Thames Gateway Water Treatment Plant

150,000 m³/day Desalination Plant

The combination of climate change and population expansion means that water demand in London will outstrip supply unless additional water resources are developed. An increase of approximately 380,000 in the population of London by 2016 is forecast. Much of London's water supply is classed by the UK Environment Agency as "seriously water stressed", with customers at risk of water restrictions during extended periods of dry weather.

Extraction point on the River Thames *Courtesy of Harrier Photography*

View from River Thames during construction of the extraction platform *Courtesy of Harrier Photography*

Much is being done to reduce water demand through the promotion of water-saving technology and increased water metering. Record sums are also being invested to tackle long-term leakage from the water distribution network. Thames Water is currently in the process of replacing ageing pipe work, much of which dates back more than 100 years.

To maintain the supply-demand balance within London, a 150,000m³/day reverse osmosis desalination facility is being constructed to treat brackish water abstracted from the Thames estuary. The plant is located on the north shore of the River Thames at Beckton, in the London Borough of Newham, and is scheduled to produce treated water by early in 2010. The tidal stretch of the river provides a practically limitless supply of water that can be harnessed without further stressing the environment.

Tidal and seasonal variability

The tidal and seasonal variability of the raw water in terms of salinity, temperature, and concentrations of dissolved and particulate organic and inorganic matter present unique treatment challenges. A pilot plant was commissioned at the proposed site in 2003 and was operated for a period of 18 months to test candidate pre-treatment technologies, and to define the raw water design envelope and full-scale plant process design criteria. The process design includes raw water intake via screens, raw water storage, mixing and equalisation, coagulation, flocculation, lamella clarification, pressure sand filtration, ultrafiltration (UF), a four stage reverse osmosis (RO) system, and post treatment including re-mineralisation, disinfection and plumbosolvency control.

Design innovations

A number of design innovations have been employed to minimise the specific energy consumption of the treatment process. The raw water storage and equalisation tank allows for raw water abstraction to be constrained to three hours per tidal cycle, on an ebb tide approaching low tide conditions. Thus the raw water salt concentration and power consumption is minimised. As well as including Pelton Turbines to recover the energy of the reject stream, the feed pumps of each of the four reverse osmosis stages are equipped with variable speed drives to reduce energy losses through throttling when the raw water osmotic pressure is low. The plant's energy demand will be met by renewable energy.

An initial feasibility study was conducted to identify the most appropriate site to locate the treatment plant and to connect to the distribution network, and to select the most appropriate treatment technologies and to develop capital and operational cost estimates. A pilot plant was designed, and construction was commenced at the selected site, to trial candidate pre-treatment technologies as well as the reverse osmosis process and post treatment.

The project was competitively tendered and a design and construct contract was awarded to a joint venture formed by Interserve and PRIDESA (now Acciona Agua). The joint venture offered the combination of Interserve's UK water industry project management and construction experience, and PRIDESA's track record in designing and operating reverse osmosis desalination plants.

Project development

The development of the project was split into stages, which are outlined below:

Stage 1:
- Background study and preliminary environmental impact;
- Preliminary project design development.

Stage 2:
- Outline Design;
- Preparation of Planning Application;
- Environmental impact assessment;
- Operation of the pilot plant;
- Project cost development.

Stage 3:
- Detailed design;
- Development of specifications;
- Development of construction, procurement, erection and commissioning programs;
- Continued operation of the pilot plant;
- Cost development towards final target cost;
- Site clearance, demolition and enabling works.

. Design . Supply . Installation . Construct . Commissioning .

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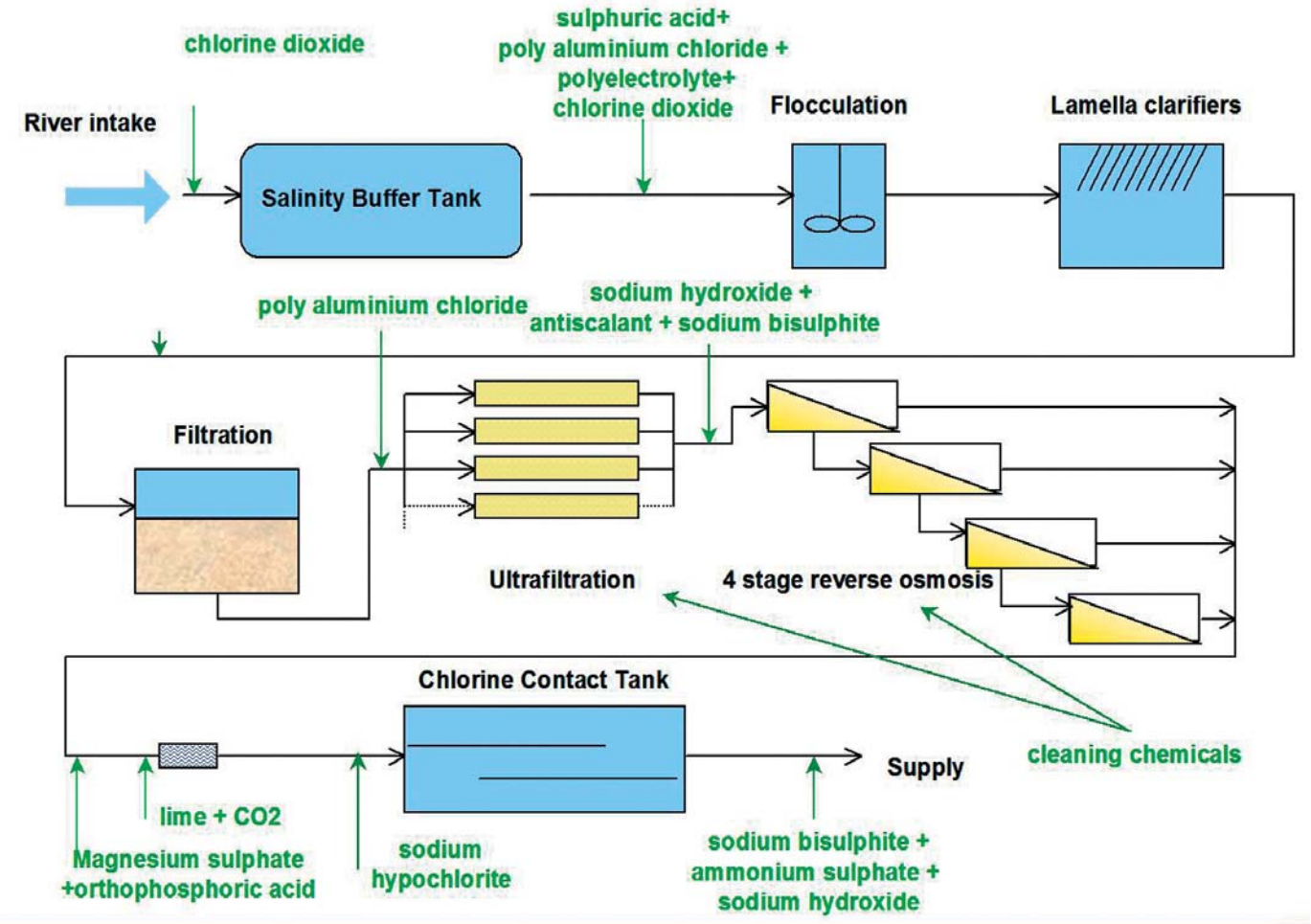

Figure 1: Beckton Desalination Plant process schematic

The project was started in January 2008, with a 24-month programme to construct and commission the plant. The plant is scheduled to produce treated water by early in 2010.

Figure 1 above shows a schematic of the water treatment processes adopted for the Beckton Desalination Plant:

Raw Water Intake

The raw water will be abstracted from the river Thames from a fixed height of approximately 3m above the riverbed, in order to avoid abstracting from within the sediment layer, and thus minimise the suspended solids within the raw water, the tidal range is significant, with the difference between high and low tides being up to 7m on spring tides.

The abstracted water will pass through copper-nickel passive wedge wire screen with an aperture size of 3mm. The screens will be periodically cleaned using an air scour system. The intake structure will also include an Acoustic Fish Deterrent and a raw water quality monitoring station.

The intake pumps will discharge via two No. 1400 mm diameter raw water transfer pipes, which are supported on new raking piles and steel trestles spanning from the intake structure to the Salinity Buffer Tanks.

Raw water is pumped intermittently to the Salinity Buffer Tank, and is transferred continuously from the Salinity Buffer Tank through the pre-treatment, reverse osmosis and post-treatment unit processes.

These structures existed prior to the project, having historically been used as shipping compartments storing sewage sludge prior to disposal at sea. The salinity buffer tanks provide some 175,000m^3 of storage.

Processes

Following buffering, the water passes to three lamella clarifiers. The lamella zones contain inclined honeycomb plates that promote laminar flow conditions to improve the settlement of solids. Clarified water from the lamella plates flows into collection launders.

The sludge that settles in the maturation and lamella zones is scraped to a central collection chamber, and re-circulated to the flocculation chamber. Excess sludge is periodically pumped to waste from the sludge collection of each lamella clarifier.

The clarified water is pumped from a storage tank through the remainder of the pre-treatment processes, to the suction of the RO first stage feed pumps without further hydraulic breaks.

Aerial view of buffer tanks *Courtesy of Harrier Photography*

There are two stages of filtration prior to the reverse osmosis stage. The first stage is pressure media filtration, where the clarified water passes through seventeen pressure filters containing a bed of 0.8mm to 1.6mm expanded clay to remove the carry over of fine suspended solids not removed by the lamella clarifiers. The pressure filters are fabricated from duplex stainless steel, and each has a nominal filtration area of 50m².

The second stage of filtration is ultrafiltration using Norit Xiga SXL 225 membranes. The ultrafiltration stage comprises 42 trains. Ultrafiltration provides a barrier against viruses and other pathogens that can be automatically integrity tested.

The reverse osmosis plant is divided into three streams, each of a nominal 50 Mld capacity. Each stream is identical, comprising four brine stages. The configuration was selected to maximise the overall system recovery to 84%. The permeate from the four RO stages flows via a common pipe to the post-treatment plant.

The treated water quality specification, developed to ensure that the treated water:

Visualisation of the Reverse Osmosis building *Courtesy of Broadway Malyan*

- Is compliant with UK legislation and Thames Water internal standards;
- Is non-aggressive to the distribution network (slightly scale forming);
- Minimises the impact on domestic and commercial customers.

A number of innovative measures have been included to minimize the specific energy consumption of the plant, including:

- The high storage capacity of the salinity buffer tank means that raw water abstraction can be targeted towards minimizing the salinity of the raw water on each tidal cycle, and hence the specific energy consumption of the RO process;
- Using variable speed drives on the four stages of RO feed pumps reduces energy wastage through permeate throttling;
- The use of Pelton turbines to recover energy from the reject stream;
- Innovative electrical engineering including the use of higher voltage transmission (33 kV as opposed to 11 kV), water cooled switch gear as opposed to air cooling and intelligent assemblies, which can monitor electrical energy use and efficiency to switch off non-essential power use during peak demands, and optimize running plant to the most efficient available.

The Beckton Desalination Plant provdes a new water resource to maintain the water supply-demand balances within London.

A comprehensive pilot-testing programme has allowed the variability of the raw water source to be measured, and an appropriate and robust design to be developed that is capable of producing wholesome treated water.

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