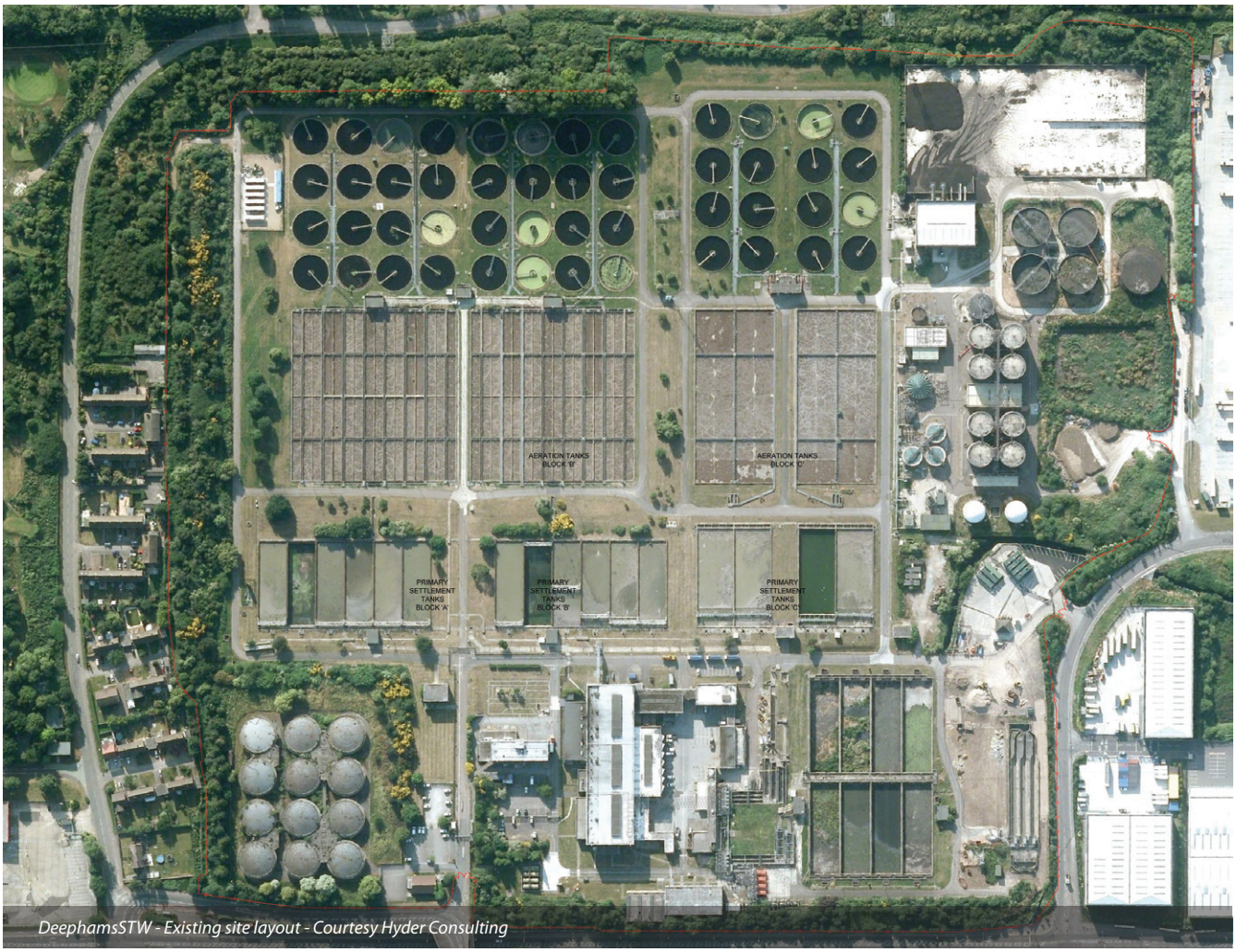
Deephams STW AMP5/6 Quality Upgrade - Phase 1

engineering and design support for the preparation of the needs report, options appraisal, site selection and initial stakeholder engagement

by Edward Ollett BEng (Hons) MICE CEng

Deephams is Thames Water's fourth largest sewage treatment works and currently serves a population equivalent (PE) of 885,000. As part of the upgrade it is proposed to increase the capacity to 941,000 PE and be designed to accept a peak design flow to full treatment of 497Mld. Under the Freshwater Fish Directive and the Water Framework Directive, the consent conditions for suspended solids, biochemical oxygen demand and total ammonia are to be tightened to 10mg/l, 5mg/l and 1mg/l N respectively on 31 March 2017 with an existing 1mg/l Phosphorous consent remaining.



DeephamsSTW - Existing site layout - Courtesy Hyder Consulting

Existing situation

The existing Deephams Sewage Treatment Works uses a diffused aeration process and was constructed in three equal capacity effluent treatment streams known as A, B and C on a constrained 35 hectare site which includes primary and secondary treatment. Stream A dates from the early 1950s, stream B from 1956 and stream C from 1966.

Future situation

To meet the new consent it is proposed to construct new primary, secondary and tertiary treatment facilities, as it is not considered practical to modify the facilities in the existing works to meet the new consent, whilst maintaining the existing consent. Hyder Consulting provided Thames Water with engineering and design support to the preparation of the needs report, options appraisal, site selection process and the initial engagement of stakeholders. This included supporting the comparative assessments of the existing asset and presenting possible alternative sites and treatment technologies for a new effluent treatment stream (primary, secondary and tertiary) plant to meet the new consent.

Thames Water, in conjunction with Hyder and the wider project team including Adams Hendry and Cascade Consulting, considered the use of a number of treatment technology options to deliver the upgrade, both on and off site, and assessed them based on a set of predetermined selection criteria and constraints.

However, the limitations of the existing site place significant additional engineering constraints on Thames Water's ability to implement the upgrade within the boundaries of the existing

sewage works site. This includes significant time pressures on the delivery of the upgrade at the existing site, with a different programme of construction required for 'on-site' solutions to any associated with the development at a wholly new site.

At the same time as considering on-site options, Thames Water assessed whether there were any potential new sites within the area that could be developed for sewage treatment use. If a suitable new site was to be identified, certain existing sewage treatment operations at Deephams would always be retained at the existing site; for example the inlet pumping stations and preliminary treatment process, treatment of sewage sludge and discharge of final effluent.

A multi-stage appraisal process was used for the assessment of wastewater treatment technology options and potential sites process. The key stages in the methodology areas follows.

Strategic analysis of options

A range of strategies was identified for achieving the required improvements in the quality of the treated wastewater, including:

- ***Strategy 1***: reduce or remove enough of the incoming flow to Deephams STW to permit each of the existing three treatment streams to be turned off and upgraded in turn.
- ***Strategy 2***: combine various options from Strategy 1 to reduce or remove incoming flow to Deephams STW.
- ***Strategy 3***: build part of a new sewage works on another site and transfer flows between the new plant and the existing Deephams Sewage Works for treatment.
- ***Strategy 4***: construct on Deephams STW.

The conclusion of this work was that the most appropriate options for delivering the necessary improvements in the quality of the treated wastewater was either through upgrading the treatment facilities on the existing Deephams STW site, or through building a new sewage works on a new site elsewhere.

Site search

The minimum area assessed to treat flows to the required standard using advance treatment technologies such as biological aerated flooded filter (BAFF) or membrane bio-reactors (MBRs) was 8Ha. Traditional process technologies, such as activated sludge, were considerably more land intensive, requiring up to 25Ha.

As it was proposed to retain the existing incoming sewers and terminal pumping stations at Deephams, additional pumping would be required to deliver flows to and from any new treatment site. The limit of the search area for potential new sites was set at the point where the energy needed for pumping was no greater than 20% of the energy that the current Deephams sewage treatment process requires from the mains electrical supply. This is considered to be a reasonable and appropriate threshold, being at the limits of what could be considered environmentally acceptable. This criterion gave a search area of approximately 3km diameter, centred on the existing works. Within the 3km radius the search produced an initial long-list of 22 sites.

Engineering assessment of potentially feasible treatment options

In order to meet the new 2017 Deephams consent, Hyder evaluated a number of different process options for the different stages involved in sewage treatment. The key differentiator was the choice of the technologies applied to the secondary treatment stage. These were:

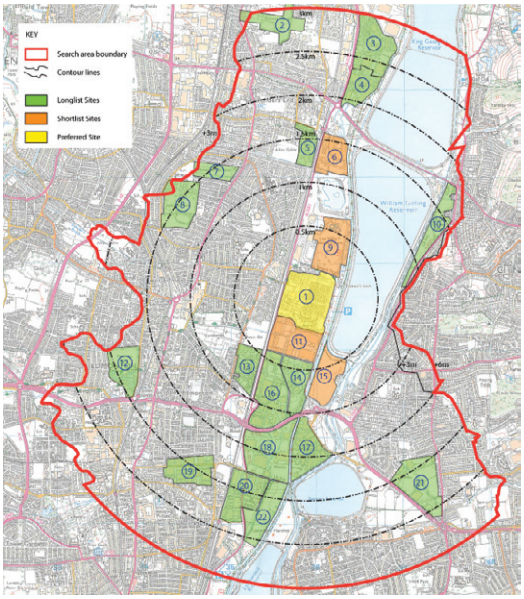
- Conventional activated sludge (AS).
- Moving bed bioreactor or integrated fixed film activated sludge (MBBR or IFAS).
- 2-stage biological aerated flooded filter (BAFF).
- Sequencing batch reactors (SBRs).
- Membrane bio-reactors (MBR).
- Activated Sludge followed by nitrifying submerged aerating filter (N-SAF).
- Bio-tower and N-SAF.

The primary treatment options include lamellas and both conventional radial and horizontal flow settlement tanks. To meet the 1mg/l phosphorous removal standard it was necessary to dose chemicals either before the primary treatment stage or into the aeration lane.

Tertiary treatment was required to meet the consent and at this preliminary stage it was assumed to be deep bed sand filtration (or rapid gravity filters).

Shortlist of sites

Potential sites were assessed using a number of criteria agreed by the project team, in consultation with stakeholders, including legal and planning issues, as well physical conditions such as ease



Deephams STW - Existing Site Layout
Courtesy of Hyder Consulting

DeephamsSTW - the wider area
Courtesy of Hyder Consulting/Google Earth

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of access, risk of flooding, environmental sensitivity and impact on the local community. Using the assessment criteria the project team reduced the initial long-list selection of 22 sites to a shortlist of five sites.

A more detailed assessment of the five shortlisted sites using similar criteria but also including whole life cost estimates, concluded that the existing Deephams STW site was the preferred development site. The main drivers for staying on site were feedback from key local stakeholder organisations and the Environment Agency requirement to discharge treated effluent at the current location, which would require flows to be pumped to and potentially from any new site. Construction on the existing site is also in line with national, regional and local planning authorities' policies.

Shortlist of treatment options

The four secondary treatment process technologies that passed an initial screening exercise undertaken by the project team were conventional activated sludge, IFAS, BAFF and MBR.

For the assessment, Hyder paired each secondary technology with an appropriate primary treatment configuration i.e. compact secondary treatment technologies were paired with the more compact lamella primary treatment units to maximise space savings. Conventional final settlement and sand filter tertiary treatment were required after both the conventional activated sludge and IFAS treatments.

The outcome of this evaluation recommended the use of conventional activated sludge as the preferred technology, with IFAS as second choice. Use of BAFF and MBR systems for treatment of 100% of design flows were rejected on a number of grounds. BAFF systems were not considered to be as sustainable as conventional activated sludge with the use of three, and potentially four stages being required to treat to the desired standards, increasing power demands. The MBR systems had significantly higher whole life cost due to the need to allow for periodic membrane replacement. There was also limited experience of MBR plants working on the scale required for Deephams STW.

It was identified that the use of MBR technology as a possible hybrid solution which could be used in combination with conventional activated sludge. Due to its small footprint, the first phase of a hybrid solution involving use of MBR technology offered most benefits when examining options for redevelopment on the existing site.

Combined assessment of shortlisted options and sites

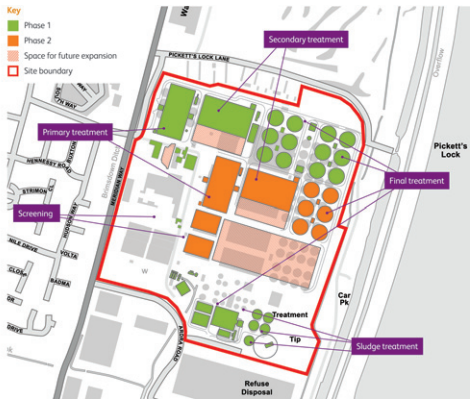
As part of the assessment, the project team considered a number of issues including:

- Flood risk associated with the five shortlisted sites. Assessments were undertaken to quantify impacts on the proposed development and effects on third parties.
- Odour arising from the new works. Odour models were developed to quantify the effects of any new works on the odour profile within the area.
- Options to generate a minimum of 20% of the additional power demands of the new development from renewable sources.

When combined with the site and process option assessment, this allowed us to identify three options for public consultation.

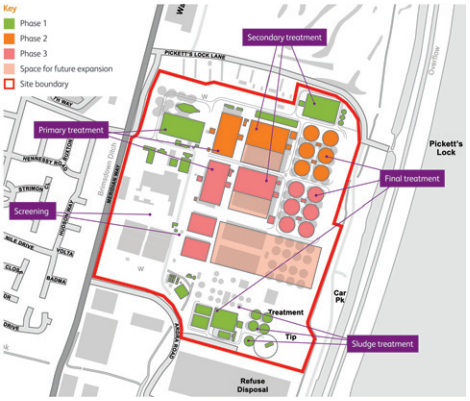
Owing to the technical and operational complexity of the Deephams upgrade, together with planning and programme challenges, Thames Water adopted an Early Contractor Involvement (ECI) procurement strategy. This approach (in progress at the time of writing) aims to encourage innovation and allow the contractor to review the options developed by Hyder and select the most

Deephams catchment area Courtesy of Hyder Consulting

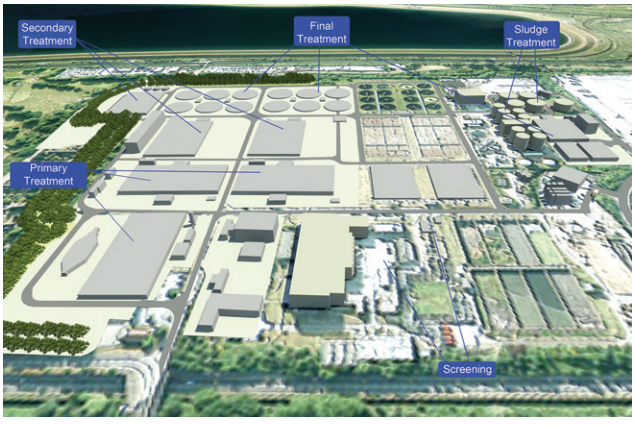


Option 1 - Conventional Activated Sludge on Deephams
Courtesy Hyder Consulting

Option 2 - IFAS on Deephams
Courtesy Hyder Consulting



Option 3 - 33% MBR Hybrid on Deephams
Courtesy Hyder Consulting



3D image of (Option 3) 33% MBR Hybrid - Courtesy of Hyder Consulting

appropriate technology to provide best value, mitigate operational compliance risk during delivery and meet the required programme. This solution will be used for obtaining planning permission, ensuring contractor buy-in. However it means that only the preferred site for the development could be selected following the first phase of consultation.

Preferred options

A conventional activated sludge treatment plant on the existing site at Deephams was considered by Hyder to be the preferred option however, due to programme constraints on the construction of the preferred option, two other solutions are also selected.

Option 1: Conventional Activated Sludge on Deephams: This option considers constructing 100% of the proposed works on the existing Deephams STW site, employing a conventional activated sludge process with conventional primary treatment, pre-dose phosphorous removal and the addition of rapid gravity filter tertiary treatment.

The shortlisted option chosen is built in two construction phases and requires the temporary use of IFAS within the existing B and C stream activated sludge lanes. Once the temporary IFAS is installed, the A stream is decommissioned allowing the first build phase to be completed.

Option 2: IFAS on Deephams: This option considers constructing 100% of the proposed works on the existing Deephams STW site employing an Integrated fixed-film activated sludge (IFAS) process with conventional primary treatment, pre-dose Phosphorous removal and the addition of rapid gravity filter tertiary treatment. The plant is built in three construction phases to allow the existing works to remain operational and meet the current Environment Agency consent during construction.

The proposed arrangement allows the first new treatment stream to be constructed off-line. Once completed, this will allow decommissioning of existing stream A to facilitate construction of the second new treatment stream without reducing the current treatment capacity.

Option 3: 33% MBR Hybrid on Deephams: This option considers constructing 100% of the proposed works on the existing Deephams STW site. It proposes the flow through the works is split into three equal streams. One stream (33%) would employ a membrane bio-reactor (MBR) process, conventional primary treatment and pre-dosing for phosphorous removal. The other two streams (67%) would employ conventional activated sludge, conventional primary treatment, pre-dose phosphorous removal and the expansion of the existing disc filter tertiary treatment plant.

The proposed arrangement allows the new MBR treatment stream to be constructed off-line. Once completed, this will allow decommissioning of stream A to facilitate construction of the second new treatment stream without reducing the current treatment capacity – thus the existing works remains operational and meets the current Environment Agency consent during construction.

These three options formed the basis of a consultation undertaken in mid-2012 to obtain feedback from the local community on various aspects of the development of a new STW at Deephams. ECI contractors have been engaged to work with Thames Water on development of detailed tender designs for the new works and it is anticipated that a contractor will be appointed in late 2013 to allow a planning submission to be completed in 2014.

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