SECTION 4: WATER QUANTITY AND FLOW

"Our Vision is a river full of water that is plentiful and clean, and varied in its flow speeds, widths and depths"

Wandle Catchment Plan Objective 1: Water supply in all sections of the river is sufficient to sustain a healthy population of native flora and fauna, and is resilient to risk of drought or flood from extreme weather events or management for human use

4.1: Overview and historic flow records

Chalk rivers like the Wandle rely on abundant autumn and winter rainfall (when evaporation and transpiration by trees and plants is reduced) to recharge their ground water aquifers, scour silt away from gravels during high winter flows, and then maintain flows at adequate levels for the rest of the year (English Nature and Environment Agency, 2004).

When flows are reduced by abstraction and other pressures such as climate change, the duration of flow in winterbournes is shortened or lost altogether, perennial habitat for fish and other animals is lost, river gravels are choked by algae as a result of increased nutrient concentrations, and pollution events become more damaging because dilution is reduced.

Most chalk rivers are located in south eastern England, where population densities are high (and growing) and rainfall is relatively low. In some river catchments, including the Wandle, ground water aquifers have historically been relied upon as a source of clean water for public supply: as a result, today's flows in the Wandle are considerably reduced from their historic highs.

By some estimates, increased abstraction has meant that natural baseflows in the river today are a mere sixth of their historic value in the early 19th century (Shew, 2012). Old descriptions of Croydon refer to the Bishop's Palace being "surrounded by a large moat and fish ponds, fed by the limpid streams of the Wandle" (*Local History Reprints: Bygone Surrey – Mediaeval Croydon*). In a description of his youth near Croydon in the 1820s, John Ruskin remembered "the cress-set rivulets in which the sand danced and minnows darted above the Springs of Wandel". Even at the time of Braithwaite's detailed survey of the full length of the Wandle in 1861, pointedly titled *On the Rise and Fall of the River Wandle: Its springs, tributaries and pollution*, flow from the Croydon springs alone totalled more than 19,000,000 imperial gallons (0.99 cumecs) every 24 hours, even before this flow was augmented by 1,200,000 gallons (0.06 cumecs) per day from Waddon Ponds. Today, flow in the newly-deculverted river channel through Wandle Park in Croydon is barely visually perceptible unless increased by rainfall and urban runoff from Croydon's modern hard surfaces, while Waddon Ponds provide most of the Croydon arm's spring flow at an average 0.07 cumecs.

Further down the river, Braithwaite noted that the gravelly soil of Mitcham Common was "generally well charged with water, so that there would be considerable difficulty in cutting a trench, or making a sewer, on account of the water which would flow in, or filter through the joints of the works". Conversely, "during dry seasons… the gravelly district not only refuses to part with its water, but even robs the river of water, which flows down from a district less influenced by evaporation". This suggests significant interaction between the Wandle and an extended hyporheic zone, which has now been damaged by general abstraction and isolation of the river by means of fully concreted channels through Earlsfield and Wandsworth.

At Garrett's oil mills in Wandsworth, Braithwaite also recorded a flow of 4.36 cumecs: more than twice the average 1.7 cumecs recorded by the EA's gauging station at Connolly's Mill, not far upstream, between the 1960s and 2010 (by which time flows in the lower river had also been considerably boosted by the addition of treated effluent from Beddington sewage treatment works).

For the purposes of public water supply, the Wandle catchment's water resources are managed by Thames Water (sewerage and supply) and Sutton & East Surrey Water (supply only). Their management systems are not mapped precisely to the river's hydrological catchment: fresh water supply is influenced by the Thames Water Ring Main, which transports water from several different catchments and reservoirs in west London. At the other end of the process, most sewage goes to Beddington STW and is thus returned to the Wandle. However, much of the sewage from the northern end of the surface water catchment is pumped "out of catchment" for treatment at Crossness.

In summary, there is no doubt that quantity (and hence the quality) of the Wandle's water supply has been severely impacted by anthropogenic activities. The question remains: how can the effects of those activities be mitigated to match this Catchment Plan's Vision?

<u>Further information required:</u>

Investigation of the actual proportion of locally-sourced water used for domestic purposes within the Wandle catchment, in order to forecast the real effectiveness of wise water use campaigns

<u>Further reading:</u>

Braithwaite (1861) *On the Rise and Fall of the River Wandle: Its springs, tributaries and pollution*

English Nature and the Environment Agency (2004) *The State of England's Chalk Rivers: A report by the UK Biodiversity Action Plan Steering Group for Chalk Rivers*

4.2: Recent and contemporary flow and water quantity assessment

River flow (also known as discharge, symbolised by the letter Q) is generally expressed as the volume of water passing over any point over a period of time, and is measured in cubic metres per second (cumecs).

In any river it is important to understand both high and low flows: high flows shape the channel profile and control sediment transport, while low flows through the river's *thalweg* represent more likely day to day conditions. High flow conditions are typically expressed as Q10 (Q represents the discharge and 10 represents the flow quantity that exceeds normal discharge volumes only 10% of the time). Low flow conditions are expressed as Q95 (discharge exceeds this amount 95% of the time). For the purposes of maintaining sustainable levels of abstraction, the EA often requires abstraction to stop when fluvial flow is at Q90.

As such it is also important to recognise that the Wandle's Q figures have changed significantly over time, and that baseflow volumes have been much reduced by pressures such as recharge deficits, abstraction for public supply and even policy-driven control of ground water levels to maintain integrity of underground structures in the London clay (although it is noted that this is unlikely to affect baseflow in the chalk-fed reaches of the Wandle).

Chalk streams are typically characterised as stable, predictable systems: however, pinched between general catchment hardening by urban development on one hand, and abstraction for industry and urban communities' consumption on the other, the Wandle's hydrograph is now almost entirely anthropogenically controlled.

High flows

Through much of the 20th century the Wandle was progressively re-engineered as a highly efficient flood relief channel for rainfall flashing off the urban surfaces of south London. As such, high flows are controlled by the following measures:

- Tilting weirs: installed as an integrated system to manage the time-response of the river to rainfall in different parts of the catchment.
- A flood flume in Beddington Park: designed to divert high flows away from the Wallington and Hackbridge area via the Beddington Mitcham Area of Opportunity (BMAO)
- Flood storage capacity in the BMAO: made available by long-term gravel extraction in this area
- An array of 8 storm tanks at Beddington STW: designed to capture over-capacity flow, often resulting from rainfall entering the surface water drainage system. These usually take 4 - 6 hours to fill, although particularly heavy rainfall could fill them in as little as 2 hours.
- When high groundwater levels trigger the appearance of the Caterham Bourne rises, flood storage capacity is provided by a bund in Bourne View allotments, and a balancing pond at Purley Oaks depot. Overpumping into the surface water drainage system is also possible (and indeed took place in early 2014).

Low flows

As a result of abstraction for public water supply, the Wandle's chalk aquifer can be rapidly depleted in periods of low recharge. The following measures go some way to mitigating the effects of massive depletion to the river's natural baseflow:

- Under the terms of Sutton & East Surrey Water's abstraction licence for the 3 boreholes associated with the Oaks Park pumping station, a minimum average daily flow of 4.5Ml/d must be maintained over the gauging weir below Carshalton Ponds. This is achieved by abstracting river water at Goat Bridge and recirculating it back upstream via an unusual augmentation system (see Section 4.6).
- Below Goat Bridge, the river's flow is dominated by treated sewage effluent. Beddington STW adds 234,000 m3 of treated sewage effluent to the Wandle every day (2.708 cumecs), a volume which contributes an estimated 60% - 90% to the seasonal flow of the river. Over the 24 period, this average flow shows clear diurnal fluctuation corresponding to peaks and troughs of human activity within the STW's catchment.

The variable and combined effects of these influences on the river's natural hydrograph makes any study of flow data exceptionally complex, unless in extreme detail and with great specificity as to location.

However, it is the Wandle Catchment Plan's partners' view that any steps taken to renaturalise the river's hydrograph, and reduce anthropogenic control of the river's processes for long-term sustainability, would be welcomed in the future.

4.3: Springs

"We love it when the springs around Carshalton are flowing, filling up the dried-out sections and washing away all that smelly black mud in the Ponds"

- from Ketso community and stakeholder workshops

The natural sources of chalk rivers often migrate considerable distances up and down their catchments according to the height of the ground water within their aquifers. These ephemeral reaches above the perennial headwaters are known as winterbournes, which can often harbour complex and highly adapted ecosystems in their subsurface hyporheic zones, but are often very vulnerable to fluctuations in rainfall and anthropogenic influences including abstraction.

Today, the sources of the perennial Wandle appear fixed: however this appearance is often illusory as a result of the impact of long-term abstraction, and hard engineering solutions such as the Goat Bridge – Carshalton augmentation system installed in the 1960s to mitigate the aesthetic impacts of severely depleted aquifers.

Several headwater reaches of the Wandle which once flowed perennially have been reduced to very occasional winterbourne status: almost within living memory the Grotto arm of the river flowed constantly from an ornamental grotto in Carshalton Park to power two large mills year round, but it now rises only in response to unusually heavy and prolonged aquifer recharge (most recently in the winter of 2013-14). Similar conditions apply to Carshalton Park's Hogpit Pond, which once supplied power for a small mill near the south western corner of Carshalton Ponds. At a slightly lower elevation, springs appear more frequently in Margaret's Pool and the lake at St Philomena's School in response to aquifer recharge, and also flow into Carshalton Ponds.

On the Croydon branch of the river, the combined effects of abstraction and the gradient on the dip slope of the North Downs (which is relatively sharp compared to the gradient of the groundwater surface) mean that most of the Wandle's springs now appear within a short distance of the main river channel, whose Croydon branch flows east to west from Waddon to Wallington along the line of the Bromley beds.

Several springs, historically formalised and ornamented to greater or lesser degrees, appear in the Beddington Park area, and converge at the London Road bridge before flowing down to the confluence with the Carshalton water body at Wilderness Island. Despite being culverted, some of these springs appear to flow consistently year round, and it has been suggested that simple deculverting may be sufficient to restore important reaches of new chalk stream headwaters for the benefit of trout and other species (pers comm. Dave Brown, 2013).

4.4: Bournes

In addition to the spring sources described in Section 4.2 above, the Wandle catchment features several winterbournes which rise very intermittently in the chalk valleys above Croydon.

Historically they acquired a reputation as "woe waters", portending national disasters including plague in London in 1665 and the revolution of 1688 (Bourne Society, 2002: Aubrey, 1723). Much more likely is the explanation that the rising of the bournes indicated high levels of aquifer recharge, which resulted in higher than average ground and surface water levels in the Croydon area and led to outbreaks of illness linked to poor sanitation.

Although unpredictable, the Caterham Bourne appears to flow most frequently, approximately once every seven to ten years. It generally rises in the area of the Woldingham viaduct, sometimes flooding areas of Whyteleafe and Kenley, before becoming fully culverted at Purley.

The Coulsdon Bourne is less easy to trace on the ground for significant distances: however a short length appears at Coulsdon South railway station and later joins the course of the Caterham bourne at Purley. At these points a low but possibly perennial flow seems apparent, which may be due to a relatively impermeable layer of surface geology maintaining surface flow.

Recent winterbourne-related flooding has occurred in the 1960s, in 1995 and through the winter of 2000-2001 when homes and roads in Kenley and Whyteleafe were submerged for several weeks (Bourne Society, 2012). Continuous aquifer recharge during 2012 and 2013 also resulted in strong winterbourne flows from January 2014.

Local geology may be complex and not fully understood: the EA's LEAP of 1999 suggests that some surface flows may sink below ground level again and continue deeper underground to join the confined London aquifer, rather than feeding into the Wandle directly via culverts under Croydon. Some water may also re-emerge as springs along the dip line. However, lack of flow in the Wandle's winterbournes can now be considered typical, even in winter, and their primary function appears to be as surface water drains for road runoff.

Further reading:

The Bourne Society (2002) *A Celebration of the Bourne*

4.5: Beddington Sewage Treatment Works

"We've been outraged by many years of pollution incidents from Beddington sewage treatment works. Now we believe everyone needs to work together to protect the Wandle from damage by future pollutions"

- from Ketso community and stakeholder workshops

Clean water supply and sewage disposal are binary issues which have long affected many urban rivers and their surrounding human populations, and the Wandle has been no exception to this rule.

Today, the catchment's main sewage treatment works (STW) at Beddington serves a population of 350,000 across 28 square miles of south London, with sewage from four sewerage systems as shown in Fig 4.1 below:

- Central and Southern Croydon Gravity Sewer
- Sewage from Carshalton received via Buckhurst Avenue pumping station
- Mitcham Gravity Sewer
- Roundshaw housing estate

According to figures released by Thames Water in November 2012, the STW discharges 234,000 m3 of treated sewage effluent into the Wandle every day (2.708 cumecs), a volume which contributes an estimated 60% - 90% to the seasonal flow of the river below the effluent channel's confluence point at Goat Bridge.

Over a 24 hour period, flows through the STW show a clear diurnal pattern in response to human activities: falling to their lowest around 4am, before rising sharply just before 8am and remaining high throughout the day apart from a dip in the mid afternoon. Volumes and patterns are roughly stable throughout the year (pers comm. Thames Water), and are sometimes thought to provide ecologically beneficial flows in drought conditions when the river's baseflow is severely depleted.

Specific water quality issues relating to Beddington STW, together with details of the sewage treatment process, are further discussed in Section 5.7.

Storm tanks

Storm tanks are commonly used at STWs to capture (and temporarily store) over-capacity flow which arrives as a result of precipitation runoff into the combined drainage system.

At Beddington STW, if the volume of sewage entering the works is greater than 2.3 m3/s, it backs up behind the inflow penstock and overflows over a weir into a channel which diverts it to an array of 8 storm tanks with a cumulative capacity of 25,900 m3. These tanks perform a function similar to primary treatment: stored sewage has the chance to settle so that solids fall to the bottom. If the tanks fill beyond capacity, the stored effluent is then released into the river. If they don't fill beyond capacity, the sewage is recirculated for treatment.

On average, Beddington STW's storm tanks take four to six hours to fill, although particularly heavy rainfall could fill them in as little as two hours. This capacity far exceeds the maximum flow to treatment retention time for most Thames Water STWs, which are designed to have only 2.67 hours' capacity before raw sewage is released. As a result, this capacity is considered to be very good.

Any overflow into the Wandle is likely to consist mainly of the watery sewage components as a result of settling in the tanks. In the course of normal operation, Beddington STW's storm tanks overflow no more than six times a year, at times when dilution is likely be maximised as a result of heavy rain throughout the catchment. Raw sewage would not be released into the Wandle for any other predictable reason.

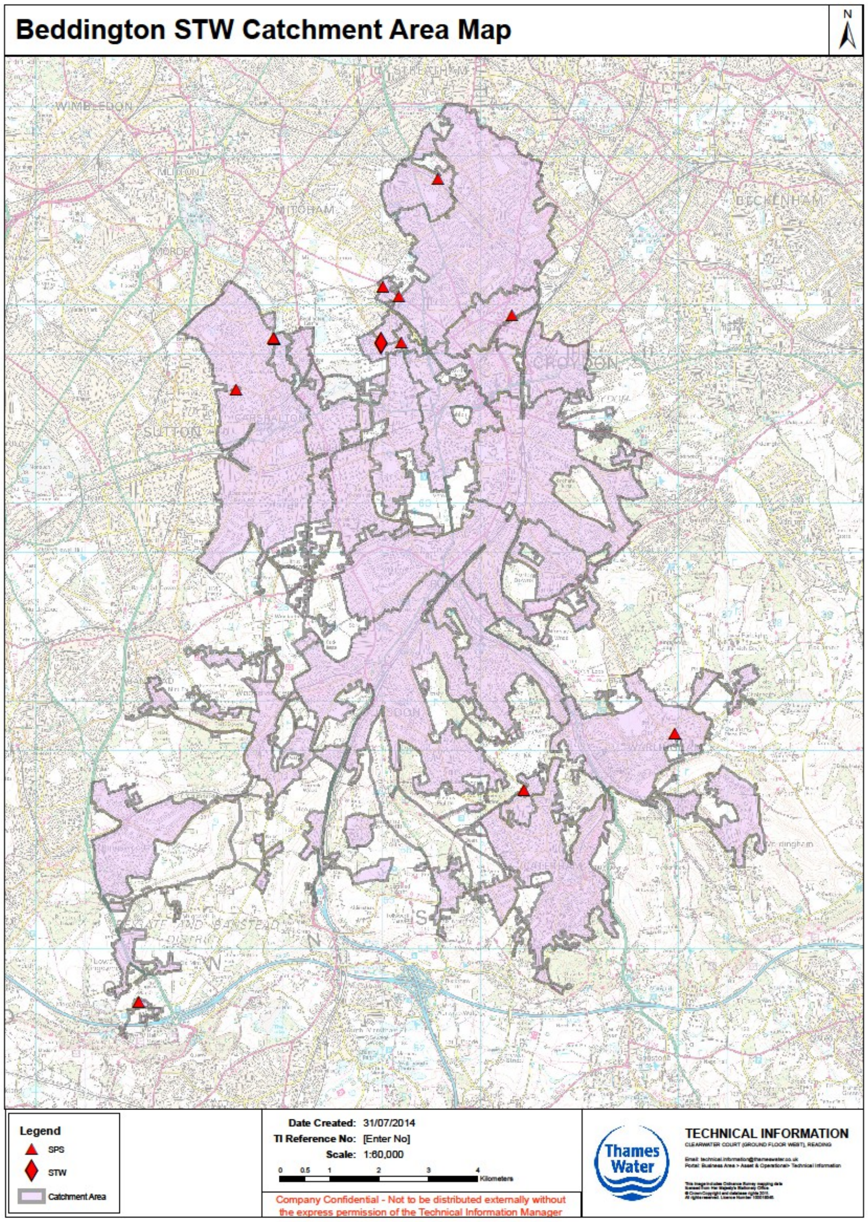

Fig 4a: The catchment area of Beddington STW

4.6: Carshalton branch augmentation system

"We're glad that the artificial recirculation system has kept the upper river flowing for so long, but we want a more natural and sustainable solution in the long term"

- from Ketso community and stakeholder workshops

In the late 1960s, when the effects of abstraction had begun to register permanent effects on the Wandle's headwater spring flow, the then Sutton District Water Company and Thames Water Authority agreed to maintain amenity water levels in Carshalton Ponds by concreting the base of the Ponds and recirculating water back upstream from the Wandle at Goat Bridge (Shew, 2012).

Under the terms of SESW's abstraction licence for the three boreholes associated with the Oaks Park pumping station, no ground water can be abstracted unless the rate of flow in the Wandle, measured at the Carshalton Ponds gauging station, is greater than 4.546 megalitres per day (SESW).

This is achieved by abstracting water from the river at Goat Bridge (a few metres above the upper river's confluence effluent channel from Beddington Park STW), passing it through sand filtration tanks, and pumping it upstream via a steel pipe under the river and adjacent roads to the upper corner of Carshalton Ponds adjacent to Honeywood House (pers comm. SESW). The sand filtration process may help to remove metal loading, since metals are associated with particles of a size range which would get caught by the sand, as well as reducing Biological Oxygen Demand (pers comm. Dave Brown, 2012). Introducing water from the Croydon arm into the Carshalton water body may also have implications for GEP.

From the time that the pumping system is triggered, water takes approximately half an hour to travel from Goat Bridge to Carshalton Ponds, and c3 hours to work its way through the Ponds to raise the river level noticeably. Likewise, there is a c3 hour lag between switching the pumps off and the river level falling

During periods of low flow, this augmentation pumping maintains a minimum average daily flow of 4.5Ml/d as measured at Carshalton Ponds gauging station. The rules for the Goat Bridge abstraction are governed by two abstraction licenses and the following key parameters (pers comm. SESW):

- Abstraction from the Wandle at Goat Bridge is limited to a maximum of 6.819 Ml/d (i.5 Mg/d)
- Abstraction from the Oaks boreholes is limited to periods when there is at least 4.546 Ml/d passing over the weir below Carshalton Ponds (measured at Carshalton Ponds gauging station)
- The output of the Goat Bridge works is increased or lowered as necessary to ensure the minimum flow requirement at Carshalton

This flow augmentation system is believed to have been unique at the time of installation, and can be fully credited with maintaining perennial flow in the Carshalton water body (and hence the possibility of achieving GEP) while comparable reaches of the Wandle's headwaters in Carshalton (such as Margaret's Pool, St Philomena's lake, the Grotto arm and the former Grove Mill channel) have been reduced to very intermittent and ephemeral appearance, usually after periods of exceptional rainfall and recharge.

However, the terms of the abstraction licence do not apply if SESW is prevented from discharging water into Carshalton Ponds due to frost, mechanical breakdown etc, and experience shows that the augmentation system has not always been entirely reliable.

In 2005, local community action was required to alert SESW to repeated mechanical and warning system failures during low flow conditions, which resulted in fluvial flow in the upper Wandle being reduced to almost nothing (Wandle Trust). It is understood that mechanical upgrades (including leaf screens on the Goat Bridge abstraction intake) have now been put in place, but this threat to the Carshalton branch should not be underestimated, especially in view of the subsequent removal of impounding structures which previously retained minimal volumes of water in the river's steep *thalweg* during these periods of flow augmentation failure.

The augmentation system has also been inadvertently affected by members of the public piling up ornamental rocks against the downstream face of the Carshalton Ponds gauging weir (thus impounding more water over the weir sill). Additional questions remain over the calibration of the gauging pipes, which may at times become blocked by debris, and the long-term sustainability and carbon footprint of such an augmentation scheme.

<u>Further information required:</u>

Results of NEP investigations

Confirmation of reliability of Carshalton Ponds gauging station (gauging pipes etc)

Investigation of sand filtration process used (rapid or slow filtration will produce different levels of treatment)

<u>Further reading:</u>

Sutton & East Surrey Water PLC (2011) *River Wandle National Environment Programme (NEP) Investigation (Phase 1 report)*

4.7: Other tributaries

"Don't forget about the Wandle's smaller tributaries – it's important to recognise their importance too"

- from Ketso community and stakeholder workshops

River Graveney

General dewatering of the Wandle catchment has resulted in many former tributaries having disappeared or being culverted into pipes from which they now emerge flow only intermittently, often carrying large volumes of urban runoff. One of the best examples of the re-engineering of the catchment is the River Graveney, which historical records suggest was once a significant water body in its own right, and certainly the Wandle's largest tributary.

Also known as the Norbury Brook in its upper reaches, which rise just to the east of Selhurst railway depot, the Graveney springs from an area of acid geology consisting of a perched layer of gravels over London clay. As such, it has no interaction with the underlying chalk, and is not a chalk stream.

In 1861 Braithwaite described the Graveney as "a considerable tributary, with a dirty appearance when the Wandle is comparatively clear". During a period of significant aquifer recharge when "the river, its bed and the adjacent soil had been saturated with heavy rains" the resulting spate "took 7 days to discharge the flood and restore the Collier Brook, or River Graveney, to its usual level". Further records from 1852 - 1853 show the Graveney adding 0.3 – 1.2 cumecs to the main flow of the Wandle.

Today, the whole of the Graveney sub-catchment has been heavily armoured for flood defence purposes, including the addition of a siphon under Tooting High Street which redirects excess runoff via an open channel alongside Lambeth Cemetery, to a lower confluence with the Wandle adjacent to the Waterside Way industrial estate. This bypass channel has been tentatively dated to the 1930s, and was designed to divert higher flows from the short culvert under the railway line, at the time when the area was being developed for housing.

The Graveney suffers from large-scale modification, lack of natural habitat, and diffuse pollution including misconnections (although possibly not as many as might be expected in an urban setting) plus runoff from the Selhurst railway depot and reported CSOs under Tooting High Street. As a result, it contributes large volumes of urban runoff to the main River Wandle, and can present a flood risk: the EA conducted a major rubbish removal exercise from the bypass channel culverts around 2002 (Wandle Trust). Apart from riverfly monitoring by the Wandle Piscators angling club at the Graveney's confluence with the Wandle, no monitoring currently takes place on this tributary, and addressing many of these problems is considered Technically Infeasible or Disproportionately Expensive at present.

As such, continuing to include the Graveney in the main Wandle water body (GB106039023460) can only bring the Wandle's overall WFD classification down, under the "one out, all out" principle. The Wandle Catchment Plan partnership therefore recommends that the Graveney should be removed from the main Wandle water body for purposes of WFD classification, and treated as its own water body with a specific set of pressures to address.

Wimbledon Brook

The Wimbledon Brook rises from several points on a spring line at the edge of the permeable terrace gravels and Claygate beds of Wimbledon Common, and joins the Wandle in Earlsfield. It is now heavily modified throughout its length, including impoundment to form Wimbledon Park Lake as a result of 18th century landscaping works by Capability Brown. The brook is not designated as a separate water body under WFD.

Pickle Ditch and Bunces Ditch

These two minor waterways epitomise the extensive re-engineering to which the Wandle has been subjected over many centuries.

The route of the Pickle Ditch may represent the historic course of the main River Wandle before it was diverted into its current course for milling purposes alongside Merton Abbey Mills and Merton High Street. Meanwhile, Bunces Ditch rises on the west bank of the Wandle, is culverted under the river's new main channel, and joins the Pickle Ditch to the south of the Merton Abbey Mills housing developments. The Pickle Ditch's name is thought to derive either from "pike and eel hole", perhaps referring to early monastic fishing habits, or from the Old English "pightle", meaning a piece of land (Montague cited by Steel and Coleman, 2012).

Both water courses are under ongoing investigation for historic misconnections: the Pickle Ditch also suffers from road runoff from the A236. A fish passage study in 2010 suggested that the Pickle Ditch could be considered as a bypass channel for the tilting weir at Merton Abbey Mills (Solomon, 2010). However, water quality issues may act as a chemical barrier to fish, while flood risk management concerns are likely to limit the attractant flow that can be diverted down this channel (very small compared to the main Wandle), and the significant height of the offtake weir would be likely to require a technical fish pass.

Neither the Pickle Ditch nor Bunces Ditch are designated as separate water bodies under WFD.

Further reading:

Braithwaite (1861) *On the Rise and Fall of the River Wandle: Its springs, tributaries and pollution*

Solomon (2010) *Fish Passage on the River Wandle*

4.8: Transitional water

"The Wandle Delta is hard for people to get to, and what should be great intertidal habitat is full of silt behind the half-tide weir. We'd like to see the whole area improved."

- from Ketso community and stakeholder workshops

The tidal area where the Wandle meets the Thames has been subject to many centuries of modification – most recently the installation of a half-tide weir during the 1990s in an attempt to make a boating marina. This enterprise was unsuccessful, but it has left a legacy of large quantities of potentially contaminated silt behind the remains of an obsolete structure.

For WFD purposes, this transitional tidal stretch of the Wandle is included in the Tidal Thames Upper Thames water body, which extends from Teddington to Cremorne Gardens in Chelsea, due to its shared characteristics. As a HMWB, it is only assessed only for chemical status and ecological potential.

Setting immediate targets for enhancement or restoration of this area will best be achieved through liaison with the Tidal Thames Catchment Plan partnership.

However, it is the desire of the Wandle Catchment Plan partnership to include it as part of the Croydon-Wandsworth Wandle water body, both because it forms part of the physical and ecological River Wandle and because the modifications maintaining this area in its current unfavourable condition are likely to change as a result of restoration works.

In order to improve the intertidal habitat in this area, tidal terraces and wooden wall boxes have been installed on the vertical riparian pilings of the Delta.

Further reading:

Tidal Thames Catchment Partnership (2012) *Tidal Thames Catchment Based Pilot Project*

4.9: Water quantity action tables

The information in these tables has been assembled from suggestions made in community consultations, TAG meetings and specific stakeholder input to develop a series of Objectives, Targets and Actions. Information on existing projects has been collated and used to identify gaps, and where additional projects may need to be developed to fulfil Actions, Targets and Objectives.

Actions to achieve the Catchment Plan's overall aim for aim for water: Water is plentiful and clean, and varied in its flow speeds, widths and depths

Objective 1: ***Water quantity:*** **water supply in all sections of the river is sufficient to sustain a healthy population of native flora and fauna and is resilient to risk of drought or flood from extreme weather events or management for human use**				
Specific Actions to attain GEP				
Target	**Actions**	**Project**	**MM**	**Indicative cost to deliver these Actions**
1.1: Groundwater abstraction is managed in a way that is considered 'acceptable' (eg availability and demand are balanced) Carshalton WB by 2015 Croydon-Wandsworth WB by 2027	1.1.1 – Identify whether abstraction activities are responsible for over-abstraction of groundwater and resultant low flows in both perennial headwaters of the Wandle. Use the NEP investigations on both Wandle water bodies for guidance, including whether abstraction activities have been responsible for the 'Grotto' headwater drying out in Carshalton Park.	NEP Investigations		These Actions are being fulfilled in part by the EA's ongoing NEP investigations on both sources of the Wandle. Thames Water, which operates the largest and closest groundwater abstraction borehole to the Croydon / Beddington branch, reported early findings in 2013. Sutton & East Surrey Water operates boreholes near to the Carshalton branch and is due to report its findings in 2015. The Environment Agency's new London Catchment Abstraction Management Strategy (CAMS) was published in 2013 and will also inform these Actions. Liaison, additional financial outlay for further investigations, monitoring and future recommendations for good practices to maintain
	1.1.2 – Define an 'acceptable' quantity of water abstraction for the River Wandle (with reference to the findings of the two NEP investigations) and draw up measures to ensure any organisation wishing to abstract water is doing so responsibly and in keeping with this 'acceptable' definition for the river (eg demand does not outstrip availability).	Tbc		

	1.1.3 – Ensure organisations currently abstracting water, or likely to do so in the future, are acting responsibly and in an acceptable manner.	Tbc	10	required flow and quality will be led by the EA, the water companies and Ofwat.
1.2: Flood risk management within the catchment is effective and has adopted water sensitive urban design as a contributing tool Carshalton WB by 2015 Croydon-Wandsworth WB by 2027	1.2.1 – Identify the main causes and locations of flooding (both fluvial and surface runoff) on the Wandle and compare to historic scenarios to highlight particular pressure points.	A9, A10	9	These Actions are being fulfilled, at least in part, by various EA and Local Authority strategies, including the Thames Catchment Flood Management Plan and the Strategic Flood Risk Assessment for LB Wandsworth, Merton, Sutton and Croydon as well as their Surface Water Management Plans. Liaison, additional financial outlay for further investigations and future recommendations for good practice working to identify and reduce flood risk will be led by the EA and the local authorities. Independent hydraulic modelling to support identification of opportunities and constraints for river improvement works in relation to flood risk management is **estimated to cost between £40,000 - £80,000**. Independent analysis of Water Sensitive Urban Design techniques for the whole catchment, including the suitability and cost-implications of various SuDS measures to help replicate natural drainage patterns is **estimated to cost £100,000**. Independent work to re-align in-stream flows at a reach-scale as a flood risk management tool (including modelling, in situ silt retention, re-profiling channel with new gravels) is **estimated to cost £250 / linear metre**.
	1.2.2 – Identify measures for attaining natural flow regimes (or a reasonable alternative) without increasing flood risk – possibly by means of a Water Sensitive Urban Design (WSUD) study that assesses suitability and cost-implications of various SuDS measures to help replicate natural drainage patterns.	A10, B12	9	
	1.2.3 – Develop and maintain surface water management plans in each borough to address flood risk effectively.	A9, A10	9	
	1.2.4 – Work closely in partnership to promote WSUD and any other measures that can contribute towards effective flood risk management, plus any added benefits including wise water use, water quality enhancement etc.	A10, B12	9	
	1.2.5 – Instigate an ongoing programme of monitoring to evaluate whether implemented measures to reduce / mitigate against flood risk are effective.	None	9	

	1.2.6 – If monitoring reveals implemented measures are not effective at reducing / mitigating flood risk, identify and obtain funding sources for researching alternative measures – and then implementing them – within the catchment as necessary.	None	N/A	Independent work to design and implement restoration of river-floodplain connectivity with local flood storage options, such as the creation of a small wetland area, is **estimated to cost £20/m^2** depending on the location and accessibility of the site and other complementary work that may also take place (such as narrowing the river channel and creating a berm).

Wider Actions to improve the ecological functioning of the river				
Target	**Actions**	**Project**	**MM**	**Indicative cost to deliver these Actions**
1.3: The natural and modified catchments and pathways of water movement into the Wandle are understood	1.3.1 – Identify where the natural catchment boundary for the different elements of the river/groundwater system actually is.	None		These Actions are being fulfilled by the EA's ongoing National Environment Programme (NEP) investigations on both sources of the Wandle. Thames Water, which operates the largest and closest groundwater abstraction borehole to the Croydon / Beddington branch reported early findings in 2013. Sutton & East Surrey Water operates boreholes near to the Carshalton branch and is due to report its findings in 2015. Liaison, additional financial outlay for further investigations and future recommendations for good practice working that maintain required flow and quality will be led by the Environment Agency, the water companies and Ofwat. Independent surveys and research to identify the original source of the Wandle is **estimated to cost £25,000**. Independent work to collate and compare the different natural and artificial catchment boundaries that exist and the implications for such differences depends largely on the findings of the two NEP investigations. **Financial estimates of other elements to be added in due course**.
	1.3.2 – Improve understanding of how groundwater behaves within the catchment and what factors affect its movement, quantity and quality (consider modelling to help).	None		
	1.3.3 – Identify whether changes to the current situation are likely, and whether these may cause conflicts or new pressures on the catchment. For example, due to changes in how the water cycle is managed by water companies, the EA or local authorities, or as a result of climate change.	None		
	1.3.4 – Identify all artificial inputs to groundwater and surface water within the Wandle catchment.	None		
	1.3.5 – Identify modifications to the natural catchment boundary which may result from these artificial interventions (eg create maps to illustrate different catchments and sub-catchments) and identify what the potential consequences might be of these differences.	None		

1.4: The Carshalton augmentation system is managed to maximise both ecological benefits and ecosystem service benefits for people	1.4.1 - Understand the role of the augmentation system* in altering fluvial flow rates and how it is managed, including any maintenance, monitoring and cleaning regimes. ** This abstracts river water at Goat Bridge and pumps it back up to Carshalton Ponds to maintain fluvial flow.*	None		These Actions are being fulfilled by the EA's ongoing National Environment Programme (NEP) investigation led by Sutton & East Surrey Water which is due to report its findings in 2015. Liaison, additional financial outlay for further investigations and future recommendations for good practice working that maintain required flow and quality will be led by the Environment Agency, the water company and Ofwat. Independent analysis of Water Sensitive Urban Design techniques for the whole catchment, including the suitability and cost-implications of various SuDS measures to help replicate natural drainage patterns is **estimated to cost £100,000**. Independent work to reduce silt volume in Carshalton Ponds by introducing activated chalk to break it down (including monitoring of chemical presence to advise on repeat applications as necessary) is **estimated to cost £3,000 for a one-off application, with repeat applications in**
	1.4.2 – Identify the benefits provided by the augmentation system for the ecological health of the river (such as diluting road runoff pollution and preventing the Ponds from becoming highly eutrophic and potentially dominated by algal blooms that could be hazardous to the health of wildlife and people).	None		
	1.4.3 – Identify the wider ecosystem service provided by the augmentation system for people (such as aesthetic/cultural value by maintaining the water levels in the Ponds and recreational/cultural value afforded by the presence of waterfowl).	None		

	1.4.4 – Identify ways in which any negative impacts of the augmentation system can be removed or compensated for. (Negative impacts may include organic nutrient and chemical pollutant dispersal downstream, elevation of water temperature. Mitigation may include re-direction of water via the maintenance pipe downstream of Carshalton Ponds to avoid organic nutrient dispersal downstream).	None		**future years as necessary, dependent on monitoring outcomes**.
1.5: Groundwater abstraction practices are amended to restore perennial flow to the headwater reach on the Carshalton water body	1.5.1 – Confirm whether the headwater of the Carshalton arm in Carshalton Park, LB Sutton (which today is predominantly dry) is the southernmost spring line of the perennial chalk headwaters on the Carshalton water body (as believed and indicated by its classification as Main River). If so, restoring flow and this habitat would rehabilitate approximately 1.5 km of rare and ecologically important lowland chalk stream habitat. It would also help to reinstate ecological flows which support the Wandle, reconnecting the Carshalton arm with more of its headwaters, and would, therefore, be a priority consideration.	None		These Actions are being fulfilled in part by the EA's ongoing NEP investigations on both sources of the Wandle. Thames Water operates the largest and closest groundwater abstraction borehole to the Croydon / Beddington arm reported early findings in 2013. Sutton & East Surrey Water operates boreholes near the Carshalton branch and is due to report in 2015. Independent work to undertake surveys and research to identify the original source of the Wandle is **estimated to cost £25,000 (as above)**. The EA's new London Catchment Abstraction Management Strategy (CAMS), published in 2013, will also inform these Actions.

	1.5.2 – Research the potential wider benefits of restoring the perennial flow at source of the Carshalton arm, eg it will a) benefit a priority habitat type b) possibly increase flow to Carshalton Ponds, thus reducing or removing the need for the augmentation system that is currently in operation between Goat Bridge and Carshalton Ponds c) improve water quality in the Carshalton arm by increasing spring fed base flow input.	None		Liaison, additional financial outlay for further investigations, monitoring and future recommendations for good practice working to maintain flow and quality will be led by the EA, the water companies and Ofwat.
	1.5.3 – Investigate likely measures and associated costs with restoring flow to the Carshalton arm source and whether these are deemed technically feasible and not disproportionately expensive, taking into account any potential wider benefits.	None		
1.6: Water consumption (per capita and total) within the catchment is reduced across all sectors (individuals, businesses etc) and water efficiency	1.6.1 – Identify the population of the catchment now and projected increases in the next 15-20 years. Then use this to calculate estimated *per capita* consumption levels and use examples from other initiatives to calculate realistic consumption reduction targets within this timeframe.	None		Use information from existing wise water use campaigns. Costs will relate to staff time and may include some budget for the provision of water saving devices, but these are often offered by water companies at no cost.

measures are implemented, including water saving appliances and metering	1.6.2 – Design and implement an education and awareness raising programme for the public, local businesses etc within the catchment to explain why reductions in water consumption are desirable, reasonable and essential to their ongoing well-being and the ecological health of the river. To help persuade people, show how the maintenance of ecosystem function underpins the cultural, regulating and provisioning ecosystem service benefits that they value.	None		
	1.6.3 – In tandem with the education and awareness raising programme, identify a suite of water-saving measures suitable for use in the Wandle catchment and promote these by making them readily available and attractive to consumers (eg free or low-cost to install, with speedy payback) .	None		
	1.6.4 – Instigate an ongoing programme of monitoring to evaluate whether implemented measures to achieve the target reduced water consumption rates (set in Action 1.7.1) are effective and, if not, amend measures accordingly.	None		
1.7: Water losses within the distribution network are addressed	1.7.1 – To complement water saving activities by consumers, the main causes of water wastage within the supply system are identified and mitigation measures are implemented where possible. Regular reviews of these causes and mitigation measures will help to maintain efficiencies.	None	N/A	This Target will need to be led by the water companies and Ofwat working with the EA and local authorities.