



University of Kent

DATE:	14 November 2024	CONFIDENTIALITY:	Confidential
SUBJECT:	Sarre Penn and Stodmarsh Connectivity Assessment		
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INTRODUCTION

The University of Kent (UoK) has identified the potential to promote 92.1 hectares of land for a housing led development of 2,000 homes on land to the north of their existing University Campus in Canterbury. The land, referred to as Sites BCD, is being promoted through the Canterbury City Council (CCC) Local Plan process.

This Technical Note (TN) has been prepared at the request of CCC, as part of ongoing discussions regarding the promotion of Sites BCD in the Local Plan to outline the proposed strategy for addressing nutrient neutrality.

The requirement to demonstrate nutrient neutrality has arisen following a November 2018 European Court of Justice decision regarding the Habitats Directive. This resulted in Natural England (NE) requiring all new developments that could increase nutrient loads in catchments affecting Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites that are deteriorating because of nutrients, to demonstrate nutrient neutrality.

The local planning authority (LPA) for the development, CCC, must be satisfied that the new development can achieve both phosphorus and nitrogen neutrality before consenting the project.

SITE LOCATION

The proposed allocation site is shown in Figure 1. The CCC wastewater treatment works (WWTW) sewerage network map¹ (Figure 2) shows that the development site is located adjacent to the sewerage catchment for Canterbury WWTW, while Figure 1 demonstrates that the site is physically located in the Sarre Penn river catchment, which is a tributary of the Great Stour. The Sarre Penn may therefore be hydrologically connected with the Stodmarsh Lakes, which are designated as an SPA, SAC, Ramsar site and a Site of Special Scientific Interest (SSSI). The Stodmarsh Lakes are at risk of deterioration caused by eutrophication from elevated nitrogen and phosphorus levels in the River Stour.

The next nearest catchment is the Swalecliffe WWTW approximately three kilometres to the north of the northernmost part of the site boundary; connection into this catchment would require construction of a new sewer and be subject to available WWTW capacity.

¹ <https://canterburycc.maps.arcgis.com/apps/webappviewer/index.html?id=86372bea6bf746ff9ba0ab0da0f2a52c>

Figure 1 Site location

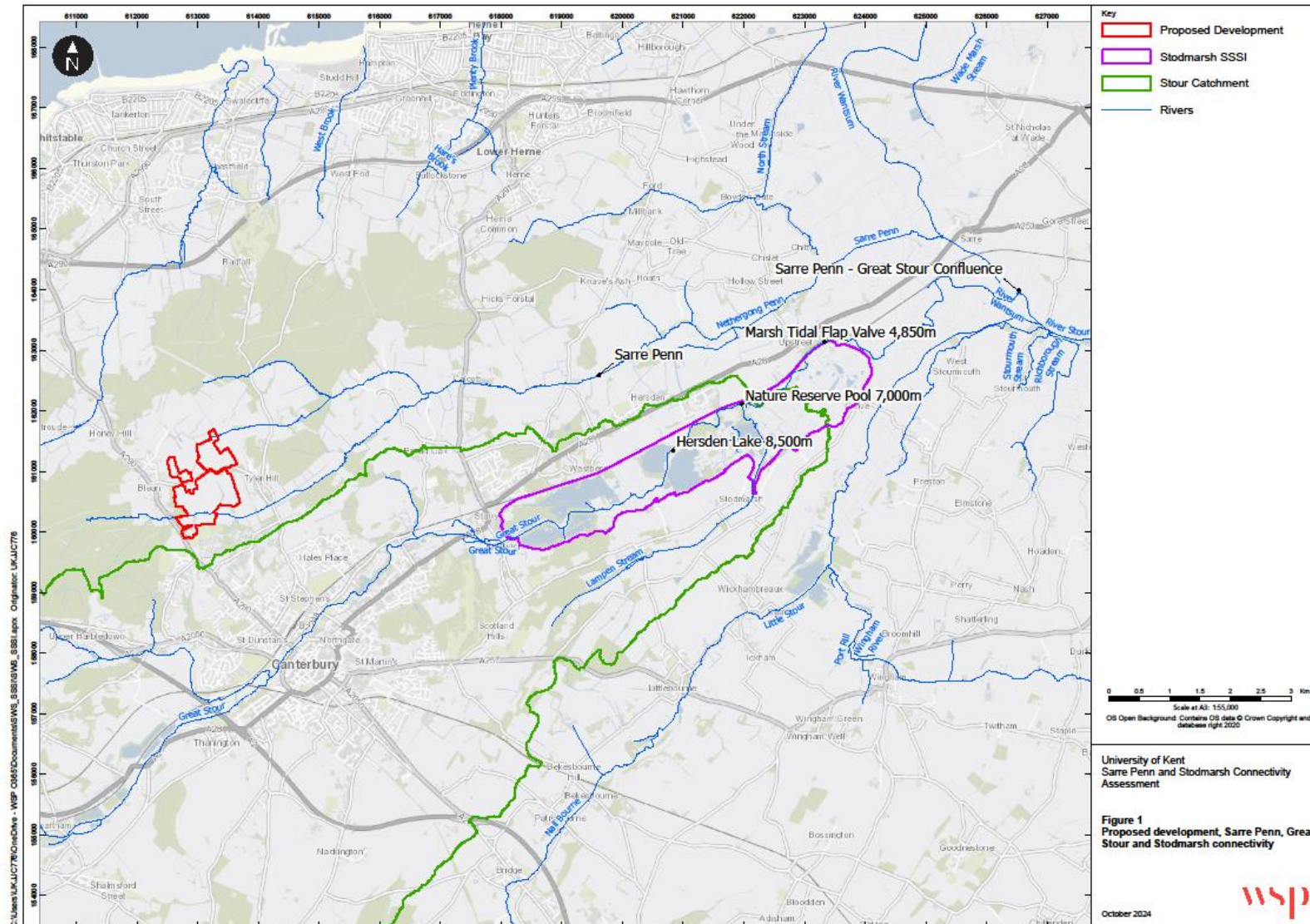
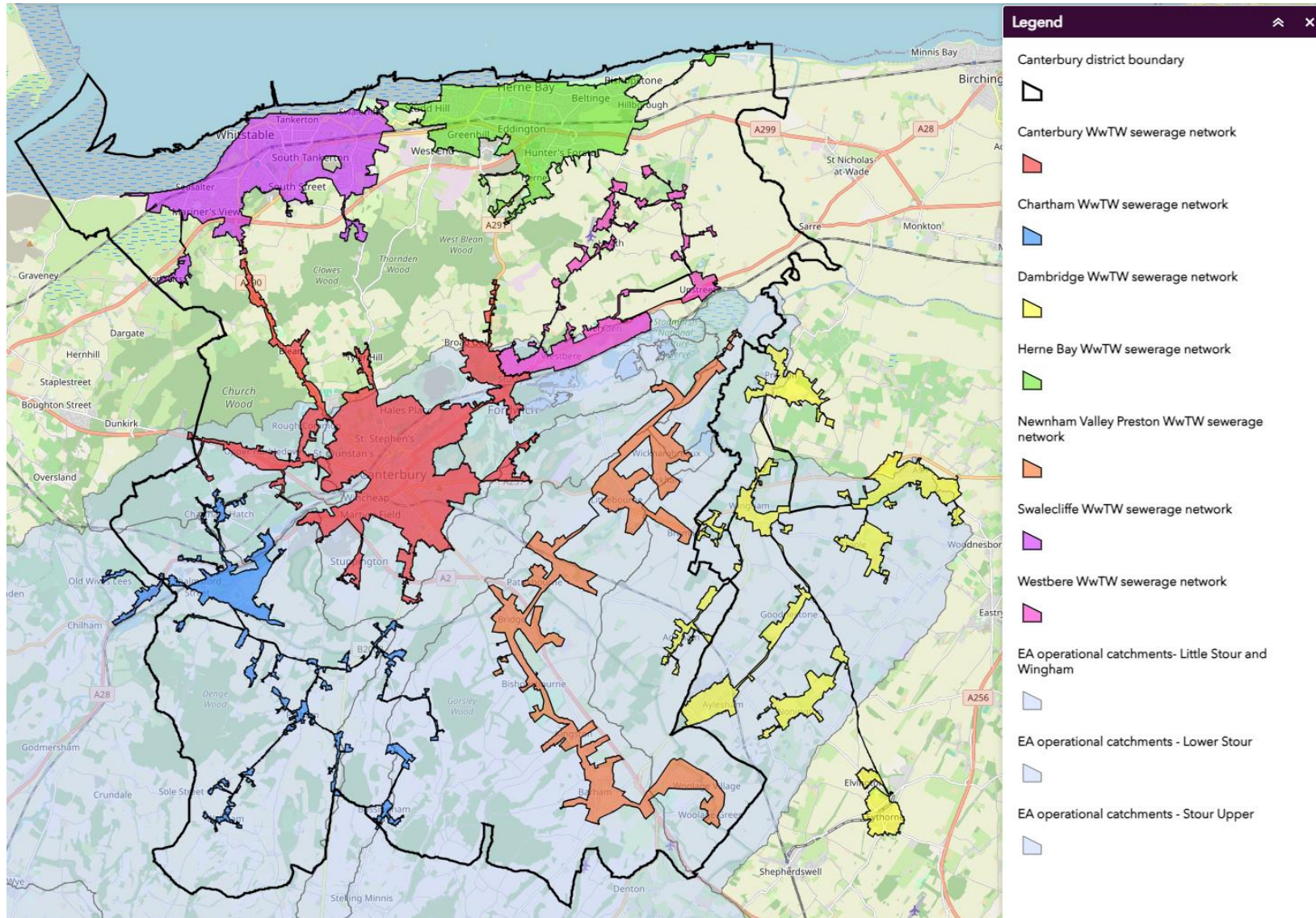


Figure 2 CCC wastewater treatment works sewerage network map



NUTRIENT LOAD CALCULATIONS

A nutrient neutrality assessment and mitigation strategy (WSP, 2023, provided in Appendix A) assessed the nutrient loads associated with the proposed development. The assessment considered three options for the treatment of foul flows generated by the development:

- Canterbury WWTW Pre-2030 with treated effluent discharged into the Great Stour.
- Canterbury WWTW Post-2030 (following the WWTW upgrade required by the Levelling Up and Regeneration Act 2023) with treated effluent discharged into the Great Stour.
- On-site WWTW with treated effluent discharged into the Sarre Penn.

A connection to Swalecliffe WWTW was not considered as part of the previous assessment as the discharge would be outside of the Stodmarsh nutrient neutrality catchment area. Any new sewerage connection to Swalecliffe WWTW would incur infrastructure costs for a new pipeline.

A refresh of the earlier calculations confirms that the proposed development would generate the nutrient loads detailed in Table 1.

Table 1 – Summary of Residual Phosphorus & Nitrogen Loads for the Three WWTW Scenarios

WWTW Scenario	TP Load (kg/year)	TN Load (kg/year)
Canterbury WWTW Pre-2030	445	5,137
Canterbury WWTW Post-2030	47	593
On-site WWTW	13	-472

The previous assessment demonstrated that it would be beneficial for the development to discharge foul flows to an on-site WWTW rather than to Canterbury WWTW, even once upgraded post-2030. The on-site WWTW could potentially (subject to Environment Agency approval and a discharge permit limit) discharge high quality treated effluent into the Sarre Penn.

As shown in Figure 1, the Sarre Penn discharges into the Great Stour downstream of the Stodmarsh site. The Great Stour is tidal at this location. The upstream movement of treated effluent discharged into and diluted by the Sarre Penn and Great Stour could theoretically provide a hydrological connection between the proposed development and the Stodmarsh site. CCC has requested that the theoretical connectivity be assessed to confirm whether there is an actual pathway for nutrients from the development to reach the Stodmarsh site.

The strategy for the site does not rule out any option. However, this TN seeks to confirm that any discharge to the Sarre Penn would not have an adverse impact on the Stodmarsh site.

ON-SITE WASTEWATER TREATMENT WORKS

The proposed on-site WWTW would discharge high quality treated effluent to the Sarre Penn. The WWTW would have permit limits of 0.10mg/l for total phosphorus and 5mg/l for total nitrogen. These are a significant improvement on the Canterbury WWTW post-2030 permit limits of 2 mg/l for total phosphorus and 10mg/l for total nitrogen. The improved permit limits would deliver nitrogen neutrality for the development and would generate a small residual total phosphorus load that would be fully mitigated, delivering phosphorus neutrality for the scheme.

An on-site WWTW would be operated by a company approved by Ofwat under the New Appointments and Variations (NAV) process². Severn Trent Connect³ and other companies can fulfil the NAV role, which would

² <https://www.ofwat.gov.uk/regulated-companies/markets/nav-market/>

³ <https://www.st-connect.co.uk/>



include designing, permitting, building and operating & maintaining the works in perpetuity (defined as the 80 – 125-year design life of the development).

Operating and maintenance costs would be recovered through the standard sewerage charges levied on each property and would provide financial sustainability in perpetuity.

The NAV would be responsible for arranging the discharge permit limit with the Environment Agency, and for confirming the discharge location into the Sarre Penn.

TREATED EFFLUENT DISCHARGE VOLUME

The proposed development is for 2,000 dwellings. Natural England specifies a national average occupancy rate of 2.4 people per dwelling, and a water consumption (and hence discharge) of 120 litres per person per day.

The volume of treated effluent discharged to the Sarre Penn would therefore be 576,000 litres per day or 576 cubic metres per day (m³/day). The annual discharge volume would be 210,384m³/year.

TREATED EFFLUENT PHOSPHORUS CONCENTRATION

The on-site WWTW would have a total phosphorus (TP) permit limit of 0.10mg/l. Natural England's nutrient neutrality calculation method specifies that a WWTW will be operated at 90% of the permit limit. The TP concentration in the treated effluent would therefore be 0.090mg/l.

TREATED EFFLUENT PHOSPHORUS LOAD

The TP load discharged from the on-site WWTW is calculated by multiplying together the flow and the TP concentration and dividing the result by 1,000,000 to convert to kilograms (kg). The daily TP load discharged to the Sarre Penn would be 0.05184kg/day. The annual load would be 18.93kg/year.

As upstream tidal movements would only occur for 50% of each day, the TP load that could theoretically impact the upstream Stodmarsh site would be just 9.465kg/year.

RECEIVING WATERCOURSE FLOWS

Gauged daily river flow data were obtained from the National River Flow Archive (NRFA) gauges 40027 for the Sarre Penn at Calcott⁴ and 40011 for the Great Stour at Horton⁵. Data for 2010 to 2023 were used to calculate flow percentiles ranging from low flow (Q95; the flow exceeded for 95% of the year) to high flow (Q5; the flow exceeded for only 5% of the year), as presented in Table 2.

Table 2 – Sarre Penn at Calcott and Great Stour at Horton Flow Percentiles, 2010 – 2023

Flow Percentile	Sarre Penn at Calcott (m ³ /d)	Great Stour at Horton (m ³ /d)
Q95	0	90,720
Q90	173	101,952
Q85	518	111,456
Q80	950	120,096
Q75	1,210	128,736
Q50	2,678	198,720

⁴ NRFA Station Data for 40027 - Sarre Penn at Calcott (ceh.ac.uk)

⁵ NRFA Station Data for 40011 - Great Stour at Horton (ceh.ac.uk)

Q10	25,004	584,582
Q5	46,639	825,120
Mean	9,856	285,815

It can be seen that under low flow conditions the Sarre Penn has a flow of 0m³/day, while the Great Stour flow is 90,720m³/day. The mean flows are 9,856m³/day and 285,815m³/day, respectively. Annualised mean and Q95 flows are presented in Table 3.

Table 3 – Sarre Penn at Calcott and Great Stour at Horton Annualised Flows

	Sarre Penn at Calcott (m³/year)	Great Stour at Horton (m³/year)
Mean	3,599,966	104,394,030
Q95	0	33,135,480

RECEIVING WATERCOURSE PHOSPHORUS CONCENTRATIONS

Orthophosphorus (OP) concentration data were obtained from the Environment Agency's WIMS database for the Sarre Penn at Calcott (sampling point SO-E0001178) and the Great Stour at Grove Ferry (sampling point SO-E0007111) for the period 2014 to 2024. The data showed a distinct downward trend over time in the Sarre Penn, and a very slight upward trend over time in the Great Stour. To reflect the most recent trends, the mean OP was calculated for the period 2019 – 2023 for the Sarre Penn (0.0817mg/l). The full data set for 2014 – 2023 was analysed for the Great Stour (0.2306mg/l).

In the absence of total phosphorus (TP) data for these sample points, the OP:TP ratio in the catchment was estimated using matched OP and TP data at eight other sampling sites⁶. The ratio ranged from 21% to 88%. The average of 74%⁷ was applied to the OP data to estimate the mean TP concentrations of 0.1104mg/l for the Sarre Penn and 0.3116mg/l for the Great Stour.

RECEIVING WATERCOURSE PHOSPHORUS LOADS

The annualised phosphorus loads in the receiving watercourses were calculated in the same way as the load for the treated effluent and are presented in Table 4.

Table 4 – Receiving Watercourse Annualised Total Phosphorus Loads at Q95 and Mean Flow

Receiving Watercourse	Annualised TP Load (kg/year)	
	At Q95 Flow	At Mean Flow
Sarre Penn	0.00	397.39
Great Stour	10,325.62	32,531.09
Combined Total	10,325.62	32,928.48

⁶ Below Slipshatch Road; Beverley Brook at Priests Bridge; Bewl Bridge (A21); Brede Woods; Burhill Gold Club; Church Road Brasted; Crab and Winkle Swalecliffe Brook; Great Stour at Fordwich Arms.

⁷ This was also the value for the Great Stour at Fordwich Arms monitoring location and is considered to be representative.

DILUTION OF TREATED EFFLUENT IN RECEIVING WATERCOURSES

The annualised mean and low (Q95) flows for the Sarre Penn, Great Stour and combined Sarre Penn plus Great Stour are presented in Table 5, along with the dilution factor that these would provide to the constant effluent discharge flow.

Table 5 – Annualised Mean & Low Flows and Effluent Dilution Factors

	On-Site WWTW	Sarre Penn	Great Stour	Sarre Penn + Great Stour
Annualised Mean Flow (m ³ /year)	210,384	3,599,966	104,394,030	107,993,996
Effluent Dilution Factor	-	17x	496x	513x
Annualised Low (Q95) Flow (m ³ /year)	210,384	0	33,135,480	33,135,480
Effluent Dilution Factor	-	0x	157x	157x

It can be seen that under low flow conditions there would be no or very little dilution of the treated effluent in the Sarre Penn, but it would be diluted by a factor of 157 times in the Great Stour. Under mean flow conditions, the Sarre Penn would provide dilution of 17 times the treated effluent flow, and this would increase to over 500 times once further diluted in the Great Stour. These flows and effluent dilution factors will be conservative as they exclude consideration of additional (ungauged) flows in the River Wantsum, which the Sarre Penn joins shortly before reaching the Great Stour.

TP CONCENTRATIONS & LOADS IN RECEIVING WATERCOURSES

The impact of the treated effluent TP concentration and load on the Sarre Penn and Great Stour combined TP concentrations and loads are presented in Table 6 (for mean flow conditions) and Table 7 (for low flow conditions).

Table 6 – TP Concentrations & Loads at Mean Flow

	On-Site WWTW	Sarre Penn	Great Stour	Combined Total
Annualised Mean Flow (m ³ /year)	210,384	3,599,966	104,394,030	108,204,380
Mean TP Concentration (mg/l)	0.0900	0.1104	0.3116	0.3045
TP Load (kg/year)	18.93	397.39	32,531	32,947
WWTW TP Load (% of River Load)	-	4.76%	<0.06%	<0.06%

Table 7 – TP Concentrations & Loads at Low Flow

	On-Site WWTW	Sarre Penn	Great Stour	Combined Total
Annualised Mean Flow (m ³ /year)	210,384	0	33,135,480	33,345,864
Mean TP Concentration (mg/l)	0.0900	-	0.3116	0.3102
TP Load (kg/year)	18.93	0	10,326	10,335
WWTW TP Load (% of River Load)	-	100%	0.18%	0.18%



The data demonstrate that the very low TP concentration in the treated effluent would result in an overall *improvement* in the TP concentrations in the Sarre Penn and Great Stour under mean flow conditions. This would also apply to the Great Stour TP concentration under low flow conditions.

The WWTW TP load would represent less than 5% of the Sarre Penn and less than 0.06% of the Great Stour TP loads under mean flow conditions. Under low flows conditions the WWTW load would be just 0.18% of the Great Stour load.

The WWTW discharge would therefore *improve* the TP concentration in the Great Stour and deliver a net benefit to the existing nutrient impacts to the Stodmarsh site.

HYDRAULIC CONNECTIVITY WITH THE STODMARSH SITE

The connectivity of flows from the Sarre Penn at its confluence with the Great Stour, and the Stodmarsh site, has been assessed based on a report prepared by Wood (since purchased by WSP) on behalf of Southern Water Services⁸. The report has been presented to both Natural England and the Environment Agency to support Southern Water's response to the Environment Agency's requirements under the Water Industry National Environment Programme (WINEP).

The report confirms that the entirety of the Stodmarsh site is hydraulically disconnected from tidal flows except for Hersden Lake, which is tidal. Under typical conditions, the water levels of the other lakes are above those in the Great Stour and water flows from the lakes *into* the river. The marshes to the east of the lakes are protected from tidal influence by a flap valve.

The Wood report assessed the risk of tidal flooding of the lakes through a review of the Environment Agency's Flood Risk models. This determined that tidal flooding would overtop Collards / Great Puckstone Lake and the Nature Reserve Pool once every 20 years, with Westbere and Fordwich Lakes being overtopped once every 200 years. Combined pluvial and tidal flooding would occur every other year, aside from at Westbere where this was modelled to occur every five years. The frequency of tidal overtopping is therefore very low and represents a negligible risk of transporting nutrients from the development's treated effluent to the Stodmarsh site.

The Wood report determined that the maximum upstream distance that tidal water could travel in the Great Stour as approximately 6,000m, based on an average speed of 0.42m/s and four hours of tidal movement per tide. Figure 1 shows that the distance from the Sarre Penn / Great Stour confluence to the marsh tidal flap valve is 4,850m, to the Nature Reserve Pool is 7,000m and to Hersden Lake is 8,500m.

While it is theoretically possible for highly diluted treated effluent discharged into the Great Stour to reach the marshes at the eastern end of the Stodmarsh site, the marshes are protected from tidal inflows by a tidal flap gate. The maximum extent of the upstream tidal flow means that nutrients discharged from the proposed development would not be transported to any point in the Stodmarsh site with tidal connectivity, except under very infrequent flood conditions (during which the impact of the effluent would be positive as it would reduce the TP concentrations in the Great Stour).

CONCLUSIONS

The proposed development has three options available for the treatment of sewage and the discharge of treated effluent to the water environment:

- Treatment at Canterbury WWTW (either pre-2030 or post-2030) and discharge into the Great Stour.
- A new sewerage connection to Swalecliffe WWTW and discharge into the sea.

⁸ Stodmarsh SSSI CSMG WINEP Investigation for Southern Water: Final Report, Wood Environment & Infrastructure Solutions UK Limited, September 2022.

- Construction of an on-site WWTW and discharge into the Sarre Penn.

All options would incur infrastructure costs, plus additional significant nutrient mitigation costs for the Canterbury WWTW option, or lower mitigation costs for the on-site WWTW option.

This technical note has considered whether the on-site WWTW option would have an adverse impact on the Stodmarsh site. It is concluded that the discharge into the Sarre Penn of high-quality treated effluent from an on-site WWTW serving the proposed development **would not have an adverse impact on the Stodmarsh site**. This conclusion is supported by data and analysis that shows that:

1. The very high quality of the treated effluent would improve the existing mean TP concentrations in the Sarre Penn and Great Stour and this would therefore act to reduce any existing impacts to the Stodmarsh site from these watercourses.
2. While the treated effluent would increase the total TP load in the catchment by 18.93kg/year, only 50% of this could theoretically be transported to the upstream Stodmarsh site by tidal flows.
3. All of the Stodmarsh site is hydraulically disconnected from the Great Stour (either through a higher water level, bunds, flow control structures or tidal flap gates) except the tidal Hersden Lake.
4. Tidal flows could move water up to 6,000m upstream of the Sarre Penn / Great Stour confluence.
5. The distance from the Sarre Penn / Great Stour confluence to Hersden Lake, the only component of the Stodmarsh site with daily tidal influence, is approximately 8,500m and it would therefore not be affected by discharges into the Sarre Penn.
6. Tidal overtopping from the Great Stour into the Stodmarsh site is predicted to be a 1 in 20-year event for Collards / Great Puckstone Lake and the Nature Reserve Pool, and a 1 in 200-year event for Westbere and Fordwich Lakes. When these rare events occur, the improvement in the TP concentration in the Great Stour as a result of the high-quality treated effluent discharged from an on-site WWTW would result in a reduction in existing impacts to the Stodmarsh site.
7. While combined pluvial and tidal flooding would occur every other year, aside from at Westbere where this was modelled to occur every five years, the improvement in the TP concentration in the Great Stour would result in a reduction in existing impacts to the Stodmarsh site.

NEXT STEPS

The following next steps are recommended:

- Engagement with Canterbury City Council to discuss the findings of this assessment.
- Engagement with Natural England to discuss and agree the outcomes of the assessment.
- Engagement with the Environment Agency to discuss the findings of the assessment and confirm their views on and requirements for an on-site WWTW and new discharge location into the Sarre Penn.
- Engagement with Southern Water to understand and confirm sewerage connection points and WWTW capacity for a connection to Swalecliffe WWTW.



APPENDIX A

University of Kent Nutrient Neutrality and Mitigation Strategy (2023)



University of Kent Nutrient Neutrality Assessment

DATE:	21 November 2023	CONFIDENTIALITY:	Confidential
SUBJECT:	University of Kent Canterbury Disposal Sites BCD: Nutrient Neutrality Assessment		
PROJECT:	70080896	AUTHOR:	James Ellaway
CHECKED:	James Ellaway	APPROVED:	Justin Sherlock

INTRODUCTION

WSP has been appointed by the University of Kent (UoK) to provide transport and environmental advice for the development of proposals at various sites in and around their Canterbury Campus.

Initial masterplanning has identified the potential to promote 92.1 hectares of land for a housing allocation for 2,000 homes on land referred to as Site BCD. The land is located within the catchment of the River Stour and is therefore hydrologically connected with the Stodmarsh Lakes, which are designated as a Special Protection Area (SPA), a Special Area of Conservation (SAC) and a Ramsar site. The Stodmarsh Lakes are at risk of deterioration caused by eutrophication from elevated nitrogen and phosphorus levels in the River Stour.

The November 2018 European Court of Justice decision regarding the Habitats Directive has resulted in Natural England (NE) requiring all new developments containing overnight accommodation, and which are located in catchments affecting SPAs and SACs that are deteriorating because of nutrients, to demonstrate nutrient neutrality. In March 2022, NE issued updated generic technical guidance and an updated nutrient neutrality calculator for the Stodmarsh catchment¹ to be used to assess whether developments are nutrient neutral.

The local planning authority (LPA) for the development, Canterbury City Council, is unable to issue decisions for new residential development in the catchment unless NE has been consulted and confirmed that they have no objection to the proposed development. NE will not provide this approval unless it can be demonstrated that the development is both phosphorus and nitrogen neutral.

The nutrient neutrality assessment detailed below establishes that the proposed development can achieve both nitrogen and phosphorus neutrality.

SITE LOCATION

The proposed allocation site of 92.1ha consists of three land parcels, B, C and D.

Additional University land holdings, including land parcel F, could be converted from agricultural use into a permanent low nutrient land use (conservation meadow or woodland) as part of the mitigation strategy for the phosphorus and nitrogen loads that would be generated by the development. Land parcel E has been excluded from consideration as it is proposed for alternative uses (potential renewable energy land use) whilst the access road corridor within the University campus is also excluded from the calculations used in this assessment.

WASTEWATER TREATMENT WORKS

Based on Southern Water's wastewater treatment works (WWTW) catchment mapping² the proposed development would discharge foul flows to Southern Water's Canterbury WWTW. NE's guidance indicates that Canterbury WWTW will, until upgraded by 2030:

¹ Nutrient Neutrality Generic Method Issue 1 dated February 2022 and issued March 2022 and the Nutrient Neutrality Budget Calculator for the Stodmarsh SAC and Ramsar, issued March 2022.

² Drainage and Wastewater Management Plan (DWMP) – River Stour Catchment

- Have a total phosphorus (TP) discharge consent limit of 2 mg/l; and
- Have no total nitrogen (TN) discharge consent limit.

NE's nutrient load calculation method requires a precautionary approach to be taken for calculation of nutrient loads. This is achieved, where the relevant WWTW has a consent limit, by calculating the wastewater nutrient load based on the WWTW discharging at 90% of its consent limit. A value of 1.8 mg/l has therefore been used to calculate the wastewater phosphorus load generated by the proposed housing allocation.

In the absence of a consent limit for nitrogen, NE specifies that a *concentration* of 27 mg/l should be adopted. The 90% value does not apply to this value, and 27 mg/l has therefore been used in the calculations.

The Levelling Up and Regeneration Bill (LURB) received Royal Assent on 26 October 2023 and is now referred to as the Levelling Up and Regeneration Act (LURA). LURA imposes a statutory requirement on water companies to upgrade large WWTWs (defined as having a population equivalent >2,000) to consent limits of 0.25mg/l for TP and 10mg/l for TN. Canterbury WWTW must be upgraded to achieve these consent limits by 2030, and the LPA can now rely upon this being achieved when taking planning decisions. The 90% value has been applied to both consent limits in the nutrient load calculations for the post-2030 scenario.

ON-SITE WWTW

An alternative to Canterbury WWTW would be to treat foul flows through an on-site WWTW. Such a system could achieve discharge consent limits as low as 0.15mg/l for TP and 5mg/l for TN.

An on-site WWTW would be operated by a company approved by Ofwat under the New Appointments and Variations (NAV) process³. Severn Trent Connect⁴ and other companies can fulfil the NAV role, which would include designing, permitting, building and operating & maintaining the works in perpetuity (defined as the 80 – 125 year design life of the development).

An indicative cost for a system serving 1,800 homes is £5.5 – 6.0M. This includes feasibility studies, environmental assessment, planning, design and construction, but excludes costs for a discharge pipeline.

Operating and maintenance costs would be recovered through the standard sewerage charges levied on each property and would provide financial sustainability, in perpetuity.

INPUT DATA FOR NUTRIENT LOAD CALCULATIONS

The nutrient load calculations have been based on NE's revised nutrient load calculator and method issued in March 2022. This method includes assessment of both total phosphorus (TP) and total nitrogen (TN).

The revised method requires the use of site-specific input data for the river catchment, rainfall, soil drainage type and the presence (or absence) of a Nitrate Vulnerable Zone (NVZ). These are used by the calculator to derive site-specific nutrient export rates for the existing and proposed land uses.

The existing land use area has been based on the total area of land parcels B, C & D (92.1 ha) and the classification as arable / cereal has been taken from paragraph 2.1 of the Agricultural Land Classification and Soil Resources Report.

The areas of each future non-urban land use in parcels B, C and D have been based on Scenario 1 detailed in the University of Kent Canterbury Design Team Meeting document dated 27 May 2021. The urban land use has been assumed as the balance of the 92.1 ha area of land parcels B, C & D. The land use areas are presented in **Table 1**.

³ <https://www.ofwat.gov.uk/regulated-companies/markets/nav-market/>

⁴ <https://www.st-connect.co.uk/>

Table 1 – Current and Future Land Use Areas (Ha) for the Development (Land Parcels B, C and D)

Land Use	Current (ha)	Future (ha)
Arable / Cereal	92.1*	0.00
Residential Urban Land	0.00	51.70
Greenspace (Parks and Garden)	0.00	1.40
Greenspace (Green Corridors)	0.00	6.08
Greenspace (Amenity Space)	0.00	6.08
Greenspace (Natural & Semi Natural Open Space)	0.00	19.44
Green Space (Sports Pitches)	0.00	4.07
Greenspace (Play)	0.00	1.40
Community Food Growing (Allotments)	0.00	1.82
Total Site Area (Ha)	92.10	92.10

Note: * This area is likely to include some non-arable land, such as drainage channels etc, and all values will need to be refined as the project progresses and georeferenced masterplans become available for detailed GIS analysis.

Additional input data includes the:

- Number of residential units proposed for the development: 2,000.
- Number of residents per residential unit: 2.3 (advised by Canterbury City Council for other projects).
- Volume of wastewater generated: 120 litres per person per day.

NITROGEN & PHOSPHORUS LOAD CALCULATIONS

Nutrient load calculations have been undertaken for three scenarios:

1. Occupation of all properties prior to Canterbury WWTW's upgrade in 2030 (Pre-2030).
2. Occupation of all properties after Canterbury WWTW's upgrade in 2030 (Post-2030).
3. The use of an on-site WWTW (On-site WWTW).

The calculations have been optimised by taking into account:

- The use of a site-specific percentage impermeable area (PIMP) value of 49.5% for future urban residential land use, rather than NE's default values of 80% for TP and 100% for TN. This significantly reduces the nutrient export rate for this land use and reduces the overall nutrient loads from the development.
- The application of sustainable drainage system (SuDS) nutrient removal efficiencies estimated at 48.2% for TP and 30% for TN in accordance with CIRIA C808⁵ and C815⁶. This assumes the SuDS consist of lined dry grassed swales conveying surface water to lined wet ponds for treatment, prior to discharging to a watercourse. These values have been applied to the surface water nutrient load components and have been deducted from the final development nutrient loads.

A summary of the load calculations is provided in Tables 2, 3 and 4 with a comparison of the nutrient loads in Table 5. The full calculations are presented in **Appendix A**.

⁵ <https://www.ciria.org/ItemDetail?iProductCode=C808F&Category=FREEPUBS>

⁶ <https://www.ciria.org/ItemDetail?iProductCode=C815F&Category=FREEPUBS>

Table 2 – Nitrogen and Phosphorus Loads – Canterbury WWTW Pre-2030

Load Element	TP Load (kg/year)	TN Load (kg/year)
Wastewater load (A)	362.91	5,443.69
Future land use load (B)	35.00	389.20
Existing land use load (C)	29.31	1,691.50
Future nutrient load (= A + (B - C))	368.60	4,141.39
Precautionary buffer (20%)	73.72	828.28
Unmitigated future nutrient load	442.32	4,969.66
SuDS nutrient load removal	16.87	116.76
Residual future nutrient load	425.45	4,852.90

Table 3 – Nitrogen and Phosphorus Loads – Canterbury WWTW Post-2030

Load Element	TP Load (kg/year)	TN Load (kg/year)
Wastewater load (A)	45.36	1,814.56
Future land use load (B)	35.00	389.20
Existing land use load (C)	29.31	1,691.50
Future nutrient load (= A + (B - C))	51.05	512.26
Precautionary buffer (20%)	10.21	102.45
Unmitigated future nutrient load	61.26	614.71
SuDS nutrient load removal	16.87	116.76
Residual future nutrient load	44.39	497.95

Table 4 – Nitrogen and Phosphorus Loads – On-Site WWTW

Load Element	TP Load (kg/year)	TN Load (kg/year)
Wastewater load (A)	27.22	907.28
Future land use load (B)	35.00	389.20
Existing land use load (C)	29.31	1691.50
Future nutrient load (= A + (B - C))	32.90	-395.02
Precautionary buffer (20%)	6.58	0.00
Unmitigated future nutrient load	39.48	-395.02
SuDS nutrient load removal	16.87	116.76
Residual future nutrient load	22.61	-511.78

Table 5 – Summary of Residual Nitrogen & Phosphorus Loads for the Three WWTW Scenarios

WWTW Scenario	TP Load (kg/year)	TN Load (kg/year)
Canterbury WWTW Pre-2030	425.45	4,852.90
Canterbury WWTW Post-2030	44.39	497.95
On-site WWTW	22.61	-511.78

The calculations confirm that the proposed development would generate a very large residual nutrient load should all houses be occupied prior to 2030.

However, the development programme indicates that all properties will be occupied after 2030. The upgrade of Canterbury WWTW would therefore reduce the development's nutrient load by around 90%. The residual nutrient loads would still require additional mitigation in the post-2030 scenario.

The use of an on-site WWTW would deliver nitrogen neutrality for the proposed development, and further reduce the residual phosphorus load that would require additional mitigation.

MITIGATION OPTIONS

Additional mitigation would be required to fully mitigate each of the three WWTW scenarios. Potential options are outlined below.

Agricultural Land Conversion – Land Parcel F

Land parcel F may be available for conversion to a low nutrient land use such as woodland or conservation meadow. This would partially mitigate the nutrient loads that would be generated from the proposed development. Using Google imagery and GIS we have estimated that land parcel F consists of, approximately:

- 13.5 ha of lowland grazing.
- 4.7 ha of arable / cereal.

As detailed in the calculations provided in Appendix A, if converted to a low nutrient land use, land parcel F could provide:

- Phosphorus mitigation of 8.16 kg/year.
- Nitrogen mitigation of 145.23 kg/year.

This would not be sufficient to deliver nutrient neutrality for any of the three scenarios. However, it would provide partial mitigation, and would reduce the on-site WWTW scenario residual phosphorus load to 14.45kg/year.

Agricultural Land Conversion – Other Land

The residual nutrient loads requiring additional mitigation, after deducting the mitigation from land parcel F, are detailed in Table 6. This table also presents the area of additional arable land conversion that would be required to mitigate the remaining TP loads (which are much more difficult to mitigate than the TN load). The areas have been based on a typical arable TP export rate of 0.32kg/ha/year, from which is deducted the low nutrient land use TP export rate (0.02kg/ha/year) to derive a beneficial export rate reduction of 0.30kg/ha/year. The residual TP loads for each scenario have been divided by 0.30kg/ha/year to calculate the area of arable land required to be converted to mitigate each scenario.

Table 6 – Areas of Arable Land Conversion required to Mitigate the Three WWTW Scenarios

WWTW Scenario	TP Load (kg/year)	TN Load (kg/year)	Required Area of Arable Conversion to Mitigate Residual TP Load (ha)
Canterbury WWTW Pre-2030	417.29	4,707.67	1,391
Canterbury WWTW Post-2030	36.23	352.72	121
On-site WWTW	14.45	-657.01	48

At a typical cost of approximately £27,000/ha of arable land⁷, the mitigation of residual nutrient loads by converting arable land to a low nutrient land use would have a land purchase cost of £1.3M – £37.6M. Additional costs would be incurred for the low nutrient land use creation process and the in-perpetuity management.

Treatment of Existing Foul Flows through an On-site WWTW

The use of an on-site WWTW offers the opportunity to potentially treat existing foul flows from the University campus through the on-site system rather than through Canterbury WWTW. The lower discharge consent limits of an on-site WWTW generate a beneficial differential in nutrient loads compared to Canterbury WWTW.

The per person nutrient loads generated by the three WWTW scenarios are summarised in Table 7 together with the nutrient benefits of diverting existing foul flows from Canterbury WWTW to the on-site WWTW. Detailed calculations are provided in **Appendix A**.

Table 7 – Per Person WWTW Nutrient Loads and Nutrient Benefits of Treating Existing Flows through the On-site WWTW (kg/person/year)

WWTW Scenario	TP Load (kg/person/year)	TN Load (kg/person/year)	TP Benefit (kg/person/year)	TN Benefit (kg/person/year)
On-site WWTW	0.006	0.197	-	-
Canterbury WWTW Pre-2030	0.079	1.183	0.073	0.986
Canterbury WWTW Post-2030	0.010	0.394	0.004	0.197

Diverting existing foul flows that are currently discharged to Canterbury WWTW to an on-site WWTW could generate considerable nutrient benefits of 0.073kgTP/person/year and 0.986kgTN/person/year but only before the upgrade of Canterbury WWTW by 2030. The nutrient benefit of this approach is negligible after Canterbury WWTW is upgraded.

Table 8 presents the on-site WWTW residual nutrient loads requiring additional mitigation, after deducting the mitigation provided by land parcel F. This table also presents the number of existing occupants on the University campus whose (pre-2030) foul flows would be required to be diverted from Canterbury WWTW to the on-site WWTW to fully mitigate the on-site WWTW scenario. This has been calculated by dividing the TP load of 14.45kg/year by 0.073kgTP/person/year.

⁷ <https://rural.struttandparker.com/article/english-estates-farmland-market-review-spring-2023/> One hectare is 2.47 acres.

Table 8 – Number of Existing Occupants’ Pre-2030 Foul Flows Diverted to On-Site WWTW to Mitigate the On-Site WWTW Scenario

WWTW Scenario	TP Load (kg/year)	TN Load (kg/year)	Number of Existing Occupants’ Foul Flows Diverted to the On-site WWTW
On-site WWTW	14.45	-657.01	198

Diverting the existing foul flows from just 200 occupants to the on-site WWTW would fully mitigate the on-site WWTW scenario. Diverting additional foul flows could deliver a significant nutrient surplus that may be traded with other developers in the catchment, or used to mitigate future additional development on the campus or other University landholdings in the catchment.

Nutrient Mitigation Credits

Natural England is developing a nutrient mitigation scheme (NMS) in the Stodmarsh catchment. Given the difficulty and expense of mitigating TP in any other way, the NMS is likely to consist of construction of a wetland. A procurement process has been undertaken for an initial feasibility stage. Assuming that a suitable site (or sites) has been identified, the detailed design and construction stage is likely to take upwards of 18 to 24 months. Mitigation credits may therefore be available in 2025 or later.

In other catchments where phosphorus mitigation credits have been generated (primarily by the private sector), they have ranged in price from £14,000/kgTP to £75,000/kgTP, with a typical price of £50,000/kgTP.

As the number of mitigation credits is often limited, and usually significantly exceeded by demand, NE is likely to sell them using a prioritisation system. In NE’s NMS in the Tees catchment, priority has been given to small and medium enterprises, smaller sites and those schemes that are more progressed through the planning process. The likelihood of a large development obtaining the required number of mitigation credits is therefore reduced.

The mitigation cost could vary widely depending on the cost per credit, estimated below at £14k – £50k/kgTP:

- Canterbury WWTW Pre-2030: £5.9M – £20.9M.
- Canterbury WWTW Post-2030: £0.5M – £1.8M.
- On-site WWTW: £0.2M – £0.7M.

The cost of mitigating the Canterbury WWTW post-2030 scenario is low compared to the indicative £5.5M – £6.0M cost of an on-site WWTW plus the extra mitigation of up to £0.7M. However, the benefit of the on-site WWTW scenario is the potential to generate additional credits that could be used to mitigate other University developments.

CONCLUSIONS

The first occupation of all homes will occur after Canterbury WWTW is upgraded by 2030 (although this could be earlier). As detailed in Table 5, this scenario would generate residual nutrient loads of 44.39kgTP/year and 497.95kgTN/year.

These would be mitigated through the delivery of one or more of the following mitigation approaches:

1. The purchase of Natural England Nutrient Mitigation Scheme credits, at a cost of £2.22M (based on a credit cost of £50,000 per kilogram of TP). Typically, the mitigation of a scheme through the purchase of TP credits would also fully mitigate the TN load although this would need to be confirmed once the scheme is operational.



2. The conversion of existing agricultural land to a low nutrient land use, potentially in conjunction with Options No 1 and/or 3.
3. The use of an on-site WWTW with the residual TP and TN loads fully mitigated in conjunction with Options 1 and/or 2.

Based upon the strategy identified and options presented above the proposed development can achieve nutrient neutrality.



APPENDIX A – NUTRIENT LOAD CALCULATIONS

Existing Landuse Areas

Parcel	Area (ha)	Existing Landuse	Future Landuse
A	5.5	Amenity Grassland and Woodland	Amenity Grassland and Woodland
B, C & D	92.1	Arable	Proposed Development Site
E	7.9	Arable	University Sports Pitches - Open Urban
F	4.7	Arable / Cereal	Phosphorus Mitigation Area
	13.5	Lowland Grazing / Permanent Grass	Phosphorus Mitigation Area
Total	123.7		

2 Site and climatic conditions

General features, land form and drainage

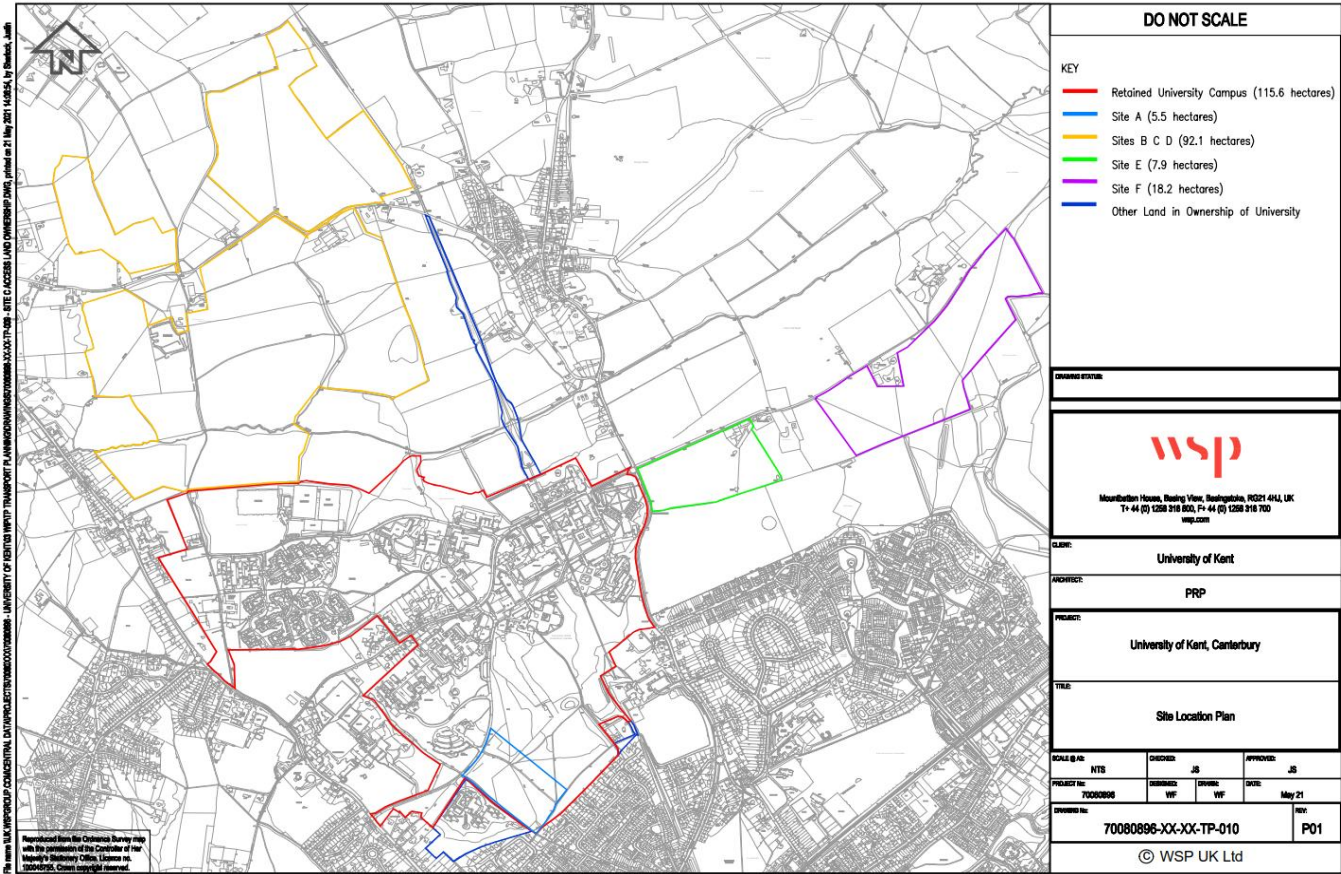
2.1 The areas surveyed collectively extend to around 123.5ha of agricultural land primarily in arable use. Area A is under permanent grass and is cut for hay annually.



April 2021

WSP UK Limited
Agricultural Land Classification and Soil Resources

at
University of Kent, Canterbury Campus



Future Landuse based on Scenario 1

Landuse	Landuse Classification	Area (ha)
Urban	Residential Urban Land	51.79
Sports Pitches	Greenspace	4.07
Parks and Garden	Greenspace	1.40
Green Corridors	Greenspace	6.08
Amenity Space	Greenspace	6.08
Natural and Semi Natural Open Space	Greenspace	19.44
Play	Greenspace	1.40
Allotments	Community Food Growing	1.82
Total Area		92.10

Totals	Residential Urban Land	51.79
	Greenspace	38.49
	Community Food Growing	1.82
	Total	92.10

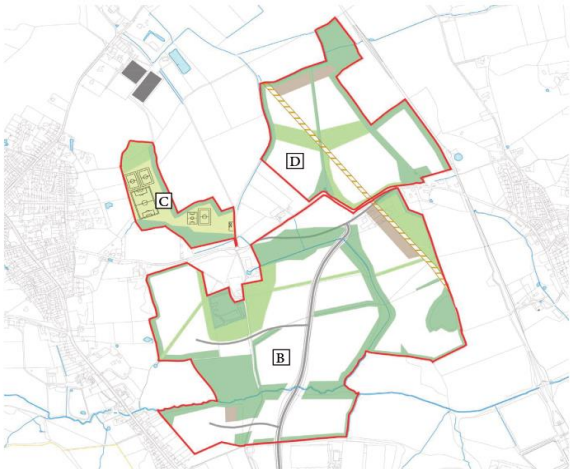
Open Space Layout and Provision
SCENARIO 1 -on site sports

- Key
- Site Boundary
 - Natural and Semi Natural Green Spaces and Green Corridors Retained
 - Amenity Space, Parks & Gardens, Play Areas
 - Allotments
 - Sport
 - Proposed Roads

- Assumptions:
- 2000 Homes (4680 people)
 - Site C used for sports
 - gas easement excluded from open space calculations

Note: Diagram has been prepared to test the potential to accommodate spacial requirements and should not be considered a design

TYPE	Option 1	Minimum required area
Parks and Gardens	1.404ha	1.404ha
Green corridors	6.084ha	6.084ha
Amenity Space	6.084ha	6.084ha
Natural and semi natural open space	19.440ha	19.440ha
Sports pitches	4.070ha	4.070ha
Allotments	1.820ha	1.820ha
Play	1.404ha	1.404ha
TOTAL on site	40.306ha	40.306ha



Scenario 1 - Illustrative diagram

Catchment, Soils, Rainfall & NVZ Data

Catchment: Stour Lower
Soils: Impeded drainage to naturally wet, with a small area of free draining. Natural England classification is 'variable'.
Rainfall: 675 - 700mm
NVZ: No

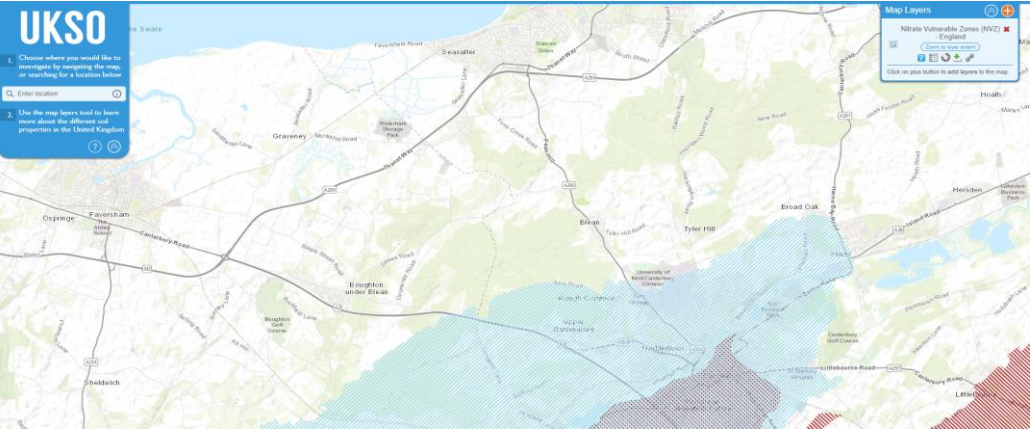
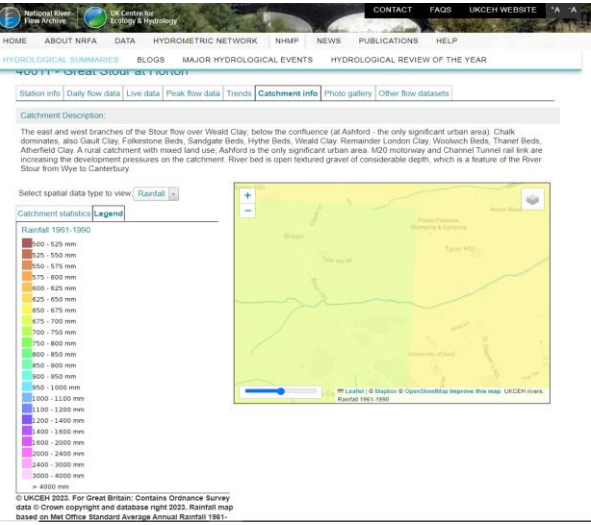
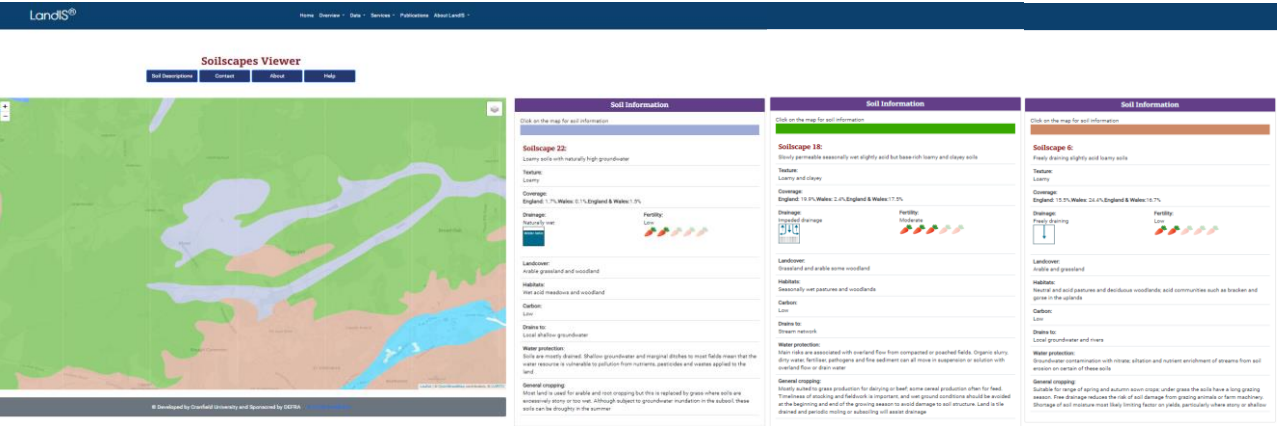


Table A.3: EMCs for nitrogen and phosphorus for three key types of urban land use.

Land use	Nitrogen concentration (mg N/l)	event concentration (mg N/l)	mean	Phosphorus concentration (mg P/l)	event concentration (mg P/l)	mean
Residential	2.85			0.41		
Commercial/industrial	1.52			0.30		
Open urban land	1.68			0.22		

The EMCs were combined with a standard method for calculating urban runoff which requires only rainfall as an input. The HR Wallingford Modified Rational Method was used, as shown in equation 1.

Equation 1

$$L = R \cdot Pr$$

Where:

L = annual average runoff (mm)

R = annual average rainfall (mm)

Pr = percentage runoff (%)

$$Pr = 0.829 \cdot PIMP + 0.078 \cdot U - 20.7$$

$PIMP$ = the percentage of land that is impervious (whole number)

U = catchment wetness index. Calculated by (use 41 if rainfall over 760 mm):

$$U = -129.5 + (0.424 \cdot R) - (2.28 \cdot 10^{-4} \cdot R^2) - (4.56 \cdot 10^{-8} \cdot R^3)$$

For phosphorus, the value for PIMP was set as 80%, as this has been suggested as the proportion of impervious surfaces once urban creep (the paving over of pervious surfaces) reaches a maximum. The use of an 80% PIMP value, while high, accounts for the potential increases in impervious surfaces that may occur over the lifetime of a development. Research has also suggested that non-paved gardens account for between 19-27% of the entire urban area. As gardens are the primary type of permeable surface within residential areas, the use of an 80% PIMP value is considered to be precautionary as an area with 19% coverage by non-paved gardens would indicate that around 80% of the remaining urban residential area would be impermeable surfaces.

Values based on 80% PIMP specified by Natural England

Variable	Residential Urban			Commercial/Industrial			Open Urban		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
L - Annual average runoff (mm)	328.36	341.15		328.36	341.15		328.36	341.15	
R - Annual average rainfall (mm)	675	700		675	700		675	700	
Pr - Percentage runoff (%)	48.65	48.74		48.65	48.74		48.65	48.74	
PIMP - Percentage of land that is impervious (%)	80.00	80.00		80.00	80.00		80.00	80.00	
U - Catchment wetness index (use 41 if rainfall > 760mm)	38.79	39.94		38.79	39.94		38.79	39.94	
Annual runoff (mm)	328.36	341.15		328.36	341.15		328.36	341.15	
Annual runoff (m)	0.33	0.34		0.33	0.34		0.33	0.34	
Volume per hectare (m3/ha/yr)	3283.60	3411.47		3283.60	3411.47		3283.60	3411.47	
TP EMC (mg/l)	0.41	0.41		0.3	0.3		0.22	0.22	
TP EMC (kg/l)	0.0004	0.0004		0.0003	0.0003		0.0002	0.0002	
TP Export Rate (kg/ha/yr)	1.35	1.40	1.37	0.99	1.02	1.00	0.72	0.75	0.74

Site-specific values

The development consists of 2,000 homes in a developable area of 51.79ha gives a development density of 39units/ha.

The development density of 39units/ha is considered to be medium density, which has typical PIMP of 45%.

Urban creep is accounted for by addition of 10% of the total PIMP to the site-specific value.

Site-specific PIMP: 45.00%

10% urban creep uplift: 4.5%

Site specific mean PIMP for the residential landuse: 49.50%

Variable	Residential Urban			Commercial/Industrial			Open Urban		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
L - Annual average runoff (mm)	157.69	164.16		328.36	341.15		328.36	341.15	
R - Annual average rainfall (mm)	675	700		675	700		675	700	
Pr - Percentage runoff (%)	23.36	23.45		48.65	48.74		48.65	48.74	
PIMP - Percentage of land that is impervious (%)	49.5	49.5		80	80		80	80	
U - Catchment wetness index (use 41 if rainfall > 760mm)	38.79	39.94		38.79	39.94		38.79	39.94	
Annual runoff (mm)	157.69	164.16		328.36	341.15		328.36	341.15	
Annual runoff (m)	0.16	0.16		0.33	0.34		0.33	0.34	
Volume per hectare (m3/ha/yr)	1576.89	1641.55		3283.60	3411.47		3283.60	3411.47	
TP EMC (mg/l)	0.41	0.41		0.3	0.3		0.22	0.22	
TP EMC (kg/l)	0.0004	0.0004		0.0003	0.0003		0.0002	0.0002	
TP Export Rate (kg/ha/yr)	0.65	0.67	0.66	0.99	1.02	1.00	0.72	0.75	0.74

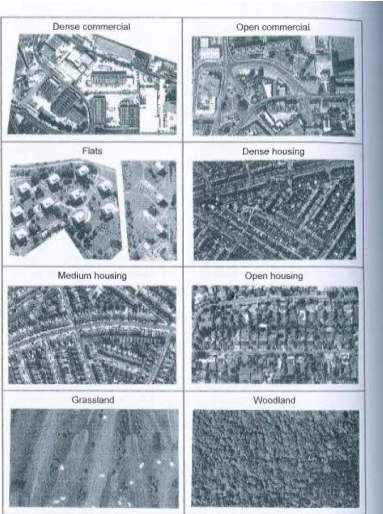


Fig 11.1 Various land use categories in London (developed by Thames Water Utilities Ltd on their Beckton and Crossness sewerage modelling projects in association with consulting engineers BGP Reid Crowther Ltd and Montgomery Watson Ltd and reproduced with permission)

Table 11.2 Approximate percentage imperviousness of land-use types in London

Land-use category	PIMP
Dense commercial	100
Open commercial	65
Dense housing	55
Flats	50
Medium housing	45
Open housing	35
Grassland	<10
Woodland	<10

Table A.3: EMCs for nitrogen and phosphorus for three key types of urban land use.

Land use	Nitrogen concentration (mg N/l)	event mean	Phosphorus concentration (mg P/l)	event mean
Residential	2.85		0.41	
Commercial/industrial	1.52		0.30	
Open urban land	1.68		0.22	

The EMCs were combined with a standard method for calculating urban runoff which requires only rainfall as an input. The HR Wallingford Modified Rational Method was used, as shown in equation 1.

Equation 1

$$L = R \cdot Pr$$

Where:

L = annual average runoff (mm)

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Pr = percentage runoff (%)

$$Pr = 0.829 \cdot PIMP + 0.078 \cdot U - 20.7$$

$PIMP$ = the percentage of land that is impervious (whole number)

U = catchment wetness index. Calculated by (use 41 if rainfall over 760 mm):

$$U = -129.5 + (0.424 \cdot R) - (2.28 \cdot 10^{-4} \cdot R^2) - (4.56 \cdot 10^{-8} \cdot R^3)$$

For phosphorus, the value for PIMP was set as 80%, as this has been suggested as the proportion of impervious surfaces once urban creep (the paving over of pervious surfaces) reaches a maximum. The use of an 80% PIMP value, while high, accounts for the potential increases in impervious surfaces that may occur over the lifetime of a development. Research has also suggested that non-paved gardens account for between 19-27% of the entire urban area. As gardens are the primary type of permeable surface within residential areas, the use of an 80% PIMP value is considered to be precautionary as an area with 19% coverage by non-paved gardens would indicate that around 80% of the remaining urban residential area would be impermeable surfaces.

Values based on 100% PIMP specified by Natural England

Variable	Residential Urban			Commercial/Industrial			Open Urban		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
L - Annual average runoff (mm)	440.27	457.21		440.27	457.21		440.27	457.21	
R - Annual average rainfall (mm)	675	700		675	700		675	700	
Pr - Percentage runoff (%)	65.23	65.32		65.23	65.32		65.23	65.32	
PIMP - Percentage of land that is impervious (%)	100.00	100.00		100.00	100.00		100.00	100.00	
U - Catchment wetness index (use 41 if rainfall > 760mm)	38.79	39.94		38.79	39.94		38.79	39.94	
Annual runoff (mm)	440.27	457.21		440.27	457.21		440.27	457.21	
Annual runoff (m)	0.44	0.46		0.44	0.46		0.44	0.46	
Volume per hectare (m3/ha/yr)	4402.75	4572.07		4402.75	4572.07		4402.75	4572.07	
TN EMC (mg/l)	2.85	2.85		1.52	1.52		1.68	1.68	
TN EMC (kg/l)	0.0029	0.0029		0.0015	0.0015		0.0017	0.0017	
TN Export Rate (kg/ha/yr)	12.55	13.03	12.79	6.69	6.95	6.82	7.40	7.68	7.54

Site-specific values

The development consists of 2,000 homes in a developable area of 51.79ha gives a development density of 39units/ha.

The development density of 39units/ha is considered to be medium density, which has typical PIMP of 45%.

Urban creep is accounted for by addition of 10% of the total PIMP to the site-specific value.

Site-specific PIMP: 45.00%

10% urban creep uplift: 4.5%

Site specific mean PIMP for the residential landuse: 49.50%

Variable	Residential Urban			Commercial/Industrial			Open Urban		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
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R - Annual average rainfall (mm)	675	700		675	700		675	700	
Pr - Percentage runoff (%)	23.36	23.45		48.65	48.74		48.65	48.74	
PIMP - Percentage of land that is impervious (%)	49.5	49.5		80	80		80	80	
U - Catchment wetness index (use 41 if rainfall > 760mm)	38.79	39.94		38.79	39.94		38.79	39.94	
Annual runoff (mm)	157.69	164.16		328.36	341.15		328.36	341.15	
Annual runoff (m)	0.16	0.16		0.33	0.34		0.33	0.34	
Volume per hectare (m3/ha/yr)	1576.89	1641.55		3283.60	3411.47		3283.60	3411.47	
TN EMC (mg/l)	2.85	2.85		1.52	1.52		1.68	1.68	
TN EMC (kg/l)	0.0029	0.0029		0.0015	0.0015		0.0017	0.0017	
TN Export Rate (kg/ha/yr)	4.49	4.68	4.59	4.99	5.19	5.09	5.52	5.73	5.62

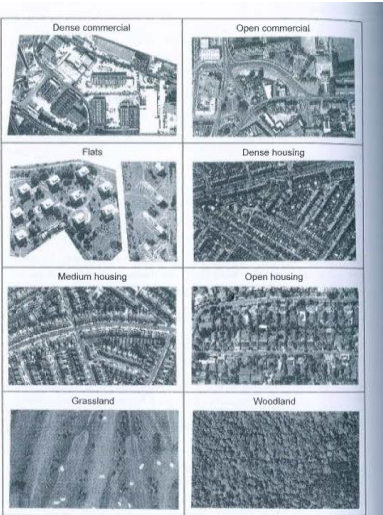


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Dense housing	55
Flats	50
Medium housing	45
Open housing	35
Grassland	<10
Woodland	<10

CIRIA C808 SuDS P Removal Analysis

1. CIRIA C808 states that 100% removal can be achieved for all runoff that can be infiltrated. A small area of the development has freely draining soils that may support this approach, but it has not been included in this assessment.
2. As the majority of the site is underlain by naturally wet soils, or those with impeded drainage, the analysis is based on an assumption that the SuDS treatment train will consist of dry grassed swales (lined, to prevent nitrogen infiltration as required by CIRIA C815) leading to lined wet ponds prior to offsite discharge to a watercourse.
3. C808 states that total phosphorus consists of 55% particulate P and 45% dissolved P and provides removal efficiencies for a range of SuDS features.
4. A nominal TP load of 1kg/year has been analysed to calculate the TP removal efficiency of a swale leading to a wet pond. The removal efficiency could be increased if the SuDS treatment train consists of additional treatment features.

Phosphorus Form	Nominal P Load (kg/year)	SuDS P Removal (%) Wet Pond	Output P Load (kg/year)	SuDS P Removal (%) Dry Grassed Swale	Output P Load (kg/year)
Particulate P	0.55	38	0.341	14	0.293
Dissolved P	0.45	50	0.225	0	0.225
Total P	1.00				0.518
TP Removal Efficiency					48.2%

CIRIA C815 SuDS N Removal Analysis

1. CIRIA C815 states that nitrogen can not be removed through infiltration. All SuDS treatment features must therefore be lined to prevent infiltration.
2. The analysis is based on an assumption that the SuDS treatment train will therefore consist of dry grassed swales leading to lined wet ponds prior to offsite discharge to a watercourse.
3. CIRIA C815 specifies that this SuDS treatment train can achieve an N removal efficiency of **30%** if the features are designed and constructed in accordance with CIRIA C753 The SuDS Manual.

Notes

1. The development will discharge foul flows to Canterbury WWTW.
2. Canterbury WWTW has a current total phosphorus discharge consent limit of 2mg/l. It does not have a total nitrogen discharge consent limit and so a default value of 27mg/l has been used as required by Natural England's guidance.
3. Natural England's nutrient neutrality calculation guidance specifies the use of 90% of a WWTW permit consent limit and this has been applied to the TP permit limit.
4. The existing land use areas have been taken from the Reading Agricultural Consultants report summarised in the Existing Landuse tab.
5. The future land use areas have been taken from the illustrative Masterplan Scenario 1 detailed in the Future Landuse tab.
6. A SUDS total phosphorus removal efficiency of 48.2% and a total nitrogen removal efficiency of 30% have been adopted in general accordance with CIRIA C808 and CIRIA C815 based on a SuDS treatment train of lined grassed swales leading to lined wet ponds then offsite discharge to a watercourse.
7. The future urban land use nutrient export rates have been optimised based on a site-specific PIMP value for a medium density development (39 units/hectare) as detailed in the Urban P and N Export Rate & PIMP tabs
8. The occupancy rate of 2.3/unit has been previously advised by Canterbury City Council for other projects in the city.
9. The wastewater volume has been increased to 120lppd based on Natural England's revised calculation method. There may be an opportunity to reduce this to 110lppd with agreement from CCC.
10. The underlying drainage ranges from naturally wet to impeded drainage with a small area of freely draining. The calculations have been assessed on Natural England's classification as 'variable' which generates a TP export rate of 0.32kg/ha/year for cereals. The export rate is 0.55kg/ha/year for areas that have impeded drainage, and just 0.05kg/ha/year for freely draining. Once the masterplan is finalised it may be beneficial to accurately map soil drainage to calculate more accurate existing land use nutrient loads to offset against the development's loads.

LOAD CALCULATION

Site Characteristics

Total site area (ha)	92.10
Number of homes	2000
No. of residents per unit (No.)	2.30
Wastewater volume (litres/person/day)	120
Wastewater generated (litres/day)	552000

Wastewater Load

	Total Phosphorus	Total Nitrogen
WWTW consent limit (mg/l)	2.00	27.00
90% of WWTW consent limit (mg/l)	1.80	
Total nutrient load from wastewater (mg/day)	993600	14904000
Total nutrient load from wastewater (mg/yr)	362912400	5443686000
Total nutrient load from wastewater (kg/yr)	362.91	5443.69

Existing Landuse Load

		Nutrient Export Rate (kg/ha/year)		Total Nutrient Load (kg/year)	
Existing Landuse	Area (ha)	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Arable / cereal	92.10	0.32	18.37	29.31	1691.50
Total	92.10	-	-	29.31	1691.50

Future Landuse Load

		Nutrient Export Rate (kg/ha/year)		Total Nutrient Load (kg/year)	
Future Landuse	Area (ha)	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Residential Urban Land	51.79	0.66	4.59	34.17	237.54
Greenspace	38.49	0.02	3.00	0.77	115.46
Community Food Growing	1.82	0.03	19.89	0.05	36.20
Total	92.1	-	-	35.00	389.20

Unmitigated Future Nutrient Load

	Total Phosphorus Load (kg/year)	Total Nitrogen Load (kg/year)
Load Contribution		
Wastewater load (A)	362.91	5443.69
Future landuse load (B)	35.00	389.20
Existing landuse load (C)	29.31	1691.50
Future nutrient load (= A + (B - C)	368.60	4141.39
Precautionary buffer (20%)	73.72	828.28
Unmitigated future nutrient load	442.32	4969.66

SUDS Mitigation (refer CIRIA C808 C815 SuDS Removal tab for details)

	Total Phosphorus	Total Nitrogen
Total nutrient load from urban land draining to the SUDS (kg/year)	35.00	389.20
Calculated SUDS removal efficiency (%)	48.2%	30.0%
Total nutrient reduction (kg/year)	16.87	116.76

Mitigated Future Nutrient Load

	Total Phosphorus Load (kg/year)	Total Nitrogen Load (kg/year)
Load Contribution		
Unmitigated future nutrient load	442.32	4969.66
SUDS nutrient reduction	16.87	116.76
Mitigated future nutrient load	425.45	4852.90

Notes

1. The development will discharge foul flows to Canterbury WWTW.
2. Canterbury WWTW will have a post-2030 total phosphorus discharge consent limit of 0.25mg/l and a total nitrogen discharge consent limit of 10mg/l as required by the Levelling Up and Regeneration Act (LURA).
3. Natural England's nutrient neutrality calculation guidance specifies the use of 90% of a WWTW permit consent limit and this has been applied to the TP and TN permit limits.
4. The existing land use areas have been taken from the Reading Agricultural Consultants report summarised in the Existing Landuse tab.
5. The future land use areas have been taken from the illustrative Masterplan Scenario 1 detailed in the Future Landuse tab.
6. A SUDS total phosphorus removal efficiency of 48.2% and a total nitrogen removal efficiency of 30% have been adopted in general accordance with CIRIA C808 and CIRIA C815 based on a SuDS treatment train of lined grassed swales leading to lined wet ponds then offsite discharge to a watercourse.
7. The future urban land use nutrient export rates have been optimised based on a site-specific PIMP value for a medium density development (39 units/hectare) as detailed in the Urban P and N Export Rate & PIMP tabs
8. The occupancy rate of 2.3/unit has been previously advised by Canterbury City Council for other projects in the city.
9. The wastewater volume has been increased to 120lppd based on Natural England's revised calculation method. There may be an opportunity to reduce this to 110lppd with agreement from CCC.
10. The underlying drainage ranges from naturally wet to impeded drainage with a small area of freely draining. The calculations have been assessed on Natural England's classification as 'variable' which generates a TP export rate of 0.32kg/ha/year for cereals. The export rate is 0.55kg/ha/year for areas that have impeded drainage, and just 0.05kg/ha/year for freely draining. Once the masterplan is finalised it may be beneficial to accurately map soil drainage to calculate more accurate existing land use nutrient loads to offset against the development's loads.

LOAD CALCULATION

Site Characteristics

Total site area (ha)	92.10
Number of homes	2000
No. of residents per unit (No.)	2.30
Wastewater volume (litres/person/day)	120
Wastewater generated (litres/day)	552000

Wastewater Load

	Total Phosphorus	Total Nitrogen
WWTW consent limit (mg/l)	0.25	10.00
90% of WWTW consent limit (mg/l)	0.23	9.00
Total nutrient load from wastewater (mg/day)	124200	4968000
Total nutrient load from wastewater (mg/yr)	45364050	1814562000
Total nutrient load from wastewater (kg/yr)	45.36	1814.56

Existing Landuse Load

		Nutrient Export Rate (kg/ha/year)		Total Nutrient Load (kg/year)	
Existing Landuse	Area (ha)	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Arable / cereal	92.10	0.32	18.37	29.31	1691.50
Total	92.10	-	-	29.31	1691.50

Future Landuse Load

		Nutrient Export Rate (kg/ha/year)		Total Nutrient Load (kg/year)	
Future Landuse	Area (ha)	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Residential Urban Land	51.79	0.66	4.59	34.17	237.54
Greenspace	38.49	0.02	3.00	0.77	115.46
Community Food Growing	1.82	0.03	19.89	0.05	36.20
Total	92.1	-	-	35.00	389.20

Unmitigated Future Nutrient Load

	Total Phosphorus Load (kg/year)	Total Nitrogen Load (kg/year)
Load Contribution		
Wastewater load (A)	45.36	1814.56
Future landuse load (B)	35.00	389.20
Existing landuse load (C)	29.31	1691.50
Future nutrient load (= A + (B - C)	51.05	512.26
Precautionary buffer (20%)	10.21	102.45
Unmitigated future nutrient load	61.26	614.71

SUDS Mitigation (refer CIRIA C808 C815 SuDS Removal tab for details)

	Total Phosphorus	Total Nitrogen
Total nutrient load from urban land draining to the SUDS (kg/year)	35.00	389.20
Calculated SUDS removal efficiency (%)	48.2%	30.0%
Total nutrient reduction (kg/year)	16.87	116.76

Mitigated Future Nutrient Load

	Total Phosphorus Load (kg/year)	Total Nitrogen Load (kg/year)
Load Contribution		
Unmitigated future nutrient load	61.26	614.71
SUDS nutrient reduction	16.87	116.76
Mitigated future nutrient load	44.39	497.95

Notes

1. The development will discharge foul flows to an on-site WWTW.
2. the on-site WWTW will have a total phosphorus discharge consent limit of 0.15mg/l and a total nitrogen discharge consent limit of 5mg/l.
3. Natural England's nutrient neutrality calculation guidance specifies the use of 90% of a WWTW permit consent limit and this has been applied to the TP and TN permit limits.
4. The existing land use areas have been taken from the Reading Agricultural Consultants report summarised in the Existing Landuse tab.
5. The future land use areas have been taken from the illustrative Masterplan Scenario 1 detailed in the Future Landuse tab.
6. A SUDS total phosphorus removal efficiency of 48.2% and a total nitrogen removal efficiency of 30% have been adopted in general accordance with CIRIA C808 and CIRIA C815 based on a SuDS treatment train of lined grassed swales leading to lined wet ponds then offsite discharge to a watercourse.
7. The future urban land use nutrient export rates have been optimised based on a site-specific PIMP value for a medium density development (39 units/hectare) as detailed in the Urban P and N Export Rate & PIMP tabs
8. The occupancy rate of 2.3/unit has been previously advised by Canterbury City Council for other projects in the city.
9. The wastewater volume has been increased to 120lppd based on Natural England's revised calculation method. There may be an opportunity to reduce this to 110lppd with agreement from CCC.
10. The underlying drainage ranges from naturally wet to impeded drainage with a small area of freely draining. The calculations have been assessed on Natural England's classification as 'variable' which generates a TP export rate of 0.32kg/ha/year for cereals. The export rate is 0.55kg/ha/year for areas that have impeded drainage, and just 0.05kg/ha/year for freely draining. Once the masterplan is finalised it may be beneficial to accurately map soil drainage to calculate more accurate existing land use nutrient loads to offset against the development's loads.

LOAD CALCULATION

Site Characteristics

Total site area (ha)	92.10
Number of homes	2000
No. of residents per unit (No.)	2.30
Wastewater volume (litres/person/day)	120
Wastewater generated (litres/day)	552000

Wastewater Load

	Total Phosphorus	Total Nitrogen
WWTW consent limit (mg/l)	0.15	5.00
90% of WWTW consent limit (mg/l)	0.14	4.50
Total nutrient load from wastewater (mg/day)	74520	2484000
Total nutrient load from wastewater (mg/yr)	27218430	907281000
Total nutrient load from wastewater (kg/yr)	27.22	907.28

Existing Landuse Load

Existing Landuse	Area (ha)	Nutrient Export Rate (kg/ha/year)		Total Nutrient Load (kg/year)	
		Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Arable / cereal	92.10	0.32	18.37	29.31	1691.50
Total	92.10	-	-	29.31	1691.50

Future Landuse Load

Future Landuse	Area (ha)	Nutrient Export Rate (kg/ha/year)		Total Nutrient Load (kg/year)	
		Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Residential Urban Land	51.79	0.66	4.59	34.17	237.54
Greenspace	38.49	0.02	3.00	0.77	115.46
Community Food Growing	1.82	0.03	19.89	0.05	36.20
Total	92.1	-	-	35.00	389.20

Unmitigated Future Nutrient Load

	Total Phosphorus Load (kg/year)	Total Nitrogen Load (kg/year)
Load Contribution		
Wastewater load (A)	27.22	907.28
Future landuse load (B)	35.00	389.20
Existing landuse load (C)	29.31	1691.50
Future nutrient load (= A + (B - C)	32.90	-395.02
Precautionary buffer (20%)	6.58	0.00
Unmitigated future nutrient load	39.48	-395.02

SUDS Mitigation (refer CIRIA C808 C815 SuDS Removal tab for details)

	Total Phosphorus	Total Nitrogen
Total nutrient load from urban land draining to the SUDS (kg/year)	35.00	389.20
Calculated SUDS removal efficiency (%)	48.2%	30.0%
Total nutrient reduction (kg/year)	16.87	116.76

Mitigated Future Nutrient Load

	Total Phosphorus Load (kg/year)	Total Nitrogen Load (kg/year)
Load Contribution		
Unmitigated future nutrient load	39.48	-395.02
SUDS nutrient reduction	16.87	116.76
Mitigated future nutrient load	22.61	-511.78

Nutrient Mitigation Available from Land Parcel F

Soilscape 18 impeded drainage

Existing Nutrient Loads

Landuse	Area (ha)	P Export Rate (kg/ha/yr)	N Export Rate (kg/ha/yr)	P Load (kg/yr)	N Load (kg/yr)
Arable/ Cereal	4.7	0.55	20.17	2.59	94.80
Lowland Grazing / Permanent Grass	13.5	0.44	7.78	5.94	105.03
Total				8.53	199.83

Future Nutrient Loads

Landuse	Area (ha)	P Export Rate (kg/ha/yr)	N Export Rate (kg/ha/yr)	P Load (kg/yr)	N Load (kg/yr)
Woodland / Conservation Meadow	18.2	0.02	3.00	0.364	54.60

Available Nutrient Mitigation

	TP	TN
Existing Nutrient Load (kg/year)	8.53	199.83
Future Nutrient Load (kg/year)	0.36	54.60
Available Nutrient Mitigation (kg/year)	8.16	145.23

Nutrient Mitigation Available from Treating Existing Foul Flows through an On-site WWTW

Notes

1. This analysis calculates the mitigation that could be generated by connecting existing residential properties into an on-site WWTW.
2. The analysis is based on a per person approach so that student halls of residence with varying occupancy rates can be considered - but the void rate would need to be applied.
3. The analysis indicates that connecting existing foul flows into the on-site WWTW prior to 2030 would deliver mitigation of 0.073kgTP/person/year and 0.986kgTN/person/year.
4. Connecting existing foul flows into the on-site WWTW after 2030 would deliver lower mitigation of 0.004kgTP/person/year and 0.197kgTN/person/year.

Occupancy	1
Wastewater generated (litres/person/day)	120
Wastewater generated (litres/day)	120

Pre-2030 and Post-2030 Wastewater Nutrient Loads

	Canterbury WWTW Pre-2030		Canterbury WWTW Post-2030	
	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
WWTW consent limit (mg/l)	2.00	27.00	0.25	10.00
90% of WWTW consent limit (mg/l)	1.80		0.23	9.00
Total nutrient load from wastewater (mg/person/day)	216	3240	27	1080
Total nutrient load from wastewater (mg/person/yr)	78894	1183410	9862	394470
Total nutrient load from wastewater (kg/person/yr)	0.079	1.183	0.010	0.394

On-site WWTW Nutrient Loads

	On-site WWTW	
	Total Phosphorus	Total Nitrogen
WWTW consent limit (mg/l)	0.15	5.00
90% of WWTW consent limit (mg/l)	0.135	4.500
Total nutrient load from wastewater (mg/person/day)	16	540
Total nutrient load from wastewater (mg/person/yr)	5917	197235
Total nutrient load from wastewater (kg/person/yr)	0.006	0.197

Available Nutrient Mitigation

	Canterbury WWTW Pre-2030		Canterbury WWTW Post-2030	
	Total Phosphorus	Total Nitrogen	Total Phosphorus	Total Nitrogen
Existing nutrient load from wastewater (kg/person/yr)	0.079	1.183	0.010	0.394
On-site WWTW nutrient load(kg/person/yr)	0.006	0.197	0.006	0.197
Available mitigation (kg/person/year)	0.073	0.986	0.004	0.197