Thames Water

Draft Water Resources Management Plan 2019

Technical Appendices

Appendix K: Process losses

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Appendix K.

Process losses

- In this section of the draft Water Resources Management Plan (WRMP) we define the method for definition of process losses for the Water Resources Management System (WARMS2) model derived from the Thames Water developed Water Treatment Works (WTW) resilience models, which are used for water asset planning purposes
- The process used for derivation of the values in the tables has been included
- We explain how the process losses of the Annual Review figures compare to those calculated in WARMS2 for the London Dry Year Annual Average (DYAA) deployable output (DO)

A. Introduction

K.1 At any WTW, even very simple plants, for every litre of water that is abstracted from the environment and is treated before passing into the distribution network, a small fraction of the water, the waste stream, will be unsuitable for supply. This waste stream carrying the separated raw water contaminants and any additional process water may be further treated and recovered.

K.2 The wastewater can arise from plant cleaning, maintenance or health and safety reasons, for example, eye baths or showers. The sum of all the waste streams is generally termed the process losses for a plant. The more complex a water treatment plant, with multiple processes, then generally the greater the process losses. Treatment plants are designed to recover, treat and recycle as much of this water as economically possible to limit the volume of water that is lost.

K.3 Process losses are generally presented as a percentage of the raw water that is abstracted, or a percentage of the water that is put into supply. Although these are often presented as a single percentage figure it is important to understand that the process losses will change as a function of the quality of the raw water. As raw water quality deteriorates, then so the volume of the waste stream to remove contaminants also increases resulting in higher process losses, as discussed in Section D (Water Resources Management System) of this appendix.

K.4 When considering process losses in the Thames catchment, some of these waste streams are treated and discharged to the river directly. Others may be discharged to a sewer and return to a river via a wastewater treatment plant. In many cases this water then supports the flow in the river which can be abstracted downstream. So whilst this represents a process loss for the WTW itself, it is returned to the environment and is not necessarily lost as a raw water resource.

K.5 In this manner although individual WTW losses may seem significant, the cost for a greater degree of recovery of waste streams may lead to the requirement for more complex treatment plants. If this was not required by the Environment Agency to protect the quality of the receiving river environment, the additional treatment would lead to disproportionate operational costs for water which already supports downstream abstraction, and which may also have environmental benefit in terms of increased flows in sections of rivers or watercourses.

K.6 In our Annual Review we present an operational mass balance for the process losses in the plants linked to reservoir storage (Figure K-1 and Table K-1). This is an operational flow mass balance for that year. It will therefore reflect the operational practices that year as well as the climate and water quality conditions. Variability in the mass balance and process losses between years is therefore normal and should be expected.

K.7 We use the simulation model entitled WARMS2 to calculate the amount of water we can put into supply as discussed in Section 4: Current and future water supply. This model evaluates the amount of raw water that is available to treat and has input values for WTW capability and process losses.

K.8 Differences between the Annual Review and WARMS2 WTW capability and process losses numbers are a function of operational practices, climate and water quality conditions during the previous year. As noted above, such differences should be expected.

Figure K-1: Raw water resource mass balance

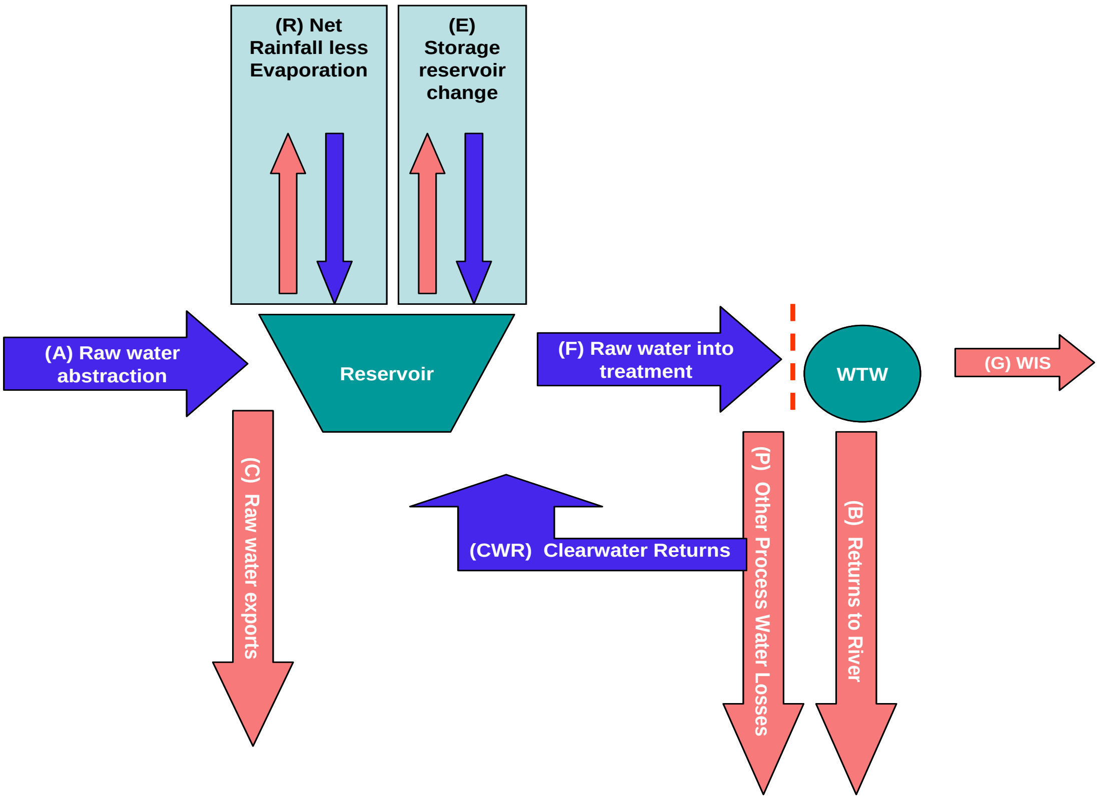

Table K-1: London water balance, units Ml/d

London water balance to calculate process water losses as presented in the Annual Returns				
Ref		**2014/15**	**2015/16**	**2016/17**
A	Raw water abstraction	2294.04	2262.35	2347.61
C	Raw water bulk supply	94.18	81.43	89.03
E	Change in reservoir storage over the year	-13.73	6.43	14.12
R	Net rainfall less evaporation	11.24	8.09	2.39
CWR	Clearwater returns	6.40	13.83	25.20
F	Raw water to WTW			
LHS	F = A - C + E + R + CWR	2203.77	2209.27	2300.29
RHS	F = G + B + P + CWR			
G	Water into supply	2045.80	2070.16	2109.45
B	Returns to river	146.53	64.71	92.42
P	Other process water losses			
	P = F - G - B – CWR	5.04	60.57	73.22
	Total losses = P + B	151.57	125.28	165.64
	WARMS2 process water losses from DO calculation	126.19	127.51	127.72
	Difference to modelling assumptions	25.38	-2.23	37.92

B. Water treatment of groundwater sources

K.9 The methodology for the determination of groundwater DO identifies treatment capability and process water losses as key constraints to the availability of water. As such the source deployable outputs (SDOs) of groundwater sources that are treated locally, and not transferred to surface water systems for treatment, include process losses as a constraint in their calculation[1]. WARMS2 uses groundwater SDOs in its calculations and does not identify the process losses at each of the groundwater sources.

C. Water treatment of surface sources

K.10 WARMS2 uses surface water treatment capability and associated process water losses in its calculation of DO as set out in Section A (Introduction) of this appendix.

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[1] Procedure for the Assessment of Groundwater Source Deployable Outputs 2017, Groundwater Resources, Water Strategy, Planning and Assurance

K.11 We have developed mass balance and resilience models for all WTWs in each water supply zone. These models form a structured, auditable basis for defining our WTW capability and process losses. The WTW mass balance and resilience models enable assessment of historical seasonal variations in raw water quality as well as potential future climate change challenges.

D. Water Resources Management System

K.12 The water resource planning model WARMS2 uses a single value for process water losses for each individual WTW; this is an average of the process losses for that WTW in a typical dry year. Where process losses return to the river and increase flow in the river or watercourse downstream, this is included in the available water modelled in WARMS2 and supports DO. WARMS2 currently uses process losses that were developed and used for Water Resources Management Plan 2014 (WRMP14). However, work is on-going with the development of the WTW mass balance and resilience models to provide an improved understanding of the losses that will be used in WARMS2 as part of our commitment to an improved understanding of DO.

K.13 A worked example has been provided in Table K-2 that gives the output for process losses for Coppermills WTW. These are derived from the mass balance and resilience model for Coppermills. The model defines the process losses anticipated under different raw water quality conditions, in particular algal bloom challenges in the stored raw water systems, which can impact the treatment process water losses and the output of the WTW. For all sites the Standard (Scenario 1) represents the WTW process losses with average water quality data, designed and operated in accordance with the Asset Standard. The Base Case (Scenario 2) represents the current design and operation including any agreed deviations from asset standards, with average site water quality data. Subsequent algal Scenarios 3 and 4 use the Base Case model with deteriorating water quality expected in a defined period for algal blooms of varying severity.

K.14 In any given year the WTW can experience a severe algal bloom and it is evident that there will be a change in process losses during such a challenge. Historically in the Thames catchment we have algal challenges during spring and autumn. Each bloom lasting four to six weeks, although there is evidence that this is changing. Typically the input to the WARMS2 model is calculated assuming ten months of average water quality in a year and two months of 1 in 1 year algal challenge, e.g. for Hampton, Ashford Common and Kempton Park, but this will be different for other WTWs, including for example, Coppermills and Chingford.

Table K-2: WARMS2 process losses for Coppermills

Coppermills	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	2.8%	4.1%	6.6%	12%
DYAA figure		7.0%		

K.15 At the Coppermills WTW the waste flow streams are treated to recover 35 Ml/d of treated water for use. In a severe algal bloom however, the plant is likely to be operating at a reduced throughput as a result of increased filter bed backwashing and recovery time.

K.16 The process loss for Coppermills reflects historical raw water conditions, including algal blooms of varying severity, and assumes five months of average water quality and four months of a 1 in 1 year algal challenge, plus three months of 1 in 5 year algal challenge. As a result, the potential average year losses are 7.0% of the plant flow minus the 35 Ml/d which can be recovered. The WARMS2 model uses the 7.0% process losses and also takes into account the recovery of up to 35 Ml/d of the wastewater.

E. Process loss figures

K.17 Table K-3 to Table K-12 give details of the WTW process losses that are input into the WARMS2 model and used in Water Resource Zone (WRZ) DO assessments. As discussed above, they are derived from the WTW mass balance and resilience models.

Hampton

K.18 The washwater treatment process at Hampton uses a system to collect and clarify the washwater. After clarification the water is discharged to the River Thames under Environment Agency consent.

Table K-3: Process losses for Hampton

Hampton	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	6.2%	6.9%	8.5%	13.6%
DYAA figure		7.2%		

Ashford Common

K.19 The washwater at Ashford Common is collected and clarified. After clarification the water is discharged to the River Thames under Environment Agency consent.

Table K-4: Process losses for Ashford Common

Ashford Common	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	4.8%	4.8%	5.5%	13.7%
DYAA figure		4.9%		

Kempton Park

K.20 Dirty washwater is collected and treated before being discharged back into the River Thames via a tributary. The sludge produced is disposed of directly to sewer.

Table K-5: Process losses for Kempton Park

Kempton Park	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	7.2%	7.6%	8.2%	15.2%
DYAA figure		7.8%		

Walton

K.21 Dirty washwater is collected, chemically treated, clarified and filtered before being discharged back into the River Thames. The sludge is collected and thickened before being disposed of to sewer. This is a very small percentage of the washwater flow. The receiving sewage treatment works (STW) discharges its final effluent into the River Thames upstream of Teddington weir.

Table K-6: Process losses for Walton

Walton	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	6.9%	12.1%	30.9%	42.9%
DYAA figure		14%		

Hornsey

K.22 The process loss input to WARMS2 is again calculated assuming ten months of average water quality in a year and two months of 1 in 1 year algal challenge. The combined wastewater is treated through a clarification process. This maintains a high quality clarified waste stream that can be recovered to the head of the WTW, minimising the process losses. This is recovered about 80% of the time as operationally we will not recover the water if there is a water quality risk. Table K-7 shows how this average value for the process losses has been calculated.

Table K-7: Process losses for Hornsey

Hornsey	**Scenario 1**	**Scenario 2**	**Scenario 3**
	Base case average quality	**95% centile water quality**	**Maximum**
Percentage loss: water recovery	1.4%	2.5%	3.2%
Average for year with recovery	1.6%		
Percentage losses: no water recovery	4.2%	7.1%	10.4%
Average for year without recovery	4.7%		
DYAA figure	2.2 %		

Chingford

K.23 The combined wastewater is treated through a clarification process. This maintains a high quality clarified waste stream which can be recovered to the head of the WTW, minimising the process losses. This is recovered about 80% of the time as operationally we will not recover the water if there is a water quality risk. This is calculated in the same manner as the Hornsey with the average values presented in Table K-8 below.

Table K-8: Process losses for Chingford

Chingford	**Scenario 1**	**Scenario 2**
	Average for year with recovery	**Average for year without recovery**
Percentage losses	0.75%	2.9%
DYAA figure	1.1%	

Gateway

K.24 The Thames Water Gateway plant is a desalination WTW treating water from the Thames tidal estuary. Its primary function is to operate during a drought only. As the raw water is abstracted from the Thames estuary and the process losses are returned to the estuary, there is no recycling of the process losses. As a result of this situation, the treated water output from the Gateway WTW is used as an input into the WARMS2 model and modelling process losses is not applicable.

Shalford

K.25 The washwater at Shalford is collected, treated and recovered. Residual waste flow is treated and discharged to the river under Environment Agency consent. The WTW process loss figures included in Table K-9 and used in the WRZ DO assessments are being reviewed to ensure confidence in WTW capability and thus the SDO.

Table K-9: Process losses for Shalford

Shalford	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year quality challenge**	**1 in 5 quality challenge**
Percentage losses	5.0%	8.2%	12.1%	15.2%
DYAA figure		8.8%		

Farmoor

K.26 The wastewater is treated to a sufficiently high quality so that it can be recovered to the head of the WTW. A process loss value of 8.4% is used in WARMS2, which accounts for algal blooms that can be prolonged and extend to six weeks in spring and autumn. These process losses are pending a review of the Farmoor mass balance and resilience model.

Table K-10: Process losses for Farmoor

Farmoor	**Scenario 1**	**Scenario 2**	**Scenario 3**
	Base case average quality	**1 in 1 year algal challenge**	**1 in 5 year algal challenge**
Percentage losses	1.64%	7.64%	8.34%
DYAA figure	8.4%		

Swinford

K.27 The wastewater is treated to a sufficiently high quality so that it can be recovered to the head of the WTW. A process loss value of 3.3% is used in WARMS2, which accounts for algal blooms that can be prolonged and extend to six weeks in spring and autumn. These process losses are pending a review of the Swinford mass balance and resilience model.

Table K-11: Process losses for Swinford

Swinford	**Scenario 1**	**Scenario 2**	**Scenario 3**
	Base case average quality	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	1.8%	3.7%	4.5%
DYAA figure	3.3%		

Fobney

K.28 The wastewater is combined and sent to sewer for further treatment at a STW. The WTW process loss figures included in Table K-12 below and used in the WRZ DO assessments are being reviewed to ensure confidence in WTW capability and thus the SDO.

Table K-12: Process losses for Fobney

Fobney	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Standards	**Base case average quality**	**1 in 1 year algal**	**1 in 5 year algal**
Percentage losses	5.5%	5.7%	6.8%	8.0%
DYAA figure		5.9%		

F. Process losses derived from mass balance and resilience models and variation from WARMS2

K.29 The process loss figures used in the WARMS2 model currently have been derived from a series of WTW mass balance and resilience models available when compiling the WRMP14. The mass balance and resilience models are reviewed and updated as part of our business as usual processes, accounting for changes in the WTW capability and process loss figures and used in the WARMS2 model and in the assessment of source and WRZ DO.

K.30 It should be noted that the process loss values used in WARMS2 and WRZ DO assessment are considered to be the most valid approximation of a single figure representative of DYAA process losses. In the event that in a single year the water quality or challenge experienced at a WTW is not that of a 1 in 1 year algal challenge but a 1 in 5 year challenge event, or the challenge period is extended, then the actual process losses as indicated in Table K-13 will be higher. Under future climate change scenarios process losses should be anticipated to change. Raw water quality challenge values greater than a 1 in 5 year event have not been presented, but are significantly higher.

Table K-13: Inputs to WARMS2

WTW	Process water losses (%)
Ashford Common	4.9
Hampton	7.2
Kempton Park	7.8
Walton	14
West London average	8.5
Chingford	1.1
Coppermills	7.0
Hornsey	2.2
Lea Valley average	3.4
Gateway	Not applicable
Farmoor	8.4
Swinford	3.3
SWOX average	5.9
Fobney	5.9*
Shalford	8.8*

** = Process losses being reviewed*

K.31 The Annual Review process loss figures are a representation of the previous year’s water quality and climate conditions and therefore should not necessarily be expected to align with the single DYAA figures included in WARMS2. It should be noted that any current differences between the WARMS2 and the reported process loss figures are within the variability that can occur due to raw water quality changes.

K.32 Returns to the river are taken into account in the assessment of DO. Where the wastewater is lost from the river system in terms of supporting water available for abstraction, cost effective recovery systems suitable for the water have been employed. Specific points to note are that the west London flows are returned to the river directly or via STW supporting the flow over Teddington weir. This is accounted for in the WARMS2 model and does not therefore present a loss of raw water resource. Schemes to reduce process losses have not been developed as resource options within this plan. Where there are losses to a river or a STW in London they have been reviewed. These sites generally have cost effective means of recovering the water available.

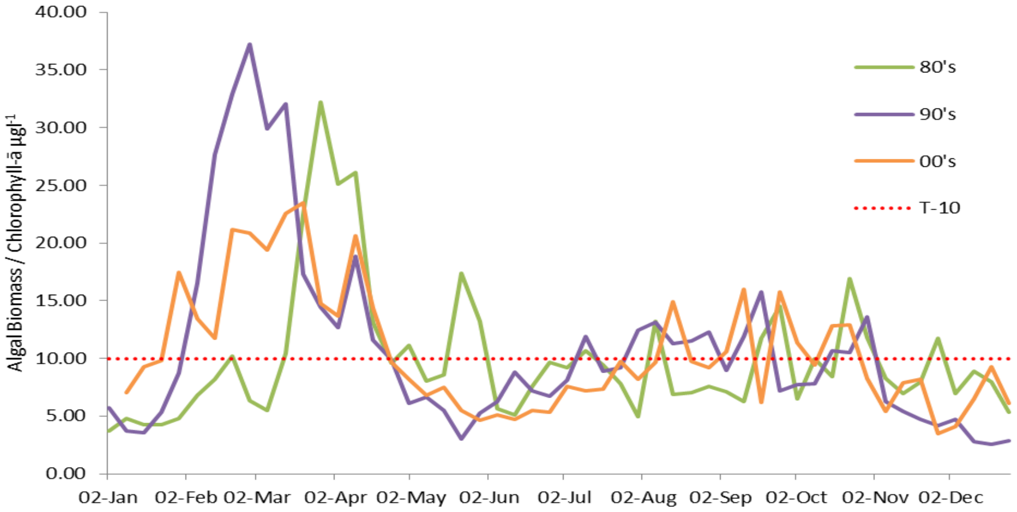
G. Implications of climate change

K.33 It is evident that our supplies and WTW outputs are vulnerable to seasonal raw water quality and the impacts of climate change affecting it. Therefore as well as raw water resource availability, the water quality challenge and how this may change in the future is important. We are working with subject matter experts to develop decision support tools to predict raw water quality (algal) behaviours in the future.

K.34 Algae can in some cases significantly affect the ability of surface WTW to produce drinking water and increase the cost of this treatment. The UKWIR study regarding climate change implications for water treatment[2] predicts algae will be more problematic for public water supply as a result of climate change and therefore further impact process losses.

K.35 In partnership with Imperial College London a study has been conducted to investigate the frequency and severity of algal events in raw water reservoirs. Using 30 years of data from the early 1980s onwards we have looked for patterns of reservoir algal behaviour correlated to climate.

Figure K-2: Changing pattern of algal blooms over past three decades



Source: Imperial College, Merle Anderson, MSc Storage Reservoirs, Algal Blooms and Climate change, June 2013

K.36 By looking at the resilience of our raw water storage and network we have found that algal bloom severity and longevity appear to be changing, depending on the reservoirs physical structure and management. For example, deeper reservoirs have better control measures to manage the raw water quality and therefore are more resilient to the impacts of climate change.

K.37 The National Environment Research Council (NERC) has funded a five year interdisciplinary UK wide droughts and water scarcity research programme to support improved decision

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[2] UKWIR, 11/CL/08/02: Climate Change Implications for Water Treatment, 2011

making. Following the 2011/12 UK drought experience a Managing the Risks, Impacts and Uncertainties of drought and water Scarcity (MaRIUS) project was initiated in order to investigate the potential for, and assess the impact of future droughts. The span of the MaRIUS project is large and covers physical and social science topics including the effects on water quality from nutrient concentration in rivers and algal concentrations in reservoirs.

K.38 We have engaged the Centre of Ecology and Hydrology (CEH), developers of the Protech model, to undertake a quantitative assessment of one of our raw water storage reservoirs in the London WRZ to determine a revised volume of raw water available for treatment. Following the results of this assessment we will continue to model the remaining 25 raw water storage reservoirs to assess the overall volume of treatable raw water storage and the impact on our existing supply/demand balance.

K.39 The potential WRZs that could become vulnerable by this research are London and, Swindon and Oxfordshire (SWOX) due to the reliance upon storage reservoirs. This may also have knock on impacts to other WRZs reliant on London and SWOX for system resilience.

K.40 The primary aim of our work in this area is to better inform our evaluation of our system resilience and to be able to base this judgement on fact based empirical modelling. Although this work is in its infancy, our initial results indicate that as we further develop our understanding of the way we operate our reservoir network we may be in a position to make better, more informed decisions and be able to better target investment to improve system resilience in future WRMPs.