North Shore City's Infiltration/Inflow Reduction Programme using Trenchless Technology

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ABSTRACT

The combination of increasing population density, ageing sewer networks, and significant year round rainfall has led to increasing levels of water pollution caused by wet weather sewer overflows on to the beaches of North Shore City in Auckland. In order to improve the beach water quality, North Shore City embarked on Project CARE in 1999 with a total estimated cost of NZ $ 280 million over a 20 year period.

The reduction of stormwater infiltration and inflow (I/I) into the sewer network is a critical element of the project and requires an extensive rehabilitation programme for significant areas of the city sewer network. After the priority mini catchments are identified through flow gauging and hydraulic modelling, all public sewer lines in the prioritised mini catchments are rehabilitated using largely trenchless technology. The condition of private drainage is also assessed and where defects are found, notification is given to property owners requiring them to carry out the remedial works. A programme has also been introduced recently to mitigate localised stormwater issues as much as possible in the I/I priority mini catchments.

Some encouraging results have been observed in the reduction of Infiltration /Inflow from the post flow gauging completed so far on rehabilitated catchments.

KEYWORDS

Inflow/Infiltration, Trenchless Technology, Private Drainage Repairs

1. INTRODUCTION

New Zealand's pure natural environment is very attractive to visitors and holiday makers. The great advantage possessed by New Zealand is that there are many different landscapes, environments and eco systems located close to each other. However, in this country of four million people, one third of the population is concentrated in the country's largest region, Auckland, and it is often voted as one of the world's best lifestyle cities in international surveys.

North Shore City boasts a fine lifestyle choice. It is bordered by urban coastline and for many residents, the sandy beaches and the recreational pursuits they allow are the main reasons they have chosen to live there.

However, the combination of an increasing population (under capacity sewers)and ageing sewer infrastructure (allowing infiltration caused by significant year- round rainfall) has led, inevitably, to increasing levels of water pollution in the Waitemata and Manukau Harbours. Poor water quality due

to sewer overflows resulted in the frequent appearance of beach warning signs recommending no swimming.

NSCC embarked on an extensive consultation programme and there was a clear mandate from the public to address the pollution issues.

2. PROJECT CARE

Project CARE (**C**ouncil **A**ction in **R**espect of the **E**nvironment)was launched in the year 1998 with a strong public mandate from the city's 200,000 plus residents with a total estimated cost of NZ $ 280 million over a 20 year period. Project CARE was designed to undertake a holistic assessment of the issues facing the Council and to develop strategic options that would provide an acceptable level of service at a cost the community could afford.

At the inception of Project CARE, an extensive data collection survey was carried out, followed by the development of wastewater network models, stormwater models and receiving water models. One of the most important conclusions drawn from the analysis of the performance of the existing systems was that the existing wastewater system was very leaky and under capacity. It was also observed that the wet weather sewer overflows were the largest source for bacteriological pollution of surrounding waterways?.

Although the first approach, regarding wastewater, would be to fix the leaky system, it has been proven in North Shore City as well as elsewhere that there is a limit as to what can be achieved through sewer repairs. In this area in general it is not possible to prevent wet weather overflows simply by reducing the inflow and infiltration. Additionally, this is certainly not possible within an acceptable budget. The Pareto effect also applies. Reducing the number and volume of the wet weather overflows can generally be achieved by a combination of the following processes.

- Reducing inflow and infiltration by sewer repairs and maintenance.
- Providing storage for peak flows during heavy rainfall.
- Increasing the capacity of the wastewater system and the wastewater treatment plant. This includes provision of alternative/new routes to augment existing lines.

A cost optimisation model (SEWCOM) was used to assist in identifying the optimal set of improvement works using a mix of the above methodologies, to meet various different performance targets and to cater for growth up to the year 2050. The SEWCOM programme identified various components that make up the overall optimal solution. Allowing only two overflows per year was recommended and adopted by the Council in July 2001 as the future design target for the wastewater system.

3. WASTEWATER NETWORK REHABILITATION AND IMPROVEMENTS

The reduction of stormwater infiltration and inflow (I/I) into the sewer network is a critical element of the project, and requires an extensive rehabilitation programme for significant areas of the city sewers. The first stage of the process is to divide the sewerage network into manageable parts or mini catchments. The severity of infiltration and inflow is then determined in these areas by flow gauging and the use of a computerised modelling programme. The leakiest mini catchments are prioritised and

grouped into an appropriate package for the physical works contracts that follow. All components of the sewerage system in the identified problem areas, including both the public sewer network and private drainage on individual properties, are investigated and renewed as necessary.

Other elements of Project CARE include the construction of wet weather wastewater storage facilities, the amplification of sewers and pumping stations, and the upgrading of the wastewater treatment plant.

A key difference between the strategy followed by NSCC and most other Australasian local authorities for I/I reduction is the emphasis placed on reducing leakage from private drainage. Studies carried out indicate that stormwater I/I into private drains can be significant, hence justifying the effort invested by NSCC into this aspect of the programme.

4. INVESTIGATION OF THE EXISTING SEWER NETWORK

The first phase of the investigation is to assess the condition of both the public and private components of the sewerage network and to identify the potential for stormwater Infiltration/ Inflow (I/I) into the system.

The private drainage of every property within the prioritised wastewater mini catchments is inspected for possible sources of inflow, infiltration and exfiltration. The main activities carried out during the source detection phase on private drainage are as follows:

- Visual investigation to confirm the layout of private drainage systems (i.e. validation process) and to locate possible sources for stormwater inflow into the sewer network
- Dye testing to determine connectivity within private drainage systems.
- Smoke testing to determine potential sources of inflow to private drainage systems.
- Closed Circuit Television (CCTV) inspecting of private drainage for condition rating.
- Checking for low and broken gully traps.

The entire public sewerage system, within prioritised wastewater mini catchments, is also inspected and condition rated for identification of sources of inflow, infiltration and exfiltration.

5. REHABILITATION OF THE PUBLIC DRAINS

The next phase of the programme is the rehabilitation or renewal phase, where identified defects in the public sewerage system are corrected. Various pipe lining techniques such as Cured in Place Pipe (CIPP), Form and Fold and Spiral Winding are used to rehabilitate the public sewers. Most of the areas in North Shore City are highly developed and it is necessary to use trenchless methods as much as possible in order to reduce the adverse effects on the environment and possible resistance from the property owners during the pipeline rehabilitation phase. In certain cases, pipelines are replaced by Directional Drilling or Pipe Bursting. Pipe Bursting is used predominantly when the existing pipes need upsizing whereas directional drilling is generally used in the situations where pipe re-routing is required. The open cut method is generally used only in short and shallow sections.

In the past, public laterals and lateral connections (junctions) were sealed using polyurethane grouting. Presently, public laterals are lined using the CIPP technique and the junctions are sealed by installing Lateral Connection Repairs (LCRs) robotically. This has enabled significant progress to be made towards achieving a fully sealed wastewater system.

Leaky manholes are generally repaired by the application of epoxy cement and polyurethane grouting. Structurally weak manholes are replaced by new manholes or converted to dry manholes.

It is also noted that often the leaky mini catchments identified, are in the older areas of the city and hence there are additional benefits obtained from an asset renewal perspective due to rehabilitation.

6. REPAIR OF DEFECTIVE PRIVATE DRAINAGE

NSCC undertakes the remedial work on the public system, but it is the responsibility of the owner of private property to fix the private drains.

NSCC defines a private wastewater drain as a drain which services only one property (the property may have more than one dwelling). It becomes public where it joins with the drains of one or more other properties or where it crosses into the road reserve or a public reserve. If a drain crosses the boundary into a neighbouring property, it remains classified as a private drain.

Since the start of Project Care, the private wastewater drains of approximately 12,000 properties have been inspected and out of that approximately 7000 properties have failed. Approximately, 5000 property owners have repaired their defective drains so far.

In order to get private drains repaired, NSCC sends the owners of properties with defective drains a Notice to Remedy Defective Drainage (NRDD) accompanied by a cover letter, the inspection results and an explanatory brochure. The notice is approved by council's Regulatory Committee and is based on powers given to council by the Local Government Act.

All documents concerning the private drainage such as the inspection reports, letters and notices are put on the respective property files and the "to be inspected" or "defective" conditions are logged against the properties where applicable. This is particularly of relevance to future buyers of the property.

All drainage work is inspected by Council before it is signed off and the drainage defect condition removed from the property file. Council's inspector uses a variety of inspection methods depending on the work done such as visual inspection, water or air test and CCTV inspections.

7. RESULTS ACHIEVED SO FAR

After the public lines are rehabilitated and a substantial amount of private drainage defects are repaired by property owners, the effectiveness of the programme is determined by re-gauging the relevant mini and full catchments. So far, regauging and modelling has been done in four catchments and the details are given in the Table 1.

Flow Gauging Results

Wastewater Catchment	% Private Drainage Repaired at the time of Gauging.	% Reduction of I/I in Rehabilitated Area.
Browns Bay South	* 4%	23%
Old Northcote	70%	48%
Narrow Neck	69%	31%
Devonport	57%	70%

Table 1

* Browns Bay catchment flow gauging work had to be done prior to completion of private drainage in order to carry out design of other augmentation work planned in the catchment.

The results are positive even though overall Inflow/Infiltration targets have not been achieved in two catchments. It is anticipated that the results would improve much further after the stormwater related issues are mitigated and repairs to private drains are completed in these catchments.

8. REDUCTION OF DIRECT STORMWATER INFLOWS TO SEWER NETWORK

Stormwater enters the wastewater system through both private and public networks. Council policy is to line almost all the public sewers in the selected priority mini catchments including installation of Lateral Connection Repairs at all connections and sealing of all leaking public manholes. As a result the amount of stormwater which could get into the system through public network should be minimal. The same cannot be said regarding private sewer networks. The stormwater can enter into the system through low & damaged gully traps, non sealed chambers and illegal connections. When private drainage is investigated, all low and damaged gully traps are identified. Also, the illegal connections are identified through CCTV of private drainage, smoke & dye tests and checks for connectivity. Property owners are requested to rectify the defects in their private drainage by issuing NRDD notices. However, if the properties are flooded during rainy periods, it is difficult to prevent stormwater entering the sewer network. This is due to the limitations in raising the gully traps and the difficulty of preventing illegal connections if there is frequent flooding of houses during rainy periods. In

general, when there is flooding, stormwater will find its way into the sewer network. Thus it has been observed that it is very important to have a program to mitigate the issues arising from stormwater in mini catchments selected for rehabilitation. Therefore, a program has been launched recently in co ordination with the stormwater section of the Council for tackling the stormwater issues in the priority mini catchments.

9. JOINT ACTION PLAN OF STORMWATER PLANNING AND WASTEWATER REHABILITATION DEPARTMENTS.

A programme is presently being developed to mitigate the issues arising from stormwater flooding in the wastewater I/I reduction programme. The implementation of improvement works identified in stormwater catchment management plans is estimated to take in the order of 70 years to complete on a citywide basis. Therefore it is important to trial and develop prioritised and cost effective solutions for stormwater issues in the affected areas as soon as possible. These improvements will form a part of the stormwater catchment management plan for the area.

During studies undertaken it was observed that the properties could get flooded due to one or more of the following reasons.

- Stormwater ponding due to a rise in water levels in the waterways and overland flow paths
- The capacity of stormwater reticulation systems in the area being exceeded during rainy periods.
- Frequent blockages in the stormwater reticulation systems.
- Inadequate road-side drainage systems.
- Obstructions to overland flow paths. (eg. Buildings & boundary walls constructed across overland flow paths.)
- Localised low lying areas resulting in ponding

Some examples of stormwater issues existing in a priority wastewater mini catchment which has been rehabilitated recently are shown in Figure.1 & Figure2.

Stormwater related issues in Wairau Catchment

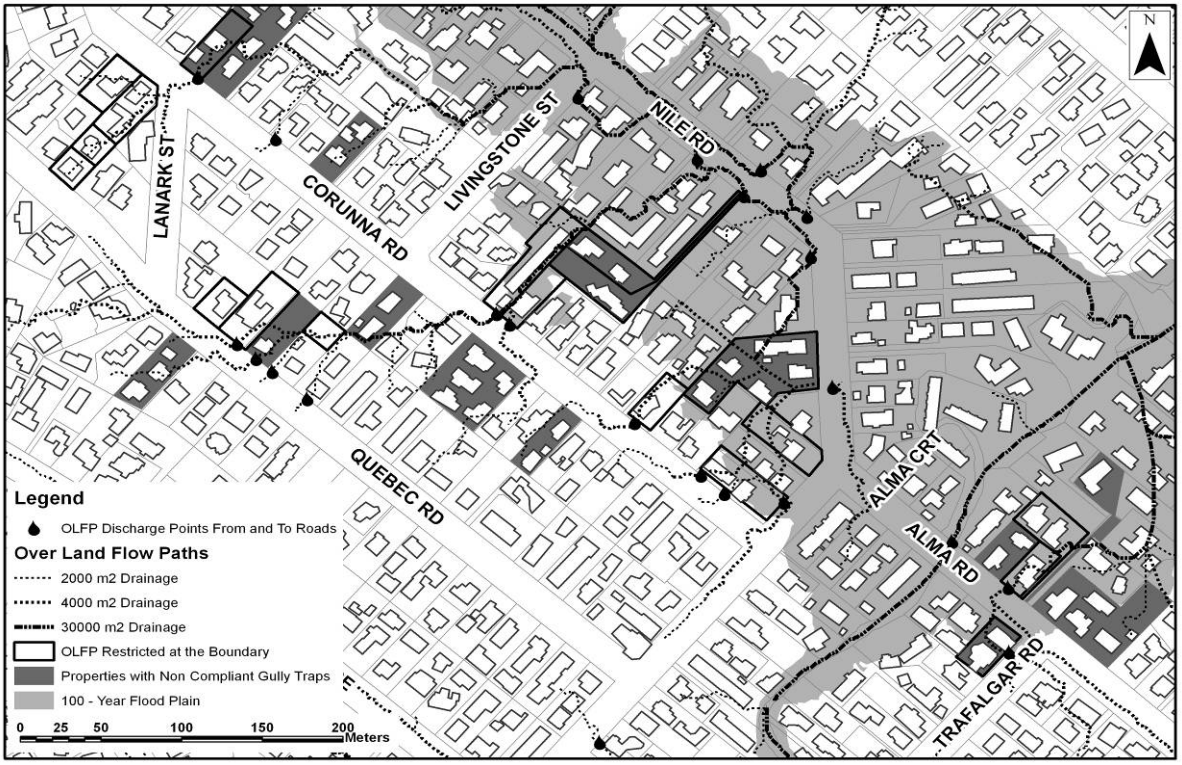

Figure 1

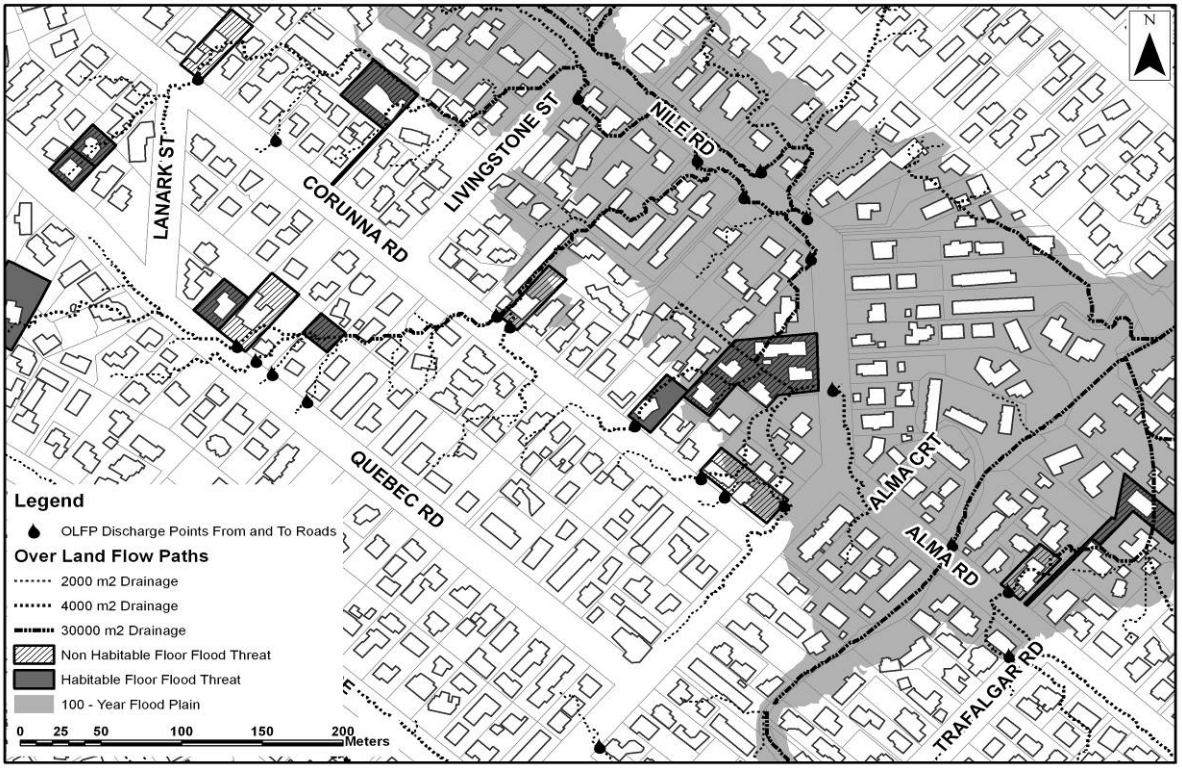

Figure 2

The following information is shown in the layout of mini catchment C 1506A of Wairau/Forrest Hill.

- Overland flow paths (OLFP) for 2000m2 ,4000m2 & 30,000m2 drainage.
- Overland flow paths discharged from, and to, roads.
- Overland flow paths restricted at the property boundary.
- Compliant gully traps(along the OLFP)
- Non compliant gully traps (along OLFP)
- Risk of flooding of Habitable & Non habitable floors in 100 year event – Ground level & sub floor level.

Compliant gully traps, non complaint gully traps and illegal connections in the Devonport catchment have been plotted in a similar way. It is an area without adequate stormwater reticulation. Some clusters of illegal connections could be observed in this layout. These are low lying areas of the mini catchment without any storm water drainage facilities. Therefore it is unsurprising that the residents try to reduce their storm water ponding issues by illegally diverting their stormwater into the wastewater network.

There will often be no realistic or practical options to mitigate flood risks associated with major storm events. However, there may be improvements that can reduce flood impacts in more frequent minor rain events.

10. COST EFFECTIVE SOLUTIONS

The following improvements have been identified as cost effective methods to reduce direct stormwater inflows to the wastewater network.

- Remove obstructions to overland flow paths or re-route overland flow paths where appropriate.
- Improve roadside drainage at certain locations to prevent stormwater overflows to the adjoining properties during rainy periods.
- Raise low level gully trap surrounds.
- Improve existing SW reticulation systems where appropriate.
- Carry out improvements to landscaping including paving in order to divert the stormwater away from the gully traps.
- Provision of sealed gully traps specifically in flood plain areas where other options might not be cost effective.

Ideally, stormwater catchment management plans should be completed and necessary improvements to the stormwater systems should be implemented prior to carrying out flow gauging or physical sewer rehabilitation work in the priority mini catchments for inflow/ Infiltration reduction. This has become practically difficult due to the differing priorities of the two programmes, resource and fund availability as well as the required time to implement catchment management plans. Therefore, it is important to address as much as possible the stormwater issues which could affect the I/I reduction programme, during the investigation phase of the sewer rehabilitation programme.

During the investigation phase, maps are prepared with all available stormwater features such as existing stormwater facilities, overland flow paths, flood plains and ponding areas . A list of known stormwater issues is also prepared. A thorough investigation of the mini catchment area will be then

carried out including house to house surveys to identify and collect information such as properties with risk of flooding, low/broken gully traps, illegal connections, obstructions to overland flow paths and issues associated with roadside drains. In the flood plain areas the level of the gully traps in relation to the two year flood plain are also noted. All the collected information will then be plotted on the maps again to assist finding integrated solutions for the area.

11. Problems Encountered / Solutions/ Key Achievements.

- Initially, Investigation, Analysis & Design and Rehabilitation was carried out in three separate phases. This included several visits to properties by contractors over 1-2 year period. This has created some resistance from the property owners and also large amount of data to be transferred from one phase to another This has now been replaced by combined Source Detection & Rehabilitation Contracts.
- Some quality issues were encountered at the inception phase of the program. These have been addressed by improving the Technical Specifications and with the introduction of Inspection and Test Plans (ITP's), Quality Assurance and Compliance Auditing procedures.

- Some manholes have been converted to dry manholes as they were uneconomical to rehabilitate and practically difficult to replace.

- Resistance from private property owners to check their private drains had been overcome by improved procedures and excellent communication. Success rate has been increased from 60% to 98%.

- By working in partnership with the local communities and due to effective communication with property owners, private sewers in approximately 5000 properties have been repaired so far as per the NRDD instructions at a cost between $ 2000 to NZ$ 5000 per property. That indicates an amount in excess of $ 10 million (approx.) has already been directly spent by the property owners. It is an indication of the level of acceptance of the NSCC sewer rehabilitation programme by the North Shore Community.

- Initially, pipelines joints and public laterals were sealed by chemical grouting. As chemical grouting was found to be ineffective with an unacceptable short life span, Pipeline grouting of public laterals has now been replaced by lining and Lateral Connection Repairs have been introduced to seal the connections.

- Some difficulties were encountered initially with hydrostatic testing of private drains. This has been replaced by a condition rating system based on CCTV inspection. This scoring system is now included in the latest edition of the New Zealand Pipe Inspection Manual.

- North Shore City Council is instrumental in introducing new technologies in sewer rehabilitation such as Form & Fold, Spiral Winding, Lateral Connection Repairs (LCR) to New Zealand.

12. CONCLUSIONS

North Shore City Council has so far achieved positive results in the reduction of Infiltration/ Inflow in the wastewater catchments by carrying out comprehensive rehabilitation of private and public sewer network in the priority mini catchments. However, the effect of potential direct stormwater inflows to the sewer network due to inadequate stormwater management in the area could have had an impact on the results. By undertaking improvements to stormwater management in the priority mini catchments , it is anticipated that better I/I reduction results will be achieved.

13. REFERENCES

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