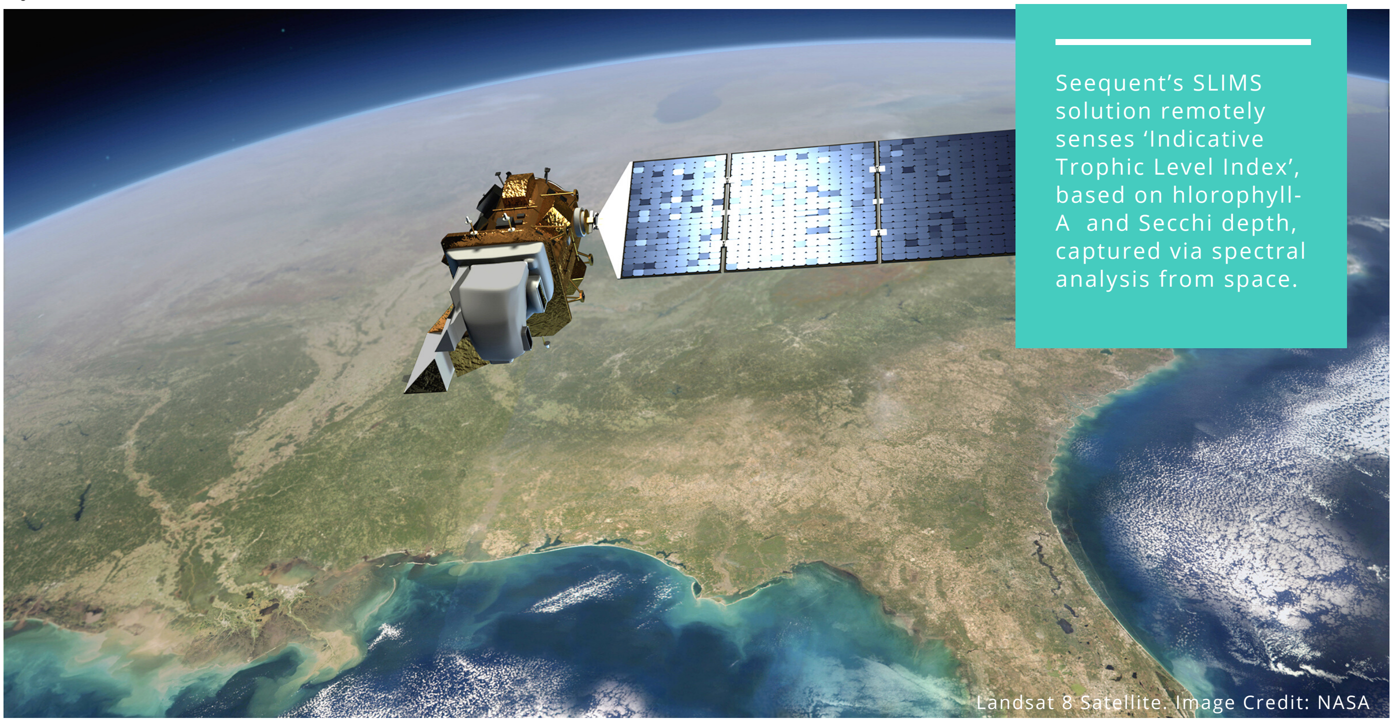
WATER SECURITY: SATELLITE-BASED REMOTE LAKE HEALTH MONITORING WITH SLIMS

The Seequent Lake Indicator Monitoring System (SLIMS) prototype, winner of the recent 2019 New Zealand Aerospace Challenge, measures indicative lake water quality using a combination of satellite vision, algorithms, and cloud technology - delivered over the web.

by Daniel Wallace



Landsat 8 Satellite. Image Credit: NASA

Water security is a topic that has increasingly concerned academia, government and NGOs in recent years – with good cause. Climate change, burgeoning populations and shifting lifestyles have all placed pressure on this critical resource. For sustainable development of an urban city much also depends on the water bodies in and around the city.

Water is the one resource for which no substitute exists says Daniel Wallace, General Manager, Civil and Environmental Industries, Seequent. "Water governs our ability to produce food and drives many aspects of industry. However, it is also seeing increasing demand and pressure due to factors such as growing population, rising incomes and accelerating consumerism.

"Couple this with increasing stress on water resources due to changes in climate and it is clear that the water scarcity is a looming issue. Water security is more than just water availability and quality, it also includes water related risks such as flooding, subsidence and slope failures," he says.

Seequent is increasingly seeing clients working to address issues

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around water availability (quantity) and water suitability (quality). Wallace says, “Helping them understand and manage this vital resource is an important part of the contribution we can make to ensuring water security for all.”

Over the past 18 years, much of Seequent’s innovation has been focused below ground, for understanding subsurface geoscience and engineering design solutions. Its geoscience analysis, modelling and collaborative technologies are used on a range of earth, environment and energy challenges to uncover valuable insights from data, ultimately leading to better decisions in areas dependent on geoscience.

Today, Seequent is extending its reach above ground to help people better understand complex infrastructure and environmental issues, including water security.

Wallace says, “We jumped at the opportunity to participate in the 2019 New Zealand Aerospace Challenge to apply our innovative technology in an exciting new space that has huge potential. Water quality and the health of our lakes sustains our way of life - so we identified it as an area with huge potential for impact.”

The company’s winning prototype, the Seequent Lake Indicator Monitoring System (SLIMS), measures indicative lake water quality using a combination of satellite vision, algorithms, and cloud technology - delivered over the web. The solution has the potential to virtually monitor the water quality of every lake globally.

Satellite-based Remote Lake Health Monitoring

As part of the New Zealand Aerospace Challenge, Seequent was tasked with developing a solution to identify, monitor or measure water or soil pollution using satellite data and unmanned aircraft technology.

Seequent’s goal was to develop a satellite-based remote sensing solution that has the potential to virtually monitor the water quality of every lake globally.

Figure 1: The Seequent Team Accept the NZ Aerospace Challenge Award from Hon Dr Megan Woods, Minister of Research, Science and Innovation (Third from Right) and Valentin Merino Villeneuve from Airbus (Far Right).

Seequent’s Lake Indicator Modelling System (SLIMS) can capture water quality data across many hundreds of lakes at once and model and visualise it through time, to help freshwater scientists identify lake health changes. An indicative lake water quality measure is derived using a combination of satellite vision, algorithms, and cloud technology - delivered over the web.

Seequent created its prototype SLIMS solution, which is globally scalable, to demonstrate how it could effectively and economically monitor the health of all New Zealand’s 3,820 lakes. With only 2% of lakes currently monitored via established methods of lake water sampling and analysis, SLIMS enables organisations to monitor changes in lake conditions with the ability to use historical satellite data to identify seasonal trends. This allows users to identify lakes exhibiting any unexpected change for closer monitoring and management.

Wallace says, “It’s not economical to visit all lakes to monitor adverse environmental impacts, but with satellite remote sensing every lake can be monitored virtually. Alga blooms sediments events and other adverse changes in lake health, which could otherwise be unseen and unknown suddenly emerge with our new monitoring solution. Subsequently these lakes could be visited to further investigate health degradation.”

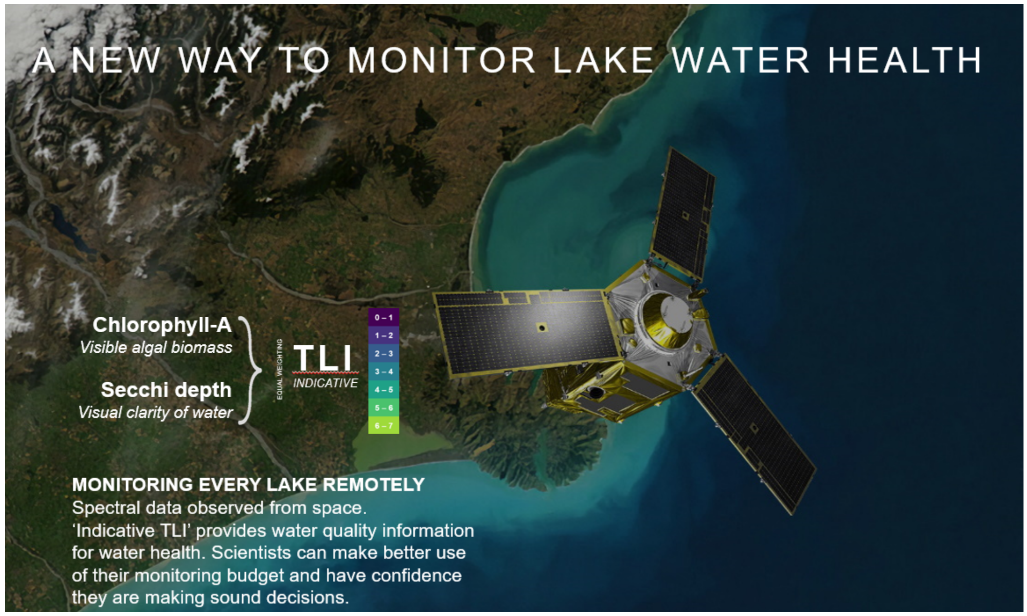
Seequent had a multi-disciplinary team working on its new SLIMS solution, including local collaborators from Lincoln Agritech and the Waterways Centre for Freshwater Management. The team was also supported by Environment Canterbury, a regional environmental authority responsible for water sampling, and the University of Waikato, who have developed a global reputation for research into regression algorithms.

Andrew Mathewson, Managing Director Airbus Australia Pacific, said the Challenge, powered by Airbus and delivered by ChristchurchNZ and SpaceBase, demonstrated that space technology and sustainability are converging in new and exciting ways.

“There is so much opportunity to use satellite data to better manage agricultural activities, but also to combat global environmental challenges like climate change. Seequent’s solution is a great example of this type of innovative and practical technology to enable better management of our environment," he said.

Entries were judged by Valentin Merino Villeneuve, Head of Airbus Defence & Space Australasia, alongside New Zealand's top space and agritech industry leaders. Merino Villeneuve announced the winners with Hon Dr Megan Woods, New Zealand's Minister of Research, Science and Innovation.

"Seequent's grand-prize winning solution demonstrated the potential of commercialising existing satellite data to monitor environmental challenges on the ground. It is these tangible solutions that will drive innovation and change in how we research and respond to our changing world," Merino Villeneuve.



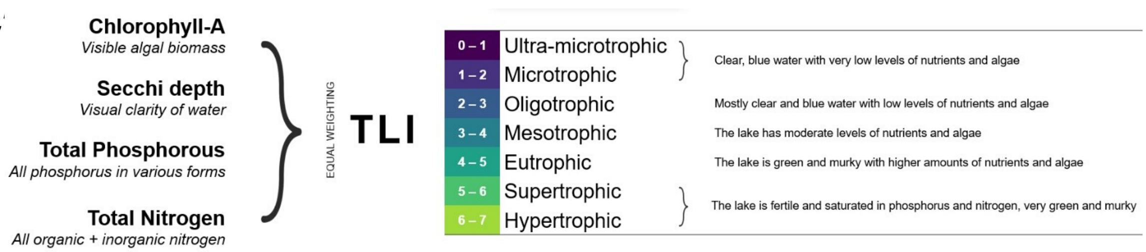


Figure 2: Seequent's Lake Indicator Modelling System (SLIMS) offers a new way to monitor lake health. The water quality in each lake is assigned a number between 1 and 7, the lower the number representing the better the water quality.

How Does Seequent's Lake Indicator Modelling System (SLIMS) Work?

Trophic Level Index (TLI)

In New Zealand an overall picture of the health of lakes is based on the Trophic Level Index (TLI), which broadly categorizes the health of a lake water. TLI is calculated through equal weighting of separate water quality components:

- Chlorophyll-A Visible algal biomass
- Secchi depth Visual Clarity of water Total Phosphorous All phosphorus in various forms
- Total Nitrogen All organic + inorganic nitrogen

Chlorophyll-a is the green colour in plants. Knowing how much chlorophyll there is in a lake gives us a good idea of how much algae the lake has. Algae can be present in a lake, but just not too much. The more algae present, the poorer the water quality.

Water clarity is a measurement of how clear the water in the lake is known as secchi depth. In general, the clearer the water, the better the water quality.

Total nitrogen and total phosphorous are nutrients that plants thrive on. Large amounts of these nutrients in the lakes encourage the growth of algae which can lead to poor water quality.

By combining these measurements, the water quality in each lake is assigned a number between 1 and 7, the lower the number representing the better the water quality.

Waterbodies in mesotrophic and higher states deteriorate through stages of murkiness through to being entirely consumed by algae. Waterbodies in these states quickly become smothered by biomass, reducing dissolved oxygen, light transmission and preventing life from functioning in the water body's 'dead-zones'.

What Impacts the TLI in a Lake?

Changes in a lake's water quality will impact the overall TLI. Regulators and landowners can play a role in reducing the TLI score of a lake over time, for example, by reducing the amount of phosphorus and nitrogen entering the lake.

Indicative TLI from Space

Only laboratory analysis can measure TLI, but we can indicate TLI trends and changes, based on cost-effective spectral data observed from space.

Seequent's SLIMS solution remotely senses 'Indicative TLI', based on Chlorophyll-A (visible algal biomass) and Secchi depth (visual clarity of water), captured via spectral analysis from space. It models the two components to provide base-level water quality information for many thousands of water bodies with each satellite flyover. Regression algorithms researched by the University of Waikato help make it possible to model the Chlorophyll-A and Secchi depth components.

Indicative TLI results can be packaged and deployed alongside lake monitoring data collected by traditional lake sampling.

Monitoring Every Lake with Remote-Sensed 'Indicative TLI'

Remote-sensed Indicative TLI allows all lakes in a region to be modelled through time, revealing changes in conditions and trends from historical satellite data. Algal blooms and sediment events which would otherwise be unseen and unknown suddenly emerge. Scientists can make better use of their monitoring budget and have confidence they see the whole picture.

How Does It Work?

- FLY-OVER: Satellite observes and collects top-of-atmosphere observation data.
- SURFACE REFLECTANCE PROCESSING: Processing for geographic registration, atmospheric processing, cloud masking and classification.
- PRE-PROCESSING: Preparation of bands 2 – 4 for bio-optical modelling, including temporal compositing and water confidence clipping for lake edges.
- MODELLING: Application of lake water regression models to derive raster outputs; Chlorophyll-A, Secchi Disk, total suspended solids, and lake surface colour.

Rapid Prototyping

A rapid cloud-based web app was developed by Seequent engineers to conduct customer interviews to derive feedback.

The lean prototype was built using Google's EarthEngine Platform, traversing the full history of the USGS's Landsat-8 Surface Reflectance Tier-1 data to calculate the Chlorophyll-A component of TLI for a small selection of lakes in Canterbury, New Zealand.

Results were packaged and deployed alongside monitoring data collected by physical sample for each lake.

Seequent is continuing to develop its prototype Seequent's Lake Indicator Modelling System (SLIMS) for the global market. For more on Seequent see: www.seequent.com

Urbanisation: Four Emerging Trends for Water Security

Water security has traditionally been challenged by factors such as degradation in quality and decline in availability. But it is in areas of growing urbanisation that concerns are now advancing, leading to four emerging trends.

1) Better Governance: Factors such as urbanisation and climate change are increasingly challenging the way water is governed. A case in point would be California's Sustainable Groundwater Management Act that aims to prevent excessive groundwater extraction causing "overdraft, failed wells, deteriorated water quality, environmental damage, and irreversible land subsidence that damages infrastructure and diminishes the capacity of aquifers to store water for the future."

2) Reuse and Recycle: Zero Liquid Discharge is becoming common in industry and society. At the industry level, it means water in a factory is kept in the factory and re-used via cleaning and treatment. In potable water situations it means once you have used the water, you use it again. Currently, sewage (used potable water) is recycled for another use such as irrigation and infiltration ponds. But that will likely change.

3) Conservation: Certainly, one of the best ways to improve water security is to make sure that water is used efficiently and not lost. This has been a focus in many parts of the world for a long time, but there are still places it has not been

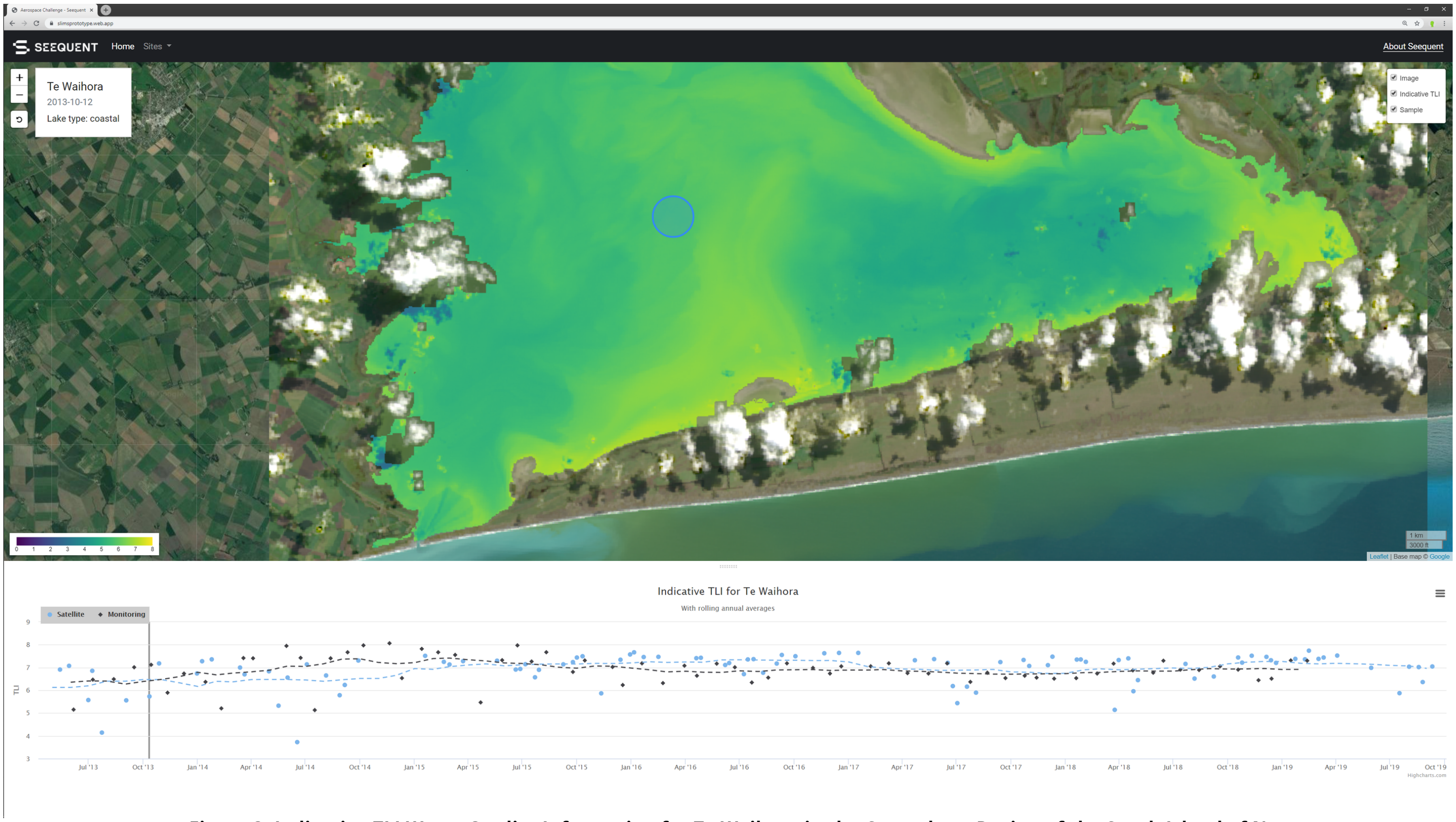


Figure 3: Indicative TLI Water Quality Information for Te Waihora in the Canterbury Region of the South Island of New Zealand Shown In SLIMS.

implemented well. On top of that, there are constantly new technological advances that improve water efficiencies such as waterless toilets and urinals.

4) Water Harvesting: Urbanisation means grassland, lawns or fields are now an urban landscape. Hard roofs, roads and sidewalks impede the recharge of aquifers whereas the previous surfaces allowed rainfall to percolate down. There are practices to ensure all water falling on those roofs, etc, is recharged as close as possible to where it fell. In addition, open landscapes could be used to capture runoff to serve as temporary storage or increase aquifer recharge. Constructing infiltration systems to capture roof water can also mitigate the flooding seen in modern urban landscapes.

More on Seequent

Seequent is a world leader in the development of powerful geoscience analysis, modelling and collaborative technologies for understanding subsurface geoscience and engineering design solutions.

Seequent's solutions enable people to analyse complex data, manage risk and ultimately make better decisions about earth, environment and energy challenges. Seequent software is used on large-scale projects globally, including road and rail tunnel construction, groundwater detection and management, geothermal exploration, subsea infrastructure mapping, resource evaluation and subterranean storage of spent nuclear fuel.

Seequent's global footprint includes its Christchurch-based HQ and R&D centre, and a network of offices across Asia/Pacific, Africa, South America, North America and Europe servicing blue chip companies and customers with leading subsurface solutions in over 100 countries.

For more on Seequent see: www.seequent.com

Water Security - Facts & Figures

- **2.7 billion** people are affected by water scarcity at least one month each year.
- **$114 billion** the degree of investment required per year to hit the world's sustainable development goals on water supply, sanitation and hygiene. This figure is three times what's actually being spent.
- **By 2025** half the world's people will live in countries with high water stress.
- **117 million** lakes in the world totalling 20.4 million km2 with a mean size of 0.2 km2 / lake.
- **3/4 of all Americans** live within 16km (10 miles) of polluted water.
- **20%** increase in salinization of the world's irrigated land area due to inefficient use of water for crop.
- **40%** The gap expected between water demand and water availability by 2030.
- **1/2 of the world's hospital beds** are estimated to be occupied, at any one time, by patients with waterborne illnesses.
- **30% of the Earth's freshwater** is in the ground