Aerial Drone-Based Inspections on Critical Infrastructure

Paul Davis[1], Mark Rippon[1], Mike Larkin[2]

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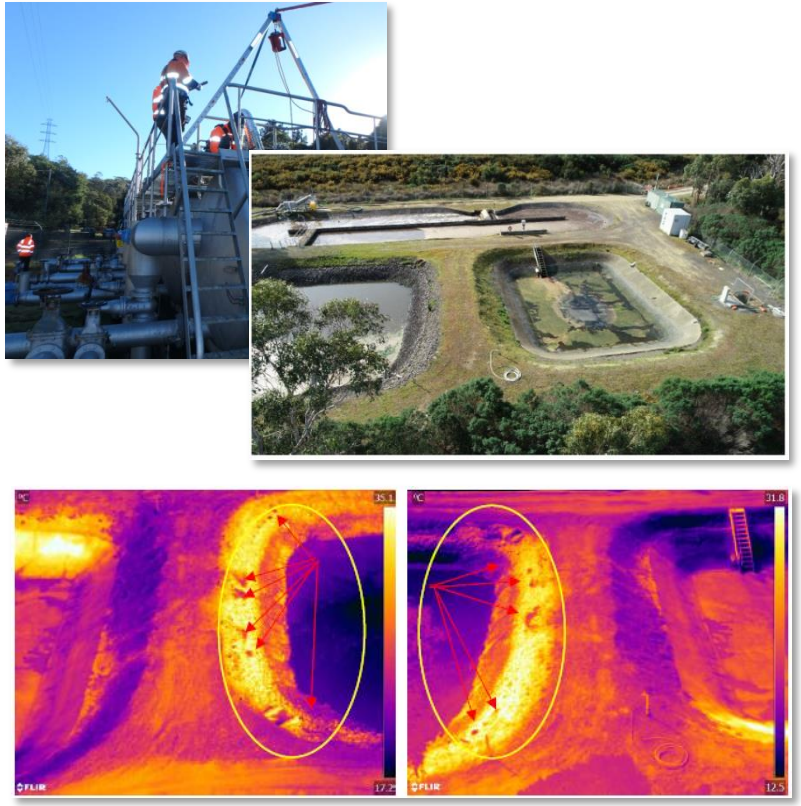
1 – TasWater Asset Performance
2 – Fulcrum Robotics

Outline

- Background
  - Current Practices for Asset Inspection & Limitations
- Aerial Drone Case Study Applications:
  - Visual inspection of water storage infrastructure
  - Infra-red thermal imaging inspection for sewage infrastructure
  - Combined surveys of structures in landslip areas
- Concluding Remarks



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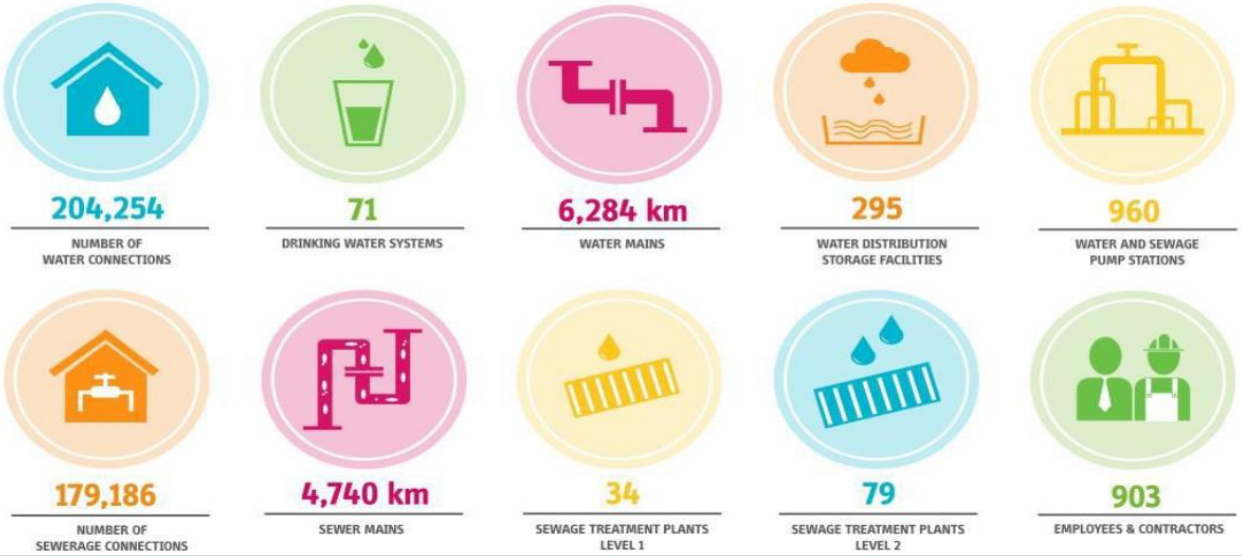
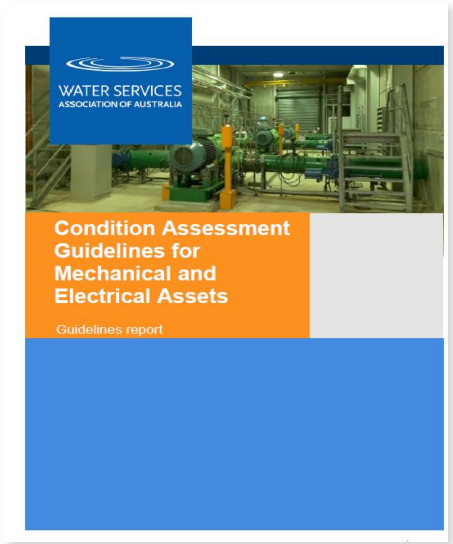
Background

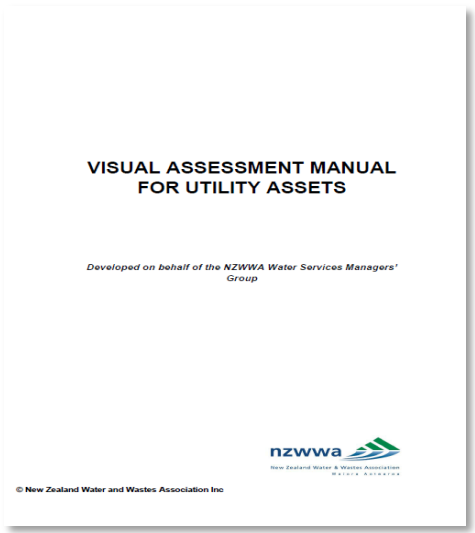


Unique infrastructure challenges means understanding Asset Condition is <u>essential</u>

Current practices for asset inspection and limitations

- Condition (Asset Health) currently assessed using…..
- Visual inspection and condition grading
  - ➢WSAA/NZWWA Industry guidelines





Current practices for asset inspection and limitations

- Detailed testing (critical assets)
  - i.e. Ultrasonics, concrete pH testing, cover-to-reinforcement

Current practices for asset inspection and limitations

- Challenge is the quantity and quality of data required to inform our renewals and maintenance interventions
  - ➢ Large number of assets on manual inspection programs
- Often relying on manual collection of data in hazardous environments; difficult to access areas
- Conventional inspections produce images/data in low resolution; from non-ideal vantage points
- Consequently asset condition difficult to establish over an entire structure; difficult to track consistently over time

Current practices for asset inspection and limitations

- Aware of increased availability of drone-based technologies to assist with inspection
- Over last 6 months partnered with Fulcrum Robotics to conduct aerial drone trials to assess if we can:
  - Remotely inspect previously inaccessible assets
  - Improve the quality/quantity of data/images captured from inspections
  - Reduce inspection times

Considering the value of aerial drone-based inspections

Equipment used – Fulcrum Robotics

- DJI Matrice Quadcopter
  - Approx 35 minute flight time
  - 3.8 kg (without camera)

- Zenmuse X4S 20 MP Gimble Camera
  - 8.8 mm/F2.8-11
  - 84 deg field of view (large ground footprint)
- Calibrated Zenmuse XT FLIR Camera for thermal surveys
  - 19 mm
  - 17 microns pixel pitch

- Ground Control Panels (GCP) for geo-referencing
  - Trimble Dual-Frequency GNSS receiver (VRS) for geo-registration
- iPad and flight planning software (Map Pilot) for waypoint navigation

Case Study application #1 – Drone-based Visual Inspection

Case #1: Visual Inspections of Water Storage Infrastructure

- **Sites**: 8 water reservoir storage tanks; 6 in-ground water storage basins with floating covers
- **Concerns**: Roofing structures/covers possibly in poor condition, breached with points of wildlife ingress; Possible contamination and water quality risks
- **Challenges**: Access to structures difficult, considered unsafe in some (floating covers)
- **Objective**: Remotely inspect roofing structures/water storage covers to identify defects and assess condition

Case #1: Visual Inspections of Water Storage Infrastructure

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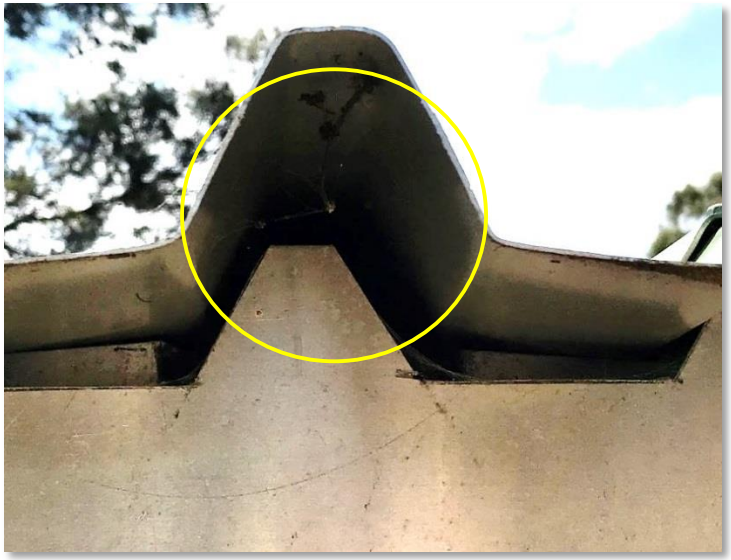


Deficiencies in roofing construction that may allow points of ingress around perimeter of reservoir

Identification and closer examination of defects

Case #1: Visual Inspections of Water Storage Infrastructure

Impaired jointing system between wall and roof presenting potential points of ingress

Difficult to detect by an operator at ground level

Case #1: Visual Inspections of Water Storage Infrastructure

Floating cover- vegetation build up impacting drainage of surface water

Floating cover- unsecured seam

Detected without operator traversing the covers

Case #1: Visual Inspections of Water Storage Infrastructure

Defect No	Deficiency Description	Recommendation
1	Safety harness attachment point exhibiting signs of corrosion.	Replace safety harness attachment point
2	Pipework penetrations are un sealed	Seal all pipework penetrating reservoir wall
3	Loose cabling of unknown voltage or use is laying on top of the metal man way. Fixing of cable/conduit syst4ms on ladder system is substandard.	Make good.
4	Possible step and touch potential risk associated with manway structure(s) and localised earthing.	Conduct AS300 and installation safety audit
5	Roof vents are not fully fixed to each housing and some mesh screes are becoming loose.	Affix roof vents and repair screens
6	Mastic seal is failing (cracking) between concrete roof hatches	Repair mastic seal between concrete roof hatches
7	The sealing arrangement (s) between concrete roof and reservoir wall has failed.	Renew seal and inspect micro cracks
8	General cracking to reservoir wall and roof structure, evidence of previous repairs.	Monitor and consider establishing fixed control points for ongoing assessment of cracking (and repairs) and general

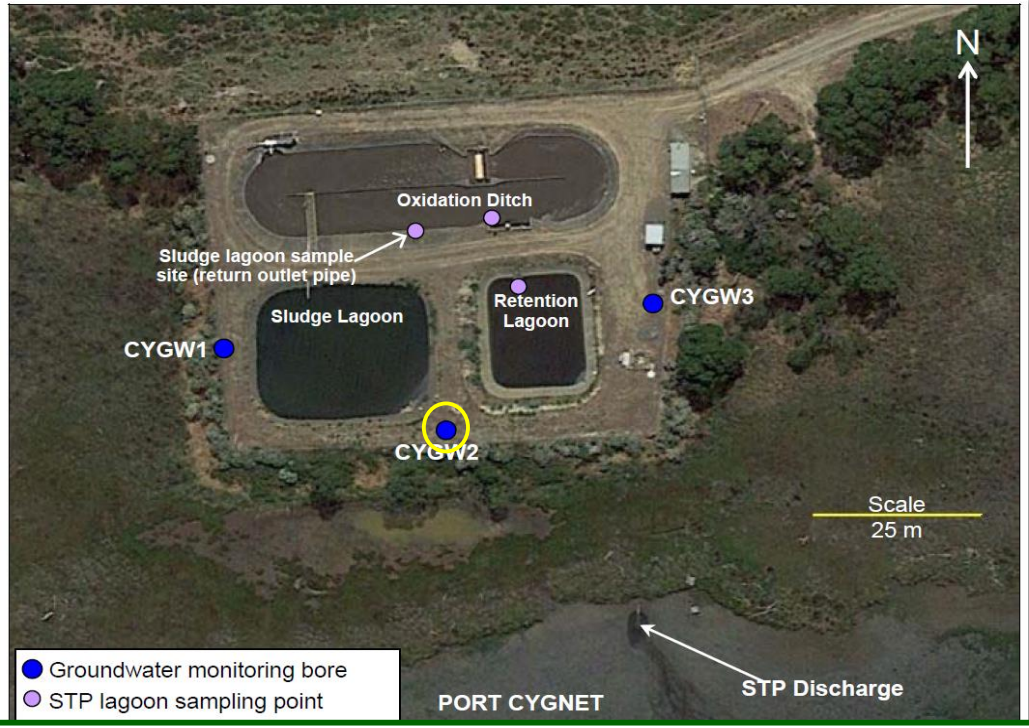
Inspection coverage far exceeds that of previous operator approach

Case Study application #2 – Thermal imaging surveys

Case #2: Thermal imaging surveys for sewage infrastructure

- **Sites**: 2 In-ground sewage lagoons as part of sewage treatment plants; 1 concrete tank as part of an anaerobic digester
- **Concerns**: Lagoon embankments are impaired allowing leakage to occur with partially treated sewage reaching receiving water; digester tanks are cracking
- **Challenges**: No accurate method to locate leakage from visual inspection; Digester interior presents a hazardous (explosive) environment
- **Objective**: Remotely inspect lagoons to locate leakage pathways; Remotely inspect digester tank to detect any cracking

Case #2: Thermal imaging surveys for sewage infrastructure



Groundwater monitoring bores previously showed impacts from lagoon leakage

Flow balancing not accurate to confirm leakage

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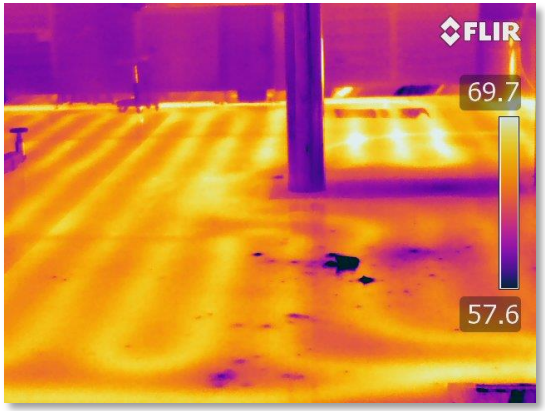
Case #2: Thermal imaging surveys for sewage infrastructure

- **Thermal imaging surveys** considered as an alternative non destructive method to locate leakage pathways

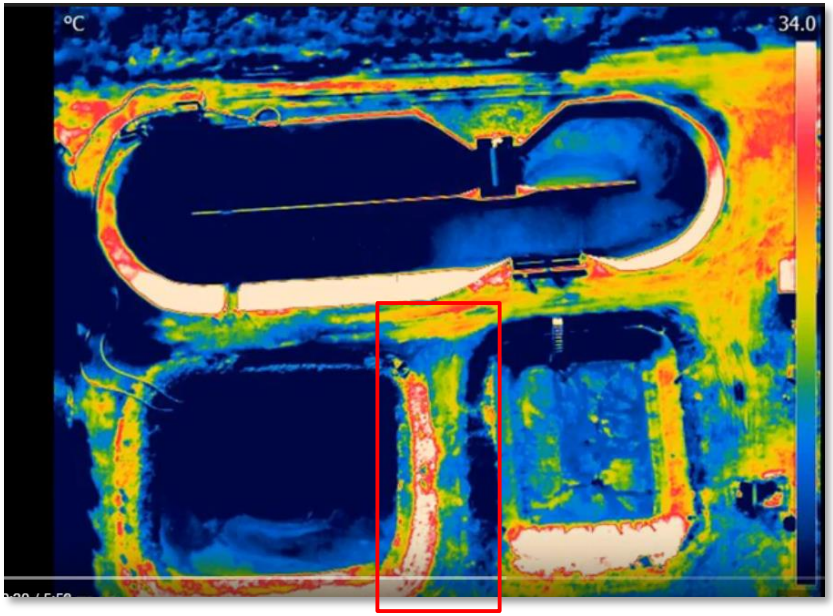
- Temperature gradients affected by presence of moisture (cooler or hotter than surrounding environment)

- Best visualised after environment has been exposed to sufficient sunlight

  ➢ Thermal surveys conducted over the course of a day

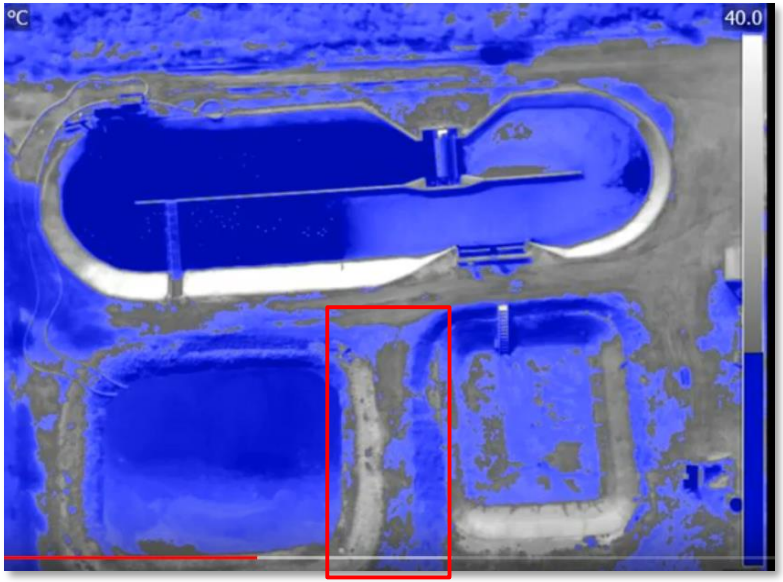


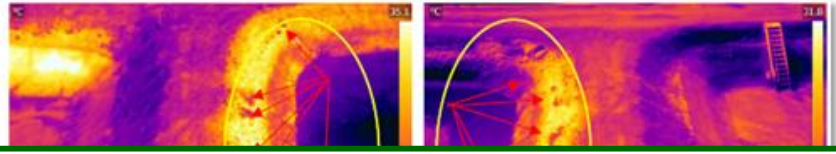
Case #2: Infra-red thermal imaging surveys for sewage



Looking for thermal anomalies <u>even though UV exposure is uniform</u>

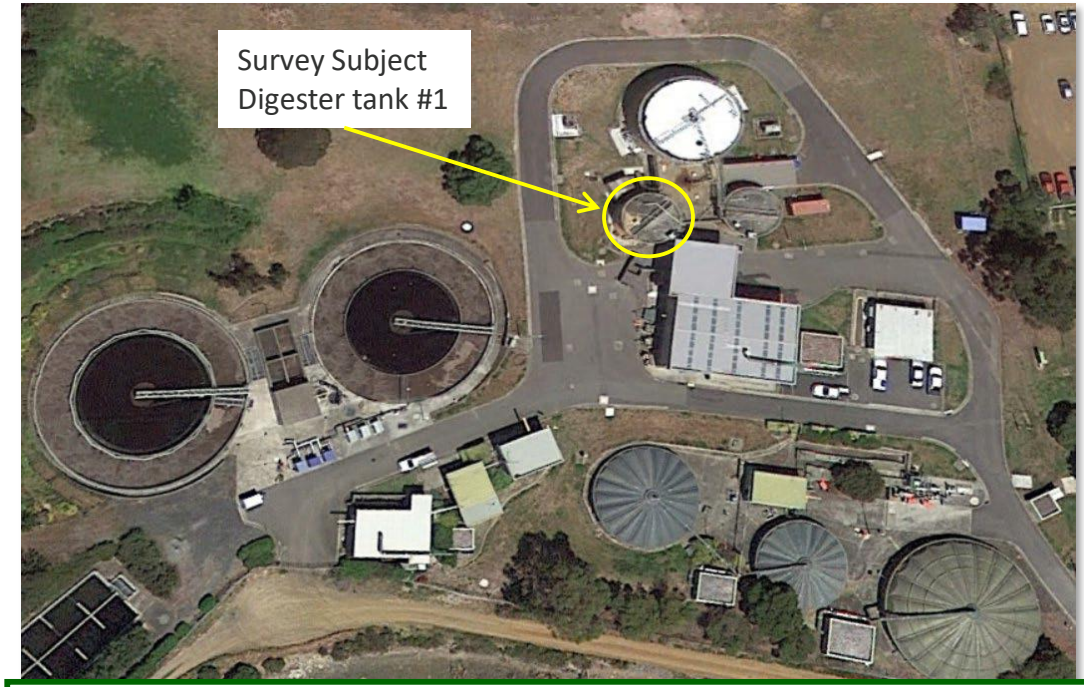
Case #2: Thermal imaging surveys for sewage infrastructure





Thermal imaging mapped out leakage pathways from lagoons

Case #2: Thermal imaging surveys for sewage infrastructure

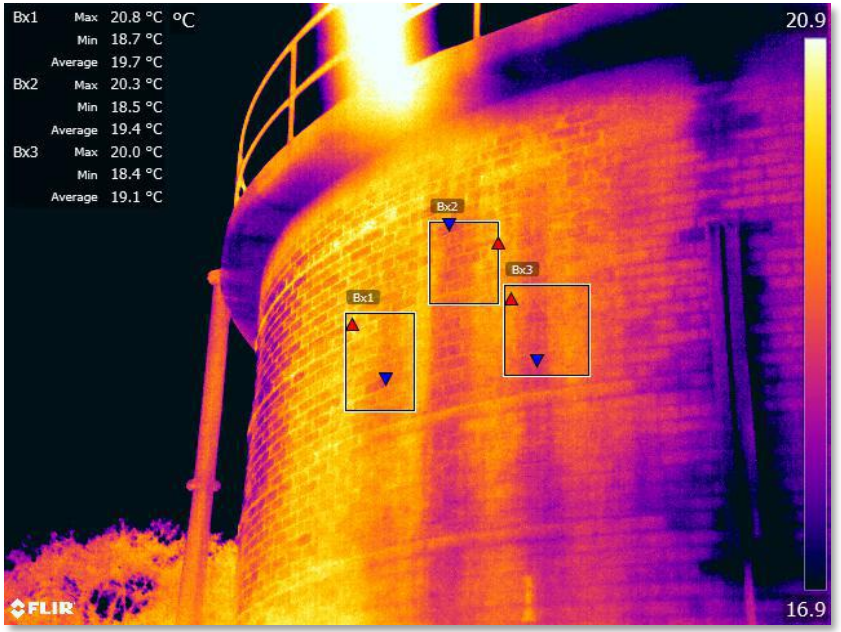


- Digester is a critical STP infrastructure asset
- No previous internal inspection
- Condition unknown……
- Risk unknown

Urgent need to understand condition and program necessary repairs

Case #2: Thermal imaging surveys for sewage infrastructure

Operational activity to flush the digester with water to remove rags



….provided contrast for thermal imaging survey

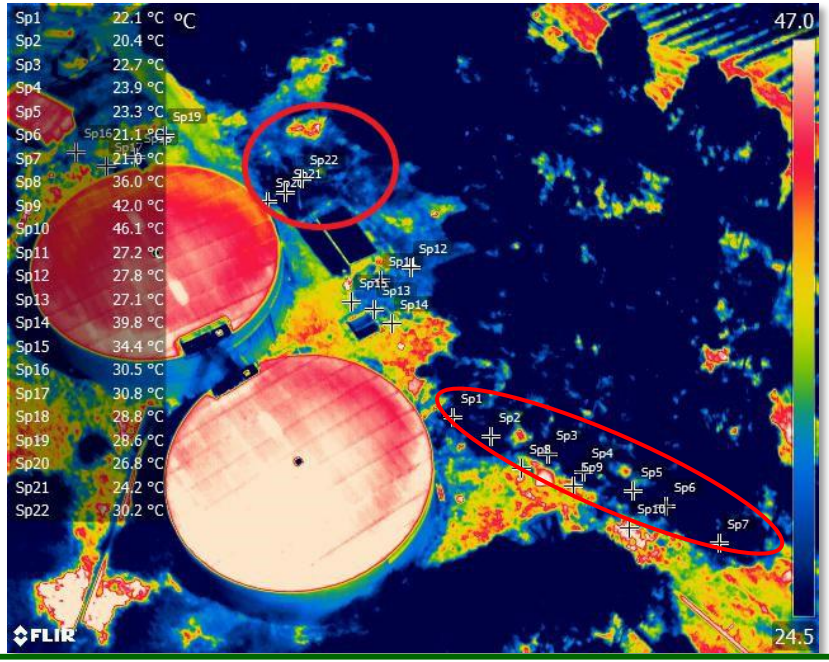
Identified cracks with penetration of flushing water

Case Study application #3 – Combined surveys of infrastructure in landslip areas

Case #3: Combined surveys for infrastructure in landslip areas

- **Sites**: 2 concrete reservoirs in close proximity to active landslip area; Reservoirs in poor condition and showing leakage; previous attempts to seal unsuccessful
- **Concerns**: Project to underpin the reservoir and reline may not fully address problem; Don't understand extent of interaction between these structures and landslip
- **Challenges**: No method to monitor interaction between structures and landslip zone
- **Objective**: Remotely inspect reservoirs to locate leakage pathways and monitor movement

Case #3: Combined surveys for infrastructure in landslip areas

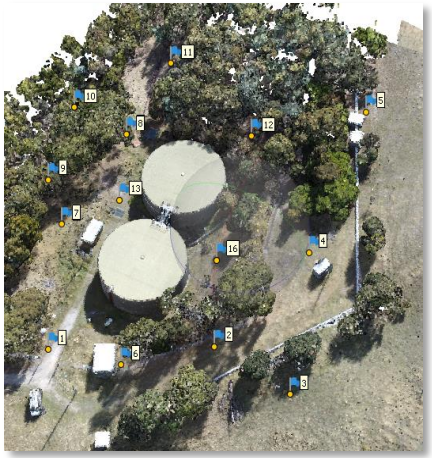


Thermal imaging showed extent of leakage and detected other leakage sources

Case #3: Combined surveys for infrastructure in landslip areas

- As project progresses, **Drone-based photogrammetry** used to monitor movement of landform and structures in landslip area
- Involves using Digital Terrain Models (DTMs) captured at different time intervals - Differences between DTMs used to detect spatial change

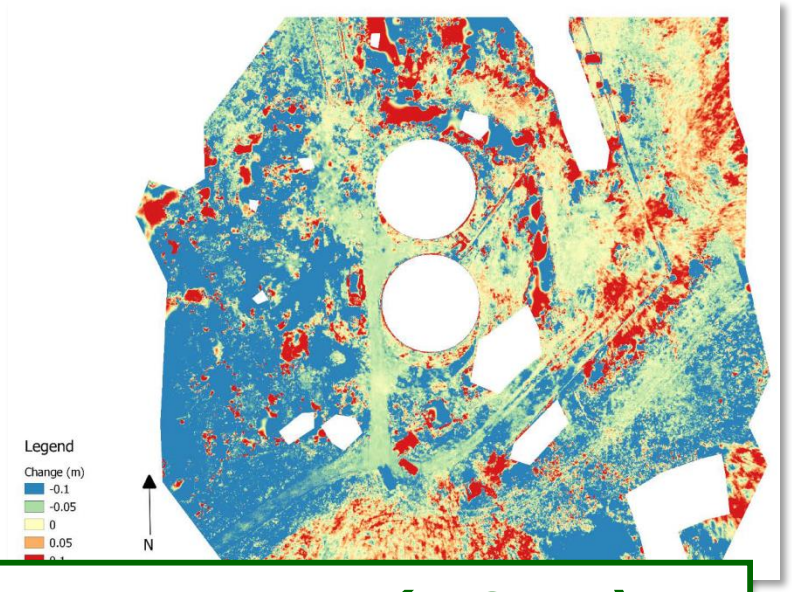
Ground Control Points placed in the study area and accurately geo-registered using precision GPS



Case #3: Combined surveys for infrastructure in landslip areas

- Drone programmed to follow pre-configured path to generate a series of overlapping images with GCPs referenced in each

Images aligned and analysed allowing a 3D Digital Terrain Model to be built



Periodic surveys allow landslip movement (1-2cm) to be detected

Concluding Remarks

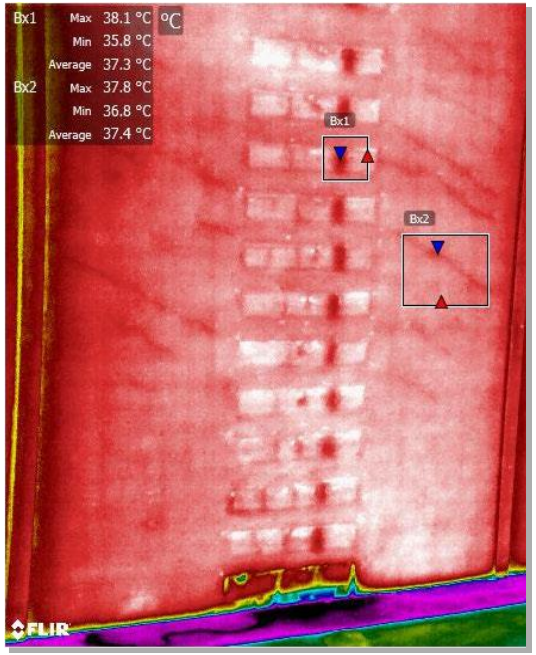
- **Challenge:** Safe capture of high quality/quantity information to support condition assessment of critical infrastructure
- **Conventional manual inspection:** Low resolution; non-ideal vantage points; hazards/difficult to access areas = incomplete information
- **Response:** Conduct a trial of aerial drone-based inspection
- **Benefits:**
  - Ability to remotely inspect assets in hazardous environments/difficult to access areas reduced operator safety risks
  - Quality/Quantity of data/information to inform asset condition and failure risk dramatically increased
  - Asset Coverage/$ spend improved

Drone-based inspections continue!

THANK YOU

Case #2: Thermal imaging surveys for water infrastructure

Post-tensioned panel construction reservoir showing signs of leakage



Thermal imaging used as a quality control inspection method

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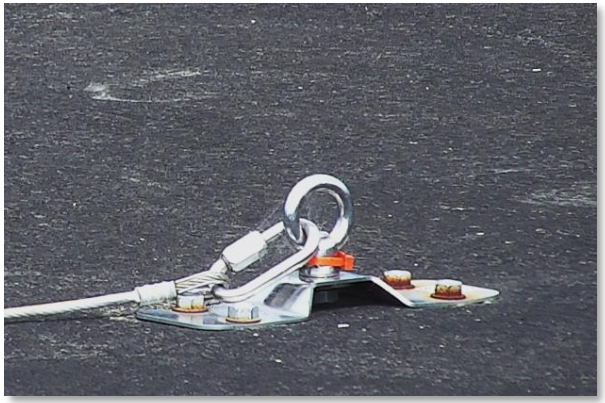

Inspection coverage <u>far</u> exceeds that of previous operator approach

Case #1: Visual Inspections of Water Storage Infrastructure

Cable not secured in gland seal for floating cover pumps

Inspection coverage <u>far</u> exceeds that of previous operator approach

Case #2: Thermal imaging surveys for sewage infrastructure

Confirmed failure of internal lining and cracking by ROV