SMART SOLUTIONS FOR UNDERSTANDING SIMPLE SYSTEMS -

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ABSTRACT

Opus International Consultants Ltd. was engaged by the Christchurch City Council to investigate their stormwater network in the Port Hills. This investigation was driven by Council to both determine the network condition and prioritise the repair of damage anticipated from the series of earthquakes in Canterbury from September 2010 – June 2011.

This investigation was required to determine:

1. The condition of the network (including the identification of earthquake specific damage).
2. Emergency (urgent) works required to address immediate failures within the network.
3. Priorities for the CCC remedial works programme.

The Opus project team faced several challenges in completing these investigations. This included the determination of the:

- Condition of a wide variety of assets in standardised repeatable manner.
- Differentiate between earthquake damage vs. age deterioration for the asset.
- Prioritisation of remedial works between assets of the same condition.
- Locating & assessing stormwater infrastructure often in heavily vegetated areas.

The project team was able to embrace technology to help meet these challenges, to aid the field data collection, condition assessment and conversion back into the Council corporate systems.

KEYWORDS

Stormwater, Condition Assessment, Earthquake, Criticality, Open Channel, Stormwater Network.

PRESENTER PROFILE

Paul King is a Senior Environmental Engineer with Opus International Consultants Ltd. He has 12 years' experience in the design of horizontal infrastructure focused primarily on the development of stormwater systems. Paul is chartered member of both the Institute of Professional Engineers New Zealand and the Institute of Civil Engineers in the United Kingdom.

1 INTRODUCTION

Christchurch City Council's (CCC) stormwater network within the Port Hills had not been fully assessed to determine the extent of damage resulting from the series of earthquakes from September 2010 – June 2011. CCC required an investigation, condition assessment and a programme of remedial works for the stormwater network in the Port Hills. The goal of this investigation and condition assessment was to identify which sections of stormwater network that require the following:

- Emergency works to immediately restore service to the network;
- Maintenance works to restore the capacity of the network;
- No maintenance works or repair works.

Emergency works would be reported immediately for the CCC to action whilst the maintenance works would be combined with a criticality rating to determine its prioritisation for future repair works.

The criticality rating assigned to each watercourse will also be used for optimising maintenance works in the future. Criticality ratings will be subject to periodic review to account for the changing nature of the hillside catchment and to keep in line with the development of the hillside areas.

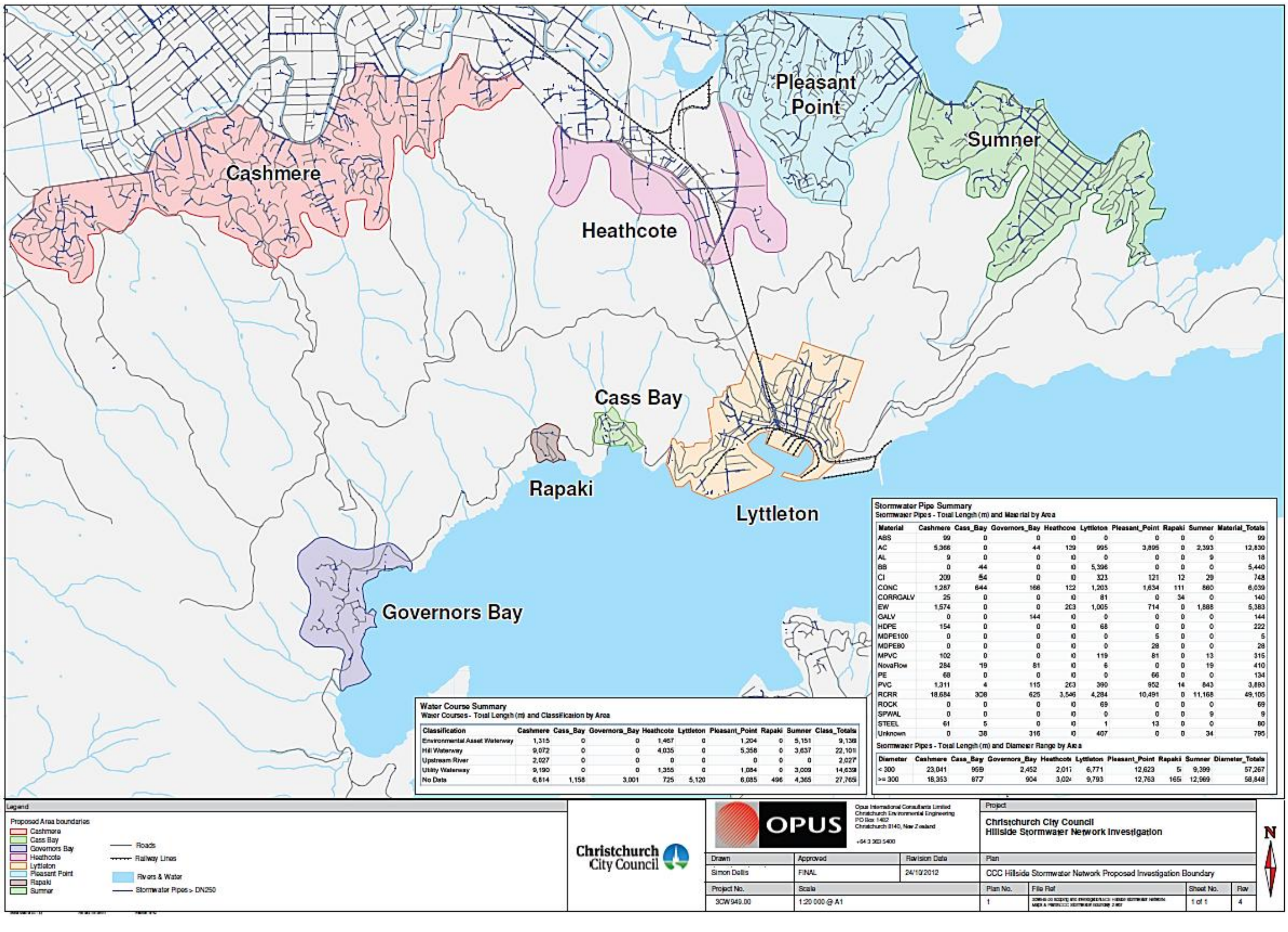

Figure 1: Hillside Investigation project areas

The Port Hills were divided into eight 'Project Areas' for this investigation. These being: Cashmere, Cass Bay, Governors Bay, Heathcote, Lyttelton, Pleasant Point (Mt Pleasant), Rapaki, and Sumner. These areas are mostly hillside suburbs and the project areas (located entirely within the Port Hills) represents the majority (60%+) of the urban areas within these catchments.

2 FIELD INVESTIGATION

The field investigation was divided into two phases. These being:

- Pilot Study – to confirm the collection methodology and delivery formats
- Field Works – to complete the balance of the works

2.1 PILOT STUDY

The first two weeks of the field investigation was used for a pilot study to:

- Confirm the format for the Standardised Assessment Record Sheet (SARS).
- Confirm the methodology for the visual inspection.
- Trial the use of a tablet device for data collection.

The pilot study was conducted in the Rapaki project area as this was finite isolated stormwater network. A range of collection methodologies could be trialled and the outputs confirmed and agreed with the CCC.

2.2 FIELD WORKS

Once the pilot study was completed a meeting was held with the CCC to confirm the format for the SARS and confirm the methodology used for the visual inspection. After successful completion of the trial of the tablet it was also decided to purchase tablets for each of the field teams.

The field works were carried out using two survey teams over a period of 4 months to complete the visual inspection of all the watercourses in the eight project areas.

2.3 USE OF TABLETS

The teams in the field collected data using electronic tablets (Apple iPads). As outlined below this helped speed up both the field work and data collation process. The tablet integrated a Global Positions System (GPS), Geographical Information Systems (GIS) and a high resolution camera into a single unit. This enable the field teams to locate watercourses in the field, input the data directly into the network database and ensured that the report and photos were assigned an exactly location to allow remedial works areas to be easily located.

Manually typing data whilst standing in the bottom of the watercourses proved to be problematic using a touchscreen. The process was simplified to address this. Given the successful use of the tablet device the SARS was then developed for use on a database format utilising dropdown menus in the field to enable efficient accurate data entry.

2.4 CHALLENGES

Several Challenges faced the project team undertaking this work for the CCC. These Challenges included:

1. The extent of the network in the Port Hills (totalling 75+ km).
2. Locating the open network in remote often heavily vegetated areas.
3. Defining Earthquake damage.
4. Determining criticality normally confined to formal (piped) networks with defined end users determining the consequences of failure (i.e. sanitary sewer or potable water customers).

2.4.1 EXTENT OF THE NETWORK

The total extent of the Port Hills open channel network totalled several hundred kilometres. It was determined through discussion with CCC that the survey should be confined to the urban areas in the northern half of the Port Hills (being those closest to the epicentre of the February event) and most likely to have sustained significant damage. The reduced study areas are shown in Figure 1; however the lengths of these watercourses in the eight project areas still totalled approximately 75km.

The timeframe for the completion of this work was short and it was quickly realised that this would require at least two teams in the field undertaking assessments in parallel. This brought two key challenges:

1. How do you achieve a consistent grade score based between the teams?
2. How can you coordinate the teams to ensure works don't overlap?

It was decided to use the New Zealand Infrastructure Asset Grading Guidelines (1999) as the basis for determining the average and peak condition and that each of the three teams would undertake a 10% audit of the other teams works to ensure consistency in approach.

The teams would also use tablets to collect data which would be updated daily with the progress of all teams to ensure that overlap only occurred when undertaking an audit of the other teams work.

2.4.2 LOCATING THE NETWORK

The challenge with the assessment of the stormwater network is that the majority of it consisted of heavily vegetated open drains, with the piped network confined to the lower reaches in the denser urban areas. In addition the majority of this network is located within Private Properties.

The use of tablets incorporating GPS and GIS of the network allowed for the real time interrogation of the network and often directed the project teams to the spot to allow the survey to be undertaken.

2.4.3 DAMAGE SOURCE (EARTHQUAKE VS. AGING)

Given the investigation was being undertaken in excess of 12 months after the initial event and in particular the February 2011 event the determination of earthquake damage could be difficult in older areas where significant age deterioration had occurred already.

To address this the team took high resolution photos of the watercourses and significant damage areas to record what was seen by the investigation teams to allow for review by the asset owner. These photos were also invaluable to the project team later as they allowed independent review of the condition grading in addition to aiding the assignment of the criticality ratings.

In addition to the photos, the local residents also possessed anecdotal knowledge of the network in their areas. This knowledge was invaluable as often they could describe the extent of damage observed directly after the earthquake events.

This was then incorporated into the data collection to indicate the spilt to CCC between regular maintenance requirements and additional damage from the earthquake for budgeting purposes.

2.4.4 USE OF CRITICALITY

Criticality was used (in addition to condition assessment) in order to prioritise the assets in the worst condition with highest consequence resultant from their failure. This then allowed for CCC to develop a forward works programme based on biggest needs within the Port Hills network.

Emergency work (i.e. assets that had already catastrophically failed) was reported immediately to the CCC to enable action to be undertaken whilst the assessment of the network was on-going.

How the criticality was determined for each watercourse is explained further in section 3 below.

3 CRITICALITY ASSIGNMENT

In addition to the condition assessment of the watercourse network the criticality of the watercourse assets had to be determined in order to prioritise the CCC remedial works programme. This enables the critical assets in the worst condition to be addressed first to limit the risk/extent of collateral damage should the assets fail.

May be add note on the range of CCC consequence rating: "Critical, essential, important, general and minor"

The criticality of an asset reflects the consequence of the asset failing (not the probability). In assessing the criticality there was a number of assumptions used by Opus for the Hillside Stormwater prioritisation process. The key assumptions were:

- Asset types included i.e. natural water course, lined water course and culverts
- Asset Types excluded i.e. headwalls and miscellaneous structures
- All assets have a minimum criticality of minor (1) i.e. unassigned assets will default to 1

Failure modes form an integral part of the criticality assessment and include

- Scouring of water course and downstream areas
- Blockages of culverts and water courses: these can be partial to full
- Slumping of water course walls and channels
- Deposition
- Tomos or tunnel gullies

The Stormwater Criticality Methodology process used the criticality matrix previously developed by CCC to ensure that this methodology and systems of analysis was consistent with their approach to their potable water and sewer networks.

This criticality matrix was modified to allow easier understanding by:

- Deleting those items not directly applicable to the Hillside stormwater network
- Adding consequence examples associated with the Hillside stormwater network
- Adding additional items within the individual impact i.e. CCC Levels of Service areas for CCC utilities due to the effect on these service from stormwater failures

The prioritisation programme of Hillside stormwater assets repairs and renewals will uses the following calculation:

Asset priority = Average asset condition score (1 - 5) x Maximum Criticality score (1 - 5)

This simple equation allows all the watercourses in the eight projects areas to be ranked and allows the CCC to direct available resources to the infrastructure most likely to fail with the highest consequences of failure first.

Figure 2: Example of the combined review data showing criticality score of each water course (coloured lines) and priority score colored dots. Refer to legend (below)

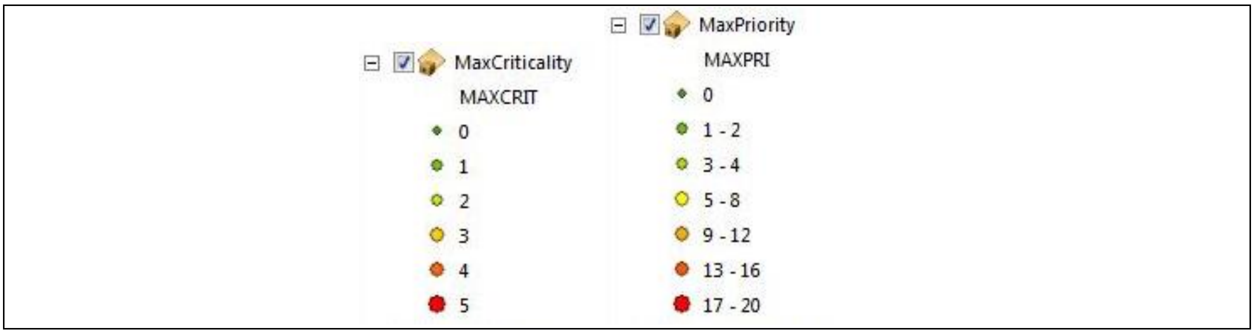

Figure 3: Scoring legends showing Criticality vs. Asset Priority

4 OUTCOMES

The condition assessment concluded in August 2012 and the data provided to CCC to enable them to update their GIS system. This data also provide the baseline not only for immediate maintenance works but for future repeat assessments.

The criticality assignment works are on-going currently (based on recent agreement of the methodology with CCC) but when complete will allow a programme of remedial works to be developed based on both the observed condition grade but also the importance of the watercourse to reduce the risk of failure for the CCC.

Future surveys will have the criticality will process will be pre-programmed into the tablet to allow for a field assessment of criticality to be conducted concurrently with the condition assessment of the watercourses. This will improve the process twofold:

1. Allow the field team to verify the criticality factors such as proximity of nearby floodable structures.

2. Further reduce time allowing a ranked list to be produced straight from the field work.

5 CONCLUSIONS

The key elements of this study were:

1. The successful development of a data collection methodology to enable the collection of condition grading data for watercourses in the Port Hills.

2. The swift identification and reporting of emergency works to the CCC (example report is included in Appendix 1). This enabled remedial works to be identified and action undertaken immediately.

3. The successful use of tablets for field data collection to improve:

    a. The timeframe for data collection (based on the successful marriage of GPS & GIS) and the elimination of the need to process data in the office (double handling).

    b. Increase the ability for independent review of the data collected by inclusion of geographically linked high resolution photographs.

    c. Enabled the field teams to locate watercourses quickly in the field (often in heavily vegetated areas) where visual identification would be problematic.

4. The development of a criticality matrix for an open channel (watercourse) stormwater system to enable the prioritisation of remedial works to initiate immediate risk reduction for the asset owner.

ACKNOWLEDGEMENTS

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REFERENCES

New Zealand Water and Wastes Association Inc (1999) *Infrastructure Asset Grading Guidelines - Water Assets.*

APPENDIX 1: Example Investigation & Urgent Remedial Works Report

Urgent Remedial Works Report

General			
Opus ID	C10-7e		
Inspection Date	2012-07-20T12:11:11Z	**Inspector**	Daniel Kozoil
Area	Cashmere	**Land Type**	Private
Address			
Coordinates	Easting: 1570465.2, Northing: 5175437.7 Google Maps		

Grade Assessments		
	Grade	**Comment**
Condition Grade	4	Other - Refer General Comment

General Comments
See comments from c10-7

Inspection Photos	
Photo 1	**Photo 2**