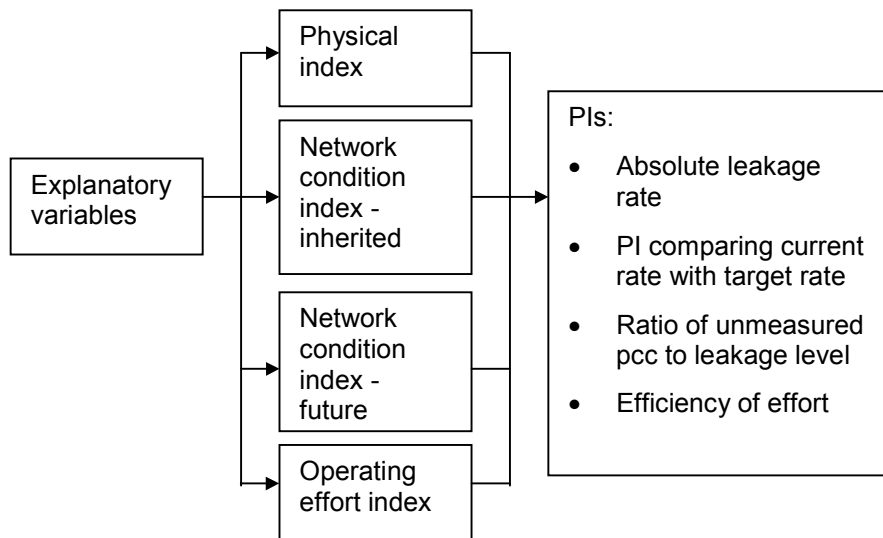
- LAMBAL (leakage as a multiple of benchmark annual leakage) index
- Ratio of unmeasured per capita consumption (pcc) to total losses

A suggested approach to development of PIs is given. The objective is to “provide indicators that explain the current level of leakage at resource zone level that can be used to assess future targets, policies and strategies”. A useful starting point might be the IWA ILI (International Leakage Index).

The report recommends that PIs should be normalised to account for the impact of fixed explanatory factors and that PIs should be:

- measurable
- few in number
- meaningful
- unambiguous
- easy to calculate

Approach suggested is:



The four indices have the following categories:

Physical index:

- location (e.g. network density)
- topography (e.g. zonal elevation range)
- network environment (e.g. soil type)

Network condition index - inherited:

- network conditions, e.g. material, age
- operating conditions, e.g. pressure
- monitoring conditions, e.g. % DMA coverage

Network condition index - future:

- network, e.g. supply pipe repair policy
- operating conditions, e.g. pressure
- monitoring conditions, e.g. % DMA coverage

Operating effort index:

- effectiveness of effort, e.g. no. of full time equivalent employees (FTEs) on leakage activity
- effectiveness of expenditure, e.g. unit costs normalised for purchasing power

Comments

The study presents initial thoughts on a range of measures that could form the basis of leakage KPIS. Some of the concepts were used during the development of the initial LPIS and explanatory factors.

- The report does not present details of how the KPIs could be developed nor how the approach works and what the outputs would be.
- Some of the explanatory variables would be very difficult to measure, e.g. climate variability and mining impacts.
- In some cases It is unclear what aspect of performance some PIs are measuring, e.g. ratio of unmeasured pcc to leakage
- Effectiveness of effort is not necessarily measured by number of FTEs.

- There appears to be a large number of factors feeding into the Pis. The next stage in the process would be “sift” these to pick out the most relevant factors.
- The hierarchical approach turning explanatory factors into indices and then indices into LPIs is complex. There is need to develop a clear methodology since calculation of PIs should be a transparent process.

APPENDIX C INITIAL SET OF LPIS AND EXPLANATORY FACTORS

INTRODUCTION

This section provides details of the LPIs and key explanatory factors that were initially developed to assess leakage management performance.

'DMA' has been used in the following descriptions as a generic term for the meter areas used by the leakage department in the prioritisation of areas for leak location. In some companies the areas will be larger than the typical 1000-2000 properties.

PRIMARY LPIS

Initially three primary LPIs were developed. These directly measure the output of the leakage management process.

LPI 1	Leaks found per property surveyed (by type)
Activity Objective	Maximise efficiency of leak location.
Description	<p>This is a measure primarily of the effectiveness of the detection process in sending leakage inspectors to the areas with the greatest number of leaks (surrogate for greatest reducible leakage). This LPI has been normalised for level of leakage above policy minimum.</p> <p>Repairs should be split:</p> <ol style="list-style-type: none"> 1.1 mains (incl fittings), 1.2 communication pipes (incl stop taps, repair and replace), 1.3 supply pipes (repair and replace).
Measurable	$(LD/PS)/(L-PM)$ where: LD is the annual number of detected leaks PS is the sum of properties surveyed in the year L is the annual level of leakage (litre/prop/day) PM is the policy minimum level of leakage (litre/prop/day)
Units	(Leaks/property) per (litre/prop/day)

LPI 2	Leaks found per inspector (by type)
Activity Objective	Maximise efficiency of leak location.
Description	<p>The measure of the effectiveness of inspectors in finding leaks. It is dependent on many aspects of the leakage control process including monitoring and detection. It is also dependent on the leakage control policy and the technology being used. The LPI has been normalised for level of leakage above policy minimum.</p> <p>Repairs should be split:</p> <p>2.1 mains (incl fittings), 2.2 communication pipes (incl stop taps, repair and replace), 2.3 supply pipes (repair and replace).</p>
Measurable	<p>(LD/IH)/(L-PM)</p> <p>where:</p> <p>LD is the annual number of detected leaks IH is the total annual number of leakage inspector hours L is the annual level of leakage (litre/prop/day) PM is the policy minimum level of leakage (litre/prop/day)</p>
Units	(Leaks/hour) per (litre/prop/day)

LPI 3	Repair time (by type)
Activity Objective	Minimise leak run times.
Description	<p>The time (in total elapsed days) between a leak being located by the leakage inspector or reported by a customer and the repair being completed. Repairs should be divided into:</p> <p>3.1 reported mains (incl fittings), 3.2 reported communication pipes (incl stop taps, repair and replace), 3.3 reported supply pipes (repair and replace), 3.4 detected mains (incl fittings), 3.5 detected communication pipes (incl stop taps, repair and replace), 3.6 detected supply pipes (repair and replace).</p>
Measurable	Average period between date leak reported/located and date repair completed
Units	Days

SECONDARY LPIS

Initially six secondary LPIs were developed. The purpose of these was to measure the output of sub-processes in the leakage management process.

LPI 4	Flow data age
Activity Objective	React quickly to bursts and direct leakage inspectors to areas of greatest reducible leakage.
Description	The normal maximum age of flow data when ranking areas for leak detection.
Measurable	The average period between consecutive flow data updates + time from update to time leakage inspectors begin work in new areas
Units	Days

LPI 5	Burst reaction period
Activity Objective	React quickly to bursts.
Description	A measure of how quickly leakage inspectors are directed to areas in which to look for bursts.
Measurable	Average number of days between consecutive data inspections (for the deployment of a leakage inspector to react to a burst) + the maximum age of the flow data used + time until inspector begins work.
Units	Days
Comment	When a large leak or burst breaks out it is important that leakage inspectors are sent to look for the burst as quickly as possible. When leakage is increasing slowly in DMAs then the frequency of data inspected is not the key to better performance.

LPI 6	Prioritisation factor
Activity Objective	Send leakage inspectors to area of greatest leakage.
Description	This is a measure of the degree of DMA prioritisation, with a higher factor showing a higher degree of prioritisation. Experience has shown that many areas require no ALC in the year, but some areas require more than one leakage survey per year.
Measurable	$\frac{\text{Properties surveyed in year} * \text{Properties not surveyed in year}}{(\text{Total connected properties})^2}$
Units	-

LPI 7	Inspector number (peak week to average)
Activity Objective	Minimise leak run time.
Description	The number of leaks that break out is affected by weather (and ground) conditions which results in a seasonal loading of work. This LPI measures the ability of the leakage department to react to these seasonal variations.
Measurable	$\frac{\text{Peak week inspector hours spent on leak detection} * 52}{\text{Annual average inspector hours spent on leak detection}}$
Units	-

LPI 8	Proportion of dry holes
Activity Objective	Maximise efficiency of leak location.
Description	The number of holes that are dug where no leak is subsequently found. As leakage inspectors look for smaller and smaller leaks (especially on plastic mains) the difficulty of confirming the leak before digging increases.
Measurable	$\frac{\text{Annual number of dry holes}}{\text{Annual number of detected repairs}}$
Units	-

LPI 9	Proportion repeat repairs
Activity Objective	Ensure reliable repairs.
Description	<p>This is a measure of:</p> <ul style="list-style-type: none"> the number of repairs that are subsequently re-repaired. due to poor workmanship of the first repair and the number of repairs in close proximity to each other which may suggest improvements are required to the renewals selection process.
Measurable (suggested)	<p>Number of repeat repairs / total number of repairs</p> <p>Where repeat repair is defined as the same communication pipe, stop tap or supply pipe (within a 5 year period) or repair to an existing mains repair.</p>
Units	-

KEY EXPLANATORY FACTORS

The following key explanatory factors were intended to be used in conjunction with the initial LPIs presented above when comparing leakage management areas. Together they allow a picture to be built up of the operating environment for leakage control.

EF1	Mains length per property
Comment	Increased mains length will increase travelling time and affect the difficulty of find leaks and the number of leaks that break out per property.
Measurable	Total length of mains / number of connected properties
Units	Metres/property

EF2	Proportion of external metering
Comment	A higher proportion of externally metered properties will result in more supply pipe leaks being picked up through meter reading instead of ALC. It should also lead to lower supply pipe leakage and therefore total leakage.
Measurable	Externally metered households / total households
Units	-

EF3	Marginal Cost of Water (Opex & Capex)
Comment	The higher the cost of water the greater the expenditure on leakage control. This should result in fewer leaks being found per inspector, shorter repair times and greater investment in technology, pressure management, etc.
Measurable	The marginal cost of water should be that associated with the current year's leakage target.
Units	Pence/m ³

EF4	Leakage repairs per 1000 properties (by type)
Comment	Used as an indicator of the breakout rate of leaks. It should include all repairs on the system carried out to rectify a leak. Repairs should be split: 4.1 mains (incl fittings), 4.2 communication pipes (incl stop taps, repair and replace), 4.3 supply pipes (repair and replace).
Measurable	Annual number of repairs / total connected properties (,000)
Units	Repairs / 1000 properties

EF5	Detected repairs per 1000 properties (by type)
Comment	Used as an indicator of the breakout rate of leaks that need to be identified through active leakage control. It should include all repairs on the system carried out to rectify a leak. Repairs should be split: 5.1 mains (incl fittings), 5.2 communication pipes (incl stop taps, repair and replace), 5.3 supply pipes (repair and replace).
Measurable	Annual number of repairs / total connected properties (,000)
Units	Repairs / 1000 properties

EF6	Policy minimum
Comment	The current policy minimum level of leakage is dependent on both the leakage control policy and local factors which are outside company control.
Measurable	The current policy minimum as used in the ELL.
Units	Litres/property/day

EF7	Leakage above the policy minimum
Comment	The higher the level of leakage above the policy minimum, the easier leakage detection should be.
Measurable	Annual leakage level – current policy minimum
Units	Litres/property/day

EF8	Average DMA size
Comment	The smaller the DMAs, the better prioritisation of areas for leakage detection should be.
Measurable	Total connected properties / number of DMAs
Units	Properties

EF9	Number of inflow/outflow meters per DMA
Comment	The greater the number of meters per DMA, the larger the potential for errors or loss of data and thus the poorer prioritisation of areas for leak detection could be.
Measurable	Total number of DMA meters / number of DMAs
Units	-

EF10	Night flow data quality
Comment	Good quality night flow data will result in better decision making and thus better prioritisation of areas for leak detection.
Measurable	<u>Total annual number of valid DMA night flows</u> (365 * No. of DMAs)
Units	-

EF11	Extent of pressure management
Comment	An indicator of the extent of pressure management.
Measurable	Total connected properties / number of PRVs
Units	Properties

EF12	Potential for pressure management
Comment	Indication of the potential for pressure management. It needs to be used in conjunction with EF11 to assess the extent of current pressure management.
Measurable	<u>Connected properties with available pressure > 30m</u> Total connected properties
Units	-

APPENDIX D DATA REQUIREMENTS AND GUIDANCE NOTES FOR FINAL SET OF LPIS

Leakage Performance Indicators

Description		Units	Report Year 2000-01
Base Data			
1	Number of detected leakage repairs on mains	nr	
2	Number of detected leakage repairs on mains fittings	nr	
3	Number of detected leakage repairs on communication pipes and stop taps	nr	
4	Number of detected leakage repairs on supply pipes	nr	
5	Total number of detected leakage repairs	nr	0
6	Number of reported leakage repairs on mains	nr	
7	Number of reported leakage repairs on mains fittings	nr	
8	Number of reported leakage repairs on communication pipes	nr	
9	Number of reported leakage repairs on supply pipes	nr	
10	Total number of reported leakage repairs	nr	0
11	Total number of leakage repairs	nr	0
12	Number of properties surveyed	000s	
13	Policy minimum level of leakage	MI/d	
14	Number of FTE leakage inspectors (active leakage control)	nr	
15	Number of connected properties	000s	
Primary Leakage Performance Indicators			
16	Detected leakage repairs per 1000 survey properties	nr/000pr	#DIV/0!
17	Detected leakage repairs per leakage inspector	nr/FTE	#DIV/0!
18	Reported repair time (mains)	days	
19	Reported repair time (mains fittings)	days	
20	Reported repair time (communication pipes and stop taps)	days	
21	Reported repair time (supply pipes)	days	
22	Detected repair time (mains)	days	
23	Detected repair time (mains fittings)	days	
24	Detected repair time (communication pipes and stop taps)	days	
25	Detected repair time (supply pipes)	days	
Secondary Leakage Performance Indicators			
26	Leakage repairs on mains per 1000 connected properties	nr/000pr	#DIV/0!
27	Leakage repairs on mains fittings per 1000 connected properties	nr/000pr	#DIV/0!
28	Leakage repairs on communication pipes and stop taps per 1000 connected properties	nr/000pr	#DIV/0!
29	Leakage repairs on supply pipes per 1000 connected properties	nr/000pr	#DIV/0!
30	Detected leakage repairs on mains per 1000 connected properties	nr/000pr	#DIV/0!
31	Detected leakage repairs on mains fittings per 1000 connected properties	nr/000pr	#DIV/0!
32	Detected leakage repairs on communication pipes and stop taps per 1000 connected properties	nr/000pr	#DIV/0!
33	Detected leakage repairs on supply pipes per 1000 connected properties	nr/000pr	#DIV/0!
34	Percentage detected leakage repairs	%	#DIV/0!
35	Policy minimum leakage per connected property	l/pr/d	#DIV/0!

GUIDANCE NOTES

Lines 1-4

- Include all leakage repairs undertaken on the potable water network as a result of active leakage control undertaken by the company, but
- Exclude all repairs initiated by a customer
- Exclude dry holes
- For repairs on mains fittings include repairs to hydrants, valves, washouts and company meters
- For repairs on communication pipes include ferrules, stop taps and customer meters
- For repairs on supply pipes include waste notices (first issue) given to customers
- Numbers should include replacements where the leak has been repaired through replacement of old or defective material or components

Lines 6-9

- Include all leakage repairs undertaken on the potable water network as a result of reported leaks or complaints by customers
- Exclude all 'detected' leaks
- Exclude dry holes
- For repairs on mains fittings include repairs to hydrants, valves, washouts and company meters
- For repairs on communication pipes include ferrules, stop taps and customer meters
- For repairs on supply pipes include waste notices (first issue) given to customers
- Numbers should include replacements where the leak has been repaired through replacement of old or defective material or components

Line 12

- Total number of connected properties in an area entered to carry out part of full leak noise survey in order to locate leakage either as a result of increased night flows or as part of a regular sounding exercise.
- If properties are resurveyed in order to reduce the initial leakage level this should be classed as a single survey and the number of properties should only be counted once.
- If an area is resurveyed as a result of leakage increasing again, following successful reduction, then this should be classed as a second survey and the number of properties should be counted a second time.
- Surveys carried out as a result of reported leaks or complaints by the customer should be not be include.

Line 13

- Also known as base level of leakage or background losses, this is the minimum level of leakage that is assumed to be possible given infinite leakage detection resources and using the least cost active leakage control policy (as derived in the ELL analysis).
- Enter the latest figure used in the economic level of leakage calculation.
- The value should be consistent with the report level of leakage and should include leakage on trunk mains and service reservoirs and MLE adjustments.
- Should represent an annual average value.

Line 14

- Average number of full time equivalent (FTE) leakage inspectors in the year employed on active leakage control work.
- Exclude inspectors time locating leaks initiated by customers
- Include contractors
- If inspectors work on a number of tasks, timesheet hours will need to be used to identify time spend on active leakage control.

Line 15

- Total number of connected properties (line 8 + 13 on Table 7 of June Return)

Lines 18-21

- The average time (in elapsed days) between a leak (or complaint) being reported by a customer and the repair being completed (excluding final reinstatement)
- Enter actual average rather than target time
- Repair types are the same as for lines 1-4.
- Enter weighted average if times vary for different areas.

Lines 22-25

- The average time (in elapsed days) between the precise location of a leak by the leakage inspector and the repair being completed (excluding final reinstatement)
- Enter actual average rather than target time
- Repair types are the same as for lines 1-4.
- Enter weighted average if times vary for different areas.

APPENDIX E Changes to original Leakage Performance Indicators document published March 2002

- Summary, page ii, Table S.1: “...~~KPIs~~ **LPIs**...”
- Summary, page iii, paragraph 3: “...have the potential to support to the current...”
- Page 2, 1.5, paragraph 1: “...output based ~~KPIs~~ **LPIs** (primary and secondary...” and “...The ~~KPIs~~ **LPIs** measured the performance...”
- Page 7, 2.5.2, paragraph 3: “...used as the ~~KPI~~ **LPI**...” and “...are independent ~~on~~ **of** the level of leakage...”
- Page 8, 2.6, paragraph 1: “...so that improving ~~KPI~~ **LPI** score...”
- Page 13, paragraph 1: “ ease of ~~interpretation~~ **interpreting** the resulting...”
- Page 17, 4.1, paragraph 1: “...of the ~~KPI~~ **initial LPIs** have been used...”
- Page 17, 4.1, bullet 2: “...~~KPI~~ **LPI**...”
- Page 18, Table 4.1: “...~~KPIs~~ **LPIs**...”
- Appendix A, page 25, paragraph 4: “...nature of a distribution system **in England and Wales** can be measured...”
- Appendix A, page 25, last paragraph: “...UARL does not **directly** address...” and “...minimum level of leakage. **The UARL calculation takes the existing pressure as a given. This is not necessarily the optimum pressure and consequently there is a danger of underestimating potential leakage reductions...**”

- Appendix A, page 26, formula: "... $L_p = \text{service pipe length (km)} - \text{length of unmetered supply pipe in km} \dots$ "
- Appendix C, pages 33 to 37: "...~~KPI 1-9~~ **LPI 1-9**..."
- Appendix C, page 34, LPI 2 description: "...The ~~KPI~~ **LPI** has been normalised..."
- Appendix C, page 36, LPI 7 description: "...This ~~KPI~~ **LPI** measures the..."