Dunsford Park: Risk assessment for treated sewage disposal

Prepared for Dunsfold Airport Ltd

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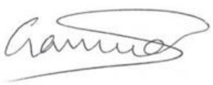
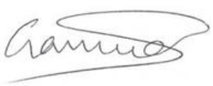
Checked by	Gareth Owen	
Reviewed by	Gareth Owen	

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1 INTRODUCTION

This report presents a quantitative risk assessment for discharge of treated sewage effluent from the proposed Dunsfold Park development.

In order to present this report in a timely manner generic data sources have been consulted to develop the risk assessment, with the aim of demonstrating:

- whether it is possible to use a public sewage facility,
- whether it is feasible to use a treatment works discharge at the site,
- how to resolve outstanding uncertainties to enable specification of robust discharge limits in due course.

It is intended that this report be sufficient to enable removal of the current Environment Agency objection in planning, subject to a site-specific assessment, using local data, being required as a reserved matter.

In due course it is intended that, as part of the reserved matters, the final detailed assessment report will set out final proposed discharge consent limits to go into the Environmental Permit.

The assessment follows the structure set out in Horizontal Guidance for Environmental Permits H1 Annex D2: Assessment of sanitary and other pollutants within surface water discharges[1] ('Annex D2'). It has also been written cognisant of the draft Water Study Requirements and Guidance[2] – Thames Area (EA, October 2016).

[1] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/489146/H1_annex_D2.pdf

[2] Environment Agency, 2016. Draft Water Study Requirements and Guidance – Thames Area. Environment Agency, October 2016

2 FACTUAL INFORMATION

2.1 The Discharge

Jubb Consulting Engineers[3] (2015) provides a peak flow estimate for sewage of 63 l/s for the various uses incorporated in the development. Options for disposal via Thames Water and Southern Water sewers were explored in that document, which concluded that it is not feasible to connect the development to public sewers:

> 'The public foul water sewer network in the immediate vicinity of the site is owned by Thames Water. The closest point of connection is the existing pumping station on Stovolds Hill approximately 800m north of the site. An alternative connection point to the foul network is the existing 150mm diameter sewer to the southeast of the site in Dunsfold Road. However, this network connects to the Clappers Meadow pump station which pumps flow to the Southern Water network and Loxwood STW. There are known issues with the Clappers Meadow SPS and this network is not deemed suitable to accommodate the flows from the site. Thames Water have stated that the existing sewerage infrastructure in the area is unable to support the level of development proposed by the scheme.'

Correspondence with Thames Water is included in Annex G of Jubb Consulting Engineers (2015).

2.2 Physical Catchment Characteristics

The development site is approximately equidistant from two Main Rivers (Figure 2.1): Cranleigh Waters to the east, and Loxwood Stream (sometimes known as River Lox, a tributary of the River Arun) to the west. Two smaller streams flow from the site boundaries towards the two main rivers: Benbow Rew flows east towards Cranleigh Waters at the northern end of the development site, and Springfield Rew flows south towards the River Lox along the western boundary of the site. The Wey and Arun Junction Canal forms the south-eastern boundary of the development site.

Catchment areas of Cranleigh Waters and Loxwood Stream, measured just downstream of the confluences of Benbow Rew and Springfield Rew, are of the same order of magnitude (48 km^2 for Cranleigh Waters vs 57 km^2 for Loxwood Stream).

Other than size, there is little to distinguish the two catchments: bedrock comprises predominantly clayey sediments of the Wealden Group, and there are limited superficial deposits. From CORINE land cover data for 2012, the Cranleigh Waters catchment is mostly pasture (with minor arable) whilst Loxwood Stream is about half and half pasture and forest (with minor arable). So, in terms of contributing to flows the larger catchment of Loxwood Stream may be compensated for by lower recharge through forest, although this may mean that there is better maintenance of summer flows.

The catchment area of the canal is not obvious and, in fact, the canal is quite disconnected. Wey and Arun Canal Trust operate a licensed abstraction (number 10/41/25/80) on the Loxwood Stream for topping up the canal. Whilst the canal is understood to currently accept stormwater discharge from the site, and hence evidently has flow, there is insufficient data presently available on flows during periods of low-flow to ascertain whether it is a suitable receptor for sewage outfall. Due to this lack of certainty at this early stage in assessment, the canal has been ruled out as a receiving water for the proposed discharge.

This assessment therefore focusses on the Loxwood Stream and Cranleigh Waters as the two Main Rivers that may receive the proposed new discharge.

[3] Jubb Consulting Engineers, 2015. Outline Planning Application to Waverley Borough Council Drainage Strategy Appendix 5.4

2.3 Sensitive Receptors

A review of downstream natural conservation sites suggests that there is one site of special scientific importance (SSSI) that might be of relevance to the risk assessment. Wey Valley Meadows SSSI is 9.4 km north of the development site and receives flood waters from Cranleigh Waters (though the River Wey is a more significant watercourse at this point). It is assumed that this is not affected by water quality during low flows, so it is not considered further in the risk assessment.

No features of historical significance have been identified on the watercourses downstream of the site, on Cranleigh Waters or Loxwood Stream, that might be sensitive to water quality at low flows.

Looking at the rivers themselves as receptors, both potential receiving waters are in nitrate vulnerable zones for surface waters. The Water Framework Directive status of relevant chemical species in the potential receiving waters is as follows.

- Cranleigh Waters[4] (water body GB106039017810 – currently at HIGH status for ammonia, MODERATE for phosphate, HIGH for BOD)
- Loxwood Stream[5] (water body GB107041017970 – currently at HIGH status for ammonia, MODERATE for phosphate – aim is GOOD by 2027, no data for BOD).

2.4 Flows

There are flow gauges on Cranleigh Waters[6] at its confluence with the River Wey, and Loxwood Stream[7] at its confluence with the River Arun. Flow data can be downloaded from the National River Flow Archive (NRFA) and pro-rated by catchment area: catchments to the gauges are 110 km^2 and 92 km^2 respectively (Table 2.1).

It seems from Table 2.1 that low flows in Cranleigh Waters are likely to be higher than in Loxwood Stream, as the watercourses pass the development site. However the NRFA record for Cranleigh Waters notes that, 'low flows [are] influenced by effluent returns', whilst for Loxwood Stream, 'abstractions and discharges have a negligible impact on overall runoff but occasional anomalous behaviour at low flow'. So it may be that the flow in Cranleigh Waters near Dunsfold is rather less than expected and that Loxwood Stream (which has the larger catchment near Dunsfold) remains in contention as a receiving water.

Indeed, for the purposes of this assessment, Loxwood Stream has been taken forward as the potential receiving watercourse. This is based on the fact that the pro rata calculation to estimate flow at the point of discharge would seem to be more reliable than that undertaken for Cranleigh Water, where the influence of sewage treatment effluent downstream of the proposed Dunsfold Park outfall makes any pro rata calculation potentially unreliable without benefit of more detailed flow data.

[4] http://environment.data.gov.uk/catchment-planning/WaterBody/GB106039017810
[5] http://environment.data.gov.uk/catchment-planning/WaterBody/GB107041017970
[6] http://nrfa.ceh.ac.uk/data/station/info/39122
[7] http://nrfa.ceh.ac.uk/data/station/spatial/41025

Table 2.1 Pro-rated flows

	Cranleigh Waters at Bramley (measured)	Cranleigh Waters d/s Dunsfold Park (calculated)	Loxwood Stream at Drungewick (measured)	Loxwood Stream d/s Dunsfold Park (calculated)
Catchment area (km^2)	110	48	92	57
Period of record	1990-2015	-	1971-2015	-
% complete	98%	-	>99%	-
Mean flow (m^3/s)	1.146	0.500	1.196	0.741
Q95 (m^3/s)	0.200	0.087	0.048	0.030
Q90 (m^3/s)	0.222	0.097	0.058	0.036
Q70 (m^3/s)	0.306	0.134	0.108	0.067
Q50 (m^3/s)	0.453	0.198	0.254	0.157
Q10 (m^3/s)	2.68	1.17	2.68	1.66

2.5 Background Water Quality

Background water quality was unavailable at the time of writing this report so in the absence of raw data on surface water quality, background concentrations have been estimated as mid-way between WFD status boundaries, or by professional judgement where there is no lower boundary (Section 3.1).

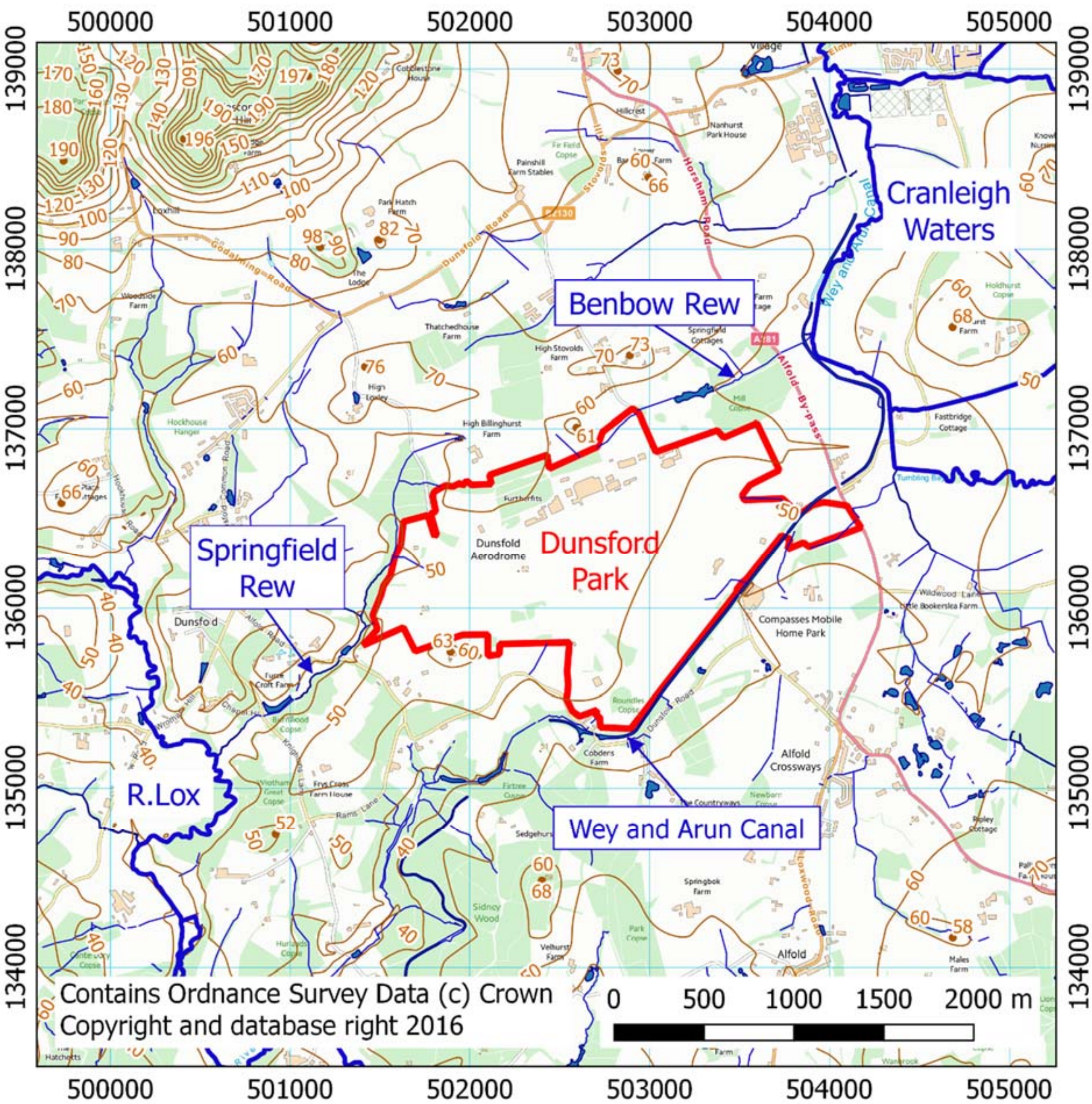

Figure 2.1 Site location and watercourses

3 RISK ASSESSMENT

3.1 Water Quality Standards

The draft Water Cycle Study guidance poses three questions that include the no deterioration requirement that is in Annex D:

1) Could the development cause greater than 10% deterioration in water quality?
2) Could the development cause deterioration in WFD class of any element?
3) Could the development alone prevent the receiving water from reaching Good Ecological Status or Potential?

Annex D and the draft Water Cycle Study require standards to be set, for continuous discharges, that ensure no more than 10% deterioration of the relevant water quality parameter at the mean or 90th percentile values. This requires knowledge of background water quality.

Without water quality datasets, the following assumptions have been made about background water quality in the streams. Where there is an upper and lower concentration boundary to the status band (i.e. that it is not high) the water quality is assumed to be mid-way between the upper and lower limits for the current status. Where there is not a lower concentration boundary to the status band (i.e. it is high) professional judgement has been used to estimate a typical concentration that is lower than the upper concentration.

- Cranleigh Waters is at high status for BOD, and Loxwood Stream has no data. However, there is no reason to expect that it is not worse than at high status. The highest limit for high status is 3.0 mg/l, and it is assumed that the representative background value is 1.0 mg/l.
- Cranleigh Waters and Loxwood Stream are at high status for ammonia. The highest limit for high status is 2.0 mg/l, and it is assumed that the representative background value is 0.5 mg/l.
- Cranleigh Waters and Loxwood Stream are both at moderate status for phosphate. The limits for moderate status are 50 to 150 ug/l, so it is assumed that the representative background value is 100 ug/l.

  Since the intention is also to achieve good status in these watercourses, a second target needs to be assessed assuming that the upstream water quality is at good status. Under this future scenario it is assumed that the background water quality is 40 ug/l, between the upper and lower limits for good status of 50 and 30 ug/l.
- There are not WFD standards for nitrate, though the nitrate concentration should not exceed 50 mg/l according to the Nitrates Directive, so it is assumed that the representative background value is 25 mg/l

(In the absence of data on alkalinity it is assumed that the lowest alkalinity should be used in setting standards, and the watercourses are both at lower elevations than 80 m.)

3.2 Calculate Limits to Meet Standards

Section 2.1 indicates that the expected peak flow rate influent to the proposed sewage treatment works is 63 l/s (0.063 m^3/s). Q90 flow in Loxwood Stream is expected to be c. 0.036 m^3/s, and the mean flow 0.741 m^3/s (Table 2.1).

Equation 1 in Annex D (Appendix A) can be re-written as follows.

$$c = \frac{T(F+f) - FC}{f}$$

Where F is the river flow upstream of the discharge (m^3/s), C is the concentration of pollutant in the river upstream of the discharge (mg/l or ug/l), f is the flow of the discharge (m^3/s), c is the concentration of pollutant in the discharge (mg/l or ug/l) and T is the concentration of pollutant downstream of the discharge (mg/l or ug/l).

Discharge limits are proposed in Table 3.1. BOD and ammonia limits are only slightly higher than the target concentrations because the discharge rate is nearly double the Q90 flow in Loxwood Stream.

Table 3.1 Proposed discharge limits

	Target concentration d/s of discharge	Treated effluent discharge limit
BOD (at 90th %ile flow)	3.0 mg/l	4.1 mg/l
Ammonia (at 90th %ile flow)	2.0 mg/l	2.9 mg/l
Phosphorus (at mean flow)*	150 ug/l	740 ug/l
Phosphorus (at mean flow)**	50 ug/l	168 ug/l
Nitrate (at mean flow)	50 mg/l	344 mg/l

* assuming maintenance of moderate status
** assuming achievement of good ecological status

3.3 Assess Technical Feasibility

Table 3.1 propose discharge limits for BOD, ammonia, phosphorus and nitrate. These can be compared to typical concentrations in sewage to establish the removal efficiency of any proposed treatment system.

(EQS values for nitrogen species are given as the concentration of the ion – NH_3 or NO_3 – which is what is used above but wastewater treatment engineers use concentrations of N. Both values are cited below for clarity.)

Domestic sewage generally has a BOD of between 250 and 400 mg/l. A removal rate to achieve 4.1 mg/l may therefore be as high as 99%. Typical secondary treatment might achieve 75% removal but tertiary treatment, such as chemical oxidation, would be required.

Entec[8] (2010) suggests that the typical concentration of phosphorous in sewage is 9 mg/l, so the required removal rate to achieve 740 ug/l is 92%. This appears to be quite challenging compared to literature values (e.g. table 15 in CREW[9], undated) but not unfeasible for a sand filter bed or filter bed system. These could be combined with up-stream measures to reduce the load to the treatment plant (e.g. using P-free detergents and/ or not flushing food waste down the sink), for further reassurance.

A P removal rate of 98% would be required to ensure that the discharge, at 168 ug/l, does not affect achievement of good ecological status.

In the professional experience of the author the limit concentration of ammonia of 2.9 mg NH_3/l (2.3 mg N/l) should be achievable by secondary treatment alone, and a rotating biological contactor (RBC), plus a final settlement tank, and recirculation facility, should be quite adequate. It seems that it is necessary for a filter bed to be installed for P removal, so this would achieve a final polish for ammonia.

Entec (2010) also suggests that the typical concentration of nitrogen in sewage is 45 mg N/l (199 mg NO_3/l), which will almost all be converted to nitrate. This is less than the suggested discharge consent limit of 344 mg NO_3/l. On the other hand, a recirculation facility will allow

[8] Entec, 2010. Cumulative nitrogen and phosphorus loadings to groundwater.
[9] CREW, undated. Practical measures for reducing phosphorus and faecal microbial loads from onsite wastewater treatment system discharges to the environment, a review. https://www.sepa.org.uk/media/163158/crew_septic_tanks.pdf

the effluent NO_3 to react with the BOD so that N will be lost via denitrification while BOD is consumed. Hence we can expect a better quality for nitrate than specified by the limit above.

The opinion of a water treatment specialist was sought on the feasibility of the required limits. Their response confirmed that, whilst challenging, the targets would be feasible with use of tertiary treatment.

3.3.1 Model conservatism

The assessment undertaken has assumed the estimated peak flow of 0.063 m^3/s. This has been calculated by Jubb Consulting Engineers using a peaking factor of 6, which in itself is a conservative assessment, used to generate the design capacity of the sewerage infrastructure, rather than to represent the actual flows that may be expected in the system.

Were flows of 0.063 m^3/s to be experienced in the system, it would be for a transient period only, and would be attenuated by the sewage treatment works themselves (i.e. this is a modelled peak for inflow to a STW, which is not representative of outflow, which would be much more moderated). As such, the use of this flow figure within the assessment herein is very conservative.

A peaking factor of 3 or 4 may be a more realistic representation of actual peak flows, which would correspondingly necessitate a smaller degree of treatment prior to discharge than has been modelled herein.

The refinement of the model parameters, including the characterisation of flows, will form part of the detailed modelling work to be undertaken during the detailed design (reserved matters) phase of the development.

4 CONCLUSIONS

A risk assessment has been undertaken for the proposed disposal of a peak flow of 63 l/s of treated sewage from the Dunsfold Park development. Generic datasets have been used to estimate discharge limits for BOD, ammonia, phosphorus and nitrate that would not cause deterioration of the receiving water body, and hence meet the three aims set out in the Water Cycle Study guidance.

These discharge limits have been reviewed to assess whether they would be feasible to achieve at flow peaks in a package treatment works. Advice from treatment specialists is that these limits are feasible to achieve with the tertiary treatment.

Two key uncertainties remain; these are the representative flow in watercourses as they pass the site, and the background water quality to be used. These datasets have been requested from the Environment Agency. Full analyses of these data sets will permit use of an appropriate modelling tool, RQP (River Quality Planning) to derive appropriate limits to be taken forward to the Environmental Permit application. The peak inflow rates to the treatment system of 63 l/s are a conservative representation of the anticipated sewerage outfall flow. Further detailed modelling of the outflows from the sewage treatment works as part of the detailed design of the development will also enable further refinement of the RQP model in due course.

In summary, the assessment set out herein demonstrates the feasibility of delivering the required limits in meeting the WFD aims set out in the Water Cycle Study guidance, through use of a high specification sewage treatment works. Notwithstanding this, it is anticipated that a reduction in conservatism in the model will be achieved during detailed modelling, following incorporation of better baseline characterisation and improved modelling of outfall flows. This in turn is anticipated to enable the revision of the specification of the sewage treatment works in due course.