SDP Capital Works
Project Summary

Project Title / Asset	Lime System Efficiency Improvements
Project Driver	Reliability / Efficiency

Purpose

The purpose of this document is to provide a high-level overview for major projects, further detailed information is available on request. Major projects have been defined as any capital expenditure that includes the addition of new assets to the Sydney Desalination Plant (Plant).

Information/justification on other elements of the proposed capex program (e.g. refurbishments and replacements of existing assets) are available on request.

Project Background

The lime plant produces lime water (calcium hydroxide solution close to saturation) from powdered hydrated lime for the purposes of remineralising the blended RO permeate. The process involved is as follows:

- Powdered hydrated lime is metered into 4 small mixing tanks (3 duty, 1 standby) with a fixed flow of service water to form a lime slurry;
- The lime slurry is pumped into 3 saturators (all duty) where a measured amount of additional service water is added to dissolve the lime slurry;
- In the saturators, the insoluble material in the hydrated lime and any undissolved lime settles. The settled sludge is collected by rake and periodically pumped out as waste sludge. To improve dissolution efficiency and settling (via flocculation), some of the sludge is continuously recirculated back into the feed well by a draft tube mixer; and
- Clarified lime water (supernatant) overflows from the saturators to a lime water holding tank, which is dosed into the permeate headers.

Whilst the lime plant is presently able to meet production demands, there are several items relating to reliability, maintenance, efficiency, flexibility, equipment obsolescence, and operability that Sydney Desalination Plant Pty Limited (SDP) and the Operator believes is worth investigating to provide a range of improvements.

The key objectives for the project are to modify the existing design of the system based on operational knowledge and experience to drive efficiencies and to improve reliability and availability by improving maintainability of the system especially in the new operating environment of variable Plant production.

Asset Details

Asset	Lime System
Asset durability/ design intent/ asset management Strategy	Mechanical assets: 25 years Electrical assets: 25 years Instrumentation / control assets: 15 years Preventative maintenance will be required on the new assets, consistent with the current/existing maintenance schedules and OEM recommendations.

Asset Function/ Subsystem/ System	Hydrated lime used for permeate water remineralisation and it contains impurities that need to be removed to enable lime to be added to the RO permeate and not affect the turbidity of the drinking water. Lime is delivered on site and stored in two silos. Each silo feeds into two lime slurry tanks where remineralisation service water (RO permeate) mixes with the powdered lime to create a slurry. A transfer pump is provided for each tank to pump the lime slurry into the lime saturators. A remineralisation service water line makes up the main feed to each of the lime saturators. Before entering the saturators, the water is dosed with sodium silicate (to aid coagulation and for turbidity control) followed by lime slurry. Polymer is dosed into the saturator to aid in the coagulation and flocculation of the undissolved particles. The saturators produce lime water, a saturated solution of calcium hydroxide without any undissolved particles, which overflows as supernatant. The undissolved particles settle to the bottom of the saturators and are removed as lime sludge. There are three saturators. Two can produce enough lime water for the plant to operate at full capacity, but normally all three saturators are in operation. The lime water gravitates into the lime water tank where it is drawn and dosed by six dosing pumps into the RO permeate water for remineralisation.
Asset Failure and its consequence	Failure of the lime system would result in loss of remineralisation and loss of production, however the system has redundancy in terms of tanks and pumps (excluding the limewater tank which has no redundancy).

Justification

The key objectives for the proposed modifications are to improve reliability and reduce operating costs. Investigation into various options has been conducted and theoretical savings have been estimated. These savings show there is an opportunity to improve the efficiency of the system and reduce lime consumption and lime sludge disposal. Further benefits may also result in reduced breakdowns, maintenance, and other operational efficiencies for the Plant.

The proposed upgrades are aimed at the following:

- Reduce lime consumption,
- Reduce lime waste disposal costs,
- Reduce time required for maintenance activities during shutdowns,
- Increase reliability of Plant, and
- Increase accuracy of Plant operation.

Each improvement will seek to have a measurable outcome, which will be assessed following completion, in order to provide a quantifiable long-term saving to the customers through reduced operating and maintenance costs.

SDP's new operating environment enables Sydney Water to make production requests which directly relate to the production output of the Plant. These production requests will be for annual production, generally at a level which inversely corresponds to the amount of volume in Sydney's dams and consideration of other factors, and other requests for increased production at short notice. SDP does not have control over how much or how little the Plant will produce, and when the other requests are made. This has three implications to this project:

1. The majority of cost savings contemplated by this project are due to a reduction in treatment cost or lime sludge disposal cost per unit of water produced. Since SDP has little control over the volume it produces, it is impossible to make accurate net present value (NPV) calculations, or characterise whether an efficiency capex/opex trade-off will be realised during the 2023-2027 Regulatory Period, or in subsequent Regulatory Periods.
2. Sydney Water has communicated the desire for the Plant to be ready to increase production at short notice, however the Plant was not designed for this duty. Ramping up capacity of the lime system, or starting up the system after periods of inactivity is one of the most challenging tasks during an increase of Plant output, and this project seeks to provide better capability to respond to this emerging operational need.
3. The emerging need for the Plant to be available to increase production for as much of the year as possible (as opposed to delivering a long term average production volume only) also requires that routine maintenance that leads to temporary capacity downgrades is optimised. This project seeks to provide better capability to access the system to clean or troubleshoot, therefore reducing ‘downtime’.

In addition, SDP has proposed an efficiency target of 0.3% per annum. While some efficiency gains will be realised by optimisation of processes without capital investment (e.g. optimised chemical dose rate), SDP will also need to make capital investments and improvements to complex treatment processes like the lime dosing system in order realise long term efficiency gains. Coupled with the fact that gains are uncertain due to unknown production requests, capital improvements with long term pay back are prudent and efficient as they lead to long-term and prevailing cost savings to customers over the life of the Plant.

Options Considered

Cardno, now Stantec, were engaged as the qualified engineering consultant to recommend and document design solutions for the issues listed in the table below, in order to improve reliability and efficiency of the plant.

Item	Issue	Contributing Causes	Current Control Methods
1.1	Large amount of undissolved (available) lime in saturator waste sludge	Draft tube mixers unable to recirculate compacted/dense sludge (draft tube mixers are only effective under ideal conditions).	Extraction of sludge to reduce compaction and density. Note: there are constraints on the amount of sludge that can be disposed of.
1.2		Saturator sludge blanket settles and compacts when saturators are taken offline for an extended period.	Back flushing of saturators with service water through sludge extraction line to expand bed. Note: there is a limit to how long this can be done before significant sludge carryover into the lime water occurs.

Item	Issue	Contributing Causes	Current Control Methods
1.3		Saturator 1 starved of service water at high production rates (insufficient dilution to dissolve lime) by Saturator 2 and 3, due to it being the first supplied from the common header (wall and momentum effects cause the dynamic pressure to be highest at the end of the header).	No available controls.
1.4		Restricted service water addition (insufficient dilution to dissolve lime) due to blockage of lime water supernatant lines with calcium carbonate and polymer.	Hydro blasting of supernatant lines during scheduled shutdowns.
1.5		Inaccurate measurement of lime slurry flowrate into saturators due to unavoidable scaling of magnetic flowmeter.	Manual cleaning of lime slurry flowmeters during scheduled shutdowns.
2	Loss of dosing capacity due to scaling of centrifugal limewater dosing pumps	Unavoidable precipitation of calcium carbonate in lime water dosing pump impellers.	Citric acid recirculation through standby dosing pump using ad hoc CIP system.
3	Loss of lime addition to slurry tanks due to high level transmitter reading or high-level switch reading in slurry tanks (lime feeding is interlocked to these instruments).	Scaling of capacitive (insertion type) level transmitter and blockage of bubble tube for level switches in slurry tanks.	Daily cleaning of level transmitter and bubble tubes by Operators. Note: the original tuning fork type level switches rapidly fouled with lime and were replaced with an ad hoc bubble tube and pressure switch arrangement, however whilst more reliable, the bubble tubes still block with lime slurry.
4	Variation in treated water alkalinity and turbidity.	Lime water dosing pump conductivity (reliable surrogate for lime water concentration) and turbidity instruments are unsuitable for use with scaling liquids and have failed.	Operators rely on upstream turbidity and conductivity measurements in saturators which have a long delay due to storage volume in the lime water tank.
5	Loss of dosing accuracy due to scaling of dosing mag flow meter.	Unavoidable precipitation of calcium carbonate in magnetic flowmeters.	Manual cleaning of dosing flowmeters during scheduled shutdowns.
6	Lime saturator scrapers become bogged during power outages.	No backup power supply for lime scraper motors.	Hire of a diesel air compressor and use of ad hoc air spargers to mix settled lime sludge so that scrapers can be restarted.
7	Equipment obsolescence.	Equipment manufactures no longer support or produce components for the following items: • Loss in weight (LIW) feeder controllers • LIW feeder load cells • LIW feeder summing boxes	Reactive replacement with new items upon failure.

Proposed Scope

The project comprises of implementing solutions to address the issues listed below:

- Large amount of undissolved (available) lime in saturator waste sludge;
- Loss of dosing capacity due to scaling of centrifugal limewater dosing pumps;
- Loss of lime addition to slurry tanks due to high level transmitter reading or high-level switch reading in slurry tanks (lime feeding is interlocked to these instruments);
- Variation in treated water alkalinity and turbidity;
- Loss of dosing accuracy due to scaling of dosing flow meter;
- Lime saturator scrapers become bogged during power outages; and
- Equipment obsolescence.

Each improvement will seek to have a measurable outcome, which will be assessed following completion, in order to provide a quantifiable long-term saving to the customers through reduced operating and maintenance costs.

The proposed solution(s) to each issue is shown in the table below.

Item	Issue	Contributing Causes	Solution Determined
1.1	Large amount of undissolved (available) lime in saturator waste sludge	Draft tube mixers unable to recirculate compacted/dense sludge (draft tube mixers are only effective under ideal conditions).	Veolia Water Australia (Veolia, SDP's operator) to replace draft tube mixer capacity by changing impeller and increasing motor size.
1.2		Saturator sludge blanket settles and compacts when saturators are taken offline for an extended period.	Connect saturator sludge extraction pumps to spare dosing port on each saturator feed line to allow the compacted sludge to be recirculated and expanded.
1.3		Saturator 1 starved of service water at high production rates (insufficient dilution to dissolve lime) by Saturator 2 and 3, due to it being the first supplied from the common header (wall and momentum effects cause the dynamic pressure to be highest at the end of the header).	Supplement Saturator 1 supply with additional offtake at end of permeate header. Manual butterfly valves to be installed on the 2 supplies to Saturator 1 to allow for flexibility in operations
1.4		Restricted service water addition (insufficient dilution to dissolve lime) due to blockage of lime water supernatant lines with calcium carbonate and polymer.	Add rodding/cleaning points by replacing elbows at the ends of limewater lines with blanked off pipe tees.
1.5		Inaccurate measurement of lime slurry flowrate into saturators due to unavoidable scaling of magnetic flowmeter.	Measure service water (clean and non-scaling) flowrate into the slurry tanks and change SCADA controls to use this measurement for dilution control for saturators. The existing slurry flowmeters would be retained to detect hose ruptures.

Item	Issue	Contributing Causes	Solution Determined
2	Loss of dosing capacity due to scaling of centrifugal limewater dosing pumps	Unavoidable precipitation of calcium carbonate in lime water dosing pump impellers.	Veolia to purchase trailer mounted CIP skid to service site. Note: this skid could be used to CIP the second pass RO feed pump motor jackets.
3	Loss of lime addition to slurry tanks due to high level transmitter reading or high-level switch reading in slurry tanks (lime feeding is interlocked to these instruments).	Scaling of capacitive (insertion type) level transmitter and blockage of bubble tube for level switches in slurry tanks.	Install flushed stilling well inside each slurry tank and relocated capacitive level transmitter and original tuning fork level switches into stilling well. Part of the service water added to the slurry tank would be added to the stilling well, so the level instruments always sit in clean water.
4	Variation in treated water alkalinity and turbidity.	Lime water dosing pump conductivity (reliable surrogate for lime water concentration) and turbidity instruments are unsuitable for use with scaling liquids and have failed.	Replace panel mounted conductivity and conductive instruments with immersion style probes which have proven to be reliable in the saturators.
5	Loss of dosing accuracy due to scaling of dosing mag flow meter.	Unavoidable precipitation of calcium carbonate in magnetic flowmeters.	Permeate is currently injected after the dosing flowmeter into the standby dosing line (duty/duty/standby configuration) to dissolve calcium carbonate deposits. With managed rotation of the duty lines, this prevents scale deposits from building up. Adding an isolation valve before each dosing flowmeter would allow the permeate addition point to be moved before the flowmeters, so they are also kept clean.
6	Lime saturator scrapers become bogged during power outages.	No backup power supply for lime scraper motors.	Install backup power supply (generator or UPS) for lime saturator scrapers
7	Equipment obsolescence.	Equipment manufactures no longer support or produce components for the following items: • Loss in weight (LIW) feeder controllers • LIW feeder load cells • LIW feeder summing boxes	Planned replacement of obsolete equipment and purchase of critical spare parts for new equipment.

Cost Estimate

The estimated budget price to implement all works is around [redacted], based on first principal pricing prepared by the designer (Stantec).

Issue Number	Solution Determined	Estimated Capital Expenditure
1.1	Veolia to replace draft tube mixer capacity by changing impeller and increasing motor size.	[redacted]
1.2	Connect saturator sludge extraction pumps to spare dosing port on each saturator feed line to allow the compacted sludge to be recirculated and expanded.	[redacted]
1.3	Supplement Saturator 1 supply with additional offtake at end of permeate header. Manual butterfly valves to be installed on the 2 supplies to Saturator 1 to allow for flexibility in operations	[redacted]
1.4	Add rodding/cleaning points by replacing elbows at the ends of limewater lines with blanked off pipe tees.	[redacted]
1.5	Measure service water (clean and non-scaling) flowrate into the slurry tanks and change SCADA controls to use this measurement for dilution control for saturators. The existing slurry flowmeters would be retained to detect hose ruptures.	[redacted]
2	Veolia to purchase trailer mounted CIP skid to service site. Note: this skid could be used to CIP the second pass RO feed pump motor jackets.	[redacted]
3	Install flushed stilling well inside each slurry tank and relocated capacitive level transmitter and original tuning fork level switches into stilling well. Part of the service water added to the slurry tank would be added to the stilling well, so the level instruments always sit in clean water.	[redacted]
4	Replace panel mounted conductivity and conductive instruments with immersion style probes which have proven to be reliable in the saturators.	[redacted]
5	Permeate is currently injected after the dosing flowmeter into the standby dosing line (duty/duty/standby configuration) to dissolve calcium carbonate deposits. With managed rotation of the duty lines, this prevents scale deposits from building up. Adding an isolation valve before each dosing flowmeter would allow the permeate addition point to be moved before the flowmeters, so they are also kept clean.	[redacted]
6	Install backup power supply (generator or UPS) for lime saturator scrapers	[redacted]
	Sub-total	[redacted]
	Contingency (30%)	
	Contractors Margin (20%)	
	Total	

Benefits Estimate

The following calculations show the uncertainty of NPV analysis dependent on production output.

2020 Mass Balance		
Drinking Water Produced	33249	ML pa
Hydrated Lime Consumed	49.7	kg/ML
Hydrated Lime Availability (Calculated)	87%	wt/wt
Dry Mass of Waste in Hydrated Lime	6.47	kg/ML
Waste Sludge Produced	127.6	kg/ML
Total Solids in Waste Sludge (Median Value)	17%	wt/wt
Dry Mass of Sludge Produced	21.7	kg/ML
Available Lime in Sludge (Median Value)	70%	wt/wt
Dry Mass of Available Lime in Sludge	15.2	kg/ML
Dry Mass of Waste in Sludge	6.47	kg/ML
Available Lime Added to Drinking Water (Calculated)	28.0	kg/ML
Hydrated Lime Unit Cost (Contract Price)	[redacted]	/tonne
Sludge Disposal Unit Cost (Contract Price)	[redacted]	/tonne
Total Lime Cost (Purchase + Disposal)	[redacted]	/ML
Post Upgrade Estimated **Mass Balance**		
Drinking Water Produced	-	ML pa
Hydrated Lime Consumed	43.6	kg/ML
Hydrated Lime Availability (2020 Value)	87%	wt/wt
Dry Mass of Waste in Hydrated Lime	5.68	kg/ML
Waste Sludge Produced	66.8	kg/ML
Total Solids in Waste Sludge (Median Value)	17%	wt/wt
Dry Mass of Sludge Produced	11.4	kg/ML
Available Lime in Sludge (Estimated Based on Upgrades)	50%	wt/wt
Dry Mass of Available Lime in Sludge	5.68	kg/ML
Dry Mass of Waste in Sludge	5.68	kg/ML
Available Lime Added to Drinking Water (2020 Value)	28.0	kg/ML
Hydrated Lime Unit Cost (Contract Price)	[redacted]	/tonne
Sludge Disposal Unit Cost (Contract Price)	[redacted]	/tonne
Total Lime Cost (Purchase + Disposal)	[redacted]	/ML
Return On Investment		
Estimated Saving in Total Lime Cost (Purchase + Disposal)	[redacted]	/ML
Cost of Upgrades to Lime Plant	$ [redacted]	
ROI @ 50 ML/d	8.2	years
ROI @ 125 ML/d	3.3	years
ROI @ 250 ML/d	1.6	years

SDP Capital Works
Project Summary

SYDNEY DESALINATION PLANT

Proposed Layout (examples of some of the modifications)