Southern Water's Water for Life: Hampshire

Technical Report 4: Habitats Regulations Assessment Consenting Risks: Marine Environment – Water Recycling Solution

Report for Southern Water

FINAL

MarineSpace and Ricardo for Southern Water

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Contact:

[redacted]
Water Team – London Office
13 Eastbourne Terrace,
London, W2 6AA
[redacted]

MarineSpace Authors:

[redacted]

Ricardo Authors:

[redacted]

Approved by:

[redacted]

Signed

Date:

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1	25/06/2021	Draft report	First draft to Southern Water.
2	14/07/2021	Second draft	Responding to Southern Water comments
3	19/08/2021	Third draft	Inclusion of 15Ml/d scenario and responding to stakeholder comments
4	10/09/2021	Fourth draft	Responding to Legal comments. Updating assessment with latest scheme details (B4) and [redacted] LSO memorandum.
5	10/09/2021	Fifth draft	FINALISED READY FOR ISSUE

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1 Introduction

1.1 Background

Water companies in England and Wales are required to produce a Water Resources Management Plan (WRMP) every five years. The Plan sets out how the company intends to maintain the balance between supply and demand for water over the selected planning horizon (minimum 25 years) in order to ensure security of supply in each of the water resource zones making up its supply area.

Following submission of WRMPs in 2019, Ofwat through the Price Review 2019 (PR19) Final Determination, has identified the potential for companies to jointly deliver strategic regional water resources solutions to secure long-term resilience on behalf of customers while protecting the environment and benefiting wider society. As part of the assessment of companies' PR19 business plans, Ofwat introduced proposals to support the delivery of Strategic Regional Water Resource Options (SROs) over the next 5 to 15 years with solutions considered to be 'construction ready' for the 2025-2030 period. Ofwat's Final Determination in December 2019 set out a gated process for the co-ordination and development of a consistent set of SROs.

This gated process provides a mechanism for the industry, regulators, stakeholders and customers to input into the development and scheduling of these strategic solutions, through a combined set of statutory and regulatory processes. These include the National Framework, Drinking Water Safety Plans, Business Plans and WRMPs.

1.2 Southern Water's Strategic Challenge and Strategic Resource Options

The River Itchen, the River Test, and the Candover Stream are the three primary surface water resources utilised in Southern Water's Western Operating Area. In March 2019, the Environment Agency (EA) enacted sustainability reductions on all three sources, imposing new abstraction limitations to protect biodiversity in periods of drought. These reductions have fundamentally changed the water resources position in Hampshire and Isle of Wight (IOW) water resource zones (WRZs), and there is uncertainty regarding the potential for further changes in the future. The scale of the sustainability reductions is expected to generate sizeable supply-deficits during periods of severe drought.

Water supply modelling completed in development of Southern Water's WRMP, published in 2019, identified a 167 Ml/d supply-demand deficit across Southern Water's Western Operating Area during a 1-in-200-year drought scenario, accounting for the sustainability reductions referenced above. The WRMP19 preferred strategy included a 75Ml/d desalination plant in the Hampshire Southampton West (HSW) Water Resource Zone (WRZ). This was confirmed as the Base Case for the Gate 1 submission.

As part of the RAPID Gated process, Southern Water have been investigating a number of alternative SROs to the Base Case including water recycling and alternative use of Portsmouth Water's Havant Thicket Reservoir. Those configurations relevant to this report are provided in **Table 1.1 Water for Life-Hampshire strategic solution review** and further described below.

Table 1.1 Water for Life-Hampshire strategic solution review: water recycling

Solution	Configuration	Definition	Description
Water Recycling	**B.2**	WfL-H Alternative Water Recycling	61Ml/d recycled water from Water Recycling (fed from [redacted]) transferred to Lake Otterbourne environmental buffer and treated at Otterbourne WSW
	B.4	WfL-H Alternative Water Recycling	15Ml/d recycled water from Water Recycling (fed from [redacted]) transferred to Havant Thicket Reservoir environmental buffer and treated at Otterbourne WSW

Solution	Configuration	Definition	Description
	B.5	WfL-H Alternative Water Recycling	75Ml/d recycled water from Water Recycling (fed from [redacted] and [redacted]) transferred to Lake Otterbourne environmental buffer and treated at Otterbourne WSW

High level environmental assessments using the principles of Strategic Environmental Assessment (SEA), Habitats Regulations Assessments (HRA) and Water Framework Directive (WFD) assessment, were completed for the accelerated Gate 1 submission in September 2020. The Gate 1 work included a gap analysis and look ahead to activities required prior to the Gate 2 submission (September 2021) to further understand the environmental risks of progressing with the Base Case or alternatives.

One of these activities, was to further understand how the water quality of the existing waste-stream from the [redacted] would change with a reuse solution, and the resulting risks to compliance with the HRA tests. This is applicable to the B2 and B4 configurations. When considering the B5 configuration, there is also a change to the waste-stream from [redacted]

1.3 Purpose and Scope of this Report

This report therefore documents further desk-based assessment into the impacts of the waste-stream changes at [redacted] and [redacted] as a result of the inclusion of the water recycling process.

This report aims to support the following workstreams being undertaken by Southern Water and the wider WfLH team:

- Review of alternative sites for the Water Recycling Plant identified through the site selection work (Stage 3) and the key risks in respect to the Solent Wader and Brent Goose Strategy site allocations.
- Review of literature to provide additional evidence as to the likely HRA consenting risks of the Base Case, focussing on:
- Sensitivity of qualifying features (directly or indirectly) to nutrient levels and other water quality parameter changes of the waste-streams:
  - Solent Maritime Special Area of Conservation (SAC) – changes to offshore features, but also effects of water quality changes if dispersion into the harbours.
  - Solent and Dorset Coast Special Protection Area (SPA) – tern species and changes to the prey availability within part of their foraging area.
  - Chichester and Langstone Harbours SPA and Ramsar – changes to availability of prey in offshore areas predominantly, but indirect effects of changes to water quality if dispersion into the harbours.
  - River Itchen SAC and compensatory habitat (River Test and River Meon) – Atlantic salmon and changes to migratory patterns and cues.

1.4 Structure of this Report

This report includes the following sections:

Section 2 Description of the Water Recycling Solution: high level description of the water recycling solution and expected activities associated with the life cycle of the solution from construction through to decommissioning;

Section 3 Marine Environmental Pressures of Water Recycling Waste-Streams: discussion of the expected pressures to the marine environment from the outfall components, using known parameters and a desk-based review of generic outfall arrangements;

Section 4 Environmental Baseline Review: a baseline review and summary of the general nature and characteristics of the marine environment in the area offshore areas considered as part of the site selection work;

Section 4 European Designated Sites, Scope for Assessment and Supporting Information: a review of the European designated sites (SAC, SPA and Ramsar sites) and their qualifying features relevant to the marine impacts of the water recycling waste-stream;

Section 6 Sensitivity of Qualifying Features: a review of the sensitivity of the qualifying features of the designated sites (SAC, SPA and Ramsar sites) to the outlined pressures;

Section 7 Site Selection Support: a review of the seven water recycling plant sites and the Solent Wader and Brent Goose Strategy allocations, with implications for development and mitigation considered.

Section 8 Consideration of Marine Impacts and Mitigation Options: a review of the fundamental HRA risks and likelihood of successful mitigation to secure consent at Stage 2 Appropriate Assessment;

Section 9 Knowledge and Evidence Gaps: a discussion of identified key evidence gaps;

Section 10 Conclusions and Next Steps: summary of the key points from the desk-based assessment completed and next steps to refine, or confirm the conclusions drawn.

2 Description of the Water Recycling Solution

2.1 Overview

Water recycling is the process by which Final Effluent (FE) from a wastewater treatment plant is converted to clean water that can be used for various applications, with a variety of deployable outputs. Configuration will utilise the waste-stream from the [redacted] as the source of recycled water for 61Ml/d). To meet a 75Ml/d demand, a second source of water from [redacted] is required (B5). For the B4 configuration, there is a smaller requirement from the [redacted], of 15Ml/d. This is because the primary purpose of the WRP in this configuration, is to make up the shortfall in the event that other programme wide targets are not achieved. The B2 and B5 configurations would require a sweetening flow of 15Ml/d, reduced to 5Ml/d for the B4 configuration.

The water is then treated and transferred to an environmental buffer (either Lake Otterbourne or Havant Thicket Reservoir) before being transferred to Otterbourne WSW for further treatment and circulation into the supply system. All waste water from the water recycling process will be discharged via the existing [redacted] Long Sea Outfall (LSO) via [redacted] The Short Sea Outfalls (SSO) into Langstone Harbour will not be used. Waste discharges from the water recycling plant will be transferred back to the [redacted] system and will be discharged downstream of the [redacted] FE outlet channel and directly into the [redacted] transfer tunnel. From this location, FE is unable to backflow to the Langstone Harbour ([redacted] SSO)[1].

2.2 Locations

A site selection process has been undertaken, within 5km of the existing [redacted], to determine a suitable site on which to construct the new water recycling plant. The results of the Stage 3 site selection process identified seven potential land parcels, as shown in **Figure 2.1**. Further work is ongoing at Stages 4 and 5 of the site selection process, to determine which of these sites should be progressed at detailed design. This includes a review of relevant planning criteria (e.g., the draft National Policy Statement and draft National Planning Policy Framework) and consenting risks, for example HRA compliance. The latter criterion has given consideration to whether land parcels are within the Solent Wader and Brent Goose Strategy allocations (see Technical Report 6).

2.3 Components

The key components of the water recycling solution include, as shown in **Figure 2.2**:

- FE from [redacted] (and [redacted] in B5 configuration) transfer pipeline to water recycling plant.
- Water Recycling Plant (WRP).
- Waste-stream via [redacted] LSO.
- Environmental buffer and transfer pipeline:
    - Lake Otterbourne (including emergency discharge to Otter Bourne watercourse) (B2 configuration) OR
    - Havant Thicket Reservoir (B4 configuration)
- Transfer pipeline from environmental buffer to Otterbourne WSW.
- Pumping stations and break pressure tanks (BPT) along transfer pipeline route.
- Pre-disinfection ceramic membrane treatment plant at Otterbourne WSW

As indicated in **Table 1.1**, three sizes for the water recycling plant are being considered; 75Ml/d, 61Ml/d and 15Ml/d. Under the 61Ml/d configuration the total waste-stream is 17.2Ml/d (13.3Ml/d is brine) and for the 75Ml/d configuration this increases to 21Ml/d (16.4Ml/d is brine). No construction work is required for the discharge, with the [redacted] LSO from [redacted] being utilised. This outfall was constructed in c.2000, as part of an environmental improvement programme to improve wastewater

[1] Southern Water (August 2021) Memorandum – W4L-H Water Recycling Plant Wastewater Discharges

treatment and water quality in Langstone Harbour and is therefore located in a well-mixed area to maximise the dispersion of the waste-stream.

The full 75Ml/d will only be required to supply potable water in a 1 in 200 year drought event, and therefore the output at this level is periodic. However, the WRP will need to be run with a sweetening flow of 15Ml/d to main operational processes, ready for output to be increased when required. The preliminary site area being searched for within the site selection process is 45,000m^2 (for a 75Ml/d plant) with 4,047m^2 as a temporary construction area. A smaller WRP is required to supply the 15Ml/d for the B4 configuration. This will need to be run with a sweetening flow of 5Ml/d, and will have a smaller footprint, c.25,000m^2.

Figure 2.1 Site selection Stage 3 output: Water Recycling Plant sites

[redacted]

Figure 2.2 Water recycling components

[redacted]

2.4 Construction Phase

No construction work is required in the marine environment as the [redacted] LSO is already in place. Works will be needed in close proximity to the intertidal areas of Langstone Harbour, however the potential for disturbance related impacts are considered separately in Technical Report 6.

2.5 Operation Phase

2.5.1 Process overview

Information on the operation of the water recycling plant has been taken from the Gate 1 submission; Strategic Solution Gate 1 Submission: Annex 5 Water Recycling Technical Report (28 September 2020), as well as information provided by the provisional concept design.

The existing treatment processes at [redacted] generate a fully denitrified FE with low solids content and a low BOD, currently being discharged into the Solent. The FE will be diverted from the existing discharge pipe at [redacted] (and [redacted] in B5 only) to a wet well that will provide suction for pumps that will transfer flow to a new water recycling plant (WRP).

At the water recycling plant, the FE will be passed through a series of microfiltration membranes where any remaining solid matter and other pathogens for example bacteria, from the source water will be removed. With pressure build-up, the membranes are cleaned using a Clean-In-Place (CIP) process. The backwash water used for cleaning is disposed of via the [redacted] LSO. With high salinity in the FE, reverse osmosis (RO) will be used to remove dissolved organic compounds, pathogens and other chemical contaminants but also important minerals in the water. Chemical cleaning is carried out using acid and anti-scalant products to clean the RO membrane. The reject water from this cleaning process is discharged as a waste to the [redacted] LSO.

The table below shows the discharge permits for [redacted].

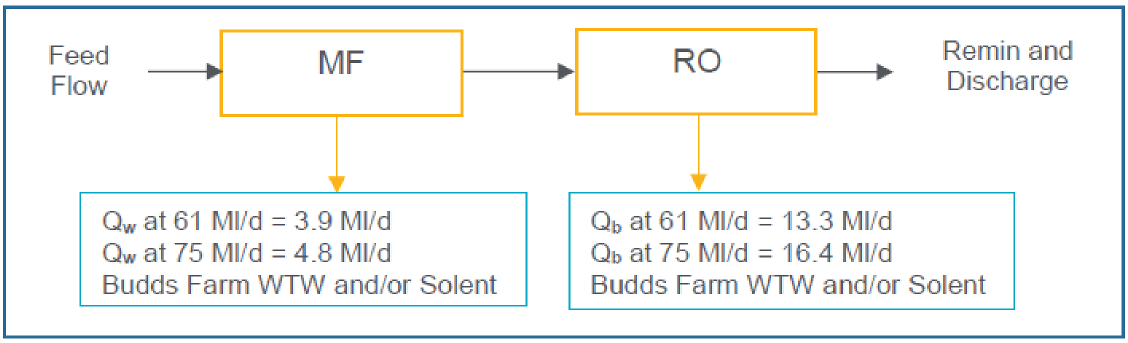
Table 2.2 FE permitted discharge quality parameters (summer conditions only)

WTW Site Name	BOD (mg/l)	TSS (mg/l)	TN (mg/l)	Total Iron (mg/l)
[redacted]	40	30	9	5
	40	60	9.7	3

The RO process produces a concentrate that is estimated to be 17% of the feed water (based on recovery identified by the pilot trials). The process flows and volumes (waste streams flow (Qw) including brine flow (Qb)) are indicated in **Figure 2.3**.

The drinking water component will then be passed through a disinfection process, before being piped to the environmental buffer and then Otterbourne WSW for treatment and distribution. The pipelines and conveyance options, environmental buffers and works required at Otterbourne WSW are not part of this report. Any HRA risks will be addressed in the Gate 2 HRA.

Figure 2.3 Estimated WRP waste stream flow (Ml/d) for 61 and 75 Ml/d recycled flow production



2.5.2 Utilisation

For the purpose of this assessment, the water recycling solution is assumed to have a life cycle of a minimum 100 years.

During normal daily operation the asset will operate on a minimum flow of 15 Ml/d. As drought severity increases the asset will be called upon to output increased volumes, with the desalination plant starting to operate above its minimum flow during a drought with an approximate return period of 65 years. During a drought with a return period of 100 years the plant will operate above minimum flow for 16 days in a 365-day period, and in a 1 in 200-year drought the plant will be operating at or near its full capacity for 49 days in a 365-day period, as shown in **Table 2.11**.

Table 2.1 Utilisation of desalination solution across drought return periods

Drought Return Period (years)	Maximum Daily Supply (Ml/d)	Annual Days Operation (above sweetening flow)	Annual Volume Transferred (Ml)
1	15	0	5475
2	15	0	5475
5	15	0	5490
10	15	0	5490
20	15	0	5490
50	15	0	5490
100	24	16	5537
200	48	49	6275

2.6 Solution Envelope Summary

Table 2.2 below provides a summary of key parameters for the scheme (relating to marine works). It is to be noted that the predicted worst-case scenarios have been tabulated where these are known, but due to currently limited level of solution design information, not all parameters have been presented.

Table 2.2 Summary of predicted worst-case scenario

Parameters	Values/Information
Operating regime	75 Ml/d maximum [redacted] – worst case (B5) 61Ml/d (B2) or 15Ml/d (B4) ([redacted] 15Ml/d sweetening flow (B2) or 5Ml/d sweetening flow (B4) ([redacted]
Operation life-cycle	Minimum of 100 years
Maximum outfall length (distance offshore)	Utilise existing [redacted] LSO
Discharge – Salinity	59 PSU
Discharge - Temperature	Same as ambient
Chemicals (during pre-treatment; desalination and disinfection)	Uncertain but likely to be: antiscalant (sodium hydroxide); sulphuric acid, ferric chloride; sodium hypochlorite; sodium bisulphate
Removal of wastewater (brine)	Discharged via existing [redacted] LSO
Removal of solid waste	None produced
Installation Method (outfall structures)	N/A – utilise existing infrastructure
Decommissioning	Marine infrastructure left *in situ*

3 Marine Environmental Pressures of Water Recycling Waste-Streams

Only two parameters of the existing waste-stream from the [redacted] will be altered; salinity and nitrogen concentrations. The remaining water quality parameters will not be altered and will be within the current permit for the [redacted] LSO. Maintenance of the LSO will remain as per the current procedures. This section focusses on a review of the pressures from RO waste-streams on marine environments from literature review and reference to the pressures listed within the Advice on Operations (AoO) category of 'Coastal Infrastructure', sub category: 'Outfalls/Intake pipes maintenance/construction/usage'[2,3].

3.1 Discharge Plumes

3.1.1 Changes in salinity

Negative effects from a change in salinity in the waste-stream may occur if the hypersaline plume interacts with a sensitive system[4]. Increased salinities from discharge plumes have been observed to range widely. Extents can range from over tens of meters, to over several kilometres in extreme cases, but in the majority of cases the plume intensity diminishes rapidly and is usually no greater than 2ppt above background within 20m of the discharge point. Plumes which extend over hundreds of meters may only be slightly greater than background levels (<0.5 ppt). The effects of a hypersaline discharge on the receiving environment will vary with the nature of the discharge itself, along with wind direction and speed, wave height and speed, bathymetry and tidal mean and average, and extents reported can also be an artefact of the sampling effort of a study itself.

There will be both spatial and temporal variation in the behaviour and extent of a discharge plume. A discharged dense RO effluent is expected to be a negatively buoyant plume, spreading as a density current on the seabed, extending further along the seafloor than at the surface. With insufficient mixing, these plumes also can alter the amount of dissolved oxygen in the water[5]. Modelling has also shown that over a tidal cycle, the greatest exposure to higher salinities may occur on flood tides which concentrate the brine plume back around the discharge point[6].

After discharge, if a plume impinges on the seabed due to its density, then this potentially increases the exposure to benthic marine species living in and on the seabed (e.g., seagrass beds, demersal fish, epifauna and infauna) than pelagic and planktonic species. Alternatively, if the plume is positively buoyant it may impact water surface processes and ecology[7]). The impact of a salinity increase may directly impact an organism's physiology (e.g., growth rate), survivability (e.g., of larval stages), reproduction (e.g., hatching success), and behaviour (e.g., avoidance)[8]. This in turn may have wider population level and ecological implications. A saline plume may significantly affect the local distribution

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[2] NE (Natural England), 2021. Designated Sites View. Solent and Dorset Coast SPA. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=solent&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

[3] NE (Natural England), 2021b. Designated Sites View. Solent Maritime SAC. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=solent&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

[4] Lattemann S, and Höpner, 2008. Environmental impact and impact assessment of seawater desalination. Desalination, 220: 1-15.

[5] Turnpenny AWH, Coughlan J, Ng B, Crews P, Bamber RN, Rowles P, 2010. Evidence - Cooling Water Options for the New Generation of Nuclear Power Stations in the UK. Report for Environment Agency. Report No., SC070015/SR3. 214pp.

[6] Roberts, S.A., Johnston, E.L., Knott, N.A., 2010. Impacts of desalination plant discharges on the marine environment: A critical review of published studies. Water Research. 44: 5117-5128.

[7] Missimer TM, and Maliva RG, 2018. Environmental Issues in seawater reverse osmosis desalination: Intakes and Outfalls. Desalination, 434: 198-215.

[8] Richards JE, and Beamish FWH, 1981. Initiation of Feeding and Salinity Tolerance in the Pacific Lamprey *Lampetra tridentata*. Marine Biology, 63: pp.73-77.

of mobile species such as echinoderms[7] and fish and create a barrier to movement in an area important for migrating species, such as Atlantic salmon (*Salmo salar*)[9].

It is important to note that a community's response to salinity changes will not be uniform across all members of an assemblage, with salinity sensitivities varying naturally between species. Osmotic conformers are organisms that have no ability to regulate osmosis and thus salinity of their cells in relation to their environment (stenohaline species), whereas osmotic regulators can control the salt content despite variations in external salinities.

Most marine fish, birds, mammals and some shellfish are osmotic regulators[7]. However, for larval and juvenile stages of fish (e.g., bream and flounder) very high salinities of 55-70 ppt have been shown to be toxic to these younger individuals, and avoidance behaviour was exhibited at 45 ppt. It may be expected that during an individual's life stages that during development its sensitivities to such pressures may change.

Single-celled organisms such as plankton may be expected to be more susceptible to fluxes in salinities, though the scale of effect will be localised if in areas of strong flow and tidal mixing[10,7]. Sessile invertebrates resident on rock (e.g., encrusting serpulid worms) that are unable to swim/crawl away from an impact, or bury within sediment, may also be naturally vulnerable than other biota that can readily migrate.

Seagrasses beds associated with intertidal and shallow waters clean or muddy sand habitats have been reported to be overall, particularly sensitive to saline plumes, where they can impact health and survival. Most laboratory studies have focussed on *Posidona oceanica* with studies reporting that only a minimal increase in salinities resulted in reduced growth and other physiological effects, and similarly, field studies reported increases in leaf necrosis and decreased carbohydrate storage in leaf tissues subject to increases of only 1-2 ppt. However, this contrasts with experiments on seagrasses from naturally hyper saline environments where growth and leaf production were greatest at salinities of 42.5 ppt[11]. Other available research suggests seagrass beds are tolerant of a range of salinities (10-39ppt)[12], and studies of *Zostera noltii* testing growth within a range of salinities (up to 35ppt) did not result in significant differences[13]. Thus, extremes in salinity may be of greatest concern. However, the variation in the literature, highlights the importance of understanding the natural conditions of the receiving environment, and the acclimatisation of the species, for drawing conclusions of a potential impact.

There is a degree of inconsistency in effects of saline plumes on marine fauna, with some reporting that it can have a substantial impact or a negligible one, and from historic studies it is likely that sensitivity results were in part due to excessive copper contents of the brine, than the higher salinities[14]. Naturally high spatial and temporal variability of a community and sampling design can make it difficult to detect if changes are occurring at a population or community level from exposure to a salinity plume[15]. Furthermore, no impact may be detected in environments already disturbed from anthropogenic activities (e.g., other water discharging facilities)[16].

[9] McInerney JE, 1964. Salinity Preference: An Orientation Mechanism in Salmon Migration. Journal Fisheries Research Board of Canada, 21: pp.995-1018.
[10] Lattemann S, and Höpner, 2008. Environmental impact and impact assessment of seawater desalination. Desalination, 220: 1-15.
[11] Missimer TM, and Maliva RG, 2018. Environmental Issues in seawater reverse osmosis desalination: Intakes and Outfalls. Desalination, 434: 198-215.
[12] Tyler-Walters, H., 2008. Zostera subg. Zostera marina Common eelgrass. In Tyler-Walters H. and Hiscock K. (eds) Marine Life Information Network: Biology and Sensitivity Key Information Reviews, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 07-07-2021]. Available from: https://www.marlin.ac.uk/species/detail/1282
[13] Suykerbuyk et al. (2018), Living in the intertidal: desiccation and shading reduce seagrass growth, but high salinity or population of origin have no additional effect. PeerJ 6:e5234; DOI 10.7717/peerj.5234
[14] Roberts, S.A., Johnston, E.L., Knott, N.A., 2010. Impacts of desalination plant discharges on the marine environment: A critical review of published studies. Water Research. 44: 5117-5128.
[15] Raventos N, Macpherson E, and Gárcia-Rubiés, 2006. Effect of brine discharge from a desalination plant on macrobenthic communities in the NW Mediterranean. Marine Environmental Research, 62: 1-14.
[16] Peterson KL, Heck N, Reguero BG, Potts D, Hovagimian A, and Paytan A, 2019. Biological and physical effects of brine discharge from the Carlsbad desalination plant and implications for future desalination plant constructions. Water, 11(208): 1-21.

3.1.2 Changes in nitrogen

The issue regarding changes in nitrogen is specific to the site location of [redacted] in the Solent, rather than being a direct impact of the water recycling process itself.

Langstone Harbour, Chichester Harbour and Portsmouth Harbour have all been classified as Nitrate Vulnerable Zones (NVZ) by the Environment Agency. The evidence presented in the Environment Agency's datasheet for the classification of Langstone Harbour as a NVZ concludes that nutrient levels are elevated in the winter months, influenced by wet winters, but are lower during the summer season. Nutrient concentrations are highest to the north east of the estuary where the River Hermitage discharges, concentrations are lower in the wider estuary and at the mouth, therefore suggesting high riverine nutrient loading. Under the WFD classification system, Langstone Harbour achieved Good status in the 2015 classification (although borderline). The three surveys undertaken in 2009, 2011 and 2014 confirm Langstone Harbour has now achieved Good status for macroalgae (yearly EQR scores of 0.59 and 0.67 and 0.63 respectively). When using the Urban Waste Water Treatment Directive criteria, the percentage of intertidal area covered by macroalgae was between 256 and 412ha, equating to 18% and 28% which is borderline on the criteria for eutrophication. Further monitoring was recommended in the review, to determine whether this was part of a long-term improvement or as a result of annual variation in macroalgal growth.

As part of water quality improvements, [redacted] was upgraded in two stages, firstly with the construction of the [redacted] LSO c.2000 to divert waste-water from Langstone Harbour itself, offshore, and secondly the incorporation of nitrogen stripping technologies in the treatment process c.2007. The activated sludge process (ASP) was modified and expanded to increase total nitrogen removal, with an additional ASP tank added and the Bardenpho method chosen for further nitrogen stripping. Modification of the ASP tanks was needed to incorporate the Bardenpho method, with these additional processes aiming to achieve 9.7mg/l total nitrogen in the FE[17].

Although the majority of nitrogen loading to Langstone Harbour is from marine sources, with the coastal background being 40%, Telemac modelling indicates that the [redacted] LSO contributes 0.78% of the total sources from the Solent, at Langstone Harbour entrance. The source apportionment data is presented in **Table 3.1**.

Table 3.1 Source apportionment of nitrogen loads to Langstone Harbour[18]

Nitrogen source	Langstone Harbour
Freshwater	**36%**
Riverine	28%
STW	0%
Urban diffuse	8%
Marine	**64%**
Coastal background	40%
Indirect riverine	19%
Indirect STW	5%

Average seasonal nitrate concentrations for sites in Langstone Harbour show considerably higher winter average nitrate concentrations, which feed into the greater average spring nitrate concentrations seen at Langstone Harbour Mouth and Russell's Lake monitoring sites. A closer analysis of seasonal variation in nitrate concentrations at 11 sites distributed across Langstone Harbour showed that nitrate concentrations peak at all sites in winter. It is worth noting that DIN concentrations at the "Nr [redacted] Long Sea Outfall" site are generally lower than those observed at sites within or at the mouth of

[17] Southern Water. No date. Management of Wastewater in Portsmouth and Havant.
[18] Note the STW (direct) refers to discharge of treated effluent directly into a harbour, as opposed to via an LSO, e.g. [redacted]. Taken from the Environment Agency's WFD DIN and Ecological Impact Investigations report (2014).

Langstone Harbour. DIN concentrations at the "Nr [redacted] Long Sea Outfall" are also very similar to those observed at the "Solent Near Horse Sand Buoy" site that is located 3.8 km away, suggesting that the coastal background DIN concentrations in the Solent are the main driver of fluctuations in nitrogen levels in the Solent. All sites have average salinities of 34 ppt and thus are assessed against the WFD Coastal DIN standard. Over the past 10 years, sites within the harbour ("NW Sinah Buoy, Langstone") and at the harbour mouth ("Langstone Harbour Mouth") have breached the WFD Good – Moderate status boundary eight times, with the sites in the Solent breaching the Good – Moderate status boundary seven times. Breaches tend to occur concurrently at all sites during the winter months, likely due to increased seasonal rainfall.

Natural England completed Marine Condition Assessments of the following Solent Maritime SAC qualifying features (of relevance to the [redacted] and [redacted] locations):

- H1110 Sandbanks which are slightly covered by sea water all the time (2018): 100% unfavourable no change
- H1140 Mudflats and sandflats not covered by seawater at low tide (2020): 70% unfavourable no change, 30% unfavourable declining
- H1130 Estuaries (2020): 70% unfavourable no change, 30% unfavourable declining.

The SSSI condition assessment of Langstone Harbour is predominantly in unfavourable-recovering condition (91.05% from underlying SSSI unit summary), with only a small proportion in favourable condition (8.39% - Farlington Marshes which is neutral grassland habitat). The latest SSSI condition assessment for Units 3, 6, 9, 13 and 14 (September 2018) states[19]:

"*Assessed in combination with other Langstone Harbour units, this part of the harbour achieves WFD Good (borderline) status on mean winter inorganic nitrogen, WFD High status on phytoplankton and WFD Good (borderline) status on opportunistic green macroalgae. However, in this unit there can be areas with a dense cover of opportunistic green macroalgae (>75% cover density), more so than in some parts of the harbour. The water environment of the unit is assessed as unfavourable for the interest features on the weight of evidence on inorganic nitrogen and biological indication of eutrophication shown by the abundance of macroalgae but recovering on the basis of a large reduction in nutrient inputs through diversion of wastewater. There remains a significant nitrogen load input carried by tidal flow from the Solent and less so by minor rivers into the head of the harbour. The unit is considered 'at risk' of not recovering to a favourable situation on the water environment as it is unclear whether the nutrient status will become adequate to substantially prevent the growth of dense macroalgae mats in this part of the harbour."*

The condition of the habitats most vulnerable to eutrophication and reductions in dissolved oxygen; estuaries, mudflats and sandflats, *Spartina*, saltmarsh, *Salicornia*, sandbanks, are stated as being bad and deteriorating for structure and function and future prospects (across the natural range of the qualifying feature)[20]. Key threats and pressures listed include water pollution and discharges. The Site Improvement Plan for the Solent European Marine Site identifies water pollution as the fourth priority threat (out of 17) to be addressed for the site through the implementation of the Diffuse Water Pollution Plan, and further investigation into other sources of pollution.

Therefore, the potential concentrating of the nitrogen load through the RO, and release back as part of the waste-stream needs to be considered in the context of the unfavourable condition of the qualifying features, and the implications of the Dutch Nitrogen case (2018).

[19] Natural England Designated Sites View Langstone Harbour SSSI unit condition assessments. Accessed at https://designatedsites.naturalengland.org.uk/UnitDetail.aspx?UnitId=1030407
[20] Taken from JNCC Article 17 reporting.

3.2 Summary of Potential Pressures from Solution

The sensitivity analysis was based on the Marine Evidence based Sensitivity Assessment (MarESA) approach (Tyler-Walters et al., 2018). The sensitivity to a pressure was assessed using the: The Advice on Operations (AoO) category of 'Coastal Infrastructure', sub category: 'Outfalls/Intake pipes maintenance/construction/usage'[21,22] have been considered. **Table 3.2** below summarises the potential pressures on the marine environment from activities associated with the solution.

[21] NE (Natural England), 2021. Designated Sites View. Solent and Dorset Coast SPA. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=solent&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

[22] NE (Natural England), 2021. Designated Sites View. Solent Maritime SAC. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=solent&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

Table 3.2 Summary of potential pressures (effects and impacts) on the marine environment from activities associated with the solution

Activity	Effect	Impact	Scoped into this assessment?
Construction			
No construction work is required, as the water recycling waste-stream will be discharged offshore using the existing infrastructure at [redacted]; [redacted] LSO.			
Operation			
Discharge plume at the outfall following RO process	Increase in salinity of ambient waters	Risk of mortality, and physiological and behavioural (e.g., avoidance) impacts of marine benthic and fish species with potential wider impacts	Yes
	Release of pollutants used during processes (pre-treatment, membrane cleaning etc.).	Disturbance of marine communities and individuals (e.g., physiological stress)	Uncertain – not included in assessment. Details of the chemicals to be used in the cleaning process are not known at this stage, however the discharge from the WRP connects to the [redacted] LSO and does not pass through the [redacted] treatment process again. Further assessment will be required to Gate 3. .
	Increase in turbidity	Reduced visibility, smothering, interference with filter-feeders.	No. Not considered to be significantly affected by the water recycling process. Will remain within current permit for [redacted] and [redacted] LSO, and therefore not one of the parameters modelled.
	Increase in suspended sediment concentration (during discharge using pumps)	Reduced visibility for visual feeders, smothering, interference with filter-feeders, mobilisation of contaminated sediments.	No. Not considered to be significantly affected by the water recycling process. Will remain within current permit for [redacted] and [redacted] LSO, and therefore not one of the parameters modelled.
	Barrier to species movement	Disturbance and displacement of migratory fish and bird species.	Yes
	Nutrient enrichment	Change in concentrations of nitrogen and characteristics of dispersion plume due to reduced volume of water in waste-stream.	Yes
Decommissioning			
Marine infrastructure left *in situ*	Collision risk	Risk of injury or mortality to diving seabirds	No. Marine infrastructure is not new, having received planning permission c.2000. Infrastructure has been constructed at depth, and unlikely to interfere with 2m dive area of terns.

4 Environmental Baseline Review

4.1 Physical Environment

The Solent is situated to the north of the Isle of Wight and is linked to the English Channel on either side of the island. The Solent and Isle of Wight system is a major estuarine system comprising 4 coastal plain estuaries (Yar, Medina, King's Quay Shore, Hamble) and 4 bar-build estuaries (Newtown Harbour, Beaulieu, Langstone and Chichester Harbour[23]. The discharge sites at [redacted] and [redacted], both existing Long Sea Outfalls (LSO), are both situated in the eastern side of The Solent Water Framework Directive (WFD) coastal waterbody (**Figure 4.1**).

The complex tides in The Solent are driven by the tidal characteristics of the English Channel, with a significant tidal gradient from 1.2 m in the west to 3.0 m in the east. Around Spithead off Gilkicker Point (just to the east of [redacted]), high tides are not double, as found in the west of The Solent or in Southampton Water, but are an extended tidal period. The tidal currents can be very strong at the entrances to the tidal inlets of Southampton Water and the harbours, and to The Solent itself[24][25]. Local wave climate is driven by the prevailing south-westerly winds, with strongest winds during the winter. However, the estuaries and harbours in the area are relatively sheltered.

The waters of The Solent and Southampton Water are eutrophic, and the water column is relatively well mixed[26]. Freshwater inputs into The Solent from the 3,050 km^2 catchment, are predominantly from the largest rivers in the area; the Rivers Test, Itchen and Hamble, which all flow into Southampton Water. Other sources that flow into the eastern area of The Solent include the River Meon from the mainland, and the River Medina from the Isle of Wight. The different land cover types within the catchment result in generation of different levels of contamination from run -off, with highest faecal coliform input from developed areas of The Solent, and with overall contributions increased following significant rainfall events[27].

Regional bathymetry of the eastern Solent shows extensive shallow areas within Southampton Water, and notably within the harbours of Portsmouth, Langstone and Chichester. Much of The Solent is less than -5 m depth. However, depths of between -10 and -30 occur in the relatively deeper central channel, notably at the extreme eastern and western ends; which is likely maintained by strong tidal currents (**Figure 4.2**)[25]. The Solent Maritime Special Area of Conservation (SAC) lists sandbanks as designated features for this area. Limited information is available on sandbank features in the area. However, the JNCC list one known sandbank in the east of The Solent[28].

The bedrock geology of the area is characterised by rock along the main channels, and nearshore, bands of softer sandstone and silt and clay are dominant. Both outfall locations are within mosaic areas of relatively fine sediments of muddy sand; sandy mud; and slightly gravelly muddy sand. To the west, the sediments are coarser, dominated by gravel. This is considered to result from the stronger currents flowing through the narrow western channel between the Isle of Wight and the mainland. To the east, the sediments are again coarse, but a mix of sand and gravel (e.g., slightly gravelly sand; and gravelly

[23] English Nature, 2005. Site Citation: South Wight Maritime. Accessed August, 2021. Available online at: http://publications.naturalengland.org.uk/publication/6242150467502080.
[24] Solent Form (2021) Waves and Tides. Accessed July, 2021. Available online at: http://www.solentforum.org/solent/our_coastal_zone/waves_and_tides/
[25] British Geological Survey (1996). Chapter 2.3 Wind and Water. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 27-30. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)
[26] Hirst AG, Sheader M, and Williams JA (1999) Annual pattern of calanoid copepod abundance, prosome length and minor role in pelagic carbon flux in the Solent. Marine Ecology Progress Series. 177: 133-146.
[27] Cefas, 2013. Sanitary Survey of The Solent. Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under of EC Regulation No. 584/2004. https://www.cefas.co.uk/media/1uufnblg/final-sanitary-survey-report-solent-2013-dj-table-issues.pdf.
[28] JNCC (2021). Distribution of SACs/SCIs/cSACs containing species 1110 Sandbanks which are slightly covered by seawater all the time. Accessed July 2021. Available online at: https://sac.jncc.gov.uk/habitat/H1110/map

sand) (**Figure 4.3**). The key coastal landforms of the area are estuarine and soft shores and shingle beaches and spits[29].

Figure 4.4 shows the nearshore sediment transport and offshore bedload sediment transport. The [redacted] LSO is located within sediment sub-cell 5b ('Portsmouth Harbour to Southampton') where tidal currents mainly run parallel to the shore, preventing onshore deposition, and local wave action causes some cliff and beach erosion along this coast (British Geological Survey, 1996c). The [redacted] LSO, situated further from the coast, is within sub-cell 5a ('Chichester Harbour to Portsmouth Harbour'), where there is westward drift of sediments. Coastal protection schemes in the area have, on the whole, reduced the rate of drift occurring, and when intercepted by harbour mouths, material is transported offshore[30].

[29] British Geological Survey (1996) Chapter 2.6 Coastal Landforms. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 35-36. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)
[30] British Geological Survey (1996). Chapter 2.4 Sediment Transport. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 31-32. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)

Figure 4.1 Water bodies of the Water Recycling zone of influence and surrounding waters (From: EMODnet, 2021)

Figure 4.2 Regional bathymetry of the Water Recycling zone of influence (From: EMODnet, 2021)

[redacted]

Figure 4.3 Seabed substrate of the eastern Solent (From: EMODnet, 2021)

[redacted]

Figure 4.4 Sediment transport of the eastern Solent[31]

[redacted]

4.2 Biological Environment

This section presents a high-level overview of the key biological communities present in the area of the LSO locations in the eastern Solent. Where relevant, cross references are made to specific information on features of conservation importance, as listed in Section 5.

4.2.1 Plankton and algal blooms

Planktonic assemblages in the region are mainly made up of neritic (coastal water) species, although southern intermediate (mixed species) can be present at certain times of the year, and annual chlorophyll concentrations in The Solent are typically of the order of 10-20 µg l^{-1}, decreasing towards deeper open waters[32]. The main spring bloom throughout The Solent and Southampton Water is initiated offshore, where it develops in the high salinity waters towards the Isle of Wight. The spring bloom tends to occur in May where diatom concentrations increase over spring or neap tides; this is followed by a series of blooms that are driven by nutrient availability in the mid and upper estuarine waters during the summer months[33]. This is supported by site-specific sampling; Chlorophyll-*a* as recorded at sample stations at Calshot (at the confluence of Southampton Water and The Solent), was reported to peak in May (11.9 µg l^{-1}), and largely remain above 2 µg l^{-1} in the colder winter and spring months. Phaeopigment concentrations peak (>8 µg l^{-1}) in March, and with a secondary peak in late summer (August)[3435]. Water sampling at different depths has shown the water column to be generally well mixed, with some stratifications during summer bloom conditions[33].

Algal blooms may produce natural aquatic toxins called "marine bioxins" and these can accumulate in filter feeding bivalve molluscs. As part of the Cefas harmful algal blooms (HABS) monitoring programme, phytoplankton was sampled at The Solent at the Browndown sampling point (located immediately north of the [redacted] LSO) to detect any taxa known to produce bioxins (January to July 2021)[36]. The following taxa were recorded and enumerated (cell counts) in the samples: *Alexandrium* spp. (April and July 2021); *Pseudo-nitzchia* spp. (April – July 2021); and *Prorocentum cordatum* (May 2021).

The cell counts for *Pseudo-nitzchia* spp. commonly exceeded the trigger levels[37]. However, the monthly HABS analysis of native oyster *Ostrea edulis* tissue from beds at Browndown, was associated with levels below the limit of quantification (LOQ) or reporting limit (RL) for different bioxins analysed. One exception was a semi-quantitative result of >400 µg kg^{-1} of Saxitoxin from specimens sampled in June[38],[36].

Zooplankton communities present in the water column are reported to be dominated by calanoid copepods and barnacle larvae with *Arcatia* spp. calanoids dominant in terms of biomass. At Calshot, annual primary copepod production was acknowledged to be relatively low compared to other studies[39], with seasonality evident, with peaks in copepod abundances May onwards, and low abundances post October[39,35].

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[32] Edwards M and John AWG (1996) Chapter 4.3 Plankton. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 74-76. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)
[33] Holley SE, Purdie DA, Hydes DJ, and Hartman MC (2007) 5 years of plankton monitoring in Southampton Water and the Solent including Ferrybox, Dock Monitor and discrete sample data. National Oceanographic Centre Southampton Research and Consultancy Report, No. 31. National Oceanographic Centre, Southampton (unpublished). https://core.ac.uk/download/pdf/9701258.pdf.
[34] Chlorophyll-*a* provides an estimate of algal biomass, and phaeopigment is the non-photosynthetic degradation product of chlorophyll.
[35] Hirst AG, Sheader M, and Williams JA (1999) Annual pattern of calanoid copepod abundance, prosome length and minor role in pelagic carbon flux in the Solent. Marine Ecology Progress Series. 177: 133-146.
[36] Cefas (2021). Harmful Algal Blooms (HABS) Surveillance Programmes and Monitoring. England and Wales – Bioxins and Phytoplankton results 2021. Accessed August 2021. Available online at: https://www.cefas.co.uk/data-and-publications/habs/.
[37] Trigger levels provide cell countthresholds; where these are exceeded additional investigation is required such as the collection of further flesh and water samples (Cefas, 2021a).
[38] Although the toxin was detected, records at this concentration remain below the action level (Cefas, 2021a).
[39] Williams JA, and Muxagata E (2006) The seasonal abundance and production of *Oithona nana* (Copepoda: Cyclopoid) in Southampton Water. Journal of Plankton Research. 28 (11); 1055-1065.

4.2.2 Vegetated shingle and sand dunes

Shingle shores are a characteristic feature of the area. A prominent fringing shingle shore present at Browndown is particularly significant due to its size and lack of fine matrix over most of its extent, supporting southern plant communities and nationally rare invertebrate species. On undisturbed shingle, pioneer communities of sea kale *Crambe maritima* and yellow horned poppy *Glaucium flavum* are present. The more inland, stable areas of shingle support acid grass heath vegetation species such as ling *Calluna vulgaris* and Gorse *Ulex europeaus.*

Along the coast at Hayling and Eastney, and Duver on the Isle of Wight, there are also good examples of sand matrix on shingle present, and recent surveys at Eastney recorded vegetated shingle above the mean high water[40]. Overall, these areas commonly have important associations with tern colonies *Sterna* spp., ringed plover *Charadrius hiaticula*, and black-headed gulls *Larus ribundus*[41]. Vegetated shingle represents the Annex I habitat (H1210 Annual vegetation of drift lines), and although for the Solent Maritime SAC it is not a primary reason for selection of the site, it is present as a qualifying feature.

There are only small, discrete areas of vegetated sand dunes in the area, and these include areas at Hayling Island (0.53km^2) and St Helen's Duver (0.11 km^2), near to the entrance of Bembridge Harbour on the Isle of Wight. The dunes at Hayling Island, along with other habitats, meet the criteria for the Chichester and Langstone Harbour Ramsar. The Duver, St Helen's dunes are comprised of stable dune grassland and scrub[42].

4.2.3 Saltmarsh

Saltmarshes in the area are dominated by the common cord-grass *Spartina anglica*, supported on sediments mostly ranging from sandy to clayey silts. Extensive areas are in Chichester Harbour and the western shore of Southampton Water and all key extents of this habitat are listed as meeting the relevant Ramsar Convention Criteria and are part of the Solent Maritime SAC.

4.2.4 Coastal lagoons

There are two coastal lagoons of interest in the area, these lie within The Solent and Isle of Wight Lagoons SAC. Gilkicker lagoon is a sluiced type, and the Bembridge Harbour Lagoon is a natural percolation form. As well as providing habitats for lagoonal specialists they are also important for supporting wading birds and wildfowl[43]. Gilkicker Lagoon was originally an extensive drainage fleet, now persists as 2 interconnected basins. and was notified as a Site of Special Scientific Interest in 1984. The lagoon is a high-salinity system (15-42 ppt salinity) supporting a diverse community, including lagoonal specialists (e.g., *Gammarus insensibilis, Nematostella vectensis; Corophium insidiosum; Cerastoderma glaucum; Ventrosia ventrosa*) and beds of *Ruppia* sp. and floating mats of *Chaetomorpha linum* and *Zostera* turf. Bembridge Harbour Lagoon is a brackish lagoon (26 ppt salinity) where the sea anemone *N. vectensis* is recorded as abundant[44].

4.2.5 Benthic

The intertidal areas within The Solent are predominantly comprised of widespread littoral sediments occurring as mixed sediments on the shores, finer mud and sand in the sheltered harbour and estuarine

[40] AQUIND Ltd, 2019a. Environmental Statement – Volume 1 – Chapter 8 Intertidal and Benthic Habitats PINS Ref: EN020022. Document Ref: 6.1.8. Accessed August 2021. Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN020022/EN020022-000576-6.1.8%20ES%20-%20Vol%201%20-%20Chapter%208%20Intertidal%20and%20Benthic%20Habitats.pdf.
[41] Randall, 1996. Chapter 3.3 Vegetated shingle structure and shorelines. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 45-47. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series)
[42] Dargie TCD (1996) Chapter 3.2 Sand dunes. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 41-43. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series)
[43] Bamber RN, and Robbins RS, 2010. Condition Monitoring of Portsmouth Area Coastal Saline Lagoons, 2010. ARTOO Marine Biology Consultants. Consultancy Report to Natural England. Repot No. R2/10/319.3. 27pp. Available at: https://www.dassh.ac.uk/dataDelivery/filestore/1/9/1_978e2ddc7e35fbf/191_bfe4a2b92c76974.pdf
[44] Sheader M, Suwailem AM, and Rowe GA (1997) The anemone, Nematostella vectensis, in Britain: Considerations for Conservation Management. Aquatic Conservation: Marine and Freshwater Ecosystems, 7: 13-25.

areas, and with littoral rock overall limited; for example, with limestone outcrops at eastern end of the Isle of Wight[45]. Much of the shingle and sandy matrices can be expected to be barren or represent mobile sandy shores[46]. The intertidal sedimentary communities can overall be split into five main community types:

- Crustacean-polychaete;
- Sand mason worm *Lanice conchilega*;
- Lugworm *Arenicola marina*;
- Carpet shell *Venerupis pullastra*;
- Furrow shell *Scrobicularia plana*[45]

Invasive non-native species (INSS) are likely to be present in the area due to the busy ports at Southampton and Portsmouth. INNS have been recorded in the intertidal areas at Eastney. These have included:

- Slipper limpet *Crepidula fornicata*;
- Leathery sea squirt *Styela clava*;
- American sting winkle *Urosalpinx cinerea*;
- Japanese wireweed *Sargassum muticum*[46].

The subtidal environmental of The Solent channel is a high energy/high turbidity regime, with limited hard substrate. It comprises extensive subtidal seabed habitats of mixed sediments, larger areas of sand further offshore, and with sediments in the 3 harbours comprising similar benthic habitats of mud and sandy mud of these more sheltered areas[45]. The mosaic of habitats and biotopes in the eastern Solent, as shown in **Figure 4.5**, is expected to reflect the distribution of sediments of the area (as shown in **Figure 4.3**). Both LSO sites are located within areas of mixed fine sediments:

- A5.25 Circlittoral fine sand;
- A5.26 Circalittoral muddy sand;
- A5.35 Circalittoral sandy mud.

The [redacted] LSO is flanked from the north and south by shallow circalittoral gravelly muddy sand, in the shallow bathymetries in these areas (**Figure 4.2, Figure 4.3; Figure 4.5**). The [redacted] LSO, situated further from shore, and to the east, is adjacent to higher energy infralittoral and circalittoral coarse sediment (A5.13 and A5.14, respectively), and high energy infralittoral seabed of slightly gravelly sand and sandy gravel. (**Figure 4.3; Figure 4.5**).

Burrowing infaunal species such as bivalve clams *Mercenaria mercenaria* and cockles *Cerastoderma edule* often characterise the sediments in The Solent, and the INNS slipper limpet *Crepidula fornicata* is common across the area where it may compete with the native oyster *Ostrea edulis*[47] (commercial shellfish species are summarised in Section 4.2.6). Recent subtidal site-specific benthic surveys (2017-2018) reported that the nearshore sandy sediments off Eastney, featured a range of faunal groups including polychaetes, amphipods, bivalves, tunicates, sea anemones and crabs[46]. Overall, the subtidal communities are characterised by polychaetes of low density and richness and a low diversity of algal and epifaunal communities, however, diversity has been shown to increase with increasing substratum size and stability, with growths of hydroids and bryozoans[45].

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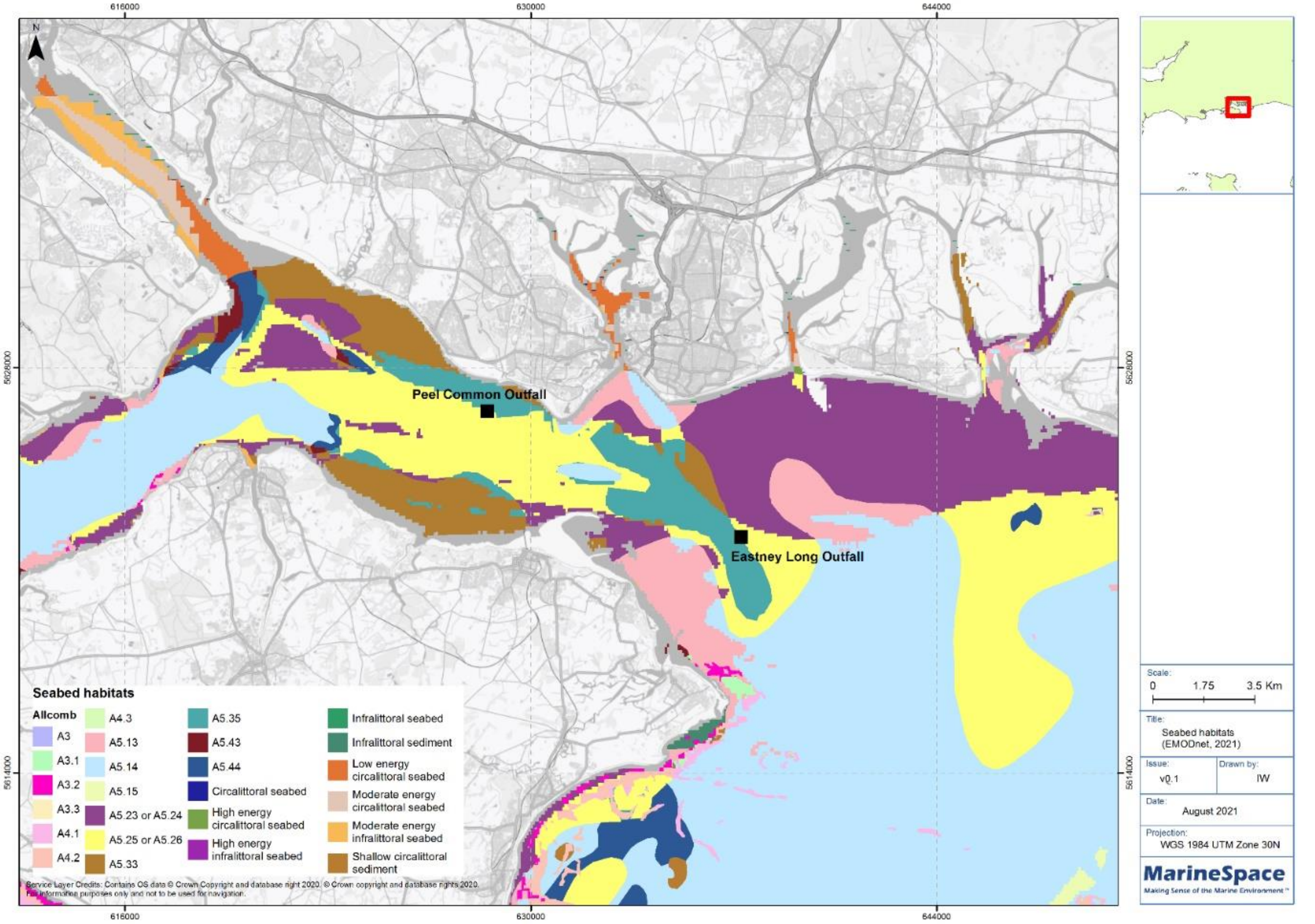
[45] Irving RA (1996) Chapter 4.2 The sea bed. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 65-73. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)
[46] AQUIND Ltd, 2019a. Environmental Statement – Volume 1 – Chapter 8 Intertidal and Benthic Habitats PINS Ref: EN020022. Document Ref: 6.1.8. Accessed August 2021. Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN020022/EN020022-000576-6.1.8%20ES%20-%20Vol%201%20-%20Chapter%208%20Intertidal%20and%20Benthic%20Habitats.pdf.
[47] Preston J, Fabra M, Helmer L, Johnson, Harris-Scott E, and Hendy I (2020) Interactions of larval dynamics and substrate preference have ecological significance for benthic biodiversity and Ostrea edulis Linneaus, 1758 in the presence of Crepidula fornicata. Aquatic Conservation. 30(11): 2133-2149.

Intertidal seagrass beds comprising features such *Zostera* spp. beds on muddy sand are recorded in various locations in the area, notably within the harbour areas, and subtidal beds are also reported across areas such as the northern Isle of Wight[48]. Within the Solent Maritime SAC, intertidal seagrass is considered to be in unfavourable condition due to continued decreases in extent and distribution when compared to historic figures, however, it has been suggested that recovery may be occurring in some areas. Subtidal seagrass beds are a sub-feature of the Annex I sandbanks in the SAC and are assessed as also being in unfavourable condition. This is due to historical comparisons in extent and distribution, along with structure, and due to nutrient enrichment, abrasion and disturbance, and contamination from transition elements and metals[49].

[48] Irving RA (1996) Chapter 4.2 The sea bed. In: Coasts and seas of the United Kingdom. Region 9 Southern England: Hayling Island to Lyme Regis, ed. by J.H. Barne, C.F. Robson, S.S. Kaznowska, J.P. Doody & N.C. Davidson, 65-73. Peterborough, Joint Nature Conservation Committee. (Coastal Directories Series.)

[49] NE (Natural England (2018). Natural England Condition Assessment. Solent Maritime Special Area of Conservation (SAC). June 2018. 38pp. http://www.solentems.org.uk/sems/Condition_assessments/Natural_England_Condition%20Assessment_Summary_Report_for_Solent_Maritime_SAC.PDF.

Figure 4.5 Predictive broadscale biotope map of the Eastern Solent showing the LSOs (EMODnet, 2021)



4.2.6 Fish and shellfish

The Environment Agency reports Annual TraC (Transitional and Coastal) fish counts data. The sample locations nearest to the two LSO locations are in Southampton Water, the River Hamble, and the River Itchen and species composition of catches at these stations as are follows:

- Gobies *Pomatoschistus* spp.;
- European Bass *Dicentrarchus labrax*;
- Dover Sole *Solea solea*;
- Dab *Limanda limanda*;
- Plaice *Pleuronectes platessa*;
- Flounder *Platichthys flesus*;
- Atlantic Salmon *Salmo salar*;
- Sea trout[50] *Salmo trutta trutta*;
- Mullet *Mugilidae*;
- Atlantic Cod *Gadus morhua*;
- Pout/Bib *Trisopterus luscus*;
- Poor Cod *Trisopterus minutus*;
- Whiting *Merlangius merlangus*;
- Sprat *Sprattus sprattus*;
- Atlantic herring *Clupea harengus*;
- Sandeel *Ammodytes* spp.;
- Sandsmelt *Atherina presbyer*;
- Pipefish *Syngnathus* spp;
- European Eel *Anguilla anguilla*.

Data collected in the last five years (2016-2020) reported a range of species with the highest abundances for sand smelt, sprat, herring, gobies and mullet (>1000 count per species, per single catch sample), and with these counts predominantly from shallow water, seine net sampling[51].

Fish spawning and nursery grounds in The Solent are difficult to determine. Ellis (2011)[52] reported on the spawning and nursery grounds in UK waters, but this had been based on data collected generally from deep waters (i.e. >20 m depth), with little information from nearshore coastal, estuarine and transitional waters. However, some assertions have been made, and it is believed that Tope *Galaeorhinus galeus* use The Solent as nursery grounds, as juveniles had been caught by recreational fisherman locally. The area is also considered to be important for the undulate ray *Raja undulata*. Fisheries surveys, targeting bass in The Solent, Southampton Water, Langstone and Chichester Harbours have been undertaken since 1981, as these sites are important nursery areas for bass on the south coast[53].

4.2.7 Commercial fisheries

The eastern Solent lies within the International Council for the Exploration of the Sea (ICES) rectangle 30E8, and partially 30E9; both are within ICES division Viid 'Eastern English Channel'. Broad scale landings data for Viid show catches are approximately 50% shellfish and 25% demersal and 25%

[50] The common name for the anadromous (sea-run) form of brown trout.
[51] Environment Agency, 2021. The National Fish Population Database (NFPD): TraC Fish Counts for all Estuaries and All Years. Accessed May 2021. Available online at: https://data.gov.uk/dataset/41308817-191b-459d-aa39-788f74c76623/trac-fish-counts-for-all-species-for-all-estuaries-and-all-years
[52] Ellis JR, Milligan SP, Readdy L, Taylor M, and Brown MJ, 2011. Spawning and nursery grounds of selected fish species in UK Waters. Sci. Ser. Tech. Rep. Cefas Lowestoft, 147: 56 pp. https://www.cefas.co.uk/publications/techrep/techrep147.pdf.
[53] Pickett GD, Brown M, Harley B, and Dunn MR 2002. Surveying Fish Population in the Solent and Adjacent Harbours using the Cefas Bass Trawl. Sci. Ser. Tech Rep., Cefas Lowestoft, 118:16pp

pelagic fish species[54]. Site specific information for the ICES rectangles themselves[55] indicate that the small inshore vessels are targeting a variety of commercial species, including:

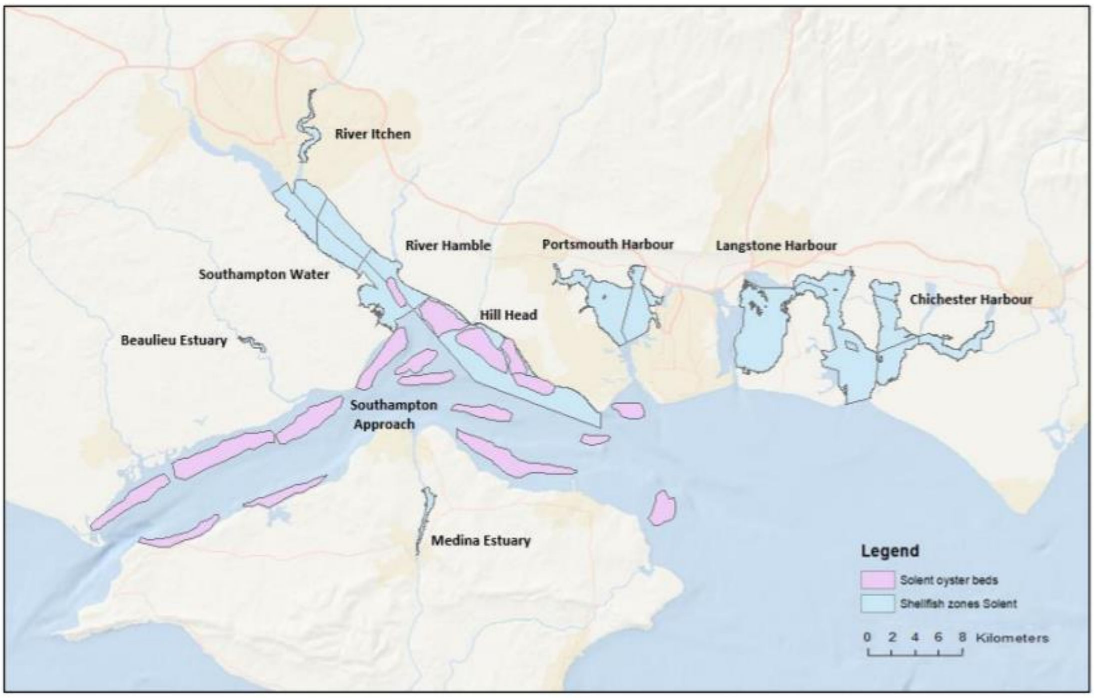
- Edible whelk *Buccinum undatum*;
- European Lobster *Homarus gammarus*;
- Edible crab *Cancer pagurus*;
- Scallops Pectinidae;
- Clams Veneridae;
- Oysters *Ostrea edulis*;
- Cuttlefish Sepiidae;
- Sole Soleidae;
- Plaice *Pleuronectes platessa*;
- European Bass *Dicentrarchus labrax.*

Shellfishery is the main fishing industry in The Solent. Traditionally, the native oyster *O. edulis* is the most important, but other priority species including the common cockle *C. edule*; hard-shell clam *M. mercenaria* and Manila clam *Ruditapes phillippinarum* are also harvested. **Figure 4.6** presents the location of designated commercial shellfish beds and zones in the harbours, estuaries and open waters of The Solent.

A recent stock assessment for *O. edulis*, reported the highest catches across all of The Solent and its associated harbours and estuaries were recorded off the east of the Isle of Wight, notably at the historic bed at Ryde Middle. The highest catch per unit effort (CPUE) was found to be 5.18 kg/m/h for >70mm individuals. With the exception of Langstone Harbour, all areas have experienced a decrease in CPUE, with none exceeding 15 kg/m/h; a figure used by Southern Inshore Fisheries and Conservation Authority (IFCA) to indicate some level of commercial fishing may be possible[56].

[54] Marine Management Organisation (MMO), 2018. UK Sea Fisheries Statistics. Accessed August 2021. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/920110/UK_sea_fisheries_statistics_2018_002.pdf.
[55] AQUIND Ltd (2019) PIER Chapter 12 Commercial Fisheries. Accessed August 2021. PINS Ref.: EN020022. Available online at: https://aquindconsultation.co.uk/wp-content/uploads/sites/13/2019/02/AQUIND-PEIR-Ch_12_Commercial_Fisheries.pdf
[56] Southern IFCA, 2019. Solent Oyster Stock Survey Summer 2019. 23pp.

Figure 4.6 Location of commercial shellfish beds and designated shellfish zones in The Solent[57]



4.2.8 Birds

The abundant and diverse benthic invertebrate and fish communities in the region provide an important food source for other species, notably birds. The Solent supports an overwintering population of around 150,000 birds, and data suggest that there are local shifts in location of these populations between areas within The Solent[58].

The area is important for supporting national and international important numbers of migratory and over-wintering waders and wildfowl, as well as important breeding gull and tern populations[59]. Large areas of The Solent are designated as Special Protected Areas (SPAs) and Ramsar sites due to their role supporting important bird assemblages. Section 5 details the list of qualifying bird species for each designated site.

The recently designated Solent and Dorset Coast SPA encompasses all of The Solent and parts of east Dorset and is designated to protect internationally important populations three tern species. The population (number of breeding pairs) for the little tern *Stenula albifrons*, Sandwich tern *Thalasseus sandvicensis* and common tern *Sterna hirundo* are 63, 441, and 492 respectively. It was observed from boat-based surveys that tern records peak in May[60].

[57] Watson SCL, Watson GL, Mellan J, Sykes T, Lines C, and Preston J (2020) Valuing the Solent Marine Sites Habitats and Species: A Natural Capita Study of Benthic Ecosystem Services and how they Contribute to Water Quality Regulations. Environment Agency R&D Technical Report No. ENV6003066R.
[58] Stillman R, Cox J, Liley D, Ravenscroft N, Sharp J, and Wells M, 2009. Solent disturbance and mitigation project: Phase 1 report, Report to the Solent Forum. 103 pp.
[59] SEMS (Solent Marine Sites), 2021. Solent Marine Sites, Solent Forum. Accessed August 2021. Available online at: http://www.solentems.org.uk/sems.
[60] AQUIND Ltd (2019) Environmental Statement – Volume 1 – Chapter 11 Marine Ornithology. PINS Ref: EN020022. Document Ref: 6.1.11. Accessed August 2021. Available online at: https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN020022/EN020022-000579-6.1.11%20ES%20-%20Vol%201%20-%20Chapter%2011%20Marine%20Ornithology.pdf.

5 European Designated Sites, Scope of Assessment and Supporting Information

5.1 Scope of the Assessment

The Gate 1 Stage 1 Screening identified LSEs with regards a number of European designated sites. This assessment is concerned with the adverse effects that could arise to the marine and intertidal qualifying features with a pathway for impact from the [redacted] LSO (being used for the discharge from the WRP) and [redacted] LSO (from which a portion of discharge will be diverted), locations, the closest distances are detailed in **Table 5.1**. The Gate 1 Stage 1 Screening has therefore been updated for these sites, based on the latest conceptual design information for Gate 2. This is provided in **Table 5.2**.

The overarching Gate 2 HRA will be assessing the implications of the construction works required for the WRP, pipeline connections, the environmental buffers and works required at Otterbourne WSW.

Table 5.1 International designated sites in the eastern Solent with distance from LSOs

Designation			Distance From	
Type	**Code**	**Name**	**[redacted] LSO**	**[redacted] LSO**
SPA	[redacted]	Solent and Dorset Coast	0 km	0km
SAC		Solent and Isle of Wight Lagoons	2.7 km	4.4 km
SPA		Solent and Southampton Water	4.4 Km	3.8 Km
Ramsar		Solent and Southampton Water	4.4Km	3.8 Km
SAC		Solent Maritime	5.0 km	4.7 km
SPA		Portsmouth Harbour	2.5 Km	7.5 Km
Ramsar		Portsmouth Harbour	2.5 km	7.5 km
SAC		South Wight Maritime SAC	10.4 km	2.9 km
SPA		Chichester and Langstone Harbours	9.6 km	6.0 km
Ramsar		Chichester and Langstone Harbours	9.6 Km	6.0 Km

Table 5.2 Qualifying features to be considered in this assessment

Designated site	Qualifying feature	Considered in this assessment?	Justification
River Itchen SAC	**Annex II species present as a qualifying feature, but not a primary reason for site selection:** 1106 Atlantic salmon *Salmo salar*	x	At Gate 1 there was uncertainty as to whether the [redacted] LSO would be used to discharge the RO waste-stream, and therefore a potential change in water quality parameters at the entrance to Southampton Water which is part of the migration route to the River Itchen and compensatory habitats (Rivers Test and Meon). However, the design has evolved for Gate 2, and only the [redacted] LSO will be used for the discharge of the waste-stream. Although a small amount of Total Nitrogen (TN) will be transferred from the water recycling plant to Otterbourne WSW with the treated water, the drinking water treatment process will remove the majority of TN, with any residual amount removed in the waste-stream and not going to the River Itchen SAC. The reject water from the water recycling process will be positively buoyant and will mix through the water column as it rises towards the surface. Salinity and TN were modelled for the discharge from the [redacted] LSO and under the 15Ml/d there is little difference with current baseline conditions. There is a slight improvement in TN distribution if the 75Ml/d and [redacted] waste stream is used. Similarly, there is little difference in salinity as a result of the 15Ml/d business as usual flow, whilst a reduced effect is noted on salinity as a result of a smaller difference from the ambient. As such, impacts to salmon populations are considered to be low risk.
River Meon SAC compensatory habitat	1106 Atlantic salmon *Salmo salar*	x	
Solent and Isle of Wight Lagoons SAC	1150 Coastal lagoons	x	Farlington Marshes is part of the Solent and Isle of Wight Lagoons SAC and comprises the Shut Lake waterbody. Almost all drainage from the marshes exits via the sluice at the south of Shut Lake. However, the sluice leaks and lets saline water from Langstone Harbour into the lake, the bank itself also allows a throughflow of saline water and receives saline water during spring tides. Gilkicker Lagoon is located to the east of Stokes Bay into which the [redacted] LSO discharges. At Gate 1, there was uncertainty as to whether the [redacted] LSO would be used to discharge the RO waste-stream, however the design has evolved for Gate 2, and only the [redacted] LSO will be used for the discharge of the waste-stream. Although there is a theoretical pathway for exchange of the waste-stream from [redacted] LSO with both saline lagoons, any interaction is considered to be minimal due to the distance between the sites and outfall location, the mixing and dispersive environment into which [redacted] LSO discharges, and the sea walls and sluice systems which operate to maintain the lagoon habitats. Pollution based risks from work at the WRP site will need to be considered because of the closer proximity, however this is covered in the overarching Gate 2 HRA.
Solent Maritime SAC	1130 Estuaries	✓	Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location and discharging via the [redacted] LSO, could give rise to adverse effects.
	1320 Spartina swards (*Spartinion maritimae*)	✓	Smooth cordgrass occurs only at Bury Marsh, Marchwood and Townsend's cordgrass is present at Hythe Marsh in Southampton Water. Small cordgrass has a restricted range, being present in Newtown Harbour (IoW) and at Northney Marsh to the north east of Hayling Island. Common cordgrass is present throughout the site, and therefore likely to be located within Langstone Harbour on the north east coastlines of Farlington Marshes, North Binness Island, Long Island and at West Hayling Nature Reserve. Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location and discharging via the [redacted] LSO, could give rise to adverse effects.
	1330 Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	✓	Atlantic salt meadows are mapped as present on the north east coastlines of Farlington Marshes, North Binness Island, Long Island and at West Hayling Nature Reserve. Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location and discharging via the [redacted] LSO, could give rise to adverse effects.
	1110 Sandbanks which are slightly covered by sea water all the time	✓	There are large areas of sandbank at the mouth of Langstone Harbour around East Winner. The current dispersion plume for the [redacted] LSO does not cover the area, however modelling of the new dispersion plume under the various modes of operation has been undertaken for the Gate 2 submission, as required to

Designated site	Qualifying feature	Considered in this assessment?	Justification
			determine the area subject to a change in concentration and how this may affect processes supporting the qualifying feature. The qualifying feature SACO has an attribute/target relating to the maintenance of physico-chemical properties that influence the feature, namely salinity, pH and temperature.
	1140 Mudflats and sandflats not covered by seawater at low tide	✓	Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location and discharging via the [redacted] and existing infrastructure, could give rise to adverse effects.
	1150 Coastal lagoons	x	The qualifying lagoons are located on the Isle of Wight (Newtown Quay Lagoon and Yar Bridge Lagoon) and therefore will not be affected.
	1210 Annual vegetation of drift lines	x	Habitat mapping identifies areas of coastal vegetated shingle along the shoreline at the mouth of Langstone Harbour. This is unlikely to be affected by changes in the concentration of the waste-stream (under all three proposed modes of operation) as the LSO discharges approximately 5km offshore into the East Solent, and information available on the existing dispersion plume does not show any interaction with these habitats.
	1220 Perennial vegetation of stony banks	x	
	1310 *Salicornia* and other annuals colonizing mud and sand	✓	Pioneer saltmarsh has been recorded in Langstone Harbour. Although not specifically mapped in the priority habitat mapping, the areas identified as saltmarsh on the north east coastlines of Farlington Marshes, North Binness Island, Long Island and at West Hayling Nature Reserve, will contain this feature. Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location and discharging via the [redacted] LSO, could give rise to adverse effects.
	2120 "Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")"	x	Areas of sand dune habitat are located at East Head and Pilsey Island in Chichester Harbour and at Norton Spit to the west of the Yar Estuary on the Isle of Wight. Although there is a theoretical pathway for impact (water exchange with the Solent), given the distance and mixing within the Solent it is considered any impacts of the discharge plume would be imperceptible.
	1016 Desmoulin`s whorl snail *Vertigo moulinsiana*	x	The feature is only present in Chichester Harbour which will not be affected (no pathway for impact).
South Wight Maritime SAC	1170 Reefs 1230 Vegetated sea cliffs of the Atlantic and Baltic Coasts 8330 Submerged or partially submerged sea caves	x	The [redacted] LSO was constructed in 2000, prior to the designation of the SAC (although it was proposed as a candidate site in 1998). The [redacted] LSO is within 3km of the South Wight Maritime SAC which extends offshore from Bembridge Point. The eastern boundary of the SAC is in close proximity to the outer extent of the dispersion plume which remains detectable (1-2% modelled discharge). The priority habitat mapping for marine SAC features however records the reef features being a further 2.5km inshore, and approximately 3.5km from the concentrated area of the waste-stream (above 50%). As such any changes in concentration of the discharge are likely be localised to the area immediately around the outfall and will not increase within the locality of the SAC.
Chichester and Langstone Harbours	**Article 4.1 During the breeding season:** Little Tern *Sternula albifrons*, 100 pairs representing up to 4.2% of the breeding population in Great Britain (5 year mean, 1992-1996) Common tern *Sterna hirundo* 85 breeding pairs of common tern (five year mean 1982-1986) Sandwich Tern *Thalasseus sandvicensis*, 158 pairs representing up to 1.1% of the breeding population in Great Britain (1998) **Article 4.2, Over winter:** Bar-tailed Godwit *Limosa lapponica*, 1,692 individuals representing up to 3.2% of the wintering population in Great Britain (5 year peak mean 1991/2 - 1995/6) Curlew *Numenius arquata* 2,937 individuals five year peak mean 1982/83-1986/87), representing more than 1% of the British population during the wintering period Dark-bellied Brent Goose *Branta bernicla bernicla*, 17,119 individuals representing up to 5.7% of the wintering Western Siberia/Western Europe population (5 year peak mean 1991/2 - 1995/6) Dunlin *Calidris alpina alpina*, 44,294 individuals representing up to 3.2% of the wintering Northern Siberia/Europe/Western Africa population (5 year peak mean 1991/2 - 1995/6) Grey Plover *Pluvialis squatarola*, 3,825 individuals representing up to 2.5% of the wintering Eastern Atlantic - wintering population (5 year peak mean 1991/2 - 1995/6) Pintail *Anas acuta* Average overwintering numbers have fluctuated from the pre-classification 323 individuals (five year peak mean 1982/83-1986/87) Red-breasted merganser *Mergus serrator* Average numbers of red-breasted merganser were at 206 individuals (five year peak mean 1982/83-1986/87) Redshank *Tringa totanus*, 1,788 individuals representing up to 1.2% of the wintering Eastern Atlantic - wintering population (5 year peak mean 1991/2 - 1995/6)	✓ **(all)**	Construction works are required directly adjacent to Langstone Harbour or watercourses discharging into the harbour (Brockhampton Stream, Hermitage Stream). Although trenchless technologies will be used for the watercourse crossings, launch and receptor pits will be required, and therefore there is a pathway for impact. The current site of the WRP has not been confirmed, with only one of the preferred sites emerging from the site selection work not being included in the Solent Wader and Brent Goose Strategy. The marine SPA supporting habitats maps the sandbanks which extend offshore from the mouth of Langstone Harbour close to East Winner and offshore at Chichester Harbour. Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location and discharging via the [redacted] LSO, could give rise to adverse effects indirectly to the prey and foraging areas used by the species.

Designated site	Qualifying feature	Considered in this assessment?	Justification
	Ringed Plover *Charadrius hiaticula*, 846 individuals representing up to 1.7% of the wintering Europe/Northern Africa - wintering population (5 year peak mean 1991/2 - 1995/6) Sanderling *Calidris alba*, in the five years before classification, numbers of sanderling averaged at 407 overwintering birds (five year peak mean 1982/83-1986/87) Shelduck *Tadorna tadorna*, five year peak mean of 4,287 overwintering birds (1982/83 - 1986/87), 4% of the West European population Shoveler, *Spatula clypeata*, 2,803 individuals, five year peak mean 1982/83-1986/87 Teal *Anas crecca*, five year peak mean of 2,553 overwintering birds (1982/83 - 1986/87 Turnstone *Arenaria interpres*, 564 individuals, five year peak mean 1982/83-1986/87 Wigeon *Mareca penelope*, 2,803 individuals, five year peak mean 1982/83-1986/87 **Over winter, the area regularly supports 93,142 individual waterfowl (5 year peak mean 1991/2 - 1995/6) including**: Wigeon *Anas penelope*, Bar-tailed Godwit *Limosa lapponica*, Dark-bellied Brent Goose *Branta bernicla bernicla*, Ringed Plover *Charadrius hiaticula*, Grey Plover *Pluvialis squatarola*, Dunlin *Calidris alpina alpina*, Black-tailed Godwit *Limosa limosa islandica*, Redshank *Tringa totanus*, Little Grebe *Tachybaptus ruficollis*, Little Egret *Egretta garzetta*, Shelduck *Tadorna tadorna*, Curlew *Numenius arquata*, Teal *Anas crecca*, Pintail *Anas acuta*, Shoveler *Anas clypeata*, Red-breasted Merganser *Mergus serrator*, Oystercatcher *Haematopus ostralegus*, Lapwing *Vanellus vanellus*, Knot *Calidris canutus*, Sanderling *Calidris alba*, Cormorant *Phalacrocorax carbo*, Whimbrel *Numenius phaeopus*.		
Portsmouth Harbour SPA	**Article 4.2** **Over winter;** Dark-bellied Brent Goose *Branta bernicla bernicla*, 2,847 individuals representing at least 0.9% of the wintering Western Siberia/Western Europe population (5-year peak mean 1991/2 - 1995/6) Red-breasted merganser *Mergus serrator* 100 individuals, representing 1% of the British population Black-tailed godwit *Limosa limosa* 70 individuals, representing over 1% of British population Dunlin *Calidris alpina* 8,010 individuals, representing over 1% of British population.	✓ **(all)**	At Gate 1 there was uncertainty as to whether the [redacted] LSO would be used to discharge the RO waste-stream for the B5 75Ml/d configuration only). The Nitrate Vulnerable Zone information for Portsmouth Harbour suggests that the [redacted] LSO is responsible for c.2% of the nitrogen loading in the harbour, therefore some exchange of water must occur. As such, further assessment was identified as being required to assess the implications of any water quality changes. As the [redacted] LSO is no longer part of the solution configuration (due to capacity issues and lower mixing environment than [redacted] this site can be screened out. The use of the [redacted] LSO for the discharge is c. 7km south east of the entrance to Portsmouth Harbour. Interaction of the discharge plume with the intertidal habitats is considered to be unlikely, however offshore feeding by red-breasted merganser could be impacted by changes in water quality parameters. The wider issue of nutrient neutrality will also need to be assessed.
Solent and Southampton Water SPA	**Article 4.1**: During the breeding season: Common Tern *Sterna hirundo*, 267 pairs representing at least 2.2% of the breeding population in GB; Little Tern *Sternula albifrons*, 49 pairs representing at least 2.0% of the breeding population in GB; Mediterranean Gull *Ichthyaetus melanocephalus*, 2 pairs representing at least 20.0% of the breeding population in GB; Roseate Tern *Sterna dougallii*, 2 pairs representing at least 3.3% of the breeding population in GB; Sandwich Tern *Thalasseus sandvicensis*, 231 pairs representing at least 1.7% of the breeding population in GB.	✓ **(all)**	The little tern, common tern and sandwich tern populations are known to nest in Langstone and Chichester Harbours. Potential adverse effects to these species due to construction and disturbance of nesting tern, and the impacts of changes in water quality due to the RO waste-stream affecting prey and the offshore feeding areas, will be assessed for these sites, where the direct pathway for impact occurs. The remaining key locations for the Solent and Southampton Water populations are considered to be at sufficient distance from the construction of the WRP such that no LSEs are considered likely. The use of the [redacted] LSO for the discharge is c. 3.5km east of the area of the Solent and Southampton Water SPA at Ryde on the Isle of Wight. Interaction of the discharge plume with the subtidal habitats is not predicted in the modelling undertaken to date. However offshore feeding by little, common and sandwich tern, plus Mediterranean gull and red-breasted merganser will need to be considered. The wider issue of nutrient neutrality will also need to be assessed.
	Article 4.2: Over winter: Black-tailed Godwit *Limosa limosa islandica*, 1,125 individuals representing at least 1.6% of the wintering Iceland - breeding population; Dark-bellied Brent Goose *Branta bernicla bernicla*, 7,506 individuals representing at least 2.5% of the wintering Western Siberia/Western Europe population; Ringed plover *Charadrius hiaticula*, 552 individuals representing at least 1.1% of the wintering Europe/Northern Africa - wintering population; Teal *Anas crecca*, 4,400 individuals representing at least 1.1% of the wintering Northwestern Europe population.	✓ **(all)**	
	Assemblage qualification: A wetland of international importance. Over winter, the area regularly supports 53,948 individual waterfowl including: Gadwall *Anas Strepera*, Teal *Anas crecca*, Ringed plover *Charadrius hiaticula*, Black-tailed Godwit *Limosa islandica*, Little Grebe *Tachybaptus ruficollis*, Great Crested Grebe *Podiceps cristatus*, Cormorant *Phalacrocorax carbo*, Dark-bellied Brent Goose *Branta bernicla*, Wigeon *Anas penelope*, Redshank *Tringa tetanus*, Pintail *Anas acuta*, Shoveler *Anas clypeata*, Red-breasted Merganser *Mergus serrator*, Grey Plover *Pluvialis squatarola*, Lapwing *Vanellus vanellus*, Dunlin *Calidris alpina alpine*, Curlew *Numenius arquata*, Shelduck *Tadorna*.	✓ **(all)**	

Designated site	Qualifying feature	Considered in this assessment?	Justification
Solent and Dorset Coast SPA	A191 *Thalasseus sandvicensis*; Sandwich tern (Breeding) A193 *Sterna hirundo*; Common tern (Breeding) A195 *Sternula albifrons*; Little tern (Breeding)	✓ **(all)**	The departmental brief for the site lists the key breeding sites for the tern species, and range of distances over which the terns typically feed (based on survey data) with zones identified where the concentration of feeding is higher, and therefore habitats of more importance. Langstone and Chichester Harbours are important sites for the breeding colonies. Construction works are required directly adjacent to Langstone Harbour or watercourses discharging into the harbour (Brockhampton Stream, Hermitage Stream) and the current site of the WRP has not been confirmed, however is in proximity to Langstone Harbour. Disturbance issues (noise, visual, lighting) will need to be considered due to the proximity of known nesting colonies. The marine SPA supporting habitats maps the sandbanks which extend offshore from the mouth of Langstone Harbour close to East Winner and offshore at Chichester Harbour. Work on the nutrient neutrality issue in the Solent and designated harbours has identified a pathway for impact between the [redacted] LSO and Langstone Harbour due to transfer of waters. Therefore, consideration needs to be given as to whether the change in water quality parameters as a result of introducing a water recycling process at this location, and discharging via the [redacted] and existing infrastructure, could give rise to adverse effects indirectly to the prey and foraging areas used by the species.
Chichester and Langstone Harbour Ramsar	**Ramsar criterion 1** Two large estuarine basins linked by the channel which divides Hayling Island from the main Hampshire coastline. The site includes intertidal mudflats, saltmarsh, sand and shingle spits and sand dunes. **Ramsar criterion 5** Assemblages of international importance: Species with peak counts in winter: 76480 waterfowl (5 year peak mean 1998/99-2002/2003). **Ramsar criterion 6 Assemblages of international importance:** **Qualifying Species/populations (as identified at designation):** **Species with peak counts in spring/autumn:** Ringed plover, *Charadrius hiaticula* Europe/Northwest Africa 853 individuals, representing an average of 1.1% of the population (5 year peak mean 1998/9-2002/3) Black-tailed godwit, *Limosa limosa islandica*, Iceland/W Europe 906 individuals, representing an average of 2.5% of the population (5 year peak mean 1998/9-2002/3) Common redshank, *Tringa totanus totanus*, 2577 individuals, representing an average of 1% of the population (5 year peak mean 1998/9-2002/3) **Species with peak counts in winter:** Dark-bellied brent goose, *Branta bernicla bernicla*, 12987 individuals, representing an average of 6% of the population (5 year peak mean 1998/9-2002/3) Common shelduck *Tadorna tadorna*, NW Europe 1468 individuals, representing an average of 1.8% of the GB population (5 year peak mean 1998/9-2002/3) Grey plover *Pluvialis squatarola*, E Atlantic/W Africa -wintering 3043 individuals, representing an average of 1.2% of the population (5 year peak mean 1998/9-2002/3) Dunlin *Calidris alpina alpina* W Siberia/W Europe 33436 individuals, representing an average of 2.5% of the population (5 year peak mean 1998/9-2002/3) **Species/populations identified after designation for possible future consideration under criterion 6.** Species regularly supported during the breeding season: Little tern, *Sternula albifrons*, W Europe 130 apparently occupied nests, representing an average of 1.1% of the breeding population (Seabird 2000 Census)	✓ **(all)**	As for the Solent Maritime SAC (habitats) and Chichester and Langstone Harbour SPA (birds). Black-tailed godwit is the only species not included in the Chichester and Langstone Harbour SPA and will therefore be considered as part of the Ramsar.
Portsmouth Harbour Ramsar	**Ramsar criterion 3** The intertidal mudflat areas possess extensive beds of eelgrass *Zostera angustifolia* and *Zostera noltei* which support the grazing dark-bellied brent geese populations. The mud-snail *Hydrobia ulvae* is found at extremely high densities, which helps to support the wading bird interest of the site. Common cord-grass *Spartina anglica* dominates large areas of the saltmarsh and there are also extensive areas of green algae *Enteromorpha* spp. and sea lettuce *Ulva lactuca*. More locally the saltmarsh is dominated by sea purslane *Halimione portulacoides* which gradates to more varied communities at the higher shore levels. The site also includes a number of saline lagoons hosting nationally important species.	✓ **(all)**	At Gate 1 there was uncertainty as to whether the [redacted] LSO would be used to discharge the RO waste-stream for the B5 75Ml/d configuration only). The Nitrate Vulnerable Zone information for Portsmouth Harbour suggests that the [redacted] LSO is responsible for c.2% of the nitrogen loading in the harbour, therefore some exchange of water must occur. As such, further assessment was identified as being required to assess the implications of any water quality changes. The [redacted] LSO is no longer part of the solution configuration (due to capacity issues and lower mixing environment than [redacted]). The use of the [redacted] LSO for the discharge is c. 7km south east of the entrance to Portsmouth Harbour. Interaction of the discharge plume with the intertidal habitats is considered to be unlikely, however offshore feeding by red-breasted merganser could be impacted by changes in water quality parameters. The wider issue of nutrient neutrality will also need to be assessed.

Designated site	Qualifying feature	Considered in this assessment?	Justification
	Ramsar criterion 6 – species/populations occurring at levels of international importance. Qualifying Species/populations (as identified at designation): Species with peak counts in winter: Dark-bellied brent goose, *Branta bernicla bernicla*, 2105 individuals, representing an average of 2.1% of the GB population (5 year peak mean 1998/9-2002/3) The area also supports nationally important numbers of the following species (figures given are average peak counts for the five year winter period between 1986/87 - 1990/91): Dunlin *Calidris alpina* (8,010), Black-tailed godwit *Limosa limosa* (70) and Red-breasted merganser *Mergus serrator* (100).	✓ **(all)**	
Solent and Southampton Water Ramsar	**Ramsar criterion 1:** The site is one of the few major sheltered channels between a substantial island and mainland in European waters, exhibiting an unusual strong double tidal flow and has long periods of slack water at high and low tide. It includes many wetland habitats characteristic of the biogeographic region: • saline lagoons • saltmarshes • estuaries • intertidal flats • shallow coastal waters • grazing marshes • reedbeds • coastal woodland • rocky boulder reefs.	✓ **(all)**	The Solent and Southampton Water habitat features and bird populations are considered to be at sufficient distance from the construction elements of the water recycling solution, such that no LSEs are considered likely. The use of the [redacted] LSO for the discharge is c. 3.5km east of the area of the Solent and Southampton Water Ramsar at Ryde on the Isle of Wight. Interaction of the discharge plume with the subtidal habitats is not predicted in the modelling undertaken to date. However offshore feeding by little, common and sandwich tern, plus Mediterranean gull and red-breasted merganser will need to be considered. The wider issue of nutrient neutrality will also need to be assessed.
	Ramsar criterion 2: Important assemblage of rare plants and invertebrates. At least 33 BRDB invertebrates and at least eight BRDB Book plants are represented on site.	✓ **(all)**	
	Ramsar criterion 5: Assemblages of international importance: Species with peak counts in winter: 51343 waterfowl. In addition to those species listed as part of the SPA designation, and in criterion 6, the following are considered as part of the waterfowl assemblage:Black headed gull *Larus ridibundus*, Slavonian grebe *Podiceps auritus*, black necked grebe Podiceps *nigricollis nigricollis*. Little egret *Egretta garzetta*, spotted redshank *Tringa erythropus*, common redshank *Tringa nebularia* and water rail *Rallus aquaticus*.	✓ **(all)**	
	Ramsar criterion 6: Qualifying Species/populations (as identified at designation): Species with peak counts in spring/autumn: Ringed plover, *Charadrius hiaticula*, Europe/Northwest Africa 397 individuals, representing an average of 1.2% of the GB population Species with peak counts in winter: Dark-bellied brent goose, *Branta bernicla bernicla*, 6456 individuals, representing an average of 3% of the population, Eurasian teal , *Anas crecca*, NW Europe 5514 individuals, representing an average of 1.3% of the population, Black-tailed godwit, *Limosa limosa islandica*, Iceland/W Europe 1240 individuals, representing an average of 3.5% of the population	✓ **(all)**	

5.2 Supporting Information

To determine whether the solution 'either alone or in combination with other plans or projects' would have an adverse effect on site integrity (AEoI), the current conservation status and the specific sensitivities of the site have been considered with reference to:

- Standard Data forms for SACs and SPAs and Information Sheets for Ramsar sites. An analysis of these information sources has enabled the identification of the site's qualifying features;
- Site conservation objectives;
- Supplementary advice to the conservation objectives (SACO; where available);
- Advice on Operations (for the marine sites);
- Favourable conservation status and site condition (using Article 12 and 17 reporting and underlying Site of Special Scientific Interest condition, or marine condition assessments);
- Site Improvement Plans;
- the supporting Site of Special Scientific Interest's favourable condition tables where relevant (e.g., if no SACOs applicable to the features were available); and
- the Marine Evidence based Sensitivity Assessment (MarESA) (for the marine sites).

The conservation objectives for each site are not provided within this report, rather reference has been made to them and the overarching concept of Favourable Conservation Status as provided in **Figure 5.1**.

Figure 5.1 Favourable conservation status as defined in Articles 1(e) and 1(i) of the Habitats Directive

"*The conservation status of a natural habitat is the sum of the influences acting on it and its typical species that may affect its long-term natural distribution, structure and functions as well as the long term survival of its typical species. The conservation status of a natural habitat will be taken as favourable when:*
• Its natural range and areas it covers within that range are stable or increasing, and
• The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
• The conservation status of its typical species is favourable.
The conservation status of a species is the sum of the influences acting on the species that may affect the long-term distribution and abundance of its populations. The conservation status will be taken as 'favourable' when:
• Population dynamics data on the species indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
• The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
• There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."

Although there aren't any formal conservation objectives for Ramsar sites, the features are often overlapping with those covered by SACs and SPAs and the objectives are relatively generic. Therefore, those same objectives can be applied.

5.3 Baseline Overview

5.3.1 Solent Maritime Special Area of Conservation

Solent Maritime SAC lies between the Isle of Wight and the south coast of England. The site was designated April 2005 and covers approximately 112.4km^2. The marine area is 91.9% of the SAC. The SAC is one of the only major sheltered channels in Europe and has the largest number of small estuaries in the tightest cluster anywhere in Great Britain. The SAC is of particular interest as it is the only site to support all four species of cordgrass (*Spartina*) found in the UK. The Solent and its inlets are unique in Britain and Europe as it has unusual tidal regimes, including double tides and long periods of tidal stand at high and low tide[61].

Langstone Harbour is cited as an example of a bar-built estuary under the H1130 Estuaries qualifying feature. Sub-features of this, present in the harbour are; intertidal mixed sediments, intertidal mud, intertidal sand and muddy sand, intertidal sea grass beds, Salicornia and other annuals colonising mud and sand, *Spartina* swards, and subtidal sand (mouth of harbour).

Survey work completed by APEM on behalf of Natural England (reported 2016) concluded that the predominant biotope across much of Langstone Harbour was A2.312 "*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud" (LS.LMu.MEst.HedMac), which was found across the north east of the harbour including SSSI Unit 13. The other SSSI Unit in direct proximity to [redacted], and into which Hermitage Stream discharges, is Unit 6 which was found to comprise A2.421 *Cirratulids* and *C. edule* in littoral mixed sediment along the coastline and A2.312 *H. diversicolor* and *M. balthica* in littoral sandy mud further into the harbour. Saltmarsh and *Z. noltii* biotopes were also recorded. During the field survey of Langstone Harbour the presence of the invasive, non-native species *A. modestus* was recorded in SSSI Units 3, 6, 7 and 10 with *C. fornicata* in Unit 3.

The key habitats within the zone of influence of the water recycling solution are; intertidal mud (predominant habitat) with small areas of pioneer salt marsh (Units 6 and 13 of the underlying SSSI), and areas of saltmarsh around North Binness Island and Long Island. Offshore, the area around East Winner bank and Spithead in the middle of the East Solent comprises the SAC habitat H1110 Sandbanks which are slightly covered by sea water all the time. The habitats otherwise comprise a mix of sublittoral sediments. The overarching H1130 Estuaries feature is also of importance, with Langstone Harbour cited as an example of a bar-built estuary. Sub-features of the estuary feature, present in Langstone Harbour are;

Condition assessments have been carried out for some of the marine habitat features of SAC:

- H1130 Estuaries - 70% unfavourable no change, 30% unfavourable declining (June 2020)
- H1140 Mudflats and sandflats not covered by seawater at low tide - 70% unfavourable no change, 30% unfavourable declining (June 2020)
- H1110 Sandbanks which are slightly covered by sea water all the time – 100% unfavourable no change (June 2018)

The underlying SSSI Units are in unfavourable recovering condition given the continuing issue of eutrophication, although some recovery has been shown on the basis of a large reduction in nitrogen inputs through diversion of wastewater. However, significant nitrogen inputs from the Solent and less so from the rivers into the head of the harbour, remains an issue. Directly adjacent to these units, within Chichester Harbour, the condition of a number of SSSI units has recently (February 2020) been downgraded to unfavourable declining, based on survey work completed in late 2019. The last field assessment undertaken in Langstone Harbour was 2008, and therefore there is some uncertainty as to whether the condition will be downgraded following the next CSM assessment (date for this unknown).

5.3.2 Chichester and Langstone Harbours Special Protection Area and Ramsar

The Estuarine Waterbirds Low Tide counts completed in 1992-93 and 1998-99[62] observed tidal movements for a number of bird species (grey plover, knot, dunlin, black-tailed godwit, and curlews) with feeding occurring in Portsmouth Harbour, and roosting in Langstone Harbour.

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[61] NE (Natural England), 2020. Natural England Conservation Advice for Marine Protected Areas Solent Maritime SAC. Available online at: https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030059&SiteName=solent&countyCode=&responsiblePerson&HasCA=1&NumMarineSeasonality=0&SiteNameDisplay=Solent%20Maritime%20SAC#SiteInfo [Accessed May 2021].

[62] British Trust for Ornithology (undated) Estuarine Waterbirds at Low Tide. Edited by: Andy Musgrove, Rowena Langston, Helen Baker and Robin Ward. Accessed at https://www.bto.org/our-science/projects/wetland-bird-survey/publications/other-webs-publications

Latest information regarding habitat/location preferences for roosting and feeding is presented in **Table 5.3**, summarised from the Supplementary Advice for Conservation Objectives available on Natural England's designated views webpage[63]. Latest population figures have also been obtained from the WeBS Annual Online Report[64].

The Chichester and Langstone Ramsar site was designated in October 1987 and covers the same area extent of the SPA. It comprises the two large estuarine basins, supporting extensive intertidal mudflats, saltmarsh, sand and shingle spit (as also designated under the Solent Maritime SAC). Peak counts of over wintering birds regularly exceed 20,000 individuals (JNCC, 1999). The qualifying bird features are also covered by the SPA, with the exception of black-tailed godwit. Baseline information for this species has been included in **Table 5.3**.

[63] Accessed at: https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9011011&SiteName=Chichester%20and%20Langstone%20Harbour&SiteNameDisplay=Chichester%20and%20Langstone%20Harbours%20SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=18&HasCA=1. Last accessed 03.07.2020.

[64] Frost, T.M., Calbrade, N.A., Birtles, G.A., Mellan, H.J., Hall, C., Robinson, A.E., Wotton, S.R., Balmer, D.E. and Austin, G.E. 2020. Waterbirds in the UK 2018/19: The Wetland Bird Survey. BTO/RSPB/JNCC. Thetford.

Table 5.3 Summary of feeding and roosting preferences, and population counts for qualifying features: Chichester and Langstone Harbours

Qualifying Feature	Feeding Preferences/Locations	Roosting Preferences/Locations	Five year average[65] (peak count (year)) Langstone Harbour	Five year average[66] (peak count (year)) Chichester Harbour	Importance	Presence on site	WeBS Alerts [67] or site trend [68]
Bar-tailed godwit (*Limosa lapponica*), Non-breeding	Feed on intertidal sediments but show a preference for sandier substrates. Important feeding area around Sword Sands (Langstone Harbour).	Roost on saltmarsh, freshwater and coastal grazing marsh and shingle RSPB Islands, Farlington Marshes, the Langstone Oysterbeds, Sword Sands and Kench Spit in Langstone Harbour	244 (416 (17/18))	576 (760 (15/16))	At the time of classification in 1987, bar-tailed godwits were present at numbers of national importance, and remain at an abundance, which represents more than 1% of the UK population.	Sep-Apr	High (SB) Medium (LT)
Common tern (*Sterna hirundo*), Breeding	Feed on small fish and crustaceans, terrestrial insects and occasionally squid. Forage throughout the harbours, in the harbour mouths and into the Solent. They are generalist and opportunist feeders, using more varied habitats, a wider range of feeding techniques and taking a wider variety of prey than other tern species, with a mean maximum foraging range of 12.6 ±10.6 km , . They take food from near the surface of the water by plunge-diving to a depth of 1-2 m, often after hovering. Prey might also be gathered by 'contact dipping':	Nest in simple shallow 'scrapes' on sand, shingle or within low vegetation[69]. Oysterbeds islets, the RSPB Islands and on floating manmade rafts	6 (29 (17/18)	40 (62 (18/19))	When classified in 1987, the Chichester and Langstone Harbours SPA supported 85 breeding pairs of common tern (five year mean 1982-1986).	Apr-Sep	Since classification, numbers of common tern using the Chichester and Langstone Harbours SPA have increased and a more recent five year mean is 126 breeding pairs (2011 to 2015). Comparisons suggest that the site population trend is exceeding both the UK and regional trends
Curlew (*Numenius arquata*), Non-breeding	Feed on marine worms, shellfish and shrimps found in the intertidal sediments within the sheltered harbours. South of Farlington Marshes and south of Bedhampton Wharf.	Farlington Marshes, the Oysterbeds, the RSPB islands and Kench Spit provide important roost habitat for curlew overwintering in the SPA, including shingle banks, marshland and manmade structures	1,077 (1,418 (15/16))	1,273 (1,595 (17/18))	When classified in 1987, the Chichester and Langstone Harbours SPA supported nationally important numbers of curlew (2,937 individuals five year peak mean 1982/83-1986/87). more than 1% of the British population during the wintering period.	Jun-Apr	Medium (MT,SB)
Dark-bellied brent goose (*Branta bernicla bernicla*), Non-breeding	Main food sources are the green algae (Ulva species) and seagrass beds growing on the intertidal sediments. Green algae is found throughout the harbours, whilst seagrass beds are located in more limited areas such as Sinah Lake and Mallard Sands in Langstone Harbour.	Roost on the water overnight.	5,154 (5,563 (15/16))	12,795 (14,260 (15/16))	When classified in 1987, Chichester and Langstone Harbours supported internationally important numbers of dark-bellied Brent geese, accounting for 12% of the West European population.	Oct-Mar	No alert
Dunlin (*Calidris alpina alpina*), Non-breeding	Feed in groups on the intertidal sediments throughout the harbours. Feed in particular to the south of Thorney Island and in the Emsworth Channel (Chichester Harbour).	Dunlin roost on sediment islands and spits, saltmarsh and coastal and freshwater grazing marsh. Farlington Marshes, the Oysterbeds, Kench Spit and Railway Bank and at Eastney Lake Spit.	12,611 (15,220 (16/17)	11,386 (14,252 (18/19))	At time of classification in 1987, 2.6% of the West European population overwintered in Chichester and Langstone Harbours SPA.	Sep-Apr	Medium (LT,SB)
Grey plover (*Pluvialis squatarola*), Non-breeding	Turnstone forage on intertidal sediment and rocky substrates. The prey on a wide variety of foods including crustaceans, barnacles and bivalves often found by turning over stones and seaweed. However, they will also feed upon bird eggs, corpses and even chips.	Turnstone roost on both natural (shingle and marshland) and artificial (pontoons and boats) habitat. In Chichester Harbour they roost in small numbers, quite widely spread. Some small concentrations are at Chidham Point, on the pontoons at Itchenor and on the boats at East Head and Bosham.	697 (865 (14/15))	1,299 (1,667 (15/16))	When the SPA was classified in 1987, there were internationally important numbers (3.9% of the Western European population) of grey plover overwintering in Chichester and Langstone Harbours.	Aug-Mar	Medium (LT,SB)

[65] Contains Wetland Bird Survey (WeBS) data from Waterbirds in the UK 2018/19 © copyright and database right 2020. WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers. Accessed at: https://app.bto.org/webs-reporting/
[66] Contains Wetland Bird Survey (WeBS) data from Waterbirds in the UK 2018/19 © copyright and database right 2020. WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers. Accessed at: https://app.bto.org/webs-reporting/
[67] ST: short-term (5 years) MT: medium-term (10 years) LT: long-term (up to 25 years) SB: since baseline
[68] Taken from the Chichester and Langstone Harbours SPA Supplementary Advice on Conservation Objectives.
[69] English Nature. 2001. Solent European Marine Site: English Nature's advice Regulation 33(2) Conservation Advice Package: English Nature.

Qualifying Feature	Feeding Preferences/Locations	Roosting Preferences/Locations	Five year average[65] (peak count (year)) Langstone Harbour	Five year average[66] (peak count (year)) Chichester Harbour	Importance	Presence on site	WeBS Alerts [67] or site trend [68]
		In Langstone Harbour they roost on the RSPB Islands and Farlington Marshes, as well as at the Kench Spit and Railway Bank, the west side of the Kench and Mullberry Harbour.					
Little tern (*Sternula albifrons*), Breeding	Forage alone in shallow water often within 1km of their breeding colony for small fish, crustaceans, and insects. Forage throughout the harbours, in the harbour mouths and into the Solent. Little tern forage for small fish, crustaceans, and insects in shallow water often within 1km of their breeding colony to a maximum of 5km[70]. They hover and then plunge dive near the surface of the water or by 'contact dipping' where only the bill enters the water and the bird remains in flight.	Nest in simple shallow 'scrapes' on bare sand and shingle. Nest on Bakers Island, Pilsey Island, the north Stakes Islands, the Oysterbeds islets and on manmade rafts	0 (0)	30 (57 (19/20))	When classified in 1987, the Chichester and Langstone Harbours SPA supported 109 breeding pairs of little tern (five year mean 1982-1986).	Apr-Aug	Since classification, numbers of little tern using the Chichester and Langstone Harbours SPA have decreased and a more recent five year mean is 49 breeding pairs (2011 to 2015). Comparisons suggest that the site population trend is declining by more than both the UK and regional trends.
Pintail (*Anas acuta*), Non-breeding	Feed at the surface of the water by dabbling (submerging the head) for vegetation. Feed throughout the harbours but particularly favour the Nutbourne Bay area and north of the Thorney Channel in Chichester Harbour	Roost on the open water. They favour areas such as the Thorney Deeps and Nutbourne Bay in Chichester Harbour. In Langstone Harbour, they also roost on the RSPB Islands, Farlington Marshes, the Oysterbeds and Southmore Spit	211 (277 (16/17))	143 (246 (17/18))	Pintail numbers have remained stable since the Chichester and Langstone Harbours SPA was classified in 1987. Average overwintering numbers have fluctuated from the pre-classification 323 individuals (five year peak mean 1982/83-1986/87) but currently average at 338 individuals (five year peak mean 2009/10-2013/14).	Sep-Mar	No alert
Red-breasted merganser (*Mergus serrator*), Non-breeding	Dive and swim to forage on fish and aquatic invertebrates in the water column. In Langstone Harbour, they favour the deeper waters to the east of Farlington Marshes and towards Langstone Bridg	Feed and roost on the water in both Chichester and Langstone harbours.	143 (205 (16/17))	105 (136 (18/19))	There were nationally important numbers of red-breasted merganser in Chichester and Langstone Harbours SPA when it was classified in 1987. Average numbers of red-breasted merganser were at 206 individuals (five year peak mean 1982/83-1986/87).	Oct-Mar	Medium (ST)
Redshank (*Tringa totanus*), Non-breeding	Feed on invertebrates, both inland and in estuaries. Prey includes earthworms and crane fly larvae as well as crustaceans, molluscs and marine worms. Feed throughout the harbours including The Kench.	Roost on the RSPB Islands, Farlington Marshes, Oysterbeds, Kench Spit, Kench Railway Bank, Eastney Lake Spit and on the beach on the north side of Kendalls Wharf in Langstone Harbour.	845 (921 (17/18))	1,654 (1728 (17/18))	At the time of classification in 1987, 1.4% of the West European population of redshank overwintered in the Chichester and Langstone Harbours SPA. Redshank overwintered in numbers of national importance and the total within the SPA accounted for more than 1% of the British population.	Jul-Apr	No alert
Ringed plover (*Charadrius hiaticula*), Non-breeding	Feed on invertebrates found on sand and shingle shores, mudflats, saltmarshes, short grassland and flooded fields. Important areas for such habitat are Pilsey Sands, East Head, north of Black Point, Hayling Beach and Sword Sands.	Roosts are on the RSPB islands, Farlington Marshes, the Oysterbeds, the Kench Spit and Railway Bank and the Eastern Road bridge.	251 (349 (19/20))	209 (271 (17/18))	Chichester and Langstone Harbours SPA supports nationally important numbers (more than 1% of the population) of overwintering ringed plover.	Aug-May	High (LT,SB) Medium (MT)
Sanderling (*Calidris alba*), Non-breeding	Feed in small groups at the edge of the tide, chasing the waves as they go out to collect crustaceans, worms, fish and jellyfish. Key area within Langstone Harbour is Sword Sands.	Roost on shingle, saltmarsh and sand. Roost in the main bird areas such as the RSPB Islands, Farlington Marshes, the Oysterbeds, the Kench and Sword Sands (Langstone Harbour)	28 (52 (18/19))	181 (217 (19/20))	Historically, in Chichester and Langstone Harbours SPA sanderling numbers accounted for 3.1% of the West European population.	Aug-May	High (SB)

[70] Woodward I D, Frost T M, Hammond M J, and Austin G E, 2019. Wetland Bird Survey Alerts 2016/2017: Changes in numbers of wintering waterbirds in the Constituent Countries of the United Kingdom, Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific interest (ASSIs). BTO Research Report 721. BTO, Thetford.

Qualifying Feature	Feeding Preferences/Locations	Roosting Preferences/Locations	Five year average[65] (peak count (year)) Langstone Harbour	Five year average[66] (peak count (year)) Chichester Harbour	Importance	Presence on site	WeBS Alerts [67] or site trend [68]
Sandwich tern (*Thalasseus sandvicensis*), Breeding	Feed on sandeels, herring and sprats, as well as crustaceans and small squid. Forage alone or in small flocks taking prey from near the surface of the water by plunge-diving to a depth of 2m. There is stronger tendency to feed at the harbour mouths. At high tide in Langstone Harbour, they form groups to forage south of South Binness island.	They nest colonially in high densities on the ground, on shingle spits, ridges and islets. In Chichester and Langstone Harbours SPA, they breed on the South Stakes islands, the Oysterbeds islets and the RSPB Islands.	0 (0)	26 (54 (18/19))	Sandwich tern numbers have risen in Chichester and Langstone Harbours SPA since classification. There was an average of 37 pairs breeding in the SPA in the five years before classification in 1987. Now, there is an average of 93 breeding pairs (five year mean 2011-2015).	Apr-Aug	Since classification, numbers of Sandwich tern using the Chichester and Langstone Harbours SPA have increased and a more recent five year mean is 93 breeding pairs (2011 to 2015). Comparisons suggest that the site population trend is exceeding both the UK and England trends
Shelduck (*Tadorna tadorna*), Non-breeding	Feed on marine snails, invertebrates and small shellfish found within intertidal sediments. Forage throughout the site but particularly prefer the Fishbourne, Thorney and Bosham Channels as well as the Warblington Coast in Chichester Harbour	Roost on saltmarsh and the open water. Favoured areas in Chichester Harbour include the saltmarsh in front of Old Park Wood, Fowley Island and Thorney Deeps. They also roost on the RSPB islands in Langstone Harbour as well as at Farlington Marshes.	463 (849 (15/16))	481 (656 (17/18))	There were Internationally important numbers (4% of the West European population) of shelduck in Chichester and Langstone Harbours SPA at time of classification in 1987.	Nov-Jun	High (LT,SB)
Shoveler (*Spatula clypeata*), Non-breeding	Feed on grazing marsh, seagrass (*Zostera* species) and other aquatic plants and roots, often at night. Favoured areas in the harbours include the Emsworth and Thorney Channels, the northern tips of the Bosham and Chichester Channels, Eames Farm, Thorney Deeps, Tournerbury Farm, School Rithe and Farlington Marshes.	Roost mostly on the open water at Thorney Deeps, in the Thorney, Fishbourne and Bosham channels, off Gutner Point and at Nutbourne Bay in Chichester Harbour. In Langstone Harbour, the main concentrations are seen to the west of Langstone Bridge and east of Farlington Marshes.	87 (122 (16/17))	481 (656 (17/18))	At the time of classification in 1987, shoveler were present in the Chichester and Langstone Harbours SPA at nationally important numbers.	Sep-Mar	Medium (MT,LT,SB)
Teal (*Anas crecca*), Non-breeding	Feed on small invertebrates and seeds. In Chichester Harbour, they forage in the Thorney Channel, at Snowhill Creek and at Mill Rythe / Yacht Haven. They favour Farlington Marshes in Langstone Harbour.	Roost on the open water, in areas such as the Thorney Deeps, at the edges of intertidal creeks, in ponds and on grazing marsh. In Langstone Harbour, they roost across Farlington Marshes and the intertidal creeks.	439 (600 (16/17))	1,070 (1,325 (16/17))	The North-western European population overwinters in the UK (5808). At the time of classification in 1987, 1% of the Western European population of teal overwintered in Chichester and Langstone Harbours SPA.	Sep-Mar	Medium (SB)
Turnstone (*Arenaria interpres*), Non-breeding	Forage on intertidal sediment and rocky substrates. Feed on a wide variety of foods including crustaceans, barnacles and bivalves often found by turning over stones and seaweed.	Roost on both natural (shingle and marshland) and artificial (pontoons and boats) habitat. In Chichester Harbour they roost in small numbers, quite widely spread. Some small concentrations are at Chidham Point, on the pontoons at Itchenor and on the boats at East Head and Bosham. In Langstone Harbour they roost on the RSPB Islands and Farlington Marshes, as well as at the Kench Spit and Railway Bank, the west side of the Kench and Mullberry Harbour.	297 (486 (15/16))	247 (324 (16/17))	At the time of classification in 1987 there were nationally important numbers (representing more than 1% of the British population) of turnstone overwintering in Chichester and Langstone Harbours SPA (564 individuals, five year peak mean 1982/83-1986/87).	Aug-Apr	No alert
Wigeon (*Mareca penelope*), Non-breeding	Feed on grazing marsh, seagrass (*Zostera* species) and other aquatic plants and roots. Their favoured areas in the harbours include the Emsworth and Thorney Channels, the northern tips of the Bosham and Chichester Channels, Eames Farm, Thorney Deeps, Tournerbury Farm, School Rithe and Farlington Marshes.	Roost mostly on the open water at Thorney Deeps, in the Thorney, Fishbourne and Bosham channels, off Gutner Point and at Nutbourne Bay in Chichester Harbour. In Langstone Harbour, the main concentrations are seen to the west of Langstone Bridge and east of Farlington Marshes.	948 (1,128 (17/18))	2,699 (3,387 (16/17))	At the time of classification in 1987, nationally important numbers of wigeon (2,803 individuals, five year peak mean 1982/83-1986/87) were present in Chichester and Langstone Harbours SPA during the wintering period.	Mar-Sep	No alert
Black tailed godwit (*Limosa limosa*) Passage (Ramsar feature only)	Feed on invertebrates such as worms, small shellfish and crabs in intertidal mudflats and sandflats mainly at the heads of the channels.	Roost in Thorney Deeps, at the head of the Fishbourne Channel and it is thought they roost at the top of the Bosham Channel. They can be found on the eastern side of Chidham where they feed around Cobnor Point and in fields to the	517 (652 (16/17))	702 (850 (19/20))	906 individuals within the Ramsar site, representing an average of 2.5% of the	Aug - Apr	No alert

Qualifying Feature	Feeding Preferences/Locations	Roosting Preferences/Locations	Five year average[65] (peak count (year)) Langstone Harbour	Five year average[66] (peak count (year)) Chichester Harbour	Importance	Presence on site	WeBS Alerts [67] or site trend [68]
		north of it. On the west side of Chidham they feed in fields to the north of the channel and roost on the east side of the channel.			population (5-year peak mean 1998/99–2002/03)[71].		

[71] https://chichester.gov.uk/media/31702/Final-Selsey-NP-SEA-Scoping-Report-April-2019/pdf/Final_Selsey_NP_SEA_Scoping_Report_April_2019.pdf

5.3.3 Solent and Dorset Coast Special Protection Area

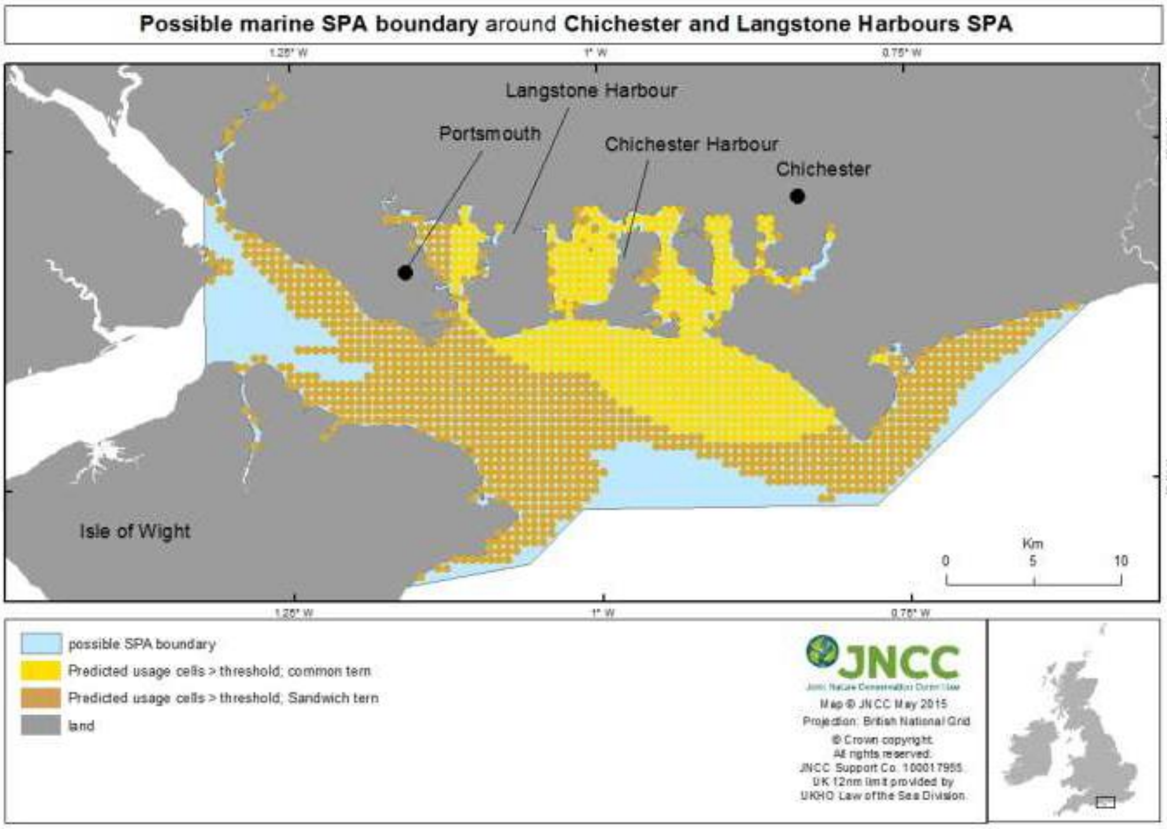
Solent and Dorset Coast SPA was classified in January 2020 to protect important foraging areas at sea, used by qualifying interest features from colonies within adjacent, already classified SPAs. The site is 889.81km^2. The qualifying interest features are three species of tern[72][73]:

- Sandwich tern *Thalasseus sandvicensis* (Breeding) (A191); 4.01% of the UK's sandwich tern breeding population.
- Common tern *Sterna hirundo* (Breeding) (A193); 4.92% of the UK's common tern breeding population.
- Little tern *Sternula albifrons* (Breeding) (A195); 3.31% of the UK's little tern breeding population.

From west to east, the adjacent SPAs with the tern species as qualifying interest features (in parentheses) are: Poole Harbour SPA (common tern); Solent and Southampton Water SPA (common, Sandwich and little tern); and Chichester and Langstone Harbours SPA (common, Sandwich and little tern).

[72] NE (Natural England), 2017. European Site Conservation Objectives for Solent & Dorset Coast SPA (UK9011061). Available online at: http://publications.naturalengland.org.uk/publication/6567218288525312 [Accessed May 2021.]
[73] NE (Natural England), 2021. Designated Sites View. Solent and Dorset Coast SPA. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=solent&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

Figure 5.2 Map showing the predicted usage of common and sandwich terns in the Chichester and Langstone Harbours Special Protection Area[74]



5.3.4 Solent and Southampton Water SPA and Ramsar

Latest information regarding habitat/location preferences for roosting and feeding is presented in **Table 5.4**, summarised from the Supplementary Advice for Conservation Objectives available on Natural England's designated views webpage[75]. Latest population figures have also been obtained from the WeBS Annual Online Report. The Solent and Southampton Water Ramsar site was designated in October 1998 at the same time as the SPA and comprises estuaries and adjacent coastal habitats including intertidal flats, saline lagoons, shingle beaches, saltmarsh reedbeds, damp woodland, and grazing marsh[76]. This diversity of habitats supports internationally important numbers of wintering waterfowl (51,361 over the winter).

5.3.5 Portsmouth Harbour SPA and Ramsar

Latest information regarding habitat/location preferences for roosting and feeding is presented in Table 4.2, summarised from the Supplementary Advice for Conservation Objectives available on Natural England's designated views webpage . Latest population figures have also been obtained from the WeBS Annual Online Report.

[74] Win I, Wilson LJ, and Kuepfer A, 2013. Identification of possible marine SPA boundaries for the larger tern species around the United Kingdom. JNCC report.
[75] Accessed at: https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK9011011&SiteName=Chichester%20and%20Langstone%20Harbour&SiteNameDisplay=Chichester%20and%20Langstone%20Harbours%20SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=18&HasCA=1. Last accessed 03.07.2020.
[76] JNCC, 2005. Information Sheet on Ramsar Wetlands (RIS): Solent and Southampton Water. Accessed June 2021. Available online at: https://rsis.ramsar.org/RISapp/files/RISrep/GB965RIS.pdf.

Table 5.4 Summary of feeding and roosting preferences, population counts for qualifying features and known locations: Solent and Southampton Water SPA and Ramsar and Solent and Dorset Coast SPA[77]

Qualifying Feature	Feeding Preferences/Locations	Roosting Preferences/Locations	Five year average[78] (peak count (year))	Importance	Presence on site	WeBS Alerts[79] or site trend[80]
Common tern (*Sterna hirundo*), Breeding	Forage alone or in small flocks for small fish and crustaceans, terrestrial insects and occasionally squid. They take food from near the surface of the water by plunge-diving to a depth of 1-2 m, often following hovering. Prey might also be gathered by 'contact dipping': where only the bill enters the water and the bird remains in flight throughout.	Breed, and nest in simple shallow 'scrapes' on sand, shingle or within low vegetation. Important breeding areas within the site include Hurst Point to Pitts Deep, and the North Solent. Common terns may also breed in areas including Lymington – Pylewell, Beaulieu Estuary, and Newtown Harbour although less frequently.	28 (94, (17/18))	The Seabird 2000 census identified 2.2% of the global population nest in England.	Apr– mid-Sep	Since classification, the numbers of common tern breeding in the Solent and Southampton Water SPA have declined. The most recent five year mean is 147 breeding pairs (2013-2017)
Little tern (*Sternula albifrons*) Breeding	Forage alone in shallow water often within 1km of their breeding colony for small fish, crustaceans, and insects. They take food from near the surface of the water by plunge-diving, often following hovering, or by 'contact dipping'. Important foraging areas in the site include Hurst Point – Pitts Deep, and the Medina estuary during later/early season.	Nest in simple shallow 'scrapes' on bare sand and shingle. Important breeding areas within the site include Hurst Point – Pitts Deep, with less frequently used sites including North Solent, Lymington to Pylewell, and Newtown Harbour.	1 (4, (25/16))	The Seabird 2000 census identified 2.2% of the global population nest in the UK.	Apr-Aug	Since classification, numbers of little tern breeding in the Solent and Southampton Water SPA have declined. The most recent five year mean is 11 breeding pairs (2013-2017)
Sandwich tern (*Thalasseus sandvicensis*) Breeding	Feed in shallow coastal waters, mainly on small fish and crustacea, as well as worms and molluscs in shallow waters overlying the sediment.	Prefer to nest on small shingle islands among or below vegetation. Tend to nest colonially with other species of tern, usually common. Important breeding areas within the site include the shingle banks and islands within Brownsea lagoon, Hurst Point to Pitts Deep, and the South Lakes islands, the oyster beds islets and the RSPB islands within Langstone Harbour, and Tern Island within Pagham Harbour. Other areas include Lymington to Pylewell, Newtown Harbour, Hawkers Island, Cockleshell and Pylewell Marsh	12 (24, (17/18))	The Seabird 2000 census identified 9.6% of the global population nest in the UK.	Early Mar/Apr - Sep	Since classification, numbers of sandwich tern breeding in the Solent and Southampton Water SPA have declined. The most recent five year mean is 95 breeding pairs (2013-2017)
Mediterranean gull (*Ichthyaetus melanocephalus*) Breeding	Forage in shallow coastal waters, particularly close to their breeding sites, where they can catch invertebrates and small fish. Feed in arable fields, and intertidal areas along the coastline. Also feed on black-headed gull eggs and chicks and have more recently been predating intensively on common tern eggs, and opportunistically on sandwich tern eggs.	Nest colonially in short to medium swards of vegetation, and sometimes on vegetated shingle islands, particularly with black-headed gulls. Important breeding areas within the site include Newtown Harbour, Hurst – Lymington, and the North Solent.	119 (165, (16/17))	When classified in 1998, the site supported 2 pairs (five year peak mean 1994 - 1998), representing at least 20% of the breeding population in Great Britain	May - Aug	Since classification, numbers of Mediterranean gulls breeding in the Solent and Southampton Water SPA have increased. The most recent five year mean is 13 breeding pairs (2013-2017).
Roseate tern (*Sterna dougallii*) Breeding	Forage over substrates that are sandy making use of shallow water where there are schools of smaller fish. Have a large foraging distance form colonies up to 30KM Feed alone or in small flocks.	Prefer to next on small islands where the nest in a hollow or under thick vegetation, rock of debris. Rely on Common terns in the colony to defend them.	None breeding since 2006	When classified in 1998, the site supported 2 pairs (five year peak mean 1993 - 1997), representing at least 3.1% of the breeding population in Great Britain	May - Aug	Since classification, numbers of Roseate terns breeding in the Solent and Southampton Water SPA have declined. One or two pairs nested each year between 2002-2006 in the Western Solent, however no other data is available
Black-tailed Godwit (*Limosa limosa islandica*) Non-breeding	Feed mostly on worms in the mudflats whilst the tide is out, but also on insects, snails, some plants, beetles, grasshoppers and other small insects during the breeding season.	Roost in areas with extensive stretches of bare ground or short vegetation with unrestricted views. Within the site, important roosting areas include Southampton Water and the North-West Solent.	588 (750, (17/18))	When classified in 1998, the site supported 1,125 individuals (five year peak mean 1992/3 - 1996/7), representing at least 1.6% of the wintering Iceland-breeding population	Jul -Apr	Medium (-25%) (ST,SB)

[77] Waterbird assemblage counts not included.
[78] Contains Wetland Bird Survey (WeBS) data from Waterbirds in the UK 2018/19 © copyright and database right 2020. WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers. Accessed at: https://app.bto.org/webs-reporting/
[79] ST: short-term (5 years) MT: medium-term (10 years) LT: long-term (up to 25 years) SB: since baseline
[80] Taken from the Solent and Southampton Water SPA Supplementary Advice on Conservation Objectives.

	Particularly important feeding areas for black-tailed godwit include Beaulieu Estuary, Newtown Harbour, and North-West Solent.					
Dark-bellied brent goose (*Branta bernicla bernicla*), Non-breeding	Feed mainly on green algae (*Ulva spp.*) and seagrass beds growing on the intertidal sediments. Important feeding sites include Southampton Water, Newton Harbour, and the North-West Solent,	Roost on the water overnight. During the day they exhibit sub-population preferences and will roost close to preferred feeding areas. Important roosting sites within the site include Southampton Water, Beaulieu Estuary, Newtown Estuary, and North-West Solent.	2223 (3355, (14/15))	When classified in 1998, the site supported 7,506 individuals of dark-bellied Brent goose (five year peak mean 1992/3 - 1996/7), representing 2.5% of the wintering Western European population	Oct – Mar	Medium (-30%) (MT)
Ringed plover (*Charadrius hiaticula*), Non-breeding	Forage for food on beaches, tidal flats and fields, usually by sight. They eat insects, crustaceans and worms.	Roost on sandbanks, bare arable fields or in low vegetation. Main roosting areas for ringed plover in the site are Southampton Water and the North-West Solent, whilst other roosting sites include Beaulieu Estuary and Newtown Harbour.	142 (205, (16/17))	When classified in 1998, the site supported 552 individuals (five year peak mean 1992/3 - 1996/7), representing 1.1% of the wintering Europe/Northern Africa wintering population.	Present most of the year May-Aug	High (-52%) (LT,SB)
Teal (*Anas crecca*), Non-breeding	Mudflats, creeks, and saltmarsh provide suitable feeding grounds, where teal feed on small invertebrates and seeds. Important feeding grounds include Southampton Water and Newtown Harbour.	Roost on the open water, with important sites including Southampton Water, Beaulieu Estuary, Newtown Harbour, and North-West Solent.	1247 (1352, (14/15))	When classified in 1998, the site supported 4,400 individuals (five year peak mean 1992/3 - 1996/7), representing at least 1.1% of the wintering North-western Europe population.	Sep – Mar	Numbers of Teal over-wintering on Solent and Southampton Water SPA have remained relatively stable long term. Consequently no Alerts have been triggered for this species.

Table 5.5 Summary of feeding and roosting preferences, population counts for qualifying features and known locations: Portsmouth Harbour SPA and Ramsar[81]

Qualifying Feature	Feeding Preferences/Locations	Roosting Preferences/Locations	Five year average[82] (peak count (year))	Importance	Presence on site	WeBS Alerts
Black-tailed godwit (Limosa limosa islandica), Non-breeding	At low tide, high densities of black-tailed godwit feed on invertebrates such as worms and snails, in the mudflats in the north western section of Portsmouth Harbour at Cams Bay and Wicor Lake.	At high tide, black-tailed godwits roost on upper saltmarsh areas in Portsmouth Harbour and on coastal grazing marsh outside the SPA boundary. Important roost sites are located at RNAD Gosport in Bedenham, Pewit Island and at Farlington Marshes in Langstone Harbour. In wet weather, black-tailed godwits also move between Portsmouth Harbour and Titchfield Haven in the Meon Valley.	394 (673 (17/18))	When classified in 1995 the site supported nationally important numbers of black-tailed godwits at 70 individuals (five year peak mean 1986/87 to 1990/91) during the overwintering period, accounting for more than 1% of the British population.	Sep-Feb	No alert
Dark-bellied brent goose (Branta bernicla bernicla), Non-breeding	The main food sources for dark-bellied Brent geese in Portsmouth Harbour are the green algae and seagrass beds growing on the intertidal mudflats. At low tide, high densities of Brent geese often feed at Paulsgrove Lake and Porchester in the north and also at Foulton Lake in the west of the harbour. Pewit Island is an important high tide feeding site for dark-bellied Brent goose within the SPA. In the Solent, dark-bellied Brent geese show diverse feeding habits and will also feed at high tide in areas outside the SPA. These areas include farmland with cereals and pasture along with amenity grasslands and coastal grazing marsh.	At night, dark-bellied brent goose roost on the water in the harbour. They generally do not roost during the day but feed either on the intertidal or on nearby grassland.	2,113 (2,304 (15/16))	When classified in 1995, Portsmouth Harbour supported internationally important numbers of over-wintering dark-bellied Brent geese with a five year mean peak count of 2,290 (1986/87 to 1990/91). This represented 1.3% of the north-west European population and 2.5% of the British overwintering population.	Oct-Apr	Medium (MT)
Dunlin (Calidris alpina alpina), Non-breeding	At low tide, dunlin feed in high densities in the north western corner of the harbour around Cams Bay and Wicor Lake. High densities also feed at Foulton Lake and along the western side of the harbour. They select snails, worms and shrimps from within and on top of the mudflats.	At high tide, dunlin roost on pontoons near Wicor Shore, on saltmarsh at RNAD Gosport, Bedenham or on an island adjacent to Priddy's Hard. Dunlin also fly over to Langstone Harbour to roost at high tide.	2,938 (5,339 (18/19))	When classified in 1995 the site supported 8,010 over-wintering individuals (five year peak mean 1986/87 to 1990/91), representing over 1% of the British population.	Nov-Mar	High (MT,LT,SB) Medium (ST)
Red-breasted merganser (Mergus serrator), Non-breeding	Red-breasted merganser forage on small fish and aquatic invertebrates in the shallow coastal waters of Portsmouth Harbour.	Red-breasted merganser spend their entire time on the water, roosting at night with other diving sea ducks, either in the mid-channel in Portsmouth Harbour or other shallow coastal waters in the Solent. Red-breasted merganser also raft in Portsmouth Harbour for shelter during times of stormy weather.	56 74 (16/17))	When classified in 1995 the site was classified with 100 birds (five year peak mean 1986/87 to 1990/91) representing 1% of the British population.	Nov-Apr	High (SB) Medium (ST,MT,LT)

81 Waterbird assemblage counts note included.
82 Contains Wetland Bird Survey (WeBS) data from Waterbirds in the UK 2018/19 © copyright and database right 2020. WeBS is a partnership jointly funded by the BTO, RSPB and JNCC, in association with WWT, with fieldwork conducted by volunteers. Accessed at: https://app.bto.org/webs-reporting/

6 Sensitivity of Qualifying Features

The sensitivity of the nature conservation features discussed in Section 4, to pressures of the solution that are summarised in Section 3.2 (Table 3.2), is presented below. Each feature has been assessed using available information on sensitivities to broad pressure types from a range of sources such as the Marine Evidence based Sensitivity Assessment (MarESA) and published reports and peer-reviewed literature.

Presented below in Sections 6.1-6.3 are the sensitivity assessments of Annex I habitats, birds, and Annex II fish features.

6.1 Annex I Habitats

6.1.1 *Salicornia* and other annuals colonising mud and sand

'*Salicornia* and Other Annuals Colonising Mud and Sand' is a pioneer saltmarsh vegetation that colonises intertidal mud and sandflats and is classed as a sub-feature of estuaries. It colonises areas protected from strong wave action and is an important precursor to the development of more stable saltmarsh vegetation. It develops at the lower reaches of saltmarshes where the vegetation is frequently flooded by the tide, and can also colonise open creek sides, depressions or pans within saltmarshes, as well as disturbed areas of upper saltmarshes. Pioneer saltmarsh provides an important feeding area and a food source for many species of waterfowl. Sizeable areas of glasswort and annual sea-blite communities are present in the east of Chichester Harbour. Pioneer saltmarsh vegetation has been recorded in Langstone Harbour[83]. They are sensitive to physical pressures and have a low resilience and resistance to such pressures[84].

Table 6.1 Sensitivity, resistance and resilience of *Salicornia* and other annuals colonising mud and sand

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Medium	Medium	Very low
Barrier to species movement	Medium	None	Medium
Changes in suspended solids (water clarity)	High	Low	Low
Habitat structure changes - removal of substratum (extraction)	High	None	Very Low
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Medium	Medium	Very low
Physical change (to another sediment type)	Medium	Medium	Low
Smothering and siltation rate changes (Heavy)	Low	Medium	High
Salinity increase	Low	High	Medium

[83] Natural England (March 2020) Designated Sites View: Solent Maritime SAC. Conservation Advice Components: Site Information. Access at https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030059&SiteName=Solent%20Maritime%20SAC&SiteNameDisplay=Solent%20Maritime%20SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=&HasCA=1#SiteInfo. [Accessed June 2021].
[84] NE (Natural England), 2021. Designated Sites View. Solent Maritime SAC. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=solent&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

6.1.2 Atlantic salt meadows

The Solent contains the second-largest aggregation of Atlantic salt meadows in south and south-west England. The Solent Maritime SAC represents 33% of the marsh of this region and almost 3% of England's total saltmarsh resource. Solent Maritime SAC is a composite site composed of a large number of separate areas of saltmarsh. Typical Atlantic salt meadow is still widespread in this site, despite a long history of colonisation by cordgrass *Spartina* spp. Atlantic salt meadow habitat in the Solent provides an important habitat for invertebrate species as well as valuable roosting and feeding areas for internationally important populations of birds. Unusual transitions of saltmarsh to freshwater reedbeds and woodlands as well as coastal grassland are found in Chichester Harbour[85]. This habitat is highly sensitive to disturbance and has low resistance and resilience to physical pressures.

Table 6.2 Sensitivity, resistance and resilience of Atlantic salt meadows

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Medium	Medium	Low
Barrier to species movement	High	Low	Low
Changes in suspended solids (water clarity)	High	Low	Low
Habitat structure changes - removal of substratum (extraction)	High	None	Very Low
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Medium	Medium	Low
Physical change (to another sediment type)	Medium	Medium	Low
Smothering and siltation rate changes (Heavy)	High	None	Very Low

6.1.3 *Spartina* swards

The Solent Maritime SAC is the only site where smooth cordgrass *Spartina alterniflora* is found in the UK. It is also one of only two sites where small cordgrass *Spartina maritima* and Townsend's cordgrass *Spartina townsendii* are present. The Solent also has extensive areas of common cordgrass *Spartina anglica*. Small cordgrass, Townsend cordgrass and smooth cordgrass have restricted distributions, and have not been recorded in Langstone Harbour. Common cordgrass is present throughout the site, with no additional information regarding distribution in Langstone Harbour. *Spartina* swards are generally have medium-high sensitivity to most physical disturbances. Their resilience and resistance to pressures ranges from very low to medium for physical pressures.

Table 6.3 Sensitivity, resistance and resilience of *Spartina* swards

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Medium	Medium	Low
Barrier to species movement	High	Low	Low
Changes in suspended solids (water clarity)	High	Low	Low

[85] Natural England (March 2020) Designated Sites View: Solent Maritime SAC. Conservation Advice Components: Site Information. Access at https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030059&SiteName=Solent%20Maritime%20SAC&SiteNameDisplay=Solent%20Maritime%20SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=&HasCA=1#SiteInfo. [Accessed May 2021].

Pressure	Sensitivity	Resistance	Resilience
Habitat structure changes - removal of substratum (extraction)	High	None	Very Low
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Medium	Medium	Low
Physical change (to another sediment type)	Medium	Medium	Low
Smothering and siltation rate changes (Heavy)	High	None	Very Low
Salinity increases	Low	High	Medium

6.1.4 Sandbanks which are slightly covered by sea water all the time

Sandbanks which are slightly covered by sea water all the time are important habitats for invertebrate species. Subtidal sand is the second most common habitat type within the Solent Maritime SAC and is a sub-feature of both Annex I habitats estuaries and sandbanks. There are seven biotopes associated with these sandbanks and their sensitivity to pressures ranges from not sensitive to medium sensitivity. Resistance is low-high and resilience is medium-high for most of the pressures.

Subtidal coarse sediments, comprising gravel and shingle, are limited in extent in the Solent Maritime SAC with only about 60 hectares present. This habitat type is found the estuary mouths of Langstone and Chichester Harbours. Subtidal sand is the second most common subtidal sediment habitat type in the Solent Maritime SAC comprising 890 hectares, and again found at the mouths of the Langstone and Chichester Harbour estuaries[86].

Table 6.4 Sensitivity, resistance and resilience of sandbanks which are slightly covered by sea water all the time

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Not sensitive to medium	Low-high	Medium-high
Changes in suspended solids (water clarity)	Not sensitive-medium	Medium-high	High
Habitat structure changes - removal of substratum (extraction)	Medium	None	Medium-high
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Low- medium	None- medium	Medium-high
Physical change (to another sediment type)	Medium	Medium	Low
Smothering and siltation rate changes (Heavy)	Low- medium	Low-medium	Medium-high
Smothering and siltation rate changes (Light)	Not-sensitive-low	Medium- high	High
Salinity increase	Medium	None-low	Medium-high

[86] Natural England (March 2020) Designated Sites View: Solent Maritime SAC. Conservation Advice Components: Site Information. Access at https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030059&SiteName=Solent%20Maritime%20SAC&SiteNameDisplay=Solent%20Maritime%20SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=&HasCA=1#SiteInfo. [Accessed June 2021].

6.1.5 Intertidal and subtidal seagrass beds

Intertidal seagrass is a sub-feature of estuaries, and mudflats and sandflats. There are over 200 hectares of intertidal seagrass beds in the Solent Maritime SAC. Three species of seagrass have been recorded in intertidal areas of the Solent Maritime SAC: dwarf eelgrass *Zostera noltii*, common eelgrass Zostera marina and beaked tasselweed *Ruppia maritima*. Seagrass beds are nationally rare and a priority habitat of conservation importance in their own right as well as providing an important feeding resource for overwintering waterfowl, a spawning, nursery and refuge areas for fish. Seagrass habitats have a high sensitivity to most pressures and low resistance and resilience. Intertidal seagrass beds are found within both Langstone and Chichester Harbours. In Langstone Harbour there is an area between Broom Channel and Russell's Lake (south of Farlington Marshes), around Baker's Island, west off Hayling Island and to the south, east of The Kench. In Chichester Harbour there are areas of intertidal seagrass beds to the west of Emsworth Channel, at Stoke and Mengham Salterns (South Hayling), and smaller areas at Cobnor and East Head. Subtidal seagrass beds have not been mapped in proximity to Langstone or Chichester Harbours.

Table 6.5 Sensitivity, resistance and resilience of intertidal and subtidal seagrass beds

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Medium	Low	Medium
Changes in suspended solids (water clarity)	High	Low	Low
Habitat structure changes - removal of substratum (extraction)	High	None	Very Low
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	High	None	Low
Physical change (to another sediment type)	High	Low	Very low
Smothering and siltation rate changes (Heavy)	High	None	Very Low
Smothering and siltation rate changes (Light)	High	None	Very Low
Salinity increase	Medium	Medium	Medium

6.1.6 Annual vegetation of drift lines

The Solent Maritime SAC supports a significant area of vegetated drift lines (also known as strandline habitat or vegetated shingle). This is a rare habitat as its total extent in the UK is estimated to be less than 100 hectares. Annual vegetation of drift lines habitat in the Solent can be found on shingle beaches, shingle spits, shingle islands and chenier banks, which are formed by the deposition of broken shells.

Examples of shingle beach vegetation within the eastern Solent are; along the south coast of Hayling Island and West Wittering. Vegetated shingle islands are present on Pilsey Island in Chichester Harbour and the RSPB islands in Langstone Harbour[87].

[87] Natural England (March 2020) Designated Sites View: Solent Maritime SAC. Conservation Advice Components: Site Information. Access at

Table 6.6 Sensitivity, resistance and resilience of annual vegetation of drift lines

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Medium	Medium	Medium
Barrier to species movement	Medium	Medium	Medium
Changes in suspended solids (water clarity)	Low	High	Medium
Habitat structure changes - removal of substratum (extraction)	Medium	None	Medium
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Medium	Low	Medium
Smothering and siltation rate changes (Heavy)	Medium	High	Medium
Salinity increase	Low	Low	High

6.1.7 Coastal lagoons

The Solent and Isle of Wight SAC includes 14 coastal lagoons. Eight of these are found in marshes in in Keyhaven to Lymington area, behind a sea-wall and as part of a network of saltmarsh ditches and ponds that run along the northern shore-line of the western Solent. The lagoons receive freshwater from rainfall and by marshland streams and sea water by groundwater percolation. Sea wall sluices allow water to exit from the lagoons.

Coastal lagoons within the SACs in the Solent support a number of 'lagoon specialist species', which are almost entirely restricted to lagoons and able to tolerate the stressful environment. Notable species present in these lagoons include the nationally rare lagoon sand shrimp *Gammarus insensibilis*, the starlet sea anemone *Nematostella vectensis*, spire snail *Ventrosia ventrose*, isopod crustaceans *Idotea chelipes,* and amphipod crustaceans *Monocorophium insidiosum*[88,89]. Coastal lagoon species have critical habitat tolerances and are highly vulnerable to changes in hydrological regime, salinity, and sediment disturbance (although will be dependent on the exact species present) [90].

Table 6.7 Sensitivity, resistance and resilience of coastal lagoons

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Low-high	Low-medium	Low-high
Changes in suspended solids (water clarity)	Non sensitive-high	Low-high	Low-high
Habitat structure changes - removal of substratum (extraction)	Medium-high	None	Very Low-medium

https://designatedsites.naturalengland.org.uk/Marine/MarineSiteDetail.aspx?SiteCode=UK0030059&SiteName=Solent%20Maritime%20SAC&SiteNameDisplay=Solent%20Maritime%20SAC&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=&HasCA=1#SiteInfo. [Accessed June 2021].

[88] Bamber, R., McLaverty, C., Robbins, R. and Pérez-Domínguez, R. 2014. Solent & Isle of Wight Lagoons Monitoring Survey Report 2013: Natural England.

[89] Bamber, R. and Robbins, R. 2010. Condition Monitoring of the Isle of Wight Coastal Saline Lagoons, 2010: Natural England.

[90] JNCC (Joint Nature Conservation Committee), 2013. Third Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2007 to December 2012. Conservation status assessment for: H1150: Coastal lagoons.: Joint Nature Conservation Committee (JNCC)

Pressure	Sensitivity	Resistance	Resilience
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Medium	Medium	Low
Physical change (to another sediment type)	High	None	Very low
Smothering and siltation rate changes (Heavy)	Low-high	Low- none	Very low-high
Smothering and siltation rate changes (Light)	Not sensitive- medium	Low-high	Medium-high
Visual disturbance	Not sensitive- medium	Low-high	Medium-high
Salinity increase	Not sensitive- high	Low-high	Medium-high

6.1.8 Intertidal coarse sediments

Intertidal coarse sediments is a sub-feature of estuaries and mudflats and sandflats. The EUNIS biotope associated with this sub-feature is 'A2.111 Barren littoral shingle and there tends to be virtually no macrofauna'. This habitat is found in exposed regions of the Solent, areas of open coast, as well as in the harbour and estuary mouths. The sensitivity ranges from medium to high with very little resistance to the two pressures listed in **Table 6.8**. This habitat has a high resilience to structural changes as there are virtually no associated species and any species that are present are brought into the habitat by the ebbing tide. Resilience against physical changes is low[91].

Table 6.8 Sensitivity, resistance and resilience of intertidal coarse sediments

Pressure	Sensitivity	Resistance	Resilience
Habitat structure changes - removal of substratum (extraction)	Medium	None	High
Physical change (to another sediment type)	High	None	Very low

6.1.9 Intertidal mixed sediments

Intertidal mixed sediment is a sub-feature of estuaries, and mudflats and sandflats. It is found across a range of sites within the Solent including in Langstone Harbour, Chichester Harbour, Southampton Water, along the north coast of the Isle of Wight, the west Hampshire coast and the Hamble Estuary[92]. There are seven EUNIS biotope associated with this sub-feature. The associated biotopes range from not-sensitive to high for most of the pressures with very low to high resilience and none to high resistance. This habitat is more sensitive to the changes in sediment and has very low resilience to this pressure.

[91] Tillin HM, Budd G, and Tyler-Walters H, 2019. Barren littoral shingle. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, Barren littoral shingle. Plymouth: Marine Biological Association of the United Kingdom. Available online at: https://www.marlin.ac.uk/habitat/detail/143 [Accessed: May 2021].

[92] NE (Natural England), 2021. Designated Sites View. Solent Maritime SAC. Advice on Operations. Available online at: https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3 [Accessed May 2021].

Table 6.9 Sensitivity, resistance and resilience of intertidal mixed sediments

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Low	Medium	High
Changes in suspended solids (water clarity)	Not-sensitive	Medium-high	High
Habitat structure changes - removal of substratum (extraction)	Medium	None	High
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Low-medium	Low	Medium-high
Physical change (to another sediment type)	High	Low	Very low
Smothering and siltation rate changes (Heavy)	Low-medium	Low- none	Medium-high
Smothering and siltation rate changes (Light)	Low	Low-medium	High
Salinity increase	Not sensitive-medium	Low-high	Medium-high

6.1.10 Intertidal mud

Intertidal mud is a sub-feature of estuaries, mudflats and sandflats. There are nine EUNIS biotopes associated with this sub-feature. Survey work completed by APEM on behalf of Natural England (reported 2016) concluded that the predominant biotope across much of Langstone Harbour was A2.312 "*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud" (LS.LMu.MEst.HedMac), which was found across the north east of the harbour including SSSI Unit 13[93]. The Solent Intertidal Survey (2005) noted that Langstone Harbour exhibited one of the highest ranges and frequencies of rock shore biotopes in the SAC area[94].

The associated biotopes range from not-sensitive to high for most of the pressures with very low to high resilience and none to high resistance. This habitat is more sensitive to the changes in sediment and has very low resilience to this pressure.

Table 6.10 Sensitivity, resistance and resilience of intertidal mud

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Low	Low-medium	High
Changes in suspended solids (water clarity)	Not-sensitive-low	Medium-high	High
Habitat structure changes - removal of substratum (extraction)	Medium-high	None	Very low-high
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Low	Low-medium	High

[93] Thomas, P.M.D., Pears, S., Hubble, M. & Pérez-Dominguez, R. 2016. Intertidal sediment surveys of Langstone Harbour SSSI, Ryde Sands and Wootton Creek SSSI and Newtown Harbour SSSI. APEM Scientific Report 414122. Natural England, April 2016.
[94] ERT Marine Environmental Consultants (2005) Solent Intertidal Survey, August to September 2005. Final report for English Nature.

Pressure	Sensitivity	Resistance	Resilience
Physical change (to another sediment type)	High	Low-none	Very low
Smothering and siltation rate changes (Heavy)	Low-medium	Low- none	Medium-high
Smothering and siltation rate changes (Light)	Not sensitive-medium	Low-high	Medium-high
Visual disturbance	Not sensitive-low	Medium-high	High
Salinity increase	Not sensitive-low	Low-high	High

6.1.11 Intertidal sand and muddy sand

Intertidal mud is a sub-feature of estuaries and mudflats and sandflats. The extent of the sub-feature within the SAC is over 3,000 hectares, with extensive areas in Langstone and Chichester Harbours. There are ten EUNIS biotope associated with this sub-feature. The associated biotopes range from not sensitive to high for most of the pressures with very low to high resilience and low to no resistance. The associated biotopes are particularly sensitive to the changes in sediment and smothering and has very low resilience to this pressure.

Table 6.11 Sensitivity, resistance and resilience of intertidal sand and muddy sand

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Not sensitive-medium	Low-medium	Medium-high
Changes in suspended solids (water clarity)	Not sensitive-low	Medium-high	High
Habitat structure changes - removal of substratum (extraction)	Medium	None	Medium-high
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Not-sensitive-high	None-high	Low-high
Physical change (to another sediment type)	Medium-high	Low-none	Very low-high
Smothering and siltation rate changes (Heavy)	Low-high	Low- none	Very low-high
Smothering and siltation rate changes (Light)	Not sensitive-medium	Low-none	Medium-high
Salinity increase	Not sensitive-medium	Low-high	Medium-high

6.1.12 Subtidal mixed sediments

Subtidal mixed sediments is a sub-feature of estuaries, mudflats and sandflats, and sandbanks. It is the most common subtidal sediment habitat type in the Solent Maritime SAC, comprising 2,619 hectares, and is widespread in the sub-tidal channels of the harbour systems. There are ten EUNIS biotopes associated with this sub-feature. The associated biotopes range from not sensitive to high for most of the pressures with very low to high resilience and low to no resistance. The associated biotopes are particularly sensitive to the changes in abrasion/disturbance and smothering and has very low resilience to this pressure.

Table 6.12 Sensitivity, resistance and resilience of subtidal mixed sediments

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	Low-high	Low-medium	Low-high
Changes in suspended solids (water clarity)	Not sensitive-low	Low-high	High
Habitat structure changes - removal of substratum (extraction)	Medium-high	None	Very low-high
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Low-medium	Low	Medium-high
Physical change (to another sediment type)	High	Low-none	Very low
Smothering and siltation rate changes (Heavy)	Low-medium	Low- none	Medium-high
Smothering and siltation rate changes (Light)	Low	Low-medium	High
Salinity increase	Not sensitive- medium	Low-high	Medium-high

6.1.13 Subtidal coarse sediments

Subtidal coarse sediments is a sub-feature of estuaries and sandbanks. There are six EUNIS biotopes associated with this sub-feature. The associated biotopes range from not sensitive to high for most of the pressures with very low to high resilience and low to no resistance. The associated biotopes are particularly sensitive to the changes in abrasion/disturbance and smothering and have very low resilience to this pressure.

Table 6.13 Sensitivity, resistance and resilience of subtidal coast sediments

Pressure	Sensitivity	Resistance	Resilience
Abrasion/disturbance of the substrate on the surface of the seabed	High	Low	Low
Changes in suspended solids (water clarity)	Not sensitive-medium	Medium-high	Medium-high
Habitat structure changes - removal of substratum (extraction)	High	None	Low
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	Not sensitive-medium	Low-high	Medium-high
Physical change (to another sediment type)	High	Low-none	Very low
Smothering and siltation rate changes (Heavy)	Medium	Low- high	Low

Pressure	Sensitivity	Resistance	Resilience
Smothering and siltation rate changes (Light)	Not sensitive-high	Low-none	Very low-high
Salinity increase	Not sensitive-medium	Low-none	Medium-high

6.2 Bird Features

A summary of the sensitivity of the qualifying bird features (Chichester and Langstone Harbours SPA, Solent and Southampton Water SPA and Solent and Dorset Coast SPA) is provided in **Table 6.14**. Although the species are not sensitive to changes in salinity directly the supporting habitats are sensitive.

Table 6.14 Sensitivity of bird qualifying features to pressures from coastal infrastructure (intakes and outfalls)[95]

Species[96]	Pressure				
	Above water noise	Changes in suspended solids	Visual disturbance	Introduction of light	Introduction of INNS[97]
Bar-tailed godwit (NB)	High		High	Low	NS
Common tern (B)	High	High	High	Insufficient evidence	High
Curlew (NB)	High		High	Low	NS
Dark bellied brent goose (NB)	Medium		Medium	Medium	Insufficient evidence
Dunlin (NB)	High		High	Low	Medium
Grey plover (NB)	High		High	Low	High
Little tern (B)	High	High	High	Insufficient evidence	High
Pintail (NB)	Low		High	Low	Low
Red-breasted merganser (NB)	High	Medium	High	Medium	NS
Redshank (NB)	High		High	Low	Medium
Ringed plover (NB)	High		High	Low	NS
Sanderling (NB)	High		High	Medium	NS
Sandwich tern (B)	High	High	High	Insufficient evidence	High
Shelduck (NB)	High		High	Low	High

[95] Natural England (March 2021) Designated Sites View. Chichester and Langstone Harbour SPA Advice on Operations. Accessed at https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9011011&SiteName=Chichester+and+Langstone+Harbours+SPA&SiteNameDisplay=Chichester+and+Langstone+Harbours+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=18. [Accessed June 2021].
[96] NB – non breeding, B – breeding.
[97] NS – not sensitive.

Species[96]	Pressure				
	Above water noise	Changes in suspended solids	Visual disturbance	Introduction of light	Introduction of INNS[97]
Shoveler (NB)	Low		NS	Insufficient evidence	NS
Teal (NB)	High		High	Low	Low
Turnstone (NB)	High		Low	Low	NS
Wigeon (NB)	High		Medium	Medium	Insufficient evidence

7 Site Selection Support

The site selection process identified seven possible locations for the water recycling plant in the locality of the [redacted] All are within direct proximity to the Chichester and Langstone Harbours Special Protection Area, and potentially provide functionally linked habitat to the waders and brent geese, as identified through the Solent Wader and Brent Goose Strategy (SW&BGS)[98]. This was a key consideration in determining suitability of the sites for selection.

Table 7.1 Water recycling plant sites and SW&BGS status

Water Recycling Site	Solent Wader and Brent Goose Strategy allocation
WRP_68	Secondary Support Area (H28A)
WRP_70	Secondary Support Area (H27)
WRP_71	Not classified – industrial/built up
WRP_72	Western part classified as Low Use (H08)
WRP_73	Low Use (H07C)
WRP_74	North west part classified as Secondary Support Area (H07B)
WRP_75	Core Area (H07A)

The latest scoring and classification of the sites was based on survey work completed in the East Solent in the winter 2016-17 period. Further data collection and survey work has not been undertaken to inform the site selection work, rather consideration of the likely suitability and mitigation requirements based on the currently SW&BGS allocations.

The SW&BGS identifies functional habitat linked to the Chichester and Langstone Harbours SPA and Solent and Southampton Water SPA. The strategy's aims are cited as; "*The principle objective of the Strategy is to inform decisions relating to strategic planning as well as individual development proposals, to ensure that sufficient feeding and roosting resources continue to be available and the integrity of the network of sites is restored and maintained, in order to ensure the survival of the Solent's coastal bird populations. The underlying principle is to, wherever possible, conserve extant sites and to create new sites, enhancing the quality and extent of the feeding and roosting resource*".

The classification of the sites into Low, Secondary, Primary and Core reflects the usage, and importance as supporting and functionally linked habitat to the SPA. The potential loss of these sites, and ability to mitigate, and therefore avoid an adverse effect on site integrity through the HRA process, is considered in the Mitigation Guidance[99].

Loss of a Core Area is not necessarily mitigatable at Stage 2 Appropriate Assessment, depending on the species that use it and frequency, which would need to be determined through survey work and comparison with historical datasets. The Mitigation Guidance developed alongside the overarching SWBGS continues to reflect the importance of the Core Areas, stating that; "*Core Areas are considered essential to the continued function of the Solent waders and brent goose ecological network and have the strongest functional-linkage to the designated Solent SPAs in terms of their frequency and continuity of use by SPA features. Securing the long term protection and appropriate management of the Core Areas is a key objective for the Solent Waders and Brent Goose Strategy. The unmitigated loss of these sites would impact on the integrity of the SPA over the long term*".

[98] Whitfield, D (2020) Solent Waders and Brent Goose Strategy Hampshire and Isle of Wight Wildlife Trust. Curdridge.
[99] Solent Waders and Brent Goose Strategy Guidance on Mitigation and Off-setting Requirements (October 2018). Accessed at swbgs-mitigation-guidance-oct-2018.pdf (wordpress.com), July 2021.

Therefore, an assessment of replicability would be required, if site WRP_75 were to be used, to determine the ecological function of the Core Area and identify alternative areas that can replicate this. A lack of opportunities, within proximity to the original Core Area, which replicate the site, may make it difficult to achieve this. In addition, the mitigation strategy sets out a list of criteria that the alternative site must meet, including:

- *A suitable replacement site of an equal, or in some circumstances greater, size and quality must be provided in close enough proximity to the Core Area affected to fully replace its ecological function.*
- *The freehold or long term lease (in perpetuity) of the replacement site must be passed to an appropriate conservation body, or the LPA, in a suitable condition and managed in perpetuity as a nature reserve for waders and / or brent geese.*

The loss of a Secondary Support Area is generally considered to be mitigatable, assuming once on-site mitigation is exhausted, suitable like-for-like replacement habitats can be found within the locality, and which is supported by a costed habitat management plan with funding secure in perpetuity. Where like-for-like replacement cannot be achieved, there are circumstances whereby additional 'off-setting' funding is provided to maintain and enhance the wider SW&BG network. The in-combination loss of these sites within other planning and development applications would need to be considered.

A similar approach is applicable to the loss of Low Use sites, with a smaller financial contribution required, reflecting the lower importance of the site in the ecological network.

8 Consideration of Marine Impacts and Mitigation Options

8.1 Construction

There is no requirement for construction activities within the offshore marine area as the [redacted] LSO already exists, and no modifications are required to it, in order to discharge the waste-water from the water recycling plant.

Depending on the final site selected for the WRP, construction works are likely to be required in close proximity to the Storehouse Lake/Brockhampton Mill Lake part of Langstone Harbour. Pipeline infrastructure will be required to transfer a portion of the FE from [redacted] to the new WRP location.

Issues likely to arise during construction are as follows:

- Changes in suspended solids - water clarity and turbidity issues.
- Smothering and siltation rate changes impacting subtidal and intertidal habitats.
- Disturbance of breeding and non-breeding birds within intertidal and terrestrial zones – noise, visual (personnel presence), lighting:
    - possible abandonment of breeding and roosting sites.
    - reduction in foraging areas.

Best practice construction techniques and incorporation of standard pollution prevention measures should minimise the potential for silt laden water runoff from construction sites. Further investigation of the pipeline routes, and potential to impede freshwater flows to the saltmarsh habitats will be required once the WRP site is confirmed and pipeline construction method known. The potential disturbance implications of these works are being considered in a separate ornithological noise assessment (Technical Note 6), and where necessary, works will need to be timed to avoid disturbance.

8.2 Operation

8.2.1 Reject Water Discharge (brine and nitrogen)

8.2.1.1 Overview

The [redacted] LSO already discharges the waste-water from the [redacted] and is subject to a discharge permit with a set of conditions that must be met with regards water quality. When incorporating the additional waste-stream from the water recycling reverse osmosis process, the only two water quality parameters that will change are salinity and nitrogen levels.

Southern Water completed modelling of the changes in these two parameters in May/June 2021 to investigate the impact of the discharge of reject water and brine, in the mid and far-field using a calibrated and validated Mike21 hydrodynamic and water quality model to understand the potential for impacts from these discharges[100]. The modelling was completed for the B5 solution (75Ml/d) i.e., using FE from both [redacted] and [redacted] as the supply to the water recycling plant. Note that for B5, less flow would be discharged via the [redacted] and this is reflected in the modelling for this scenario. Modelling was also completed for the 15Ml/d sweetening flow, which utilises FE from [redacted] only, and is the likely business as usual operational scenario for B2 and B5, and maximum flow for B4. The modelling work considered the dry weather flow with predicted population growth within the catchments, and the headroom available within the existing permits.

As modelling has not been completed for the 61Ml/d option (B2), the results of the modelling completed to date have been used (assuming 15Ml/d as a worst case as smaller change in volume diverted from estuary), plus discussions with the Southern Water engineering and water quality modelling teams (30

[100] Southern Water (June 2021) Water for Life Hampshire Coastal Modelling - Reuse Option Total Nitrogen and Salinity Assessment.

June 2021); to determine likely impacts from this scenario. For the 5Ml/d sweetening flow required for B4, it has been assumed there will be no discernible change over the existing baseline (worse case).

8.2.1.2 Potential Effects and Impacts

The effects likely to arise are as follows:

- Deoxygenation from an increase in area and density of algal blooms smothering the sediment (sandbank qualifying feature) leading to changes in the invertebrate and macrophyte assemblages, and a resulting effect on the prey availability for foraging terns.
- Changes in salinity resulting in a change in availability or composition of prey species for birds.
- Changes in salinity resulting in barrier to movement for migratory fish species.

Salinity

The potential impacts and effects of changes in salinity have been discussed in Section 3.1.1. The Solent Maritime SAC, has the following target/attribute in the Supplementary Advice to Conservation Objectives relevant to salinity:

"Supporting processes: physico-chemical properties (habitat): Maintain the natural physico-chemical properties of the water: The physico-chemical properties that influence habitats include salinity, pH and temperature. They can act alone or in combination to affect habitats and their communities in different ways, depending on species-specific tolerances. In coastal habitats they can vary widely and can influence the abundance, distribution and composition of communities at relatively local scales. Changes in any of these properties, as a result of human activities, may impact habitats and the communities they support."

Nitrogen

The potential impacts and effects of changes in nitrogen have been discussed in Section 3.1.2. To summarise, the majority of nutrient discharge from the [redacted] is via the [redacted] LSO (approximately 5.7km offshore), with nitrogen limits set at 9.7mg/Tn/l for the discharge. As part of work to designate areas as Nitrogen Vulnerable Zones, the Environment Agency assessed the percentage contributions of nitrogen to Portsmouth Harbour, Langstone Harbour and Chichester Harbour using a range of modelling techniques (CPM, SAGIS and Telemac) (see Section 3.1.2). The [redacted] LSO is shown to contribute a small percentage ≤1% of nitrogen to each harbour (measured at the entrance), although in-combination, the nitrogen contribution of offshore WTWs to the three harbours equates to 6% for Langstone, 5-6% for Portsmouth and 4-5% for Chichester. However, for all harbours, the contribution of nitrogen from indirect STWs are the least significant nitrogen input, with diffuse agricultural sources and coastal background being bigger contributors.

The Solent Maritime SAC, Chichester and Langstone Harbours SPA both have targets in the Supplementary Advice to Conservation Objectives for water quality/nutrients:

"*Restore water quality to mean winter dissolved inorganic nitrogen levels at which biological indicators of eutrophication (opportunistic macroalgal and phytoplankton blooms) do not affect the integrity of the site and features*".

Therefore, to avoid adverse effects to site integrity, the following targets should be met, using the WFD opportunistic macroalgae and phytoplankton quality assessment tools to monitor:

- Opportunistic macroalgae levels should be restored so there is no adverse effect to the feature through limited algal cover (< 15 %) and low biomass (< 500 g m^2) of macroalgal blooms in the available intertidal habitat. The area of available intertidal habitat affected by opportunistic macroalgae should be less than 15 %.
- There should also be limited (< 5 %) entrainment of algae in the underlying sediment (all accounting for seasonal variations and fluctuations in growth).

- Phytoplankton levels should be restored to above a WFD assessment tool score of 0.6, where there is only a minor (a) decline in species richness, and (b) disturbance to the diatom-dinoflagellate succession in the spring bloom compared to reference conditions.

The Solent waterbody is not currently classified as eutrophic by the Environment Agency, and therefore a similar source apportionment study has not been completed, favourable condition information is also not available as there are no offshore SSSIs. Given the circulation and mixing within this waterbody, effects are considered less likely. The Solent and Dorset Coast SPA includes the above water quality attribute, however to 'maintain' rather than 'restore', and predominantly covers the estuaries where eutrophication is a known problem (Langstone, Chichester and Poole). Over 80% of the SPA in the wider Solent is considered as being at low risk of eutrophication using the Environment Agency's Weight of Evidence approach. However, the Dutch Nitrogen Case (2018) limits the ability to permit activities which would give rise to 'additional pollution' where a European site is in unfavourable condition.

8.2.1.3 Modelling Results

Reject water from the water recycling process is positively buoyant and will mix through the water column as it rises towards the surface. The model assumed a simple low velocity discharge into the water column therefore outfall dimensions and potential diffuser arrangements were not built into the model output. Detailed modelling for a planning application would need to include the arrangements at [redacted] LSO and confirm requirements for any alterations (currently assumed not to be required as [redacted] LSO built in c.2000) and for the 61Ml/d scenario if this is to be progressed. As requested by Natural England, the detailed modelling should also consider tidal patterns and long-shore drift[101].

Nitrogen

The contour plots for the existing scenario, change under 75Ml/d scenario and change under the 15Ml/d scenario are presented in **Figure 8.1** to **Figure 8.3**, with details of the discharge characteristics presented in **Table 8.1**.

Table 8.1 Flow and nitrogen load for the existing and future scenarios

Discharge	Existing				Future			
	Flow (ML/day)	Flow (m3/s)	TN Load (kg/day)	Conc (mg/l)	Flow (ML/day)	Flow (m3/s)	TN Load (kg/day)	Conc (mg/l)
Scenario -75 ML/D								
[redacted]	92.6	1.07	898.22	9.7	28.12	0.33	272.74	9.7
[redacted]	58.1	0.67	522.90	9.0	15.03	0.17	135.3	9
Reverse Osmosis+ MF Reject					22	0.25	916	41.64
Total to Solent (from PC and BF brine and FE flow)	150.7	1.74	1,421.12	N/A	65.15	0.75	1,324.04	N/A
Scenario -15 ML/D								
[redacted]	92.6	1.07	898.22	9.7	67.12	0.78	651	9.66
[redacted]	58.1	0.67	522.9	9	54.03	0.63	485	9.00
Reverse Osmosis+ MF Reject					4.5	0.05	250	56
Total to Solent (from PC and BF brine and FE flow)	150.7	1.74	1,421.12	N/A	125.65	1.45	1,387	N/A

[101] Natural England (August 2021) Discretionary Advice Service (Charged Advice) DAS UDS 4533 Development proposal and location: Gate two RAPID pre-submission document review.

Figure 8.1 Modelled Mean Total Excess Nitrogen Concentration – Existing Scenario

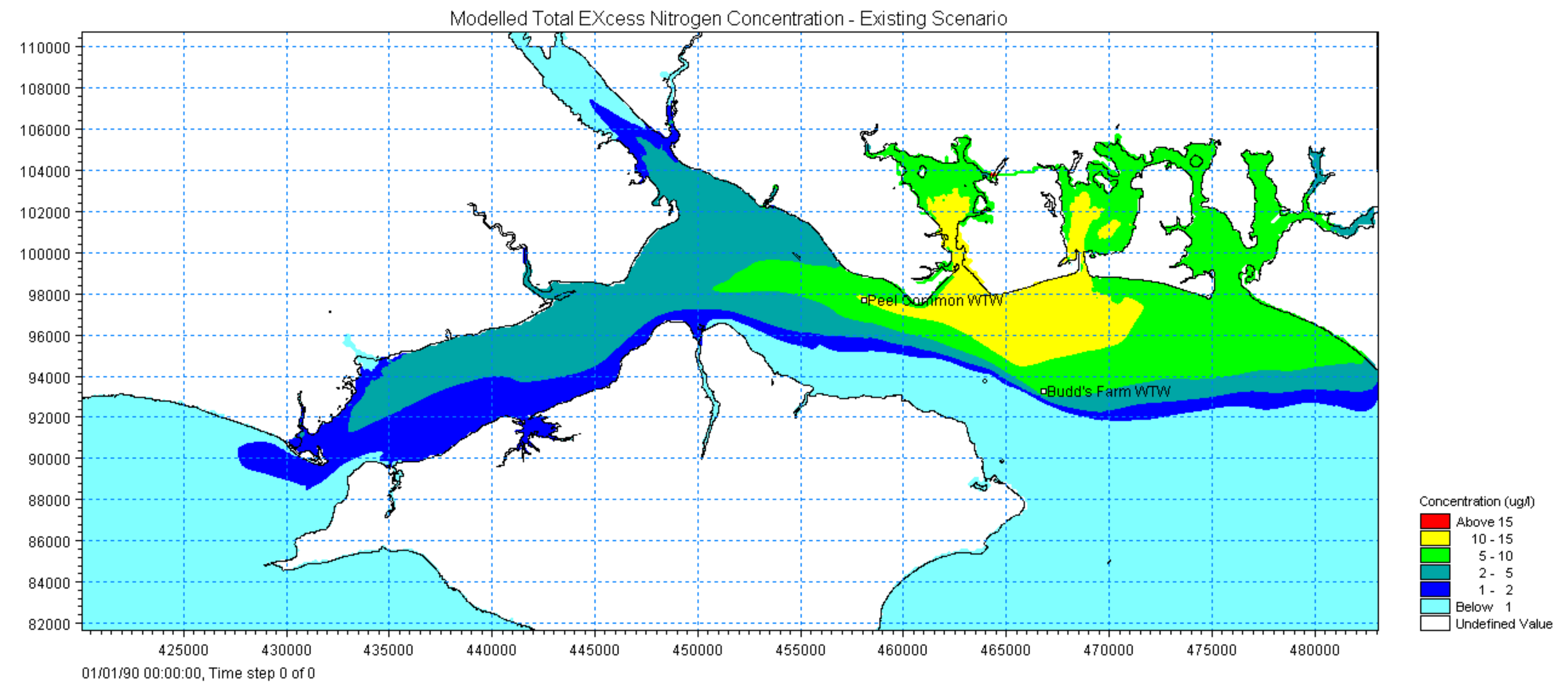


Figure 8.2 Modelled Mean Total Excess Nitrogen concentration – Future Scenario 75ML/D

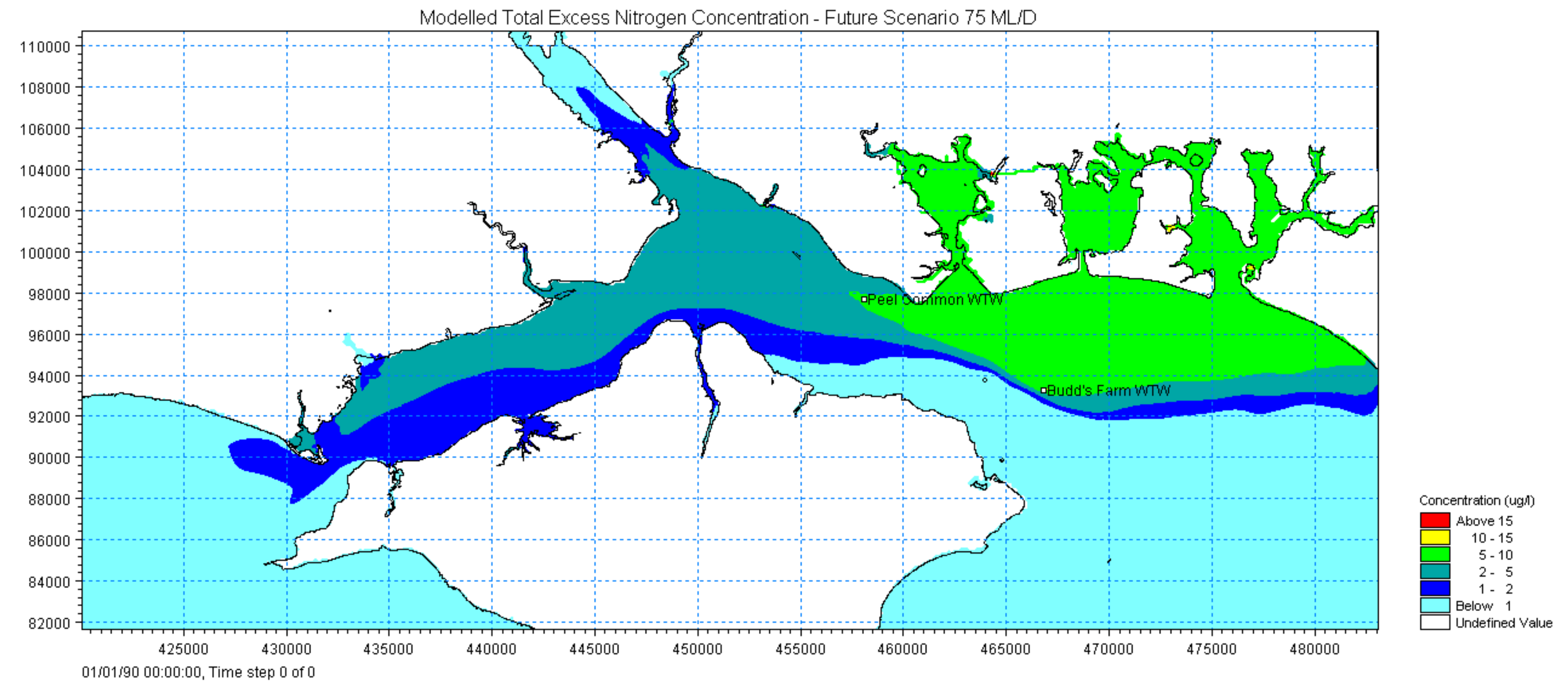
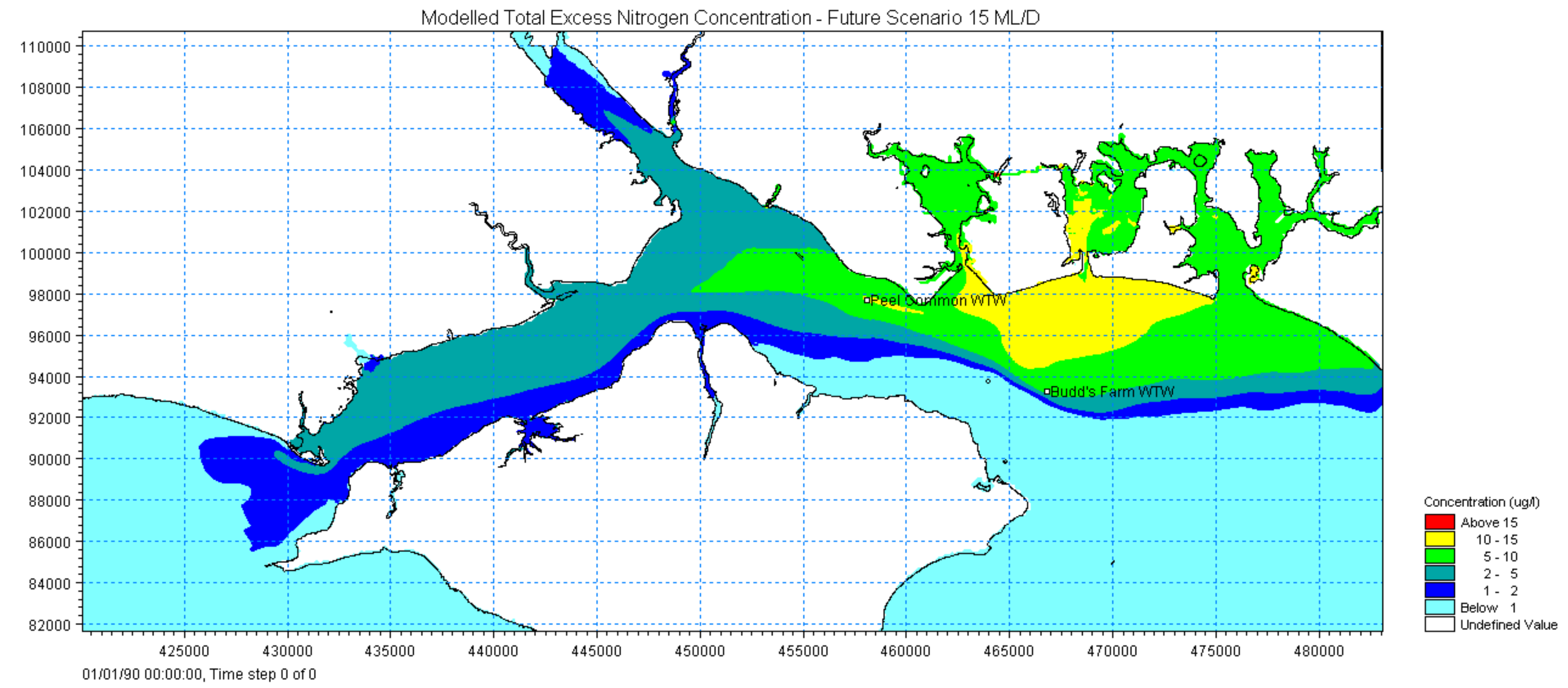


Figure 8.3 Modelled Mean Excess Total Nitrogen concentration – Future Scenario 15ML/D



Salinity

The excess salinity and flow rates are presented in **Table 8.2**, with contour plots of the salinity deficit under existing, future (75Ml/d) and future (15Ml/d) provided in **Figure 8.4** to **Figure 8.6**.

Table 8.2 Flow and excess salinity load for the existing and future scenarios

Discharge	Existing					Future				
	Flow (ML/day)	Flow (m3/s)	TDS Load (kg/day)	Conc (mg/l)	Salinity (psu)	Flow (ML/day)	Flow (m3/s)	TDS Load (kg/day)	Conc (mg/l)	Salinity (psu)
Scenario – 75Ml/d										
[redacted]	92.6	1.07	253,724	2740	2.74	28.12	0.33	77,043	2,740	2.74
[redacted]	58.1	0.67	54,614	940	0.94	15.03	0.17	14,131	940	0.94
Reverse Osmosis						22	0.25	182,457	8,293	8.30
Total to Solent	150.7	1.74	308,338			65.15	0.75	273,631		N/A
Scenario – 15Ml/d										
[redacted]	92.6	1.07	253,724	2740	2.74	67.12	0.78	183,903	2,740	2.74
[redacted]	58.1	0.67	54,614	940	0.94	54.03	0.63	50,791	940	0.94
Reverse Osmosis						4.5	0.05	3,8369	11,928	11.9
Total to Solent	150.7	1.74	308,338			125.65	1.45	273,090		

Figure 8.4 Modelled Maximum Salinity Deficit – Existing Scenario

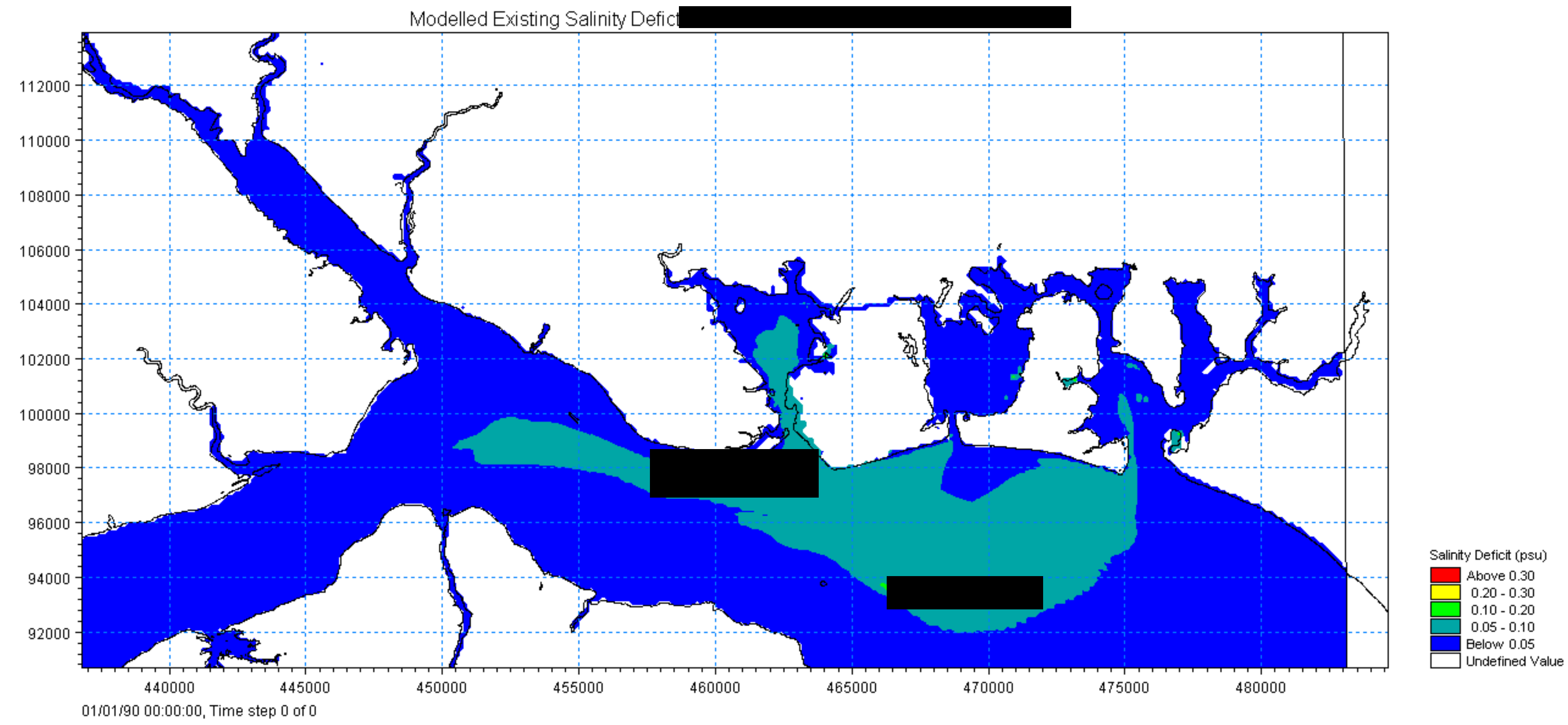


Figure 8.5 Modelled Maximum Salinity Deficit – Future Scenario 75Ml/d

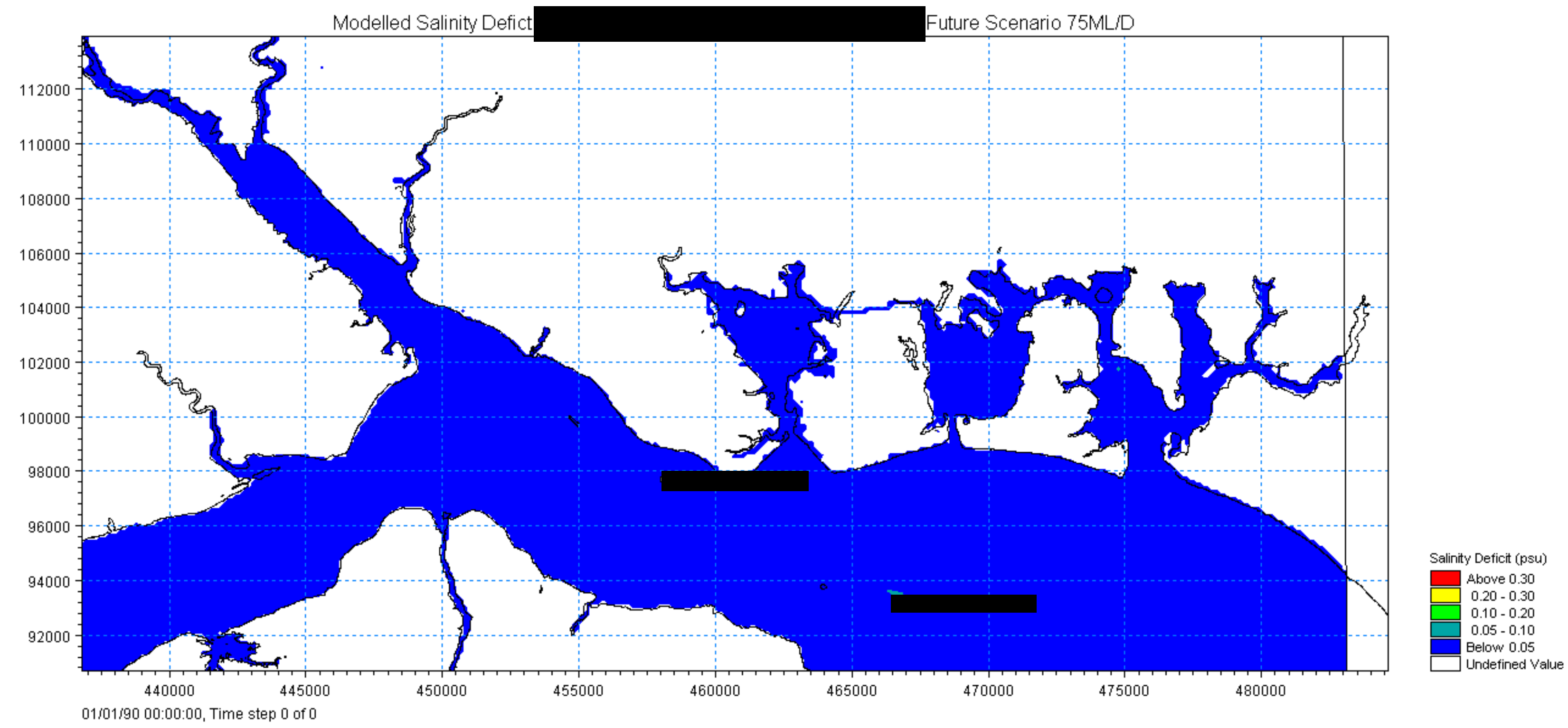
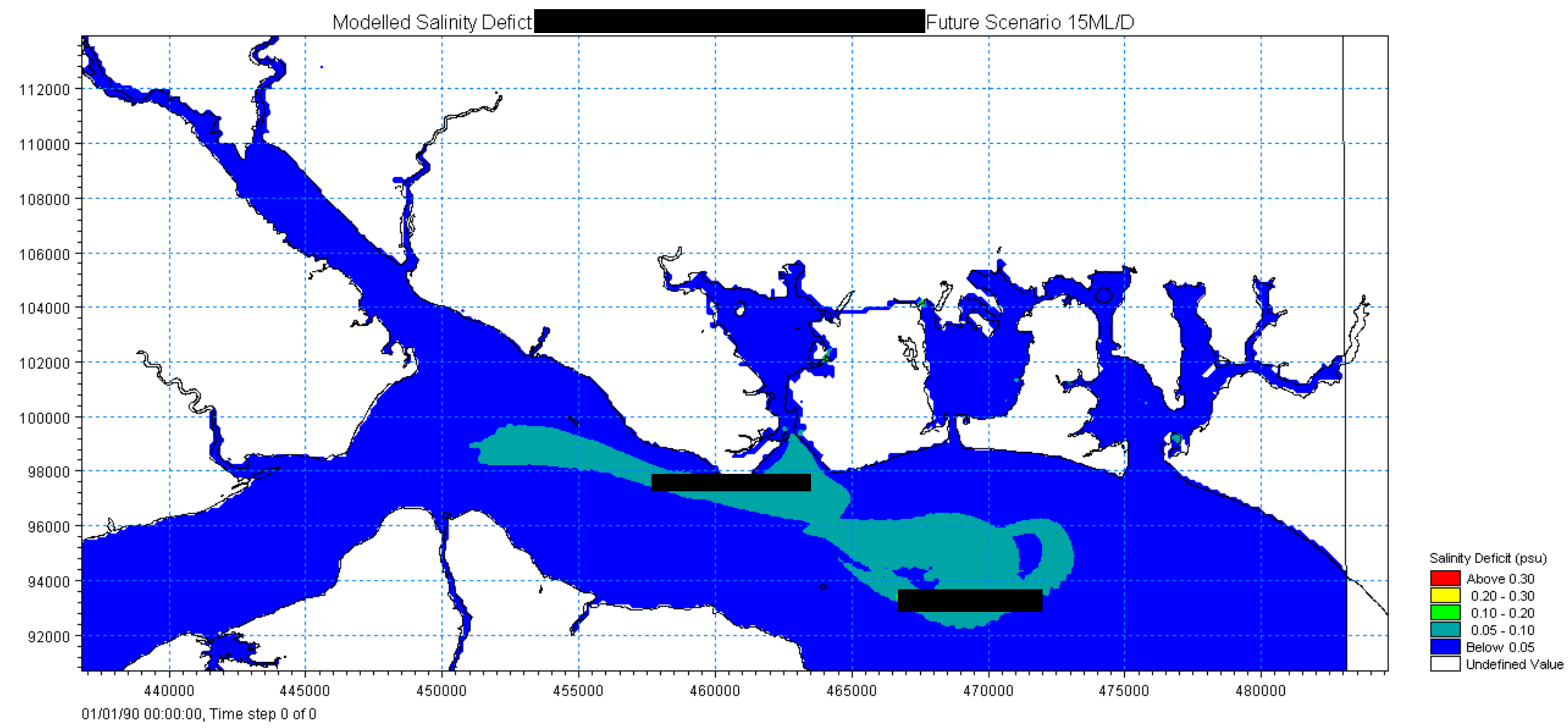


Figure 8.6 Modelled Maximum Salinity Deficit – Future Scenario 15Ml/d



8.2.1.4 Significance

Salinity

The results of the modelling work show that when the water recycling process is added at [redacted] there is less of a deficit in the salinity than under the current conditions i.e. the discharge is more saline than currently, but not above ambient. This is due to the RO waste-stream having a higher salinity than the existing wastewater treatment process waste-stream, the latter being more similar to a freshwater output.

A key point to note is that unlike the hypersaline plume associated with desalination, the plume from the water recycling plant is positively buoyant. This means that the plume will rise through the water column, becoming increasingly diluted. The Solent is subject to strong currents and as such the dilution effects will be strong. The model used in this study does not take account of 3D effects, and as such is likely to be precautionary and underestimate the level of dilution. This conservatism will be accentuated by the fact that the modelling was carried out based on an assumption of calm conditions. It is expected that in reality the discharge will be subject to turbulent mixing within receiving waters.

Therefore, with the resulting discharge reflecting the ambient conditions more closely, there is considered to be limited impact to the Solent European Marine Site, the Solent and Isle of Wight Coastal Lagoons SAC, and the movement of migratory Annex I Atlantic salmon. Advice regarding the sensitivity of tern prey to changes in salinity in the water column suggests a low sensitivity, on the basis that offshore salinity changes are unlikely to persist or be major enough to affect food availability, and is within the natural tolerance range of the biotopes/supporting habitats[102]. In addition, the positive buoyancy of the plume will ensure that there is minimal chance for any changes in discharge characteristics to affect any sensitive benthic habitats or species (e.g., seagrass[103]).

The impacts of salinity from the existing discharge were examined through the Environment Agency's Review of Consents process (c.2005). This concluded that there were no adverse effects from the discharge on the Chichester and Langstone Harbours SPA, either directly to the qualifying features or as a result of impacts to the supporting habitat.

The 'sandbanks which are slightly covered by sea water all the time' qualifying feature of the Solent Maritime SAC is considered to be sensitive to changes in salinity, however the pressure benchmark is set where the salinity changes by one MNCR salinity category, outside the usual range of the biotope/habitat for one year. The Environment Agency Review of Consents process concluded no adverse effects from the existing [redacted] LSO.

With regards migratory fish, the smaller salinity deficit in the area immediately around the outfall and in the mid to far-field, is unlikely to be of significance, given the locality of this in relation to migration routes up Southampton Water. The existing and proposed extent of the discharge plumes do not interact with the mouths of any of the spawning watercourses, and as such disruption to the period of acclimatisation and spawning cues is very unlikely.

As coastal waters and estuaries have a more variable salinity than the offshore environment due to the greater influence of freshwater input in coastal regions, it would be unlikely that changes in salinity offshore would be persistent or major enough to affect food availability for qualifying bird features.

Nitrogen

When the sweetening flow, or maximum flow for B4, (15Ml/d) is in operation, the modelling has shown that there is limited change in the concentrations across the area as a whole, with a slight betterment than the current situation (c.2%) due to process losses of nitrogen. There remains some localised uplift

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[102] Natural England Designated Sites View. Solent and Dorset Coast SPA, Advice on Operations: Outfalls/Intake pipes – salinity increase and salinity decrease. Accessed at https://designatedsites.naturalengland.org.uk/Marine/FAPMatrix.aspx?SiteCode=UK9020330&SiteName=Solent+and+Dorset+Coast+SPA&SiteNameDisplay=Solent+and+Dorset+Coast+SPA&countyCode=&responsiblePerson=&SeaArea=&IFCAArea=&NumMarineSeasonality=3

[103] Not currently recorded in area, based on publicly available habitat mapping. This should be confirmed through site survey work.

to the higher concentrations (<15 µg/l) in the nearfield area surrounding the discharge point, and in the nearshore of the Solent extending between the between the mouths of Portsmouth and Chichester Harbour. There is an increase in concentration at the [redacted] LSO outfall and due to a reduction in flow, there is a shift of higher concentrations (by c.5ug/l) of N along the Hayling Bay shoreline.

This corresponds with the offshore area of the Solent Maritime SAC, characterised as the qualifying feature; H1110 Sandbanks which are slightly covered by sea water all the time, and consisting a mix of subtidal sand and subtidal mixed sediments. With the exception of subtidal seagrass beds, which have not been recorded in Hayling Bay, the remaining sandbank habitats (subtidal coarse sediment, subtidal mixed sediments and subtidal sand) are not categorised as sensitive to nutrient enrichment[104]. This is due to the biotopes being characterised by a lack of species present due to sediment mobility[105]. The features are sensitive to reductions in dissolved oxygen, which could occur due to increases in nutrients, especially in warmer months. However, maintenance of the dissolved oxygen (DO) concentration at levels equating to High Ecological Status (WFD) will ensure no adverse effect. The latter has not been modelled and therefore it is recommended that this, and a survey to confirm the biotopes present on the sandbank be undertaken.

When operational at 75Ml/d, there is a marginal reduction in nitrogen concentration (c.7%) across the wider Solent and harbour systems, although again an increased concentration around the [redacted] LSO. The change in total nitrogen (TN) load is due to the loss from the system through the RO process i.e. some is transferred in the drinking water component for treatment at Otterbourne WSW. When the FE is treated through the RO process, desktop data shows that 18% of the TN goes into the RO permeate (or the treated water) and 82% of the TN goes into the discharge. When the 18% goes to Otterbourne WSW via the environmental buffer, there is further removal of TN through the drinking water treatment process. Any remaining TN goes to the waste-stream; there is no pathway to the River Itchen SAC. The waste-stream at [redacted] LSO is discharged to a better mixing environment than Peel Common, and therefore the waste-stream is more readily dispersed away from the harbours and into the English Channel.

Where changes are seen these can be considered to be positive changes, i.e., a reduction (75Ml/d, uncertainty as to level of reduction under 61Ml/d, if any). The Solent is a eutrophic water body and the unfavourable condition of various sub-features of the Solent Maritime SAC (i.e., intertidal and subtidal eelgrasses) has been in part attributed to nutrient enrichment. A reduction in nitrogen may thus be beneficial for the extent and structure of these beds. However, in all modelled outputs (both existing and future) the extent of this change in nitrogen load (change from existing conditions) does not extend to the Isle of Wight, where there are distinct areas of subtidal seagrass beds along the northern fringes.

The fish and prey species of the terns are susceptible to the pressures of nutrient enrichment. However, there is minimal change in concentration within Langstone and Chichester Harbours under the 15Ml/d sweetening flow, and when operational at 75Ml/d a marginal reduction in concentration in the harbours. Therefore, the immediate feeding grounds around the little tern breeding colonies within the harbour are unlikely to be adversely impacted. Similarly, an increase in concentrations around the outfall in the offshore area are unlikely to adversely impact the prey such that foraging is impacted.

However, further work will be required to demonstrate nutrient neutrality of the solution as the design progresses. If an impact is identified, and mitigation required, an additional nitrogen stripping treatment process can be added to reduce the load further.

[104] Natural England (2021) Designated Sites View: Solent Maritime SAC. Advice on Operations – Outfalls and Intakes.
[105] Tillin, H.M. 2016. Sublittoral coarse sediments in variable salinity (estuaries). In Tyler-Walters H. and Hiscock K. (eds) *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*, [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 29-06-2021]. Available from: https://www.marlin.ac.uk/habitat/detail/53

9 Knowledge and Evidence Gaps

During this assessment, important knowledge and evidence gaps were identified that may subsequently affect an informed assessment of potential impacts of the solution to European designated site qualifying features, and thus the risks to consenting under HRA.

At each stage, a number of gaps have been identified in relation to:

- Solution design information;
- Pressures from changes resulting from the reverse osmosis process;
- Baseline information of the solution area and their broad receptor groups;
- Sensitivity of designated conservation features.

Table 9.1 summarises knowledge gaps identified and describes their potential to constrain the assessment completed.

The assessment of consenting risk could be improved through refinement of the current known solution envelope and construction methods/programme, this in turn will provide a more accurate understanding of the characteristics of each pressure that will impact each feature.

Table 9.1 Review of knowledge and evidence gaps

Information Type	Knowledge/Evidence Gap	Potential Constraints
Project Design	Salinity of discharge	Assumed the constant model parameter. However, this value may naturally change throughout the year and be dependent on site location. The impacts of increased salinities cannot be accurately assessed against a receptor's individual tolerance range, however a broad assessment can be made based on the results of the modelling.
	Chemicals used during processing and presence in the discharge plume (e.g., antiscalants, chlorine)	Currently a paucity of information available to understand the chemicals involved in the water recycling process, and how these will be discharged into the marine environment. As such, no assessment has been completed within this report or the WFD which has been used as a source of information.
	Period of operation (years)	Assumed 100 years. Potential longevity of operations may make it difficult to predict long term effects against natural changes/fluctuations in populations and the surrounding environment.
	Decommissioning options	Assumed all infra-structure is left *in situ* and not removed. This assumption excludes the potential for further physical disturbance to the seabed and surrounding waters should the option of full removal be considered for decommissioning.
	General: Identification of likely **regional** related pressures (expected in UK waters)	An overall paucity of information on impacts from reverse osmosis processes in temperate climates (including the UK), means that assumptions has been made on pressures that may occur in these regions using available evidence.
	Specific: Pressures from hypersaline (brine) discharges	Overall agreement on the potential pressures from brine discharges (the effects), however there is limited agreement on thresholds that are considered significant (or unacceptable) (the effect). This may deem it difficult to confidently ascertain effects from increased salinities on individual receptors for assessment (qualifying features).
	Benthic	EMODnet predictive mapping provides indicative broad scale habitat information for the area but does not detail biotope information of the key benthic species supported on or within these substrates. Only broad scale predictive evaluations can be made, and not site specific, or species-specific assessments that may have important implications for the wider system (e.g. food availability for birds and fish). A survey is required to confirm the biotopes present on the sandbank offshore of Hayling Island (part of Solent Maritime SAC).
	Birds	It is understood that there is a systematic collection of data for bird populations at low tide in the Solent area, that thus focusses on species such as waders, gulls and ducks. However, this data excludes groups such as terns, that may have breeding colonies at sites away from the Project area, but still use it for foraging. It may be difficult to assess accurately the pressures for the different bird functional groups that use the area.
Sensitivity of Nature Conservation Features	Habitats	Locations of specific habitats has been based on priority habitat mapping and EMODnet only at this stage.

10 Conclusions and Next Steps

The existing [redacted] LSO will be utilised as part of the water recycling solution to discharge the waste-stream. The LSO was constructed in c.2000 into a highly mixed zone to disperse the existing waste-stream from [redacted] as effectively as possible.

No construction works are required offshore, and therefore the impacts to the marine environment, and European designated sites (Solent and Dorset Coast SPA, Chichester and Langstone Harbours SPA, Solent Maritime SAC) relate to the waste-stream only.

Three scenarios are being considered for the operation of the water recycling solution; one with use of FE from just [redacted], operating at a 15Ml/d sweetening flow, then at 61Ml/d during drought events (B2), or with a 5Ml/d sweetening flow and then 15Ml/d drought flow (B4). The third uses FE from both [redacted] to supply 75Ml/d during drought events (B5). The latter has been modelled to determine changes in salinity and total nitrogen, as well as the 15Ml/d sweetening flow from just [redacted]. The remaining parameters of the waste-stream will not be changed by the inclusion of the water recycling process and therefore have not been modelled. There is uncertainty as to the chemicals to be used in the process and how these will be discharged, and therefore further work is required prior to Gate 3 to understand the risks associated with this.

The modelling demonstrates that there is a betterment in the salinity changes at the outfall, in that there is less of a difference between the ambient and waste-stream when the water recycling process is operating. This is because the water recycling process adds brine to the otherwise 'freshwater' waste-stream, thereby reducing the difference. Due to the reduction in flow when the water recycling process is added, the area over which the plume disperses interacts with the offshore sandbank slightly more than the current waste-stream. Based on available evidence, it is anticipated that the biotopes of the sandbank are not sensitive to these minor changes in salinity. However, survey work will be required to verify the biotopes present and confirm this conclusion.

The water recycling process itself results in a removal of Total Nitrogen, and the redistribution of a portion of the FE from [redacted] will reduce the flows through the [redacted] LSO, which is a less well mixed environment than the [redacted] LSO. Under the 15Ml/d sweetening flow, and as a worst-case the 61Ml/d solution (as this has not been modelled) there is little change in the concentrations in the wider Solent, although a higher concentration in immediate proximity to the outfall. However, as with the changes in salinity, the reduced flow changes the dispersion pattern slightly, with a greater overlap of the plume with the offshore sandbank and Hayling Island coastline. When operating at 75Ml/d this is less apparent. Further assessment will be required to understand the nutrient budgets of the final solution selected, however additional nitrogen stripping technologies could be incorporated at Budds Farm WTW to provide additional mitigation.

Appendices

Appendix A Stakeholder Comments Log

[redacted]

[redacted]

[redacted]

T: +44 (0) 1235 753000

E: enquiry@ricardo.com

W: ee.ricardo.com