Earthworks, Erosion and Sediment Generation

Technical Report A

20-Apr-2016
Prepared for – Watercare Services Limited – Co No.: N/A

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Client: Watercare Services Limited

Co No.: N/A

Prepared by

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E	20-Apr-2016	Final for AEE submission	Martin Evans Senior Principal – National Water Marketing Manager	

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Executive Summary

This earthworks, erosion and sediment generation technical assessment has been completed for the construction of the North Harbour 2 Watermain (NH2) from Titirangi, West Auckland to Albany Reservoir, North Shore. The earthworks, erosion and sediment generation effects are not required to be assessed in relation to the designation of that part of the Northern Interceptor (NI) Project between Westgate and Hobsonville, where a shared corridor is proposed for wastewater infrastructure.

The construction of the NH2 watermain will predominantly be by open trenching with sections using trenchless technologies, and pipe bridges over permanent streams. The assessment of erosion and sediment generating activities has been based on the preliminary design and likely construction methodology as presented in the North Harbour 2 Watermain and Northern Interceptor in the Shared Corridor Assessment of Effects on the Environment (the AEE report). Site conditions, detailed design and construction methodologies have potential to change between submission of this earthworks, erosion and sediment generation technical assessment and construction of NH2. Changes are to be captured in the Contractors Erosion and Sediment Control Plan (ESCP).

The construction activities associated with NH2 have potential to have an adverse impact on the environment, especially streams and the Upper Waitemata Harbour through the release of sediment laden runoff into the water ways. Sediment will adversely affect water quality by increasing turbidity and total suspended solids, this in turn will adversely affect the ecology and biota of the receiving water bodies. Auckland Council's Technical Publication 90 "*Erosion and sediment control guidelines for land disturbing activities in the Auckland Region*" (TP90) sets out the key principles and measures suitable for reducing impacts on the environment as a result of earthworks and construction activities. All mitigation measures prescribed in this technical report are to be designed and implemented in accordance with TP90 guidelines. The key principles for managing erosion and sediment from earthworks and construction activities are as follows:

- Stage construction to limit the time and area that soil is exposed and prone to erosion;
- Protect steep slopes by using diversion bunds, or maintaining existing vegetation;
- Stabilise exposed areas rapidly with vegetation;
- Install perimeter controls above the site to keep clean runoff out of the worked area; and
- Install perimeter controls below the site to detain sediment and prevent contamination of the existing receiving environment.

The earthworks associated with NH2 have been assessed as a restricted discretionary activity under the Auckland Council Regional Plan (Sediment Control). Consent will also be required under the Proposed Auckland Unitary Plan for general earthworks (discretionary activity), earthworks within the 100 year flood plain and Significant Ecological Area overlays, and for groundwater and stormwater diversions and discharges associated with dewatering and construction of access roads.

Representative sections of the NH2 route have been identified within this technical assessment to describe in more detail the layout of required erosion and sediment control measures (ESCMs). Once detailed designs are complete and the Contractor has confirmed the construction methodologies, their ESCP should be developed to detail implementation of the ESCMs identified in this technical assessment. With correct design and construction of ESCMs it is anticipated that the effects on the environment will be less than minor.

1.0 Introduction

AECOM Consulting Services (NZ) Ltd (AECOM) has been commissioned by Watercare Services Limited (Watercare) to assess the potential earthworks, erosion and sedimentation effects related to the construction, operation and maintenance of Watercare's proposed North Harbour 2 Watermain (NH2) project between Titirangi and Albany.

The NH2 will convey potable water from storage reservoirs in Titirangi, via west Auckland and North Shore to storage reservoirs in Albany (a length of approximately 33km). Its purpose will be to increase capacity and resilience of the water supply network to western and northern Auckland.

The NH2 project incorporates:

- Pipeline installation, operation and maintenance of a new watermain of 1,200 mm (west of Greenhithe Bridge) and 900mm (east of Greenhithe Bridge) nominal diameters;
- Pipeline length of approximately 33 km mostly within public road reserve; and
- Other features including valve chambers, scour valves, air valves, line valves, bulk supply points, pipe bridges, and associated works.

Most of the watermain will be constructed by open trenching, micro tunnelling or bored tunnel (the latter two referred to as "trenchless technology" or tunnelling within this report) within a typical construction corridor of approximately 12 – 22 metres width with additional areas required for erosion and sediment control devices, traffic management, construction yards and storage areas at intervals along the route for construction purposes.

The Northern Interceptor (NI) project comprises of a new wastewater pipeline and associated activities to convey flows from north-west Auckland to the Hobsonville Pump Station, and then to the Rosedale Wastewater Treatment Plant (WWTP).

The proposed NI project in the shared corridor begins in the vicinity of Hobsonville Road (West Harbour), near the intersection of the Upper Harbour and North Western Motorways (SH18 and SH16). From this location, the alignment follows the southern side of the SH18, continuing northeast to the Hobsonville Pump Station. Future phases of the NI project will also include new pipelines between the Hobsonville Pump Station and the SH18 causeway.

The part of the NI project falling within the shared corridor with NH2 incorporates the following:

- A new 5km wastewater pipeline of 2100mm DN;
- 16 pits / shafts for trenchless technology construction purposes. Five of these will be permanent manholes (MT Pits 2, 7, 11, 13 & 17) while the others (MT Pits 3, 4, 5, 6, 8, 9, 10, 12, 14, 15 and 16) will be temporary only until construction / testing is completed;
- MT Pit 7 will be a drop structure with permanent access, to allow for a future wastewater pipeline connection across SH18;
- A new 50m long wastewater pipeline and manholes connecting the 2100mm ND pipeline to the existing pump station;
- A new 1750 l/s Pump Station with future capacity across the site of 3,500l/s;
- Wastewater storage (within pipeline);
- Two 800m 1500mm DN rising mains (length to the causeway); and
- A 2100mm DN pipe installed by trenchless technology at SH18.

The proposed alignment of NH2 and the location of the NI project are shown in Figure 1 below.

A full description of the proposed works and construction methodology is included in in the North Harbour 2 Watermain and Northern Interceptor Shared Corridor Assessment of Effects on the Environment (the AEE report) prepared by AECOM Consulting Services (NZ) Ltd (AECOM) and Jacobs New Zealand Limited (Jacobs).

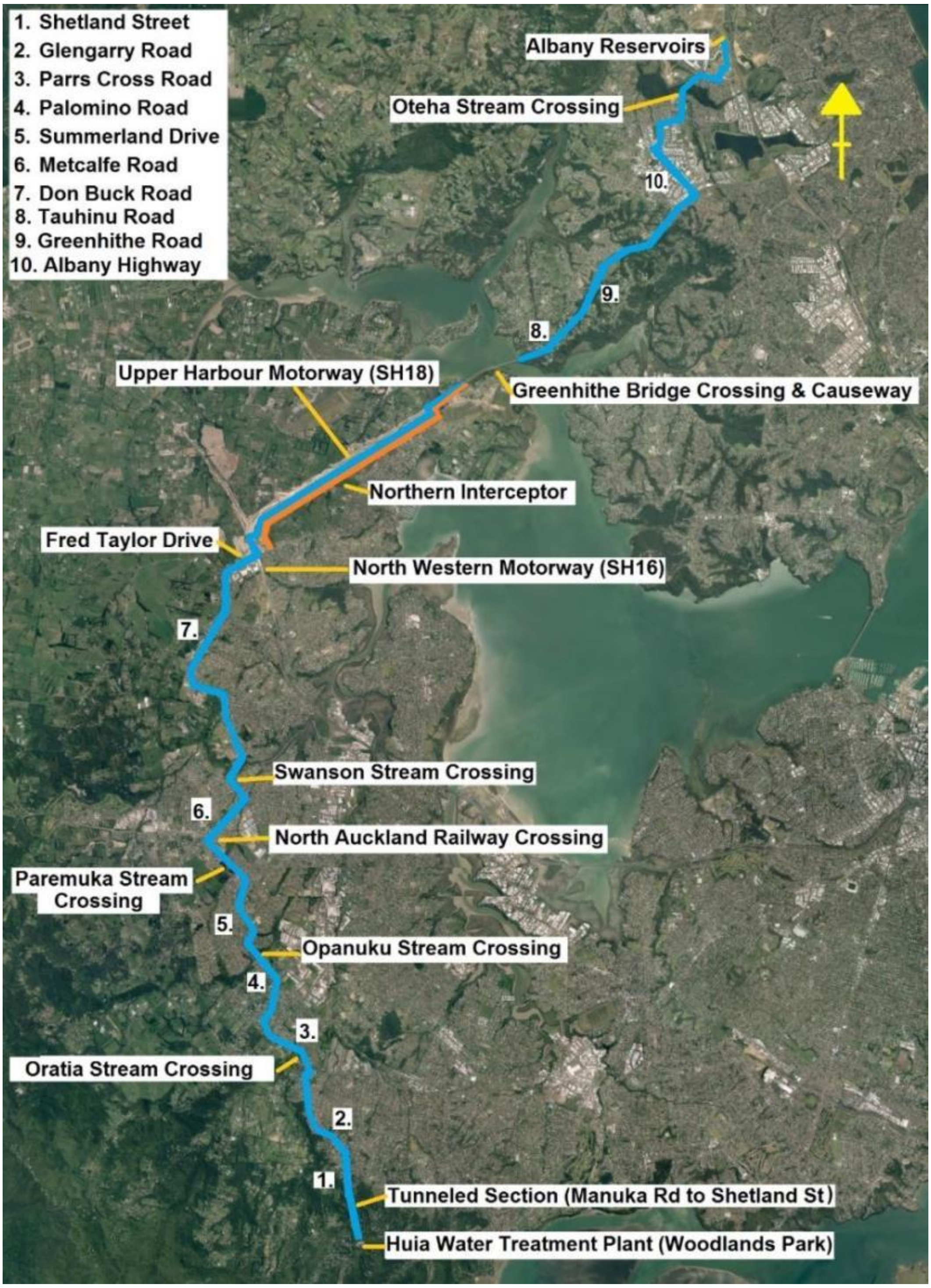


Figure 1 Alignment of NH2 (blue) and relevant section of Northern Interceptor (orange)

Watercare is proposing to designate land for the NH2 project between Titirangi and Albany and the NI project in the shared corridor between Westgate and Hobsonville, and will also be seeking various resource consents for NH2 under the Resource Management Act 1991 (RMA). Resource consents for NI in the shared corridor are not part of this assessment. This technical report provides specialist input for the AEE which supports the resource consent application for NH2 only. The earthworks, erosion and sediment generation effects are not required to be assessed in relation to the designation of that part of the Northern Interceptor (NI) Project between Westgate and Hobsonville, where a shared corridor is proposed for wastewater infrastructure. Resource consents required for works associated with the NI project will be sought by Watercare at a later date, nearer to the proposed date of construction. The alignment drawings referred to in this report are contained within Volume 3 of the AEE.

This report provides the following in relation to NH2:

- A description of the environmental baseline for the particular receiving environment(s) potentially affected by the NH2 project;
- Description of specific aspects of the NH2 project in relation to the subject area being investigated;
- Description of the investigations undertaken to assess earthworks, erosion and sediment generation;
- An assessment of the actual or potential effects on the environment (construction, operation and maintenance). This includes the identification of activities that could result in potential adverse effects and, in turn, identifying design refinements or construction methodologies that could avoid, remedy or mitigate potential adverse effects; and
- Conclusions.

2.0 NH2 Proposed Works

2.1 North Harbour 2 – Project Description

The NH2 project involves constructing a 1,200 mm nominal diameter (DN) watermain to supplement the existing North Harbour No. 1 Watermain (NH1). The NH2 will convey potable water from storage reservoirs in Titirangi, via West Auckland and North Shore to storage reservoirs in Albany (a length of approximately 33 km). Its purpose will be to increase capacity and resilience of the water supply network to western and northern Auckland.

The NH2 works assessed in this report include the construction, operation and maintenance of the proposed NH2 watermain (open trenching, trenchless technology and up to five pipe bridges), including the associated NH2 ancillary components – valve chambers, scour valves, air valves, line valves, weld-down manholes, bulk supply points, inline flow meters and three cathodic protection measures.

The recently consented Greenhithe Bridge Watermain Duplication (GBWD) and Causeway widening project will be integrated into the NH2 project.

2.2 Construction Methodology and Sequence

The full construction methodology is presented in the AEE report, Section 2. The information presented in this section is particularly relevant to the development of this earthworks, erosion and sediment generation technical assessment report. The Contractor with agreement from Watercare will be responsible for determining the final construction methodology however it is anticipated that the watermain pipeline will be constructed with a combination of open trenching methods following the land topography within the road corridors (approximately 30 km in total); and trenchless techniques where access is limited or above ground conditions restrict open trenching (approximately 2.8 km in total, locations listed in Table 1). There are five pipe bridges where NH2 crosses water bodies. All pipe bridges have been designed to accommodate estimated flood levels for their respective locations and with the support columns located as close as possible to the top of the valley sides to reduce the extent of access works for construction and avoid any works within the watercourse. These pipe bridges are listed in Table 2 below.

Table 1 Location of trenchless technology use on NH2 alignment

Trenchless Technology Location	Approximate Tunnel Length (m)
Woodlands Park (Waitakere Ranges Regional Park)	900
North Auckland Railway Line, Metcalf Road – *Option 2*	62
State Highway (SH) 16/ SH18 Interchange Crossing	140
SH18 (Sinton road)	40
Tauhinu Road Crossing – *Option 1*	210
SH18 (Wicklam Lane) – *Option 1*	310
Albany Highway Crossing	520
Greenhithe Road Crossing	150
Oteha Stream and Bush Road – *Option 2*	400
Albany Expressway Crossing	120

Table 2 Location of pipe bridges on NH2 alignment

Pipe Bridge Location	Approximate Pipe Bridge Length (m)	Number of Support Columns (Monopole)
Oratia Stream (Parrs Cross Road)	20.5	2 x 0.9 m diameter
Opanuku Stream (Border Road/ Palomino Drive)	43.5	4 x 0.9 m diameter
Paramuka Stream (Summerland Drive)	38.5	3 x 0.9 m diameter

Pipe Bridge Location	Approximate Pipe Bridge Length (m)	Number of Support Columns (Monopole)
Swanson Stream (Don Buck Corner Reserve)	19	2 x 0.9 m diameter
Oteha Valley Stream (Bush Road) – *Option 1*	81	4 x 0.9 m diameter

2.2.1 Open Trenching

All construction will occur within the designation corridor. If the Contractors require a main site yard outside the designation separate arrangements (e.g. lease and resource consents as required) will need to be made and are the responsibility of the Contractor(s). The construction corridor will be approximately 12-22 m in width. To achieve at least 1.5 m of cover over the watermain pipe, trenching will be approximately 2-3 m wide and generally 3 to 4 m deep. The length of open trench at any one time will generally be 20-30 m, laying one to two pipe lengths per day. This rate of progress will equate to earthworks volumes between 120-360 m^3 at any one time for the open trenching. Figure 2 depicts a typical open trenching construction footprint which can be expected on this project.

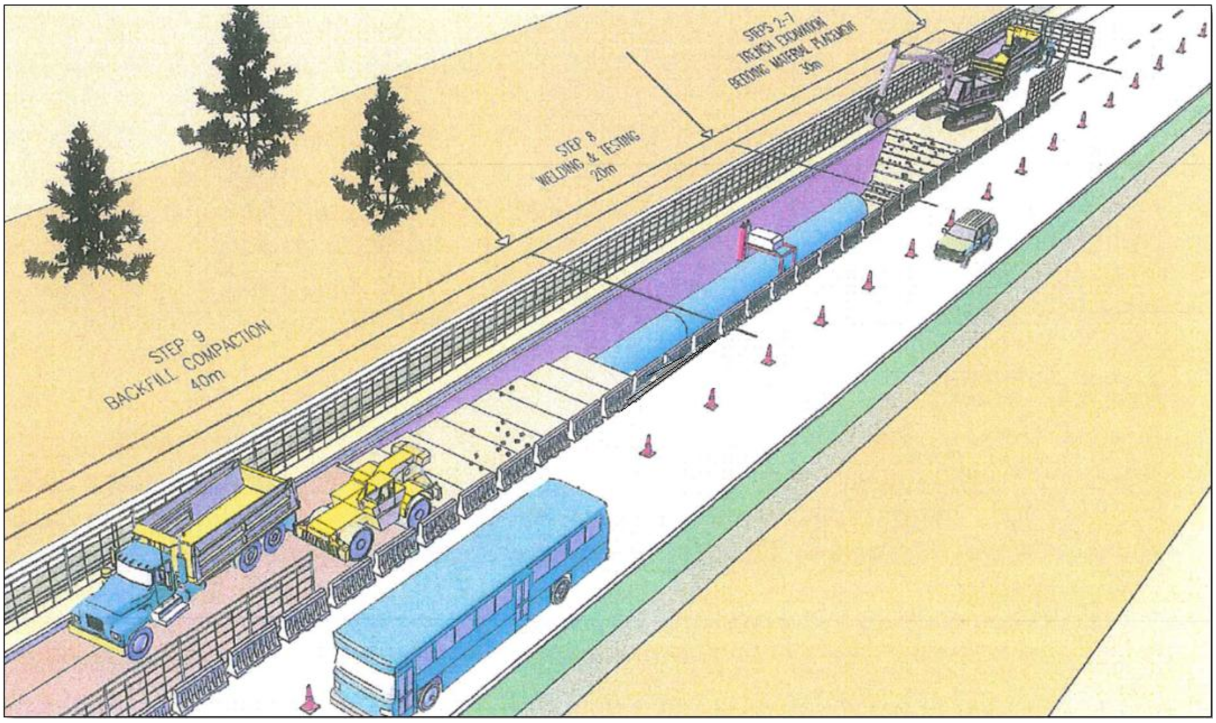


Figure 2 Typical open trenching construction footprint

The following outlines the typical sequence for open trenching construction illustrated in Figure 2 above:

1) Site safety, traffic control and ESC device set up as required;
2) Cut into ground surface, with road surface and sub-base removed for disposal;
3) Trench support where required with the type and extent determined by the geotechnical conditions;
4) Excavation of trench to approximately 150-300 mm below the pipe invert level with surplus excavated material loaded onto a truck for immediate removal from site or re-use;
5) Dewatering as required, depending on groundwater table level;
6) Placement of granular pipe bedding material;
7) Pipes lowered into the trench using a large excavator or crane;
8) Where required, installation of shoring boxes for safe welding and wrapping of pipe joints;

9) Internal and external welding of pipe joints carried out and tested; internal concrete lining repair and application of external wrapping;

10) Backfilling of trench and compaction up to ground level. Compaction usually required in layers every 200-300 mm of fill depth;

11) Reinstatement of the road surface with pavement material to match the adjacent pavement in compliance with the Code of Practice for Temporary Traffic Management (COPTTM); and

12) Removal of site safety, traffic controls and ESC devices.

2.2.2 Trenchless Technologies

The sections of trenchless technologies (as listed in Table 1) will require excavation of shafts at the beginning of the trenchless section (jacking station), and at the end of the trenchless section (reception shaft). These vertical shafts can be secured with sheet piles to the required depth that the jacking station operates from. The proposed boring machine has a closed loop slurry system where spoil from the recycling slurry water is ‘separated and pumped to a waiting truck/ tank for removal from site.

The trenchless technology shafts will vary in depth depending on location and site requirements. The jacking stations will generally measure approximately 4 m by 16 m and the reception shaft will measure 4 m by 4 m. These shafts may be slightly smaller on confined sites such as Metcalf Road. In total, approximately 17 access shafts will be required for the trenchless sections of the NH2 route.

It is assumed that the reservoirs and associated hard stand areas at Woodlands Park Road will have been constructed prior to NH2. Therefore access to the Woodlands Park Road jacking station for tunnelling will be via the reservoir compound which is yet to be built. The reservoir construction is not included in the scope of this technical assessment.

2.2.3 Laydown Areas

A laydown area is used to provide secure storage for materials, machinery, staff and visitor parking, fuelling facilities, and office accommodation (including toilets). Laydown areas will be surrounded by temporary fencing for safety and security purposes; they will consist of hard stand and bunded areas for storage of hazardous materials (e.g. fuel) and stockpiles. Laydown areas will be located in practical and convenient places along the NH2 route. It is possible that the main laydown areas, site yards and pipe storage areas may be located away from the NH2 route. The number and location of laydown areas will be determined by the Contractor and will depend on available land at the time of construction. It is anticipated that each laydown area will be occupied for several months. The Contractor’s ESCP will specify laydown areas and required ESCMs within the site.

2.2.4 Access Ways

Access ways are required along sections of SH18 for construction and maintenance purposes (and possibly provision of a cycleway by Auckland Transport). It is anticipated that access ways will be gravelled. The location of the access ways are presented in Table 3 and depicted in the drawings provided in Volume 3 of the AEE report.

Table 3 Access way locations and areas

Location	Area (m^2)
Titirangi to Westgate SH18 Corridor	
Hobsonville Road to SH18 (NI Shaft 2)	2,000
SH18 – NI Shaft 3	740
SH18 / 175 Brigham Creek Road (between NI Shafts 9 to 13)	5,000
SH18 / Brigham Creek Road (between NI Shafts 13 to 15)	2,500
Sinton Road (NI Shaft 15) to Squadron Drive	5,000
Greenhithe Bridge to Albany	
Albany Highway	3,000
Greenhithe Road	4,000

Location	Area (m^2)
Tauhinu Road	4,000
Total Area (m^2)	**26,240**

The use of the SH18 corridor has been agreed in principle with NZTA on the understanding that, where practicable, access ways developed for the NH2 watermain be available for future upgrade to a cycleway by Auckland Transport (the Cycle Metro).

An access way will be provided along the majority of the watermain within the SH18 corridor to facilitate access to watermain valves and associated structures. In some sections, particularly east of the Greenhithe Bridge, it is impractical to provide a continuous access and identified entry points together with end turning heads will be required within the motorway corridor. Entry to the access ways will be via gated locations off local streets and from the motorway itself.

The proposed Cycle Metro will need to accommodate the occasional passage of Watercare vehicles for the purpose of maintaining the watermain and watermain structures. Access for routine maintenance is expected to occur on a three monthly basis using a light truck or utility vehicle. In the rare event that repair of the watermain or structures are required, larger vehicle access may be necessary.

In a number of sections the access way will traverse embankments where there will be a requirement to retain one or both sides of the access way. It is proposed that a proprietary mass block retaining systems would be typically used. The access way width has been preliminarily selected as 3.5m. Turning and parking areas will also be required. The access ways may be a standard gravel construction consisting of compacted natural ground (or fill as required) overlaid by 300mm GAP 65 and finished with GAP 25 aggregate. In some instances the access way will be positioned over the NH2 watermain (as per the drawing for Typical SH18 Construction Section in Volume 3 of the AEE report).

2.2.5 Construction Sequence

The NH2 is expected to be constructed in different stages to meet the demands of different areas of the system and the growth in demand. The following timeframes listed in Table 4 for the construction of various stages of the NH2 Watermain are approximate and dependant on factors such as the rate of development in the Auckland area and assumption of the approval of detailed design.

Table 4 NH2 Indicative Programme

NH2 Stage	Anticipated Timeframe
Greenhithe Bridge Watermain Duplication and Causeway	2016/2017
Eastern end of Greenhithe Bridge to Albany Reservoir (NoR 2)	2018-2022
Titirangi to western end of Greenhithe Bridge (NoR 1 and NoR 3)	2022-2025

Open trenching will likely occur throughout the year including the winter months. The small open earthworks areas and confined sites mean that management of erosion and sediment generating activities can be easily implemented to mitigate impacts on the receiving environments. Open trenching construction may be undertaken at a number of concurrent work areas along the watermain route.

Pipe bridge construction work will need to occur when flows within the water courses are low and timed for the summer earthworks seasons as far as practical. Trenchless construction will be scheduled based on location, availability of equipment and level of risk associated with the immediate receiving environment..

3.0 Statutory Framework

The AEE prepared to support the Notice of Requirements (NORs) and resource consent applications for NH2 provides a review of the necessary district and regional plans applicable to the earthworks component of the project. This section summarises the applicable sections of each plan.

The total volume of earthworks associated with the 33km open trenching, trenchless technologies and pipe bridges is likely to be in excess of 257,000 m^3 (area 9.8ha). Table 5 provides a breakdown of the earthworks volume and area for each geographical area of the NH2 route.

Table 5 Estimated earthworks volumes and area for each geographical area

Route Area	Earthworks Volume (m^3) (likely in excess of)	Estimated Area (m^2) (likely in excess of)
Titirangi to Westgate	140,000	39,000
Westgate to western side of GBWD and Causeway Project (SH18 Corridor)	52,000	29,000
Eastern side of GBWD and Causeway Project to Albany reservoir	65,000	30,000

Due to the identified construction methodologies and staging, the earthworks volumes and areas stated in Table 5 will not open at the same time. These values are total estimates until the completion of all construction works. The construction period is expected to take several years.

3.1 Auckland Council Regional Plan (Sediment Control)

The NH2 watermain alignment crosses into areas described and identified as "Sediment Control Protection Areas" and are defined as follows:

a) 100 m either side of a foredune or 100 m landward of the coastal marine area (whatever is the more landward of mean high water springs); or

b) 50 m landward of the edge of a watercourse, or wetland of 1,000 m^2 or more.

Due to the slope of the land along the route, proximity of streams and the volume of earthworks for the pipe bridges, trenchless access shafts and the open trenching the work is a restricted discretionary activity.

Table 6 Auckland Council Regional Plan (Sediment Control) – Table C Restricted Discretionary Activities (S.5.4.3.1)

Type of Activity	Within the Sediment Control Protection Area	Outside the Sediment Control Protection Area
Earthworks – on all Soils including Sand Soils	Area greater than or equal to 0.25 ha.	Area greater than or equal to 5.0 ha on land with a slope less than 15°. Area greater than or equal to 0.25 ha on land with a slope greater than or equal to 15º.
Roading/Tracking/Trenching – on Sand Soils on all Soils except Sand Soils	Length of 100 m or more. Length of 100 m or more.	(Refer to Table Above – Permitted Activities) Area greater than or equal to 5.0 ha where the land has a slope less than 15º. Area greater than or equal to 0.25 ha where the land has a slope greater than or equal to 15º.

Section 6 Information Requirements of the Auckland Council Regional Plan (Sediment Control) outlines the necessary information to be submitted with any earthworks consent application. This earthworks, erosion and sediment generation technical report has been prepared in accordance with the information required for the Sediment Control Management Plan and Section 6 of the Regional Plan.

3.2 Proposed Auckland Unitary Plan

The NH2 construction works would be considered under the activity 'network utilities' and under the PAUP earthworks include open trenching and trenchless methods which result in soil disturbance. The relevant clauses of the PAUP include:

- 3H.4.2.1.1 Activity Table – Earthworks – Zones;
- 3H.4.2.1.2 Activity Table – Earthworks – Overlays; and
- 3H.4.2.1.3 Activity Table – Outstanding Natural Feature.

The scale of earthworks (greater than 2,500m^2 or 2,500m^3) is a discretionary activity requiring consent (PAUP rule H.4.2.1.1). For earthworks occurring within the 100 year flood plain overlay the activity status is restricted discretionary and within the Significant Ecological Area (SEA) is a discretionary activity (PAUP Rule H.4.2.1.2).

4.0 Site Descriptions and Environmental Baseline

The 33 km NH2 route passes through a number of different land use types. These include:

- Parks and reserves, both open space and bush covered;
- Residential, commercial and industrial;
- State highway transport network;
- Streams; and
- Adjacent to Coastal marine environment at Squadron Drive.

For the most part, the route is along the existing road network with the designation allowing enough space for construction and maintenance of the watermain. The construction works have potential to cause erosion and sedimentation of receiving environments. The most sensitive receiving environments are the streams (listed in Table 2) and the Upper Waitemata Harbour in the vicinity of the Greenhithe Bridge and Wallace Inlet (refer to drawing number 2010673.525 included in Volume 3 of the AEE). A detailed site description and baseline environmental assessment is provided in the AEE report and the following supporting Technical Reports:

- Soil, Sediment and Groundwater Contamination;
- Ecological Assessment;
- Landscape and Visual Assessment; and
- Geotechnical Assessment.

4.1 Geology

The full geological assessment is documented in the geology section of the AEE report. In summary, the route crosses the following underlying geology which each present different rates of erodibility and potentially different earthworks and construction methodologies. The Contractor's ESCP will document where the underlying geology may require particular erosion management and or sediment treatment.

- East Coast Bays Formation (ECBF). Early Miocene age flysch, a greenish grey, alternating muddy sandstone and mudstone, with occasional interbedded harder grit lenses (Parnell Grit). The weathered rocks of the ECBF weathers at the surface to brown and grey colour variations of soft to stiff, low to moderate plasticity clayey silt; soft to firm, non-plastic to high plasticity sandy silt; and very loose to very dense fine to medium sand.
- Cornwallis Formation. Early Miocene age volcanogenic flysch (alternating layers mudstone and sandstone) of the Waitemata Group, comprising grey brown, alternating, thick bedded sandstone and thin bedded mudstone.
- Albany Conglomerate. Early Miocene age well rounded pebbles and boulders in a medium to very coarse grained sandy matrix.
- Nihotupu Formation. Early Miocene age fine grained volcaniclastic sandstone which can include beds of reworked tuffaceous and pumiceous material and tuff breccia debris flows.
- Puketoka Formation. Pleistocene age fluvially deposited pumiceous deposits of light grey to orange brown pumiceous mud, sand and gravel with black muddy peat and lignite.
- Alluvium. Holocene age clays, silts and sands, muddy peat and unconsolidated organic-rich sediments.

4.2 Titirangi to Westgate

The section of watermain from Titirangi to Westgate starts in the Waitakere Ranges, a high standing hill range dissected by steep sided ridges and gullies. From Glen Eden to Swanson the topography becomes less steep and is characterised by gently sloping hills and valleys. The NH2 route crosses Oratia Stream, Opanuku Stream, Paremuka Stream and Swanson Stream. This section of the NH2 route is predominantly through residential suburbs with commercial land uses in Westgate through to Hobsonville.

4.3 Westgate to western start of GBWD and Causeway Project

Westgate through to Greenhithe Bridge has low lying areas with flat ground dominated by SH18 with relatively new residential developments on either side of the NH2 route. A number of drainage and stream channels traverse SH18.

4.4 Eastern Side of Greenhithe Bridge to Albany Reservoir

The section of watermain from the eastern side of Greenhithe Bridge to Albany reservoir is through Puketoka Formation which is characterised by low angle slopes. The NH2 route then moves into the steeper Waitemata Group material. This section of the NH2 route follows SH18 which is bordered by residential land uses. Land uses transition to commercial and light industrial in Albany. The section of NH2 from Oteha Stream along Bush Road is on the edge of Albany Scenic Reserve to the west and Bushlands Park Reserve to the east. The topography through this section of the route is steep, with Oteha Stream in a deep gully.

5.0 General Erosion and Sediment Control Approach

Erosion and sediment control measures will be designed, installed and maintained in accordance with Auckland Council (AC) Technical Publication No. 90 "*Erosion and sediment control guidelines for land disturbing activities in the Auckland Region*" (TP 90).

5.1 Key Principles

Key principles of sediment and erosion control have been identified as the following:

- Stage construction to limit the time and area that soil is exposed and prone to erosion;
- Protect steep slopes by using diversion bunds, or maintaining existing vegetation;
- Stabilise exposed areas rapidly with vegetation;
- Install perimeter controls above the site to keep clean runoff out of the worked area; and
- Install perimeter controls below the site to detain sediment and prevent contamination of the existing stormwater system and receiving environment.

5.2 ESCM Design Philosophy

The erosion and sediment control measures (ESCMs) detailed in this report and drawings (refer to Volume 3 of the AEE report) have been designed based on the likely construction methodology presented in Section 2.2. Actual site conditions may vary from the information available at the time this technical report was prepared, therefore a general "tool box" of ESCMs are presented based on the following likely construction methodology types:

- Typical open trench within the road corridor;
- SH18 cut and fill;
- Access shafts (jacking and reception) for trenchless technologies and associated work platforms; and
- Stream crossing pipe bridges.

The Contractor will review and apply the proposed ESCMs as appropriate. The ESCM design will be confirmed by the Contractor through their ESCP as the detailed design of NH2 has yet to be completed and the construction methodology is not confirmed.

The following documents were referenced in the preparation of this technical report:

- TP90;
- Auckland Council, *Best Management Practice Guidelines* (e.g. catchpit protection, trenching, dewatering);
- Auckland Regional Plan: Sediment Control; and
- Proposed Auckland Unitary Plan.

5.3 Erosion and Sediment Source Control

The following erosion and sediment source controls have been identified as applicable to the NH2 route.

Table 7 General source control measures applicable to NH2 route for elimination/ minimisation of erosion and sediment generation

Source/Activity	Source Control Measure
General site management. - Check the weather forecast and plan accordingly if there is to be heavy rainfall/wind; - Stabilise work areas with high sediment generation potential by placing geotextile and covering with clean hardfill or other approved method; - Regularly sweep or remove any accumulated sediment associated with the works; - Stabilise disturbed ground as soon as possible; and - Use water carts to minimise wind distribution of sediments.	
Stockpiled soil.	- Where possible, spoil to be stored uphill of trench so that any sediment laden runoff will be captured by trench; - Cover with tarpaulin/polythene/geotextile during wet/windy weather; - Stockpiles not associated with trenching to be located at the lowest point of the site just before the ESCM; - Plan works so that stockpiled soil is used within the site before wet weather or removed if excess to requirements; - Stockpiles associated with trenching or access pits must be temporary and kept small to reduce potential for dust generation and runoff; - Stockpiles in laydown areas are not to be placed within overland flow paths, open drains, over catchpits or within 20 m of surface water (e.g. stream or pond); and - Large, long-term (greater than two weeks) stockpiles must be bunded to capture runoff.
Sediment transport due to runoff from external catchments entering the construction site.	- Construct diversion bunds/channel to divert runoff from external catchments entering site; and - Use clean water diversions (e.g. sandbags) where there is steep terrain uphill of the trench to reduce the volume of water requiring management.

Source/Activity	Source Control Measure
Dewatering.	- Where possible, allow water collected in trench or access pit to settle before dewatering; - When decanting or using a pump, skim from the surface to avoid suction of accumulated sediment; - Monitor and moderate pump rate to minimize scour; and - Identify a legal point of discharge. **Dewatering to Ground** - Decant or pump water to a grassed or vegetated area well away from receiving environments (e.g. surface water, stormwater drain); - Pump through geotextile or a filter bag for primary treatment followed by discharge through a turkey's nest. If discharge is directly to the stormwater system (e.g. catchpit) additional treatment may be required (e.g. chemically treated filter sock); - Make sure that the rate of flow does not exceed the ground's capacity for the water to soak in (e.g. no ponding or runoff); - Make sure that there is no scouring at the pump outlet; and - Remove any accumulated sediment at the end of each day (the above source control measures relating to trench dewatering are extracted from "Auckland Council, Best Management Practice: Dewatering").
Erosion due to runoff travelling over reinstated ground.	- Do not remove ESCMs until the reinstatement is established.

5.4 General Erosion and Sediment Control Measures

Table 8 outlines possible ESCMs to be applied to the different construction zones of the NH2 route.

Table 8 General erosion and sediment control measures

Erosion and Sediment Control Measure	Application
Bio-degradable mats	Install on cut/fill batters until vegetation is established.
Catchpit/Stormwater inlet protection	Install sand logs/coir logs in series upstream of the catch pit/ stormwater inlet to act as check dams; Cover catchpit grate and inlet with geotextile to filter sediment laden runoff before discharge into stormwater network; and Other proprietary catchpit protection systems.
Decanting Earth Bund	Use where space permits within the designation along SH18 or pipe bridge construction for treatment of construction zone runoff; and Discharge to existing stormwater network (e.g. stormwater pond) or land.
Diversion channel/bund	Install to divert runoff from external catchments entering site or for conveyance of sediment laden runoff within construction areas.
Filter bag	Attach to dewatering discharge hose from sedimentation tank (ST) before discharge to stormwater network.
Filter sock (flocculation)	Filter sock media can include flocculation chemicals for additional treatment.
Floating silt curtain	There is low likelihood that floating silt curtains will be required, however as full details of the stream pipe bridge construction works and design have not been finalised there is potential for use of floating silt curtains in the larger streams (e.g. Opanuku, Paremuka and Oteha streams).
Geosynthetic Erosion Control system (GECS)	Install hessian cloth on batter slopes; and Install low permeability synthetic such as polypropylene liner to base of diversion channel/bunds.
Hydroseed	Hydroseed any backfilled areas as soon as possible.
Level spreader	Install at outlet of diversion bunds/channels.

Erosion and Sediment Control Measure	Application
Sand logs/coir logs/hay bales	Use in carriageway to divert clean water from construction site where there is steep terrain uphill or unfavourable carriageway crossfall.
Sedimentation tank (ST)	Route dewatering discharge to ST to remove sediment. Add flocculants if insufficient retention time is not available.
Silt fence	Erect around stockpiles and lay down areas to prevent transport of sediment; and Erect between temporary access road and permanent watercourse to prevent sediment discharging directly to a stream.
Stabilised entrance	Install at egress points for construction outside of the carriageway.
Super silt fence	Erect on the banks of receiving waters into which sediment laden runoff may discharge.
Temporary access roads	Install alongside SH18 for open trenching and trenchless technology access.
Wheel wash	Install at egress points to construction site.

6.0 Specific Erosion and Sediment Control for Representative Construction Areas

The NH2 watermain is approximately 33 km long from Titirangi through to Albany across Greenhithe Bridge. This earthworks, erosion and sediment generation technical assessment report is based on the preliminary design and suggested construction methodology. This technical report identifies representative sections of the NH2 route and how ESCM will be set up on these representative construction zones. All ESCMs are to be designed and constructed in accordance with TP90 requirements. Corresponding layout plans and drawings are provided in Appendix A (and within Volume 3 of the AEE).

6.1 General Open Trenching

As the majority of the route is within the road corridor and will be constructed using the conventional open trenching methodology these ESCMs and layout are applicable for all sections of the route (Titirangi to Westgate, western side of Greenhithe Bridge, and eastern side of Greenhithe Bridge to Albany reservoir).

Approximately 20-30 m of trench will be open to lay the watermain within a 2-3 m wide trench. A number of crews may be operating along different sections of the route.

With the proposed mitigation measures in place, as identified in this section, the effects on the environment are assessed to be no more than minor.

Establishment

Prior to opening the trench for installation of the watermain, the ESCMs identified in this section must be in place. The open section of trench will require clean water diversion up slope from the excavation to reduce sediment laden flow. Catchpits immediately down gradient and within the open trench work area must have catchpit protection installed. Dirty water diversion bunds are to be set up to direct runoff to the trench.

Dewatering and Runoff Treatment

Runoff within disturbed areas of the work area should be directed to the trench for settling and then to be pumped out through a filter bag and turkey nest onto grass (e.g. roadside berm). In areas where there is no grassed area the treated runoff from the turkey nest will likely require additional treatment prior to discharge to the stormwater system. Filter socks should be used for additional treatment if required and to reduce flow rates. Filter socks are available with flocculation chemicals entrained in the media. Depending on the soil types the additional level of treatment by flocculation may be required. The catchpit protection provides a secondary level of treatment and control.

If dewatering rates or sediment type exceed the treatable volume of the filter bag and turkey nest then a sedimentation tank with chemical treatment may be required. Alternatively the sediment laden water will need to be collected via sucker truck and removed to an approved treatment facility. If there is any risk of contamination with concrete wash water or fines (from concrete cutting) then the water must be collected by sucker truck for treatment. Concrete contaminated water is alkaline and must undergo pH treatment prior to discharge. This will not be possible within the confines of the road side open trench work area.

Access and Stockpiling

For sections of trenching within the road, stabilised entrances and or wheel wash are unlikely to be required however trucks and vehicles must be inspected and cleaned if sediment is visible on the wheels. Some of the excavated material will be used to backfill and reinstate the trench. Surplus material will be removed to the Contractor’s approved laydown site or alternative approved site (e.g. clean fill site or landfill if material is contaminated). Small stockpiles of material to be reused may remain within the work area for backfilling. All stockpiles must be bunded (e.g. filter sock, sand bags) and geotextile or tarpaulin available to cover the stockpile if rain or wind (dust generation) are predicted or experienced.

Reinstatement

The surface finish of the open trench will vary along the length of the watermain route, depending on whether the pipe is laid within the road, grassed / vegetated berm or footpath. Surface reinstatement will either be asphalt surface (to comply with Auckland Transport or New Zealand Transport Authority specifications), topsoil and grass or replanting, or concrete.

As the environmental risk of concrete or asphalt works is high, it is recommended that stormwater drains are completely isolated with drain plugs and a submersible pump or vacuum truck is used to remove contaminated run off from the catch pit. If this is not practicable then careful sandbagging or bunding around the catch pit grate can be used as an alternative. This will be required when cutting and reinstating roads or footpaths.

Other controls recommended are:

- Minimise the amount of water used on site (e.g. in dust suppression, concrete cutting, cement mixing) so there is less to control;
- Use saws that can have a vacuum attached to minimise the amount of dust; particularly during dry concrete or asphalt cutting.
- Use a wet/dry vacuum, or vacuum truck for larger jobs, to collect all concrete or asphalt contaminated material or run off on site;
- If this is not practical, divert all run off to a construction pit or unsealed ground, away from surface water and overland flow paths. All captured runoff from concrete cutting and or cement mixing must be treated to bring pH back to neutral (pH 7) as runoff or wash water contaminated with concrete fines/dust is highly alkaline and cannot be diluted (refer to Auckland Council Best Management Practice, Concrete and Asphalt, 2012);
- Wash all equipment and tools in a designated wash area or on a large grassed area well away from stormwater drains, streams and the coast;
- Use tarpaulin sheets under concrete pumps and delivery chutes to capture any spills; and
- Do not allow concrete trucks or concrete pumpers to wash out on site unless there is a designated wash area.

All ESCMs are to remain in place until the site has been reinstated. If reinstatement is to grass or other vegetation, ESCM are to remain until grass has started to grow or planted area has been mulched.

6.2 Open Trenching along SH18

The ESCMs listed in Section 6.1 above are for the most part applicable to the open trenching along SH18 with some additional requirements. With the proposed mitigation measures in place, as identified in this section, the effects on the environment are assessed to be no more than minor.

Access and Stabilised Entrances

Access ways will be required along the NH2 route alongside SH18 in places. The access ways are to be gravelled for construction and maintenance purposes. The construction access road will be needed in sections from

Hobsonville Road to Olive Sinton Lane (south eastern side of SH18) to where the NH2 route crosses SH18 (via trenchless construction methodology) to Sinton Road (north eastern side of SH18). An access road will be required from Sinton Road to Greenhithe Bridge. On the eastern side of Greenhithe Bridge the access road will be required in sections from The Close to Albany Highway.

Temporary construction access roads are proposed to be established by removing grass / vegetation and topsoil and laying woven geotextile overlaid with aggregate (e.g. GAP65, 300 mm minimum basecourse) or geogrid type structure. If the temporary access road passes within 50 m of a permanent watercourse[1], a silt fence will be installed between the temporary access road and the stream (to remain for the duration of the construction works). At the entry points to the temporary access roads from the road network stabilised entrances with wheel wash will be constructed in compliance with TP90. The stabilised entrance will consist of geotextile overlaid with aggregate. Wheel washes are available as complete moveable units with inbuilt treatment or can be undertaken manually. Wash water is to be collected and treated via a sedimentation tank or discharged to land depending on the quantity and duration of discharge.

Eastern Side of Greenhithe Bridge to Wicklam Lane Cut and Fill

Some sections of the NH2 route along the SH18 through Greenhithe will require a cut and fill of the existing state highway embankment with potential for retaining walls in places (subject to detailed design).

It is envisaged that fill material will be used from excavations along the NH2 alignment. Sections are to be kept to a small, manageable size and progressively stabilised or reinstated to keep disturbed areas to a minimum.

Silt fences or super silt fences, sized according to TP90 will be used on the down gradient side of the construction work area. Clean water diversion bunds or channels are to be constructed up slope from the construction area. Existing stormwater ponds along SH18 are not to be used to discharge untreated sediment laden runoff. If space within the designation permits runoff from within the construction area should be directed to a decanting earth bund (compliant with TP90) or sedimentation tank prior to discharge to the stormwater network or land.

Watercourse and Overland Flow Path Crossings (Open Trenching)

Along SH18 there are a number of overland flow paths (OLFP) and watercourses which the NH2 watermain will cross (underground). Many of the OLFP and watercourses were formed by the construction of SH18 and consist of defined channels, erosion protection and culverts under roads and SH18. The location of the affected OLFPs and streams, and the OLFP category are listed in Table 9 and shown in Figure 3. The OLFP category is determined by the catchment size of the OLFP e.g. 2,000m^2 to 4,000m^2, 4,000m^2 to 3ha, and 3ha and above. Only surface OLFPs or streams are shown, all others are piped or not directly affected. Many of these OLFPs or streams are likely to be dry (or have low flow) during the low rainfall summer months. The stormwater assessment section of the AEE report will provide more detail on these crossings however for the purposes of ESC it has been assumed that works within a watercourse is likely to be required for some of the open trench crossings. Works in or around OLFP or streams have the potential to have a direct impact on watercourse habitat (e.g. by habitat disturbance or destruction) and on watercourse ecology (such as through sediment and temperature related effects). OLFP and stream diversions are required to establish dry, off-line work areas to allow the open trenching to be undertaken while minimising the risk of erosion and sediment generation.

Table 9 SH18 overland flow paths and watercourse crossings

Map ID	Description of Location	Stream Name	OLFP Category[(a)]
1	East of SH18 Hobsonville Road Off Ramp		>3ha
2	North of 27 Trig Rd	Trig Stream	>3ha
3	North east of 27 Trig Rd	Rawiri Stream	>3ha
4	South west of Brigham Creek Rd On Ramp adjacent to stormwater pond		>3ha
5	South west of Brigham Creek Rd On Ramp adjacent to stormwater pond		4000m^2 to 3 ha
6	South East of SH18 – Brigham Creek Rd On Ramp		>3ha

[1] Within 50 m of a permanent water course is considered a Sediment Control Protection Area (refer to Auckland Regional Plan (Sediment Control) which requires additional protection measures.

Map ID	Description of Location	Stream Name	OLFP Category[(a)]
7	Permanent stream adjacent to 6 Sinton Road		>3ha
8	Adjacent to 1 Ockleston Landing		>3ha
9	Adjacent to 30 Ockleston Landing		4000m^2 to 3 ha

(a) The OLFP Category is as per Auckland Council GIS 'Catchments and Hydrology' layer

Figure 3 **Indicative location of surface OLFPs and streams identified along SH18 potentially affected by the NH2 watermain route (Auckland Council GIS Viewer)**

These are small crossings and construction should be scheduled for the driest part of the earthworks season (generally January to March) when flow rates are usually at their lowest. Weather forecasts must be closely monitored so that crossings can be stabilised before rainfall. Temporary stabilisation will include removal of debris and covering of exposed areas with geotextile. Every effort must be made to complete work within an OLFP or stream in the shortest time possible. Work sites within OLFP or streams must not be left exposed when the works area is unattended or for greater than 12 hours.

Given the likely low flow rates, diversion around the works area can be achieved using an upstream dam and pumping around the work area to discharge back into the channel downstream of the work area. Figure 4 is an example of this set up. Diversions of this nature are likely to be in place for a short period of time (approximately 12 days), therefore the dam and pump capacity will need to be designed to manage the 1 in 20 year event flow (in accordance with TP90).

Figure 4 Example of dam and pumping diversion (New Zealand Transport Authority, 2014. Erosion and Sediment Control Guidelines for State Highway Infrastructure)

Fish passage will need to be considered with the dam and pump diversion method. Manual fish capture and relocation downstream of the work area and the use of screens over pump and pipe inlets is sufficient given the short timescale the diversion will be in place and the type of OLFPs and streams to be crossed.

Within the off line dry work area diversion bunds and silt fences will be used as necessary for clean water diversion (up gradient of the site), and dirty water capture and treatment (silt fence).

6.3 Trenchless Technologies

Reception and jacking shafts with accompanying work platforms are required for the sections using trenchless technology. The size of the pits will vary depending on available space and the depth of the watermain. Access pits are to be as small as possible for safe operation of trenchless equipment. Reception shafts are smaller than jacking shafts and unless specified in the detailed design drawings are likely to measure approximately 4 m by 4 m, compared to jacking shafts which will measure approximately 14-16 m by 3.5-6 m.

The drilling fluid used in trenchless technologies is within a closed system which removes spoil (cuttings) as the tunnel progresses. This spoil is potentially contaminated with bentonite and or polymers. Spoil will be collected by the Contractor and removed for offsite disposal at an approved facility (whether landfill or for further treatment).

Work platforms will be stabilised using geotextile and aggregate with silt fences installed along the down gradient side of the work area and clean water diversion bunds or channels along the up gradient boundary. Dewatering and capture of runoff from within the construction work area will be as specified in the general open trenching ESC methodology (Section 6.1).

With the proposed mitigation measures in place, the effects on the environment are assessed to be no more than minor.

Drilling Fluid Release Prevention and Response

Trenchless technologies use a drilling fluid (also referred to as drilling mud) which consists of fresh water and bentonite to create a slurry. Sometimes other polymers are added to enhance the properties of the drilling fluid for drilling. The drilling fluid is recycled and reused on site with the cuttings being cleaned out for offsite disposal. This drilling fluid has potential to break through to a surface release, particularly in areas close to the ground surface, where fractures exist in the soil or rock or where ground has been previously disturbed. The detailed design and geotechnical investigations will inform the alignment of the trenchless sections and any unsuitable ground conditions. The Contractor is responsible for having a site specific Drilling Fluid Management Plan and training staff on fluid release prevention, containment and clean up. This plan should be approved by Auckland Council and Watercare prior to any trenchless construction work commencing.

A risk area for fluid release is when the trenchless construction is beneath permanent and intermittent streams (e.g. Oteha Stream) as these receiving environments could be significantly adversely affected if drilling fluid was released into the watercourse. The drilling fluid would temporarily increase the turbidity of the water and cause siltation of the stream bed thus affecting water quality and aquatic life.

The Drilling Fluid Management Plan should include as a minimum:

- Procedure for monitoring and preventing potential fluid release (e.g. pressure monitoring, spotters in high risk areas);
- When containment should be implemented and equipment to use for containment (land based and within the watercourse); and
- Restoration and or remediation required for spills on land and within a watercourse (to be site specific).

6.4 Stream Crossing Pipe Bridges

Preliminary designs of all pipe bridges crossing permanent streams (as listed in Table 2) have placed monopole support columns as high on the valley sides as possible to avoid construction works within the permanent water levels of a watercourse. However the proximity of the stream and sensitivity of the receiving environment requires implementation and ongoing maintenance during construction of ESCMs to prevent impacts on the water quality and in-stream ecology. The location of the monopoles will be within the 1% AEP floodplains of the watercourse. With the proposed mitigation measures in place, as identified in this section, the effects on the environment are assessed to be no more than minor.

Construction of the pipe bridges is restricted to the summer period December to March (within the earthworks season) when flow within the streams is expected to be at their lowest. Specific weather forecasting and contingency measures (as discussed in Section 9.0) are required for all pipe bridge construction. The Contractor through their ESCP is required to identify specific site constraints regarding work areas, ESCMs and discharges. Runoff from within active work zones must not discharge directly to the stream.

Establishment

The pipe bridge locations are across permanent streams located within reserves. Fencing must be set up to define work areas and prevent public access to work areas. The fencing will also work to contain construction activities and prevent encroachment into areas where ESCMs are not set up. Work areas for cranes and piling equipment will need to be stabilised. The exact specification of the stabilised work areas will be confirmed by the Contractor based on the equipment being used but will generally consist of removal of grass and topsoil (to be stockpiled for reinstatement), compaction and laying of geotextile overlaid with aggregate. The stabilised access and work area will measure approximately 6m wide and length will vary depending on location. A stabilised gravel platform may also be required for drilling/ piling equipment. All ESCMs must be installed prior to any physical works commencing.

Clean and Dirty Water Diversion and Silt Fences

Clean water diversion will be used up gradient of the work area. Within the work area diversion bunds will be used directly up gradient of the monopole construction area.

Immediately down gradient of the monopoles, silt fences (or super silt fence depending on slope and catchment area) are to be installed. If there is no room for installation of a silt fence between the monopole and the stream, a floating silt curtain will be required within the stream channel. The floating silt curtain is be installed according to the manufacturer's requirements but will generally be anchored to the stream bank (below the monopole, above the stream water level) and have enough length and depth to allow for water level fluctuation and to prevent stress on the barrier. The floating silt curtain will form a semicircle from the stream bank into the stream but not extend more than $^{1}/_{3}$ of the channel width into the channel. Refer to Figure 5 below for details.

Dirty water diversion within the construction work area will be directed to a decanting earth bund or sedimentation tank (depending on available space and catchment area).

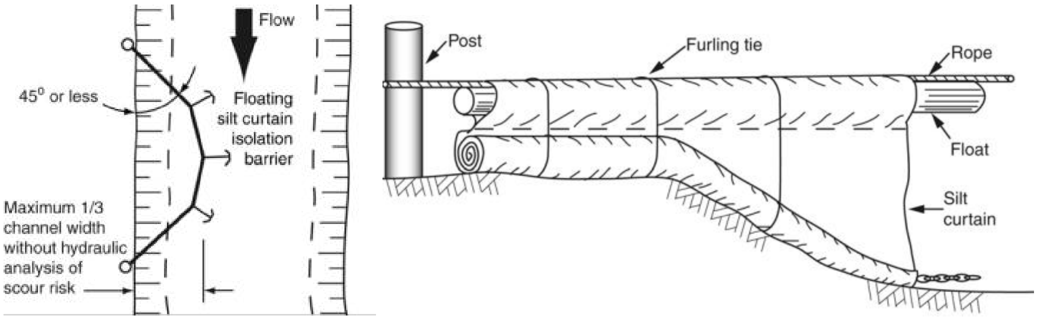


Figure 5 Floating silt curtain location and anchorage detail (Source: Catchments & Creeks Pty Ltd, 2010)

Monopole Spoil

Spoil from installation of the monopoles may be temporarily stored in stockpiles on site if space permits. However it is likely that spoil will be immediately collected into trucks and removed from site. Spoil material will need to be disposed of at an approved facility (whether contaminated or cleanfill).

If temporary stockpiles are to be used they are to be located on a geotextile base, bunded to contain sediment laden runoff and covered if weather conditions require it (rain or wind).

Reinstatement

Depending on the exact location on the valley sides, riparian replanting may be required for reinstatement (refer to the Ecological Assessment and or Landscape and Visual Assessment). The work areas will likely be located in areas already in grass so reinstatement will consist of top soiling and grassing. ESCMs must remain in place until all reinstatement has been undertaken.

7.0 Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE) is often used to assess the amount of soil that may be lost from earthworks. It is recognised that this means of estimating the soil loss differs significantly from the actual losses. The formula and parameters are often used to compare the potential scale of the impact that earthworks might have on receiving environments.

The following areas are of particular interest:

- At risk (i.e. steeper) sites can be identified as these can discharge significantly more sediment;
- Larger earthworks projects, with longer durations of exposure are likely to discharge more sediment; and
- Smaller projects, with poor erosion and sediment control measures could also discharge large amounts of sediment relative to size.

The open trenching, pipe bridges and trenchless technologies construction methodologies have small areal extents which are not ‘open’ all at the same time, therefore it was deemed that the USLE calculations would not serve to identify any specific areas of concern, and as such a more appropriate approach would be to use best practice sediment control methods as detailed in TP90.

Sections of the NH2 route along parts of SH18 require greater earthworks for a cut and fill along the existing state highway embankment with potential for retaining walls. The USLE has been calculated for these sections and is presented in Table 10. The section of SH18 between Clarks Lane to Squadron Drive is within the Westgate to the western start of the GBWD and Causeway Project, with the other sections on the eastern side of Greenhithe Bridge to Albany reservoir.

The USLE takes into account a number of factors when determining soil loss including:

- Rainfall;
- Exposed ground area;
- Soil composition;
- Site slope;

- Ground cover; and
- Effectiveness of the ESCM.

Table 10 SH18 Cut and Fill USLE Calculation

Earthworks Area	Max Area (m^2)	Unmitigated Soil Loss (tons)	Mitigated Soil Loss (tons)
Clarks Lane to Squadron Drive	3,000	0.068	0.026
Adjacent to Kimberely Grove to Olwyn Place	2,840	0.199	0.075
Adjacent to 112 George Deane Place to 30 Wicklam Lane	1,680	0.020	0.008

Refer to Appendix B for the detailed calculations. The majority of sediment generation occurs when exposed ground is left un-stabilised thus progressive stabilisation is a key approach to reducing sediment generation. The mitigated soil loss figures presented in Table 10 are likely to be conservative estimates based on use of silt fences as the primary ESCM. Exposed areas will be progressively stabilised as trenching works are completed (20-30m sections open at any one time). Stabilisation will consist of the access way, planted and mulched embankment or grassed (unless specifically identified in the construction methodology).

8.0 Monitoring During Construction

The Contractor will identify a responsible person for erosion and sediment control (most likely the Site Supervisor). The Contractor will keep daily records of site inspections and any erosion or sediment issues that may arise. The records will be included with other site information required under the Contract and will be available for inspection by the Engineer to the Contract during normal working hours. These records will be retained for the duration of the Contract.

Should excessive sediment be found in the downstream system directly attributed to failures of sediment management at an NH2 works site, then the Contractor may be required to cover the cost of cleaning or remediation.

All silt fences, bunds, sediment pits and specific measures constructed for the purpose of erosion and sediment control will be inspected on a weekly basis and after rainfall events. Inspections will include, but will not be limited to, the following:

- Scouring and adequacy of scour protection;
- Areas of damage;
- Damage caused by adjacent earthworks; and
- Visual inspection of sediment pond/pit discharge water for clarity and presence of sediment.

9.0 Heavy Rainfall Response and Contingency Measures

The NH2 construction works are scheduled to begin in 2018 and the programme of work is likely to extend over seven years. The programme will be finalised once a Contractor(s) has been appointed. High intensity rainfall events can occur during the summer months as well as prolonged rain events during the winter months. The Contractor is responsible for monitoring weather forecasts, inspecting all erosion and sediment control measures and undertaking any remedial works required prior to the forecasted rain event.

In general, the Contractor will:

- Inspect daily weather patterns to anticipate periods of risk and be prepared to undertake remedial works on erosion and sediment control measures to suit the climatic conditions;
- Monitor the effectiveness of such measures after storms and incorporate improvements where possible in accordance with best management practice;
- Ensure appropriate resources are available to deal with the installation of additional controls as and when needed; and

- Inform Auckland Council if there are any concerns associated with the measures in place.

9.1 Support Column Construction for Pipe Bridge Crossings

TP90 requires the management of the 1 in 20 year average recurrence interval (ARI) event. Section 6.4 details the specific approach to ESC for construction of the pipe bridges. However additional contingency measures should be adopted specifically for the pipe bridge construction.

The approximate upstream catchment size for each stream crossed by the NH2 route has been provided in Table 11. The size of the upper catchment provides an indication of potential flow through the streams and range from approximately 2.3km^2 to 22.6km^2. The locations of the piles are positioned as far as possible to the top of the valley sides to reduce the extent of access works for construction and avoid any within the watercourse. The duration of ground disturbing activities will be kept to a minimum with disturbed areas reinstated immediately after completion of the physical works. Temporary stabilisation will be with geotextile and permanent reinstatement with grass or planting and mulch.

Given the magnitude of potential flow in some streams, the appropriate management / mitigation measures are deemed to be as follows:

a) Effective monitoring of weather patterns and forecasts; and

b) Immediate stabilisation of open ground (where feasible), reinforcement of ESCMs and evacuation from the works area in advance of the storm event.

Table 11 Approximate catchment size and flow calculation for 1 in 20 year ARI event for stream pipe bridges

Stream	Approximate Upstream Catchment Size (km^2)
Oratia Stream	16.3
Opanuku Stream	22.2
Paremuka Stream	2.3
Swanson Stream	22.6
Oteha Stream	9.6

9.2 Emergency Spill Response

The pipe bridge streams and the SH18 OLFPs and streams are sensitive receiving environments which can be adversely affected by spills from construction activities. The Contractor is responsible for preparing a spill response plan for the pipe bridge construction work and open trenching through the SH18 OLFPs and streams. Mobile spill kits must be available at all works sites. For sites adjacent to the streams the spill kits must include aquatic booms and equipment for isolating and neutralising (if possible) spills within the watercourse. Cement or concrete spills to a watercourse will result in immediate fish kills as the pH of the water becomes alkaline. Cement or concrete spills cannot be diluted. If the response is immediate the spill will require impoundment and pump out of the contaminated water to a holding tank or into a sucker truck.

Auckland Council pollution response hotline (phone: 09 377 3107) must be notified of any spills whether sediment or non-sediment contaminant to a watercourse.

10.0 Site Reinstatement

Original grassed and existing stream areas of the NH2 route are to be reinstated with topsoil (if required) and re-grassed or planted in line with pre-construction vegetation cover (i.e. similar native species found within the riparian vegetation of the stream) or as specified in the Technical Report D Ecology Assessment and / or Technical Report G Landscape and Visual Assessment (provided in Volume 2 of the AEE report).

Removal of control measures is only to occur once the grass and vegetation has been established. Due care will be taken during the removal process so as not to mobilise any sediment. Any trapped sediment will be moved off site to landfill.

Once all controls are removed all parties are to sign off that the works are complete and have been completed satisfactorily.

11.0 Final ESCP

The erosion and sediment control measures detailed in this technical report are based on the construction works and sequence described in Section 2. As the detailed design is not complete and the Contractor(s) has yet to be appointed the construction methodology may change. Therefore prior to work commencing on the NH2 route, the Contractor is responsible for developing an ESCP. The ESCP will likely address the following sections of the NH2 route:

Titirangi to Westgate

1) General open trenching (Shetland Street, Glengarry Road, Parrs Cross Road, Palomino Road, Summerland Drive, Metcalfe Road, Don Buck Road and Fred Taylor Drive);
2) Woodlands Park trenchless technology construction method (Manuka Road to Shetland Street);
3) Oratia Stream pipe bridge construction and reinstatement of riparian vegetation;
4) Opanuku Steam pipe bridge construction and reinstatement of riparian vegetation, and cathodic protection proposed in Plumer Domain;
5) Paremuka Stream pipe bridge construction and reinstatement of riparian vegetation, and retaining wall support works;
6) Metcalfe Road rail crossing (option to be confirmed)
    - Option 1: open trenching with KiwiRail reinstatement specifications (by approved Contractor); or
    - Option 2: trenchless technology; and
7) Swanson Stream pipe bridge construction and reinstatement of riparian vegetation.

Westgate to western start of GBWD and Causeway Project

8) General open trenching (SH18);
9) SH16 / SH18 Interchange crossing trenchless technology construction method;
10) Trig Road and possibly Sinton Road cathodic protection; and
11) SH18 crossing (Sinton Road) trenchless technology.

Eastern Side of Greenhithe Bridge to Albany Reservoir

12) General open trenching (SH18, William Pickering Drive, Douglas Alexander Parade, Rosedale Road, Bush Road, Albany Expressway, Corinthian Drive);
13) Tauhinu Road Crossing (option to be confirmed);
    - Option 1: trenchless technology; or
    - Option 2: open trenching;
14) Greenhithe Road crossing trenchless technology;
15) Rosedale Road reserve cathodic protection;

16) Oteha Stream and Bush Road (option to be confirmed);

- Option 1: Oteha Stream pipe bridge construction and reinstatement of riparian vegetation, and open trench along Bush Road to Albany Expressway; or
- Option 2: Oteha Stream trenchless technology to Albany Expressway;

17) Albany Expressway crossing trenchless technology construction method; and

18) Albany reservoir connection.

11.1 ESCP Information Requirements

The Contractor's ESCP must include as a minimum the following information:

- ESC drawing(s) showing locations of ESCMs, site contours, flow directions and runoff calculations (if appropriate);
- Detailed designs of specific ESCMs as required (e.g. diversion bunds, decanting earth bund);
- Any requirement for chemical treatment including design and details of dosing rates, etc;
- Specific contingency measures (particularly for stream pipe bridge work); and
- Roles and responsibility of Contractor, Watercare and Auckland Council, including names and contact details (this may be specific to the type of construction or as specified in the Construction Management Plan).

11.2 Changes to the ESCP

During construction, the installed erosion and sediment control measures will be reviewed as construction progresses. The review will address any changes of design assumptions, catchments and construction methodology. If ground conditions, stabilisation works, or catchments are different to those adopted in the detailed design of the control measures then the system will be amended accordingly in order to comply.

Changes to the ESCP can be made after consultation with the following parties:

- Supervising Engineer;
- Watercare; and
- Auckland Council.

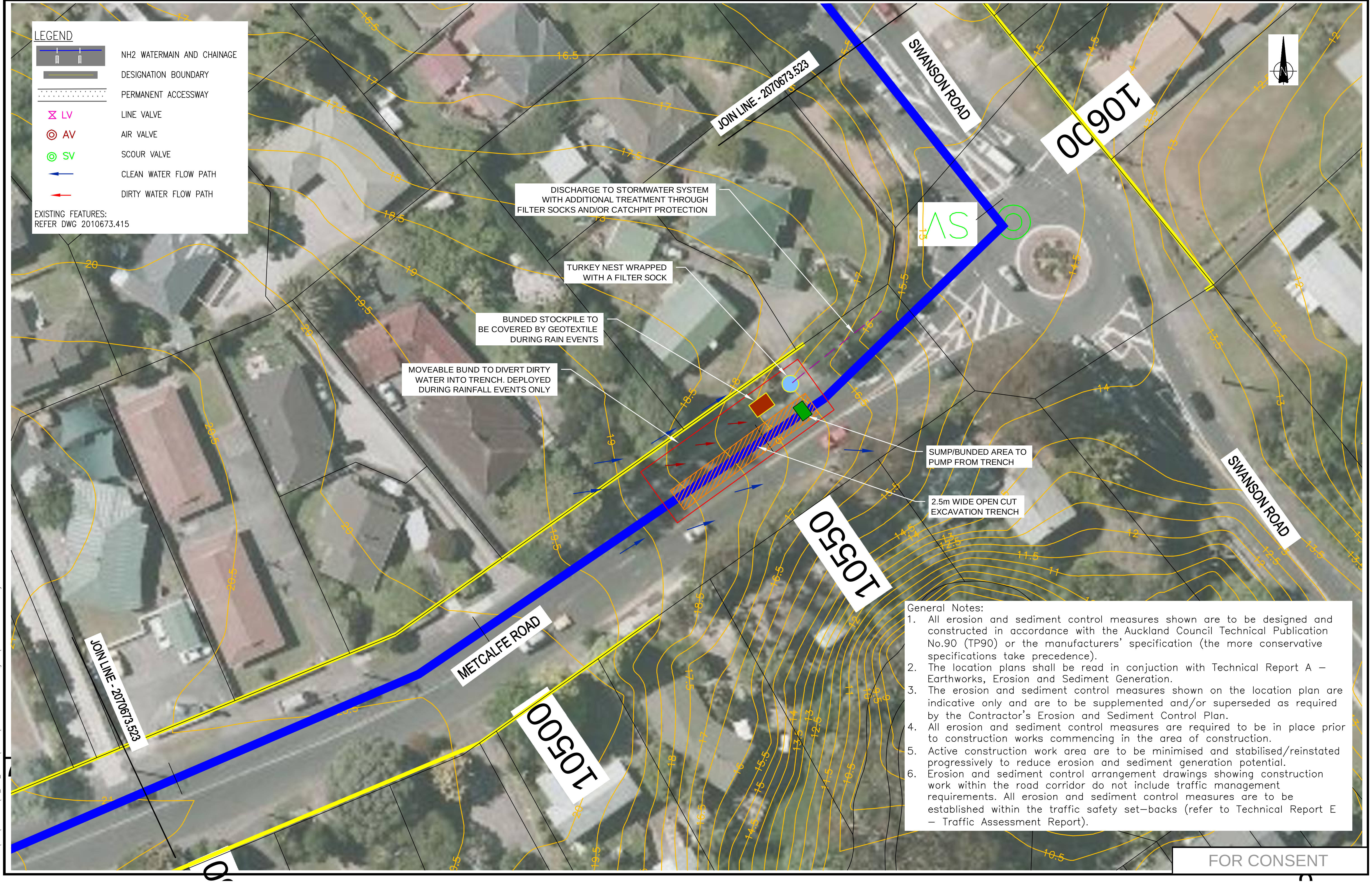
Auckland Council is to be notified in writing of any significant changes. Notice of approval must be sought from Auckland Council prior to works associated with the amendments being undertaken.

12.0 Conclusions and Recommendations

All construction activities associated with installation of the NH2 watermain have potential to cause erosion and generate sediment. Based on the preliminary designs and likely construction methodology a suite of erosion and sediment control measures have been identified to avoid or mitigate potential effects on the receiving environments. Representative sections of the NH2 route have been identified to describe in more detail the layout of required ESCMs. Once detailed designs are complete and the Contractor has confirmed the construction methodologies, the Contractor's ESCP should be developed to detail implementation of the ESCMs identified in this technical report. With correct design and construction of ESCMs it is anticipated that the effects on the environment will be less than minor.

Appendix A

ESCP Drawings



General Notes:

1. All erosion and sediment control measures shown are to be designed and constructed in accordance with the Auckland Council Technical Publication No.90 (TP90) or the manufacturers' specification (the more conservative specifications take precedence).
2. The location plans shall be read in conjuction with Technical Report A – Earthworks, Erosion and Sediment Generation.
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5. Active construction work area are to be minimised and stabilised/reinstated progressively to reduce erosion and sediment generation potential.
6. Erosion and sediment control arrangement drawings showing construction work within the road corridor do not include traffic management requirements. All erosion and sediment control measures are to be established within the traffic safety set-backs (refer to Technical Report E – Traffic Assessment Report).

FOR CONSENT

ISSUE	DATE	AMENDMENT	BY	APPD.
2	22.02.16	ISSUED FOR CONSENT – UPDATED WITH WSL COMMENTS	W.O.	M.A.E.
1	16.12.15	EROSION AND SEDIMENT CONTROL PLANS	W.O.	N.H.

DESIGNED	N.H.	02.16
DES. CHECKED	M.A.E.	02.16
DRAWN	W.O.	02.16
DWG. CHECKED	N.H.	02.16
PROJECT LEADER	M.A.E.	02.16
INFRAST'R APP'D		

OPERATIONS

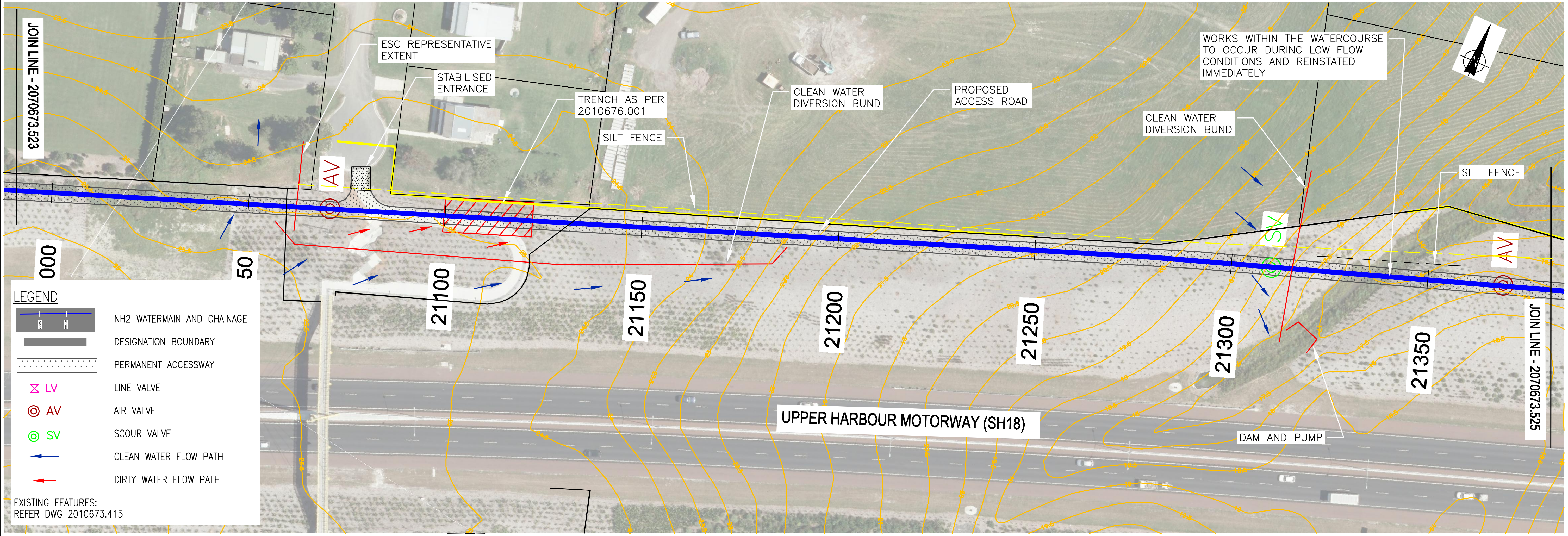
INFRASTRUCTURE

Watercare

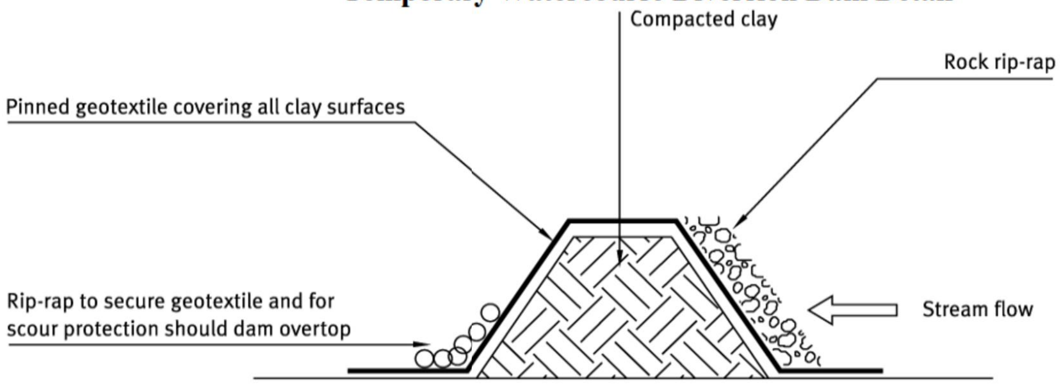
NORTH HARBOUR No.2 WATERMAIN
EROSION AND SEDIMENT CONTROL ARRANGEMENT
REPRESENTATIVE OPEN-CUT TRENCH ESC LOCATION PLAN

CAD FILE 2010676.001-006 DATE 22.02.16
ORIGINAL SCALE A3 1:500 CONTRACT No. 5663
REF No. WMNH2-91-E-001 ISSUE –
DWG No. 2010676 .001 2

Plot Date: Mar 03, 2016 – 9:23am U:\Jobs\42073300\01_DWG_Current\08 AEE\Main Route AEE Drawing Set\ 2010676.001-006.dwg



Temporary Watercourse Diversion Dam Detail



Cross Section

General Notes:

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1	16.12.15	EROSION AND SEDIMENT CONTROL PLANS	W.O.	N.H.

DESIGNED	N.H.	02.16
DES. CHECKED	M.A.E.	02.16
DRAWN	W.O.	02.16
DWG. CHECKED	N.H.	02.16
PROJECT LEADER	M.A.E.	02.16
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OPERATIONS

INFRASTRUCTURE

Watercare

NORTH HARBOUR No.2 WATERMAIN
EROSION AND SEDIMENT CONTROL ARRANGEMENT
REPRESENTATIVE SH18 CUT TO FILL OPEN-CUT TRENCH LOCATION PLAN

CAD FILE 2010676.001-006	DATE 22.02.16
ORIGINAL SCALE A3 1:2,000	CONTRACT No. 5663
REF No. WMNH2-91-E-002	ISSUE –
DWG No. 2010676 .002	2

General Notes:

1. All erosion and sediment control measures shown are to be designed and constructed in accordance with the Auckland Council Technical Publication No.90 (TP90) or the manufacturers' specification (the more conservative specifications take precedence).
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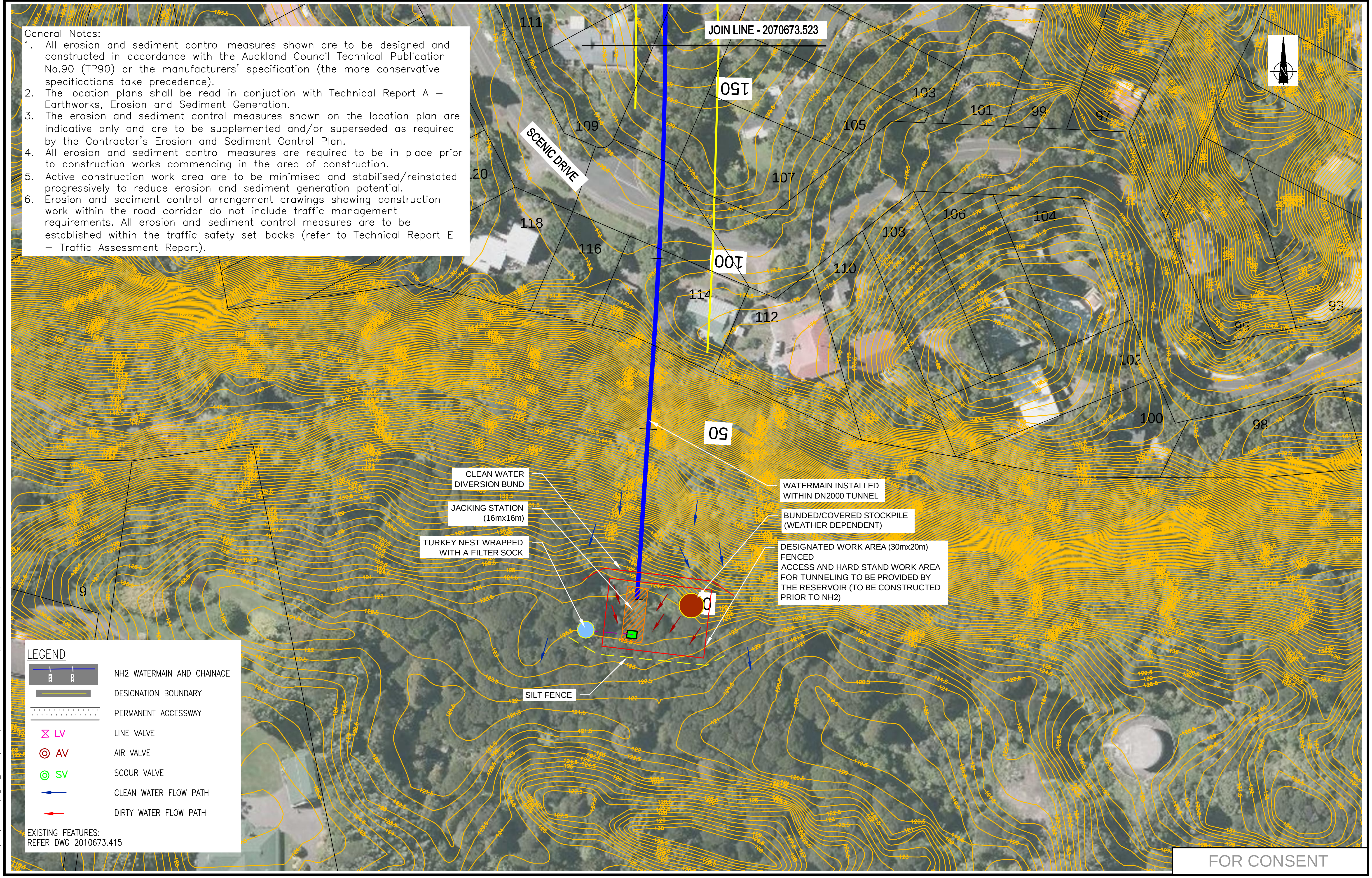

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ISSUE	DATE	AMENDMENT	BY	APPD.
2	22.02.16	ISSUED FOR CONSENT – UPDATED WITH WSL COMMENTS	W.O.	N.H.
1	16.12.15	EROSION AND SEDIMENT CONTROL PLANS	W.O.	N.H.

DESIGNED	N.H.	02.16
DES. CHECKED	M.A.E.	02.16
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DWG. CHECKED	N.H.	02.16
PROJECT LEADER	M.A.E.	02.16
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OPERATIONS

INFRASTRUCTURE

Watercare

NORTH HARBOUR No.2 WATERMAIN
EROSION AND SEDIMENT CONTROL ARRANGEMENT
REPRESENTATIVE TUNNELLING ACCESS SHAFT ESC LOCATION PLAN

CAD FILE 2010676.001-006 DATE 22.02.16

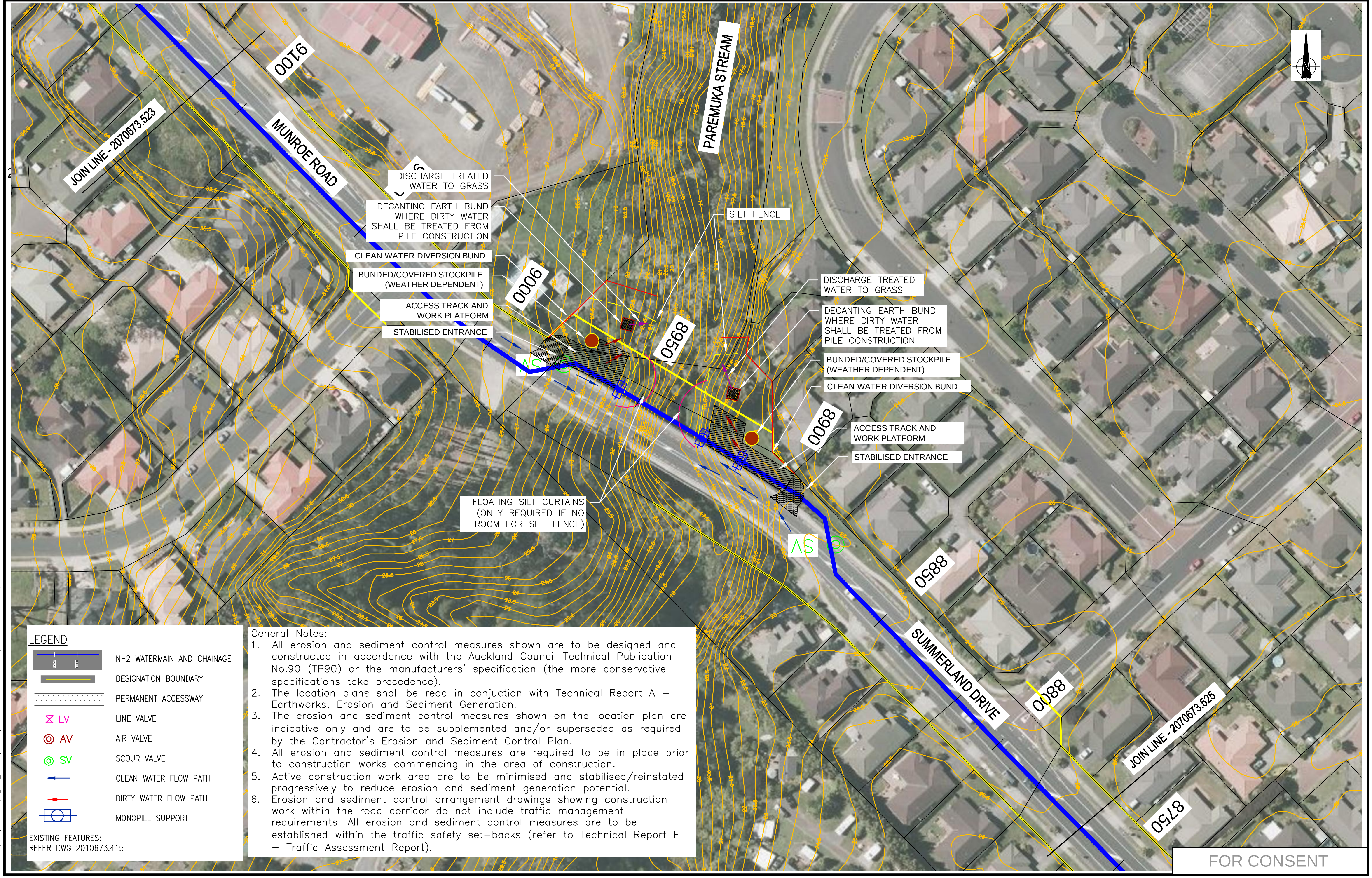
ORIGINAL SCALE A3 1:1,000

CONTRACT No. 5663

REF No. WMNH2-91-E-003 ISSUE –

DWG No. 2010676 .003 ISSUE 2

Plot Date: Mar 03, 2016 – 9:28am



LEGEND

	NH2 WATERMAIN AND CHAINAGE
	DESIGNATION BOUNDARY
	PERMANENT ACCESSWAY
LV	LINE VALVE
AV	AIR VALVE
SV	SCOUR VALVE
	CLEAN WATER FLOW PATH
	DIRTY WATER FLOW PATH
	MONOPILE SUPPORT

EXISTING FEATURES:
REFER DWG 2010673.415

General Notes:

1. All erosion and sediment control measures shown are to be designed and constructed in accordance with the Auckland Council Technical Publication No.90 (TP90) or the manufacturers' specification (the more conservative specifications take precedence).
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1	16.12.15	EROSION AND SEDIMENTATION CONTROL PLANS	W.O.	N.H.

DESIGNED	N.H.	02.16
DES. CHECKED	M.A.E.	02.16
DRAWN	W.O.	02.16
DWG. CHECKED	N.H.	02.16
PROJECT LEADER	M.A.E.	02.16
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OPERATIONS

INFRASTRUCTURE

Watercare

NORTH HARBOUR No.2 WATERMAIN
EROSION AND SEDIMENT CONTROL ARRANGEMENT
REPRESENTATIVE PIPE-BRIDGE ESC LOCATION PLAN

CAD FILE	2010676.001–006	DATE	22.02.16
ORIGINAL SCALE A3	1:1,000	CONTRACT No.	5663
REF No.	MWNH2–91–E–004	ISSUE	–
DWG No.	2010676 .004		2

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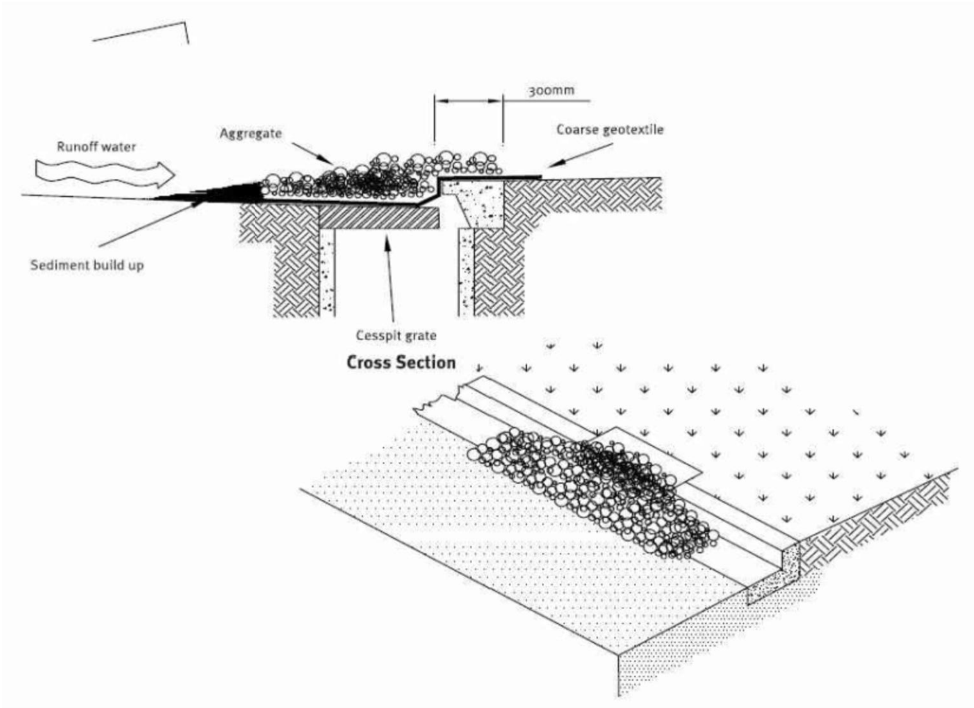
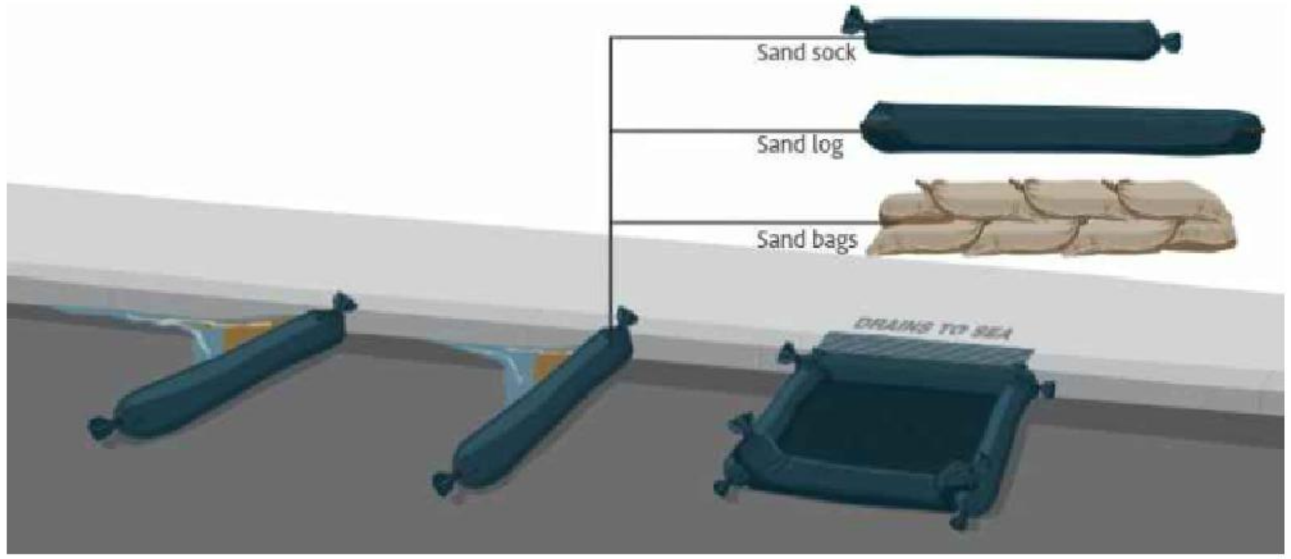
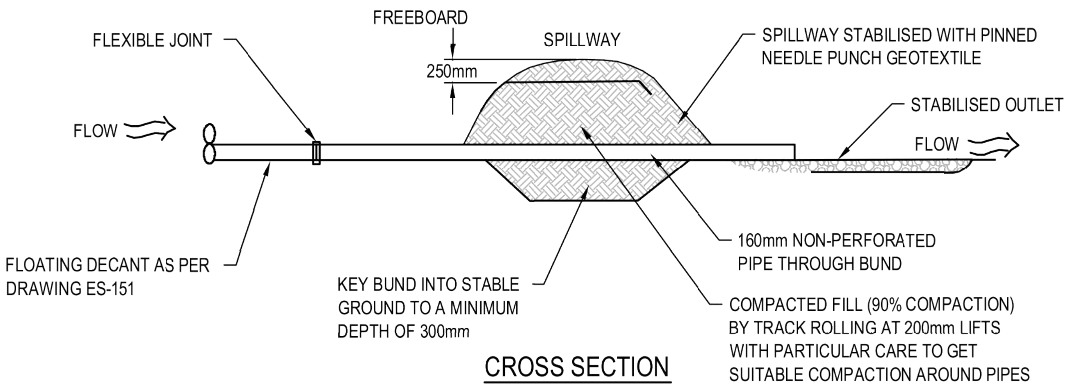


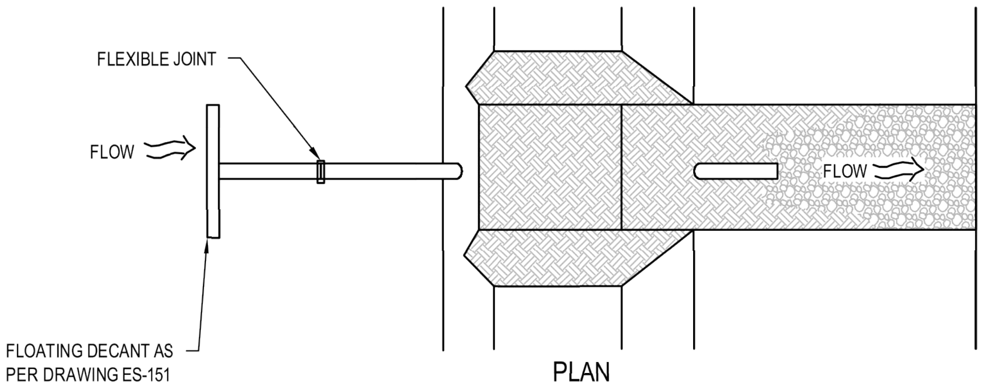
STORMWATER INLET PROTECTION
SCALE. N.T.S



CATCHPIT PROTECTION ARRANGEMENT
SCALE. N.T.S



CROSS SECTION

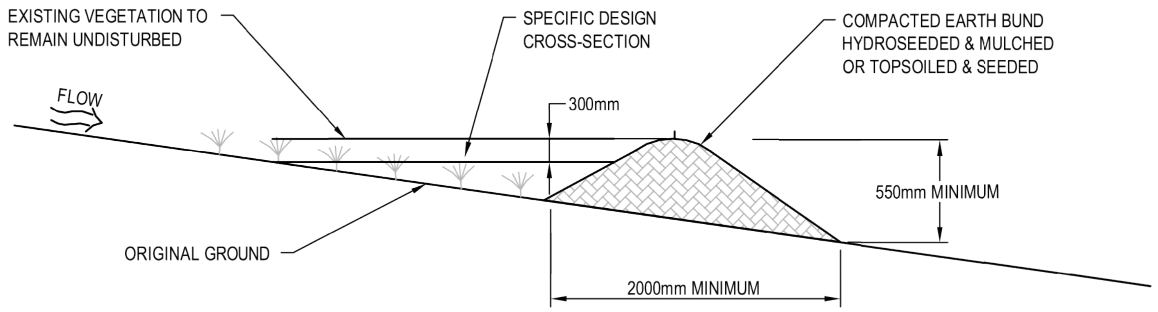


PLAN

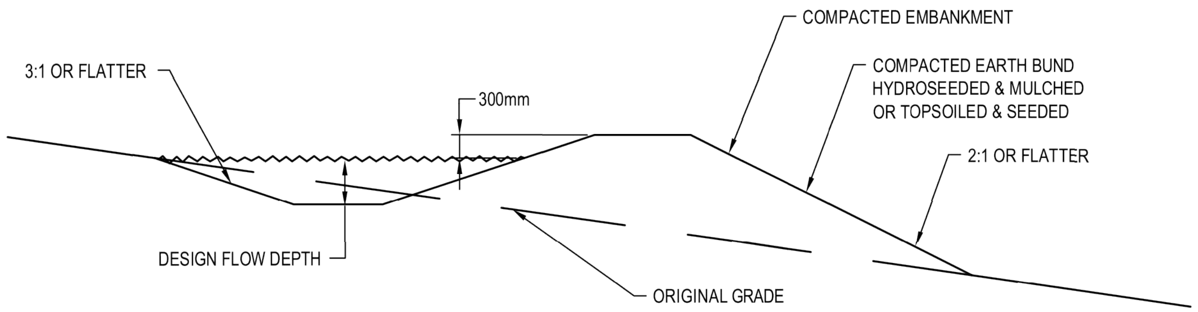
DECANTING EARTH BUND
NOT TO SCALE

NOTE:

1. CHEMICAL TREATMENT (FLOCCULATION) TO BE PROVIDED FOR ALL DECANTING EARTH BUNDS



CROSS SECTION - CLEANWATER RUNOFF DIVERSION BUND
NOT TO SCALE



CROSS SECTION - DIRTYWATER DIVERSION CHANNEL
NOT TO SCALE

FOR CONSENT

ISSUE	DATE	AMENDMENT	BY	APPD.
2	22.02.16	ISSUED FOR CONSENT – UPDATED WITH WSL COMMENTS	W.O.	N.H.
1	16.12.15	EROSION AND SEDIMENTATION CONTROL PLANS	W.O.	N.H.

DESIGNED	N.H.	02.16
DES. CHECKED	M.A.E.	02.16
DRAWN	W.O.	02.16
DWG. CHECKED	N.H.	02.16
PROJECT LEADER	M.A.E.	02.16
INFRAST'R APP'D		

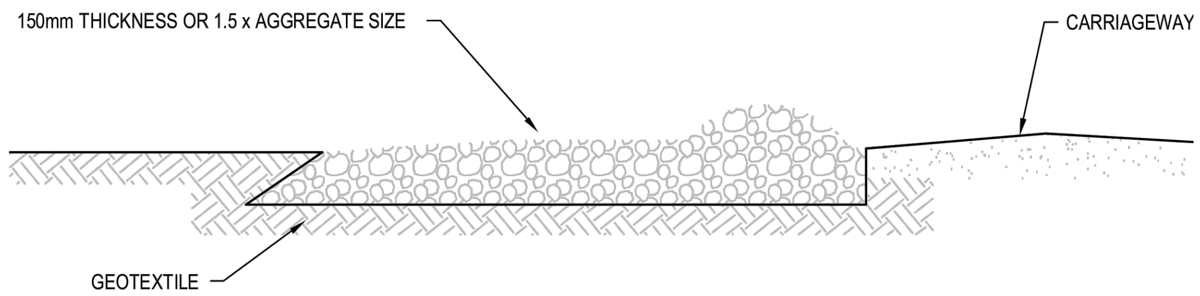
OPERATIONS

INFRASTRUCTURE

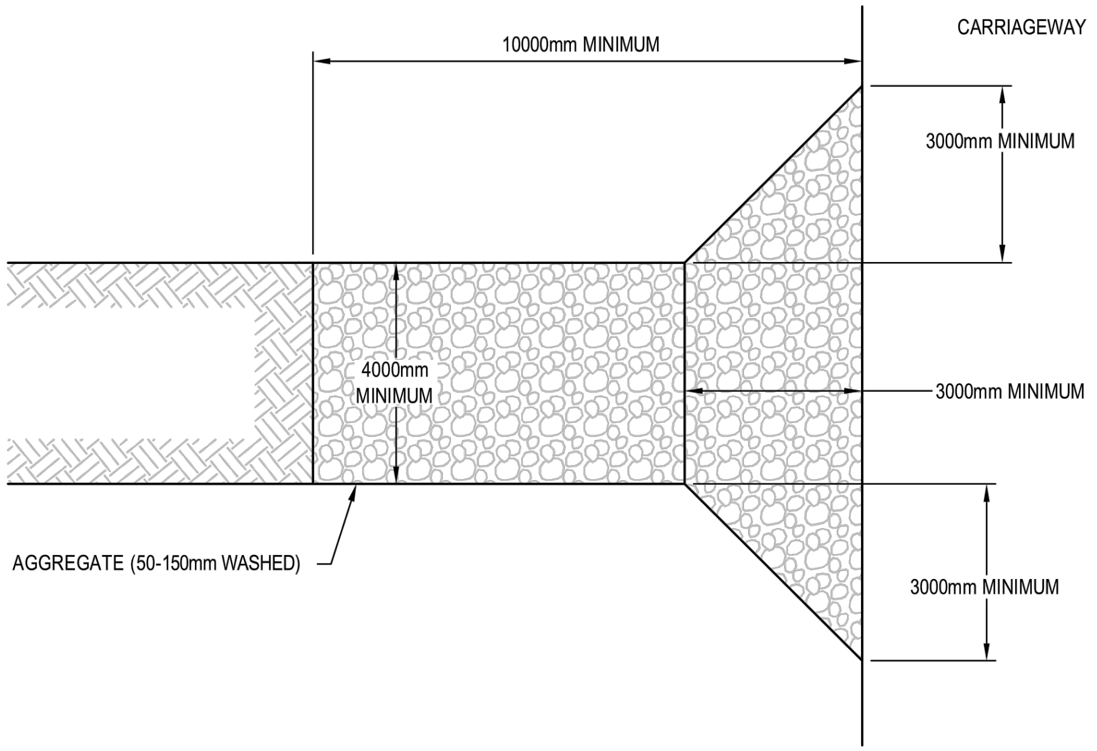
Watercare

NORTH HARBOUR No.2 WATERMAIN
EROSION AND SEDIMENT CONTROL ARRANGEMENT
CATCHPIT PROTECTION, DECANTING EARTH BUND, DIVERSION BUNDS (TYPICAL DETAILS)

CAD FILE 2010676.001-006 DATE 22.02.16
ORIGINAL SCALE A3 NTS
CONTRACT No. 5663
REF No. WMNH2-91-E-005 ISSUE –
DWG No. 2010676 .005 2



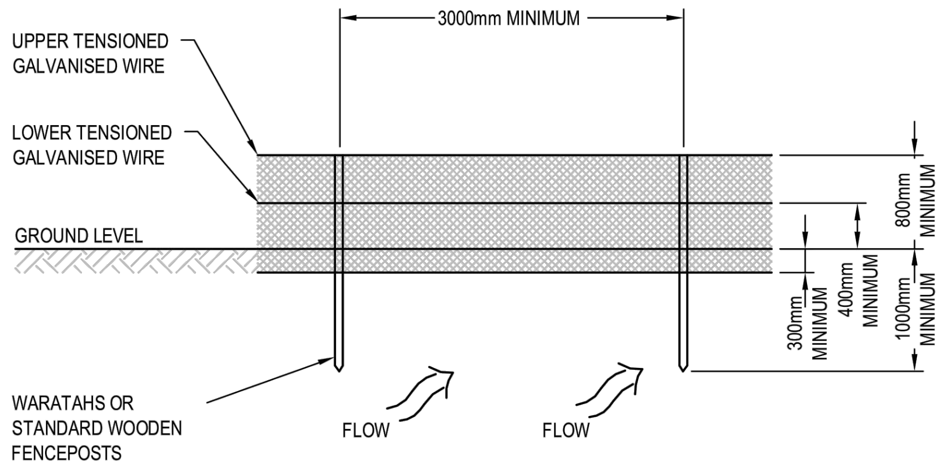
SIDE ELEVATION

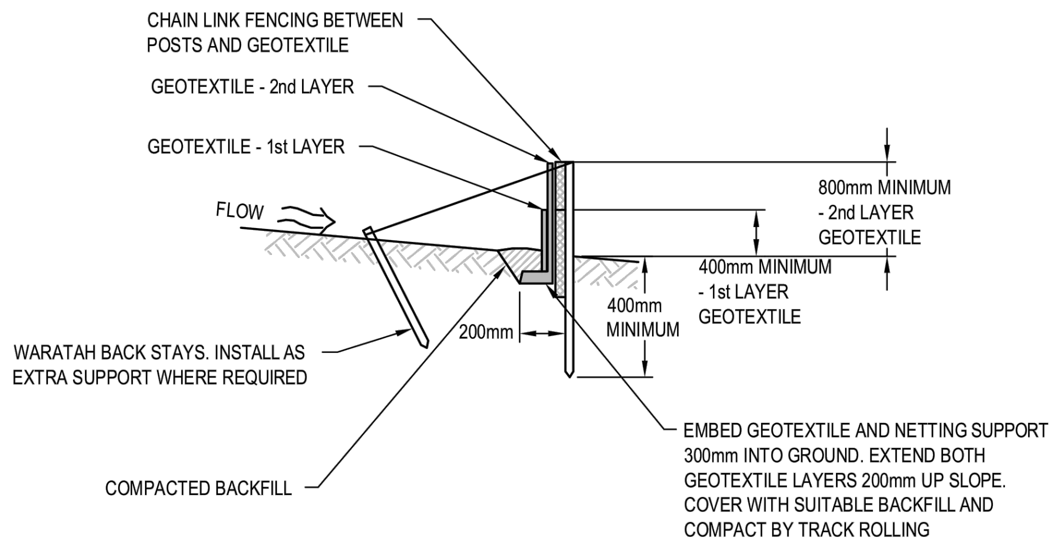


PLAN VIEW

STABILISED CONSTRUCTION ENTRANCE

NOT TO SCALE





SUPER SILT FENCE

NOT TO SCALE

FOR CONSENT

ISSUE	DATE	AMENDMENT	BY	APPD.
2	22.02.16	ISSUED FOR CONSENT - UPDATED WITH WSL COMMENTS	W.O.	N.H.
1	03.12.15	ISSUED FOR CONSENT	W.O.	N.H.

DESIGNED	N.H.	02.16
DES. CHECKED	M.A.E.	02.16
DRAWN	W.O.	02.16
DWG. CHECKED	N.H.	02.16
PROJECT LEADER	M.A.E.	02.16
INFRAST'R APP'D		

OPERATIONS

INFRASTRUCTURE

Watercare

NORTH HARBOUR No.2 WATERMAIN
EROSION AND SEDIMENT CONTROL ARRANGEMENT
STABILISED ENTRANCE, SUPER SILT FENCE (TYPICAL DETAILS)

CAD FILE 2010676.001-006		DATE 22.02.16	
ORIGINAL SCALE A3 NTS		CONTRACT No. 5663	
REF No.	WMNH2-91-E-006	ISSUE	-
DWG No.	2010676.006		2

Plot Date: Mar 03, 2016 - 9:55am U:\Jobs\42073300\01_DWG_Current\08 AEE\Main Route AEE Drawing Set\ 2010676.001-006.dwg

Appendix B

ESCP Calculations

USLE Caluclation - Cut to Fill SH18

Project: North Harbour No. 2 Watermain

Subject	**Universal Soil Loss Equation (USLE) Calculations**	By	**Kristina Healy**	Date	10-Dec-15
File Ref	**42073300**	Checked		Date	

Reference: ARC Land Fact Sheet 8
Estimating Sediment Yield, Universal Soil Loss Estimation (USLE)

The general form of the equation is:

A = R x K x (LS) x C x P

Where
- A = soil loss (tons/hectare/year)
- R = rainfall erosion index (J/hectare)
- K = soil erodibility factor (tonnes/unit of R)
- LS = slope length and steepness factor (dimensionless)
- C = vegetation cover factor (dimensionless)
- P = erosion control practice factor (dimensionless)

In addtion, the following factors are taken into account

Sediment delivery ratio = Ratio of sediment that is deopsited on site prior to runoff being treated by sediment retention measures.
Assumed to be 0.75

Sediment containment efficiency = Efficiency of sediment control measures.
Assumed to be 50%

Staging / timing: The works will be undertaken in discrete sections and for this analysis it is assumed that bare soil will be exposed for a maximum of 2 months for the first 2 sections and 1 month for the last.

SUMMARY CALCULATION:

Staged Site Construction

Component	Area of Earthwork (m2)	Rainfall Factor R	Soil Erodability K	Slope Length m	Slope %	Slope Grad Factor LS	Vegetation Factor C	Rough Factor P	Worked Period (years)	Unmitigated Soil Loss (tons)	Sediment Delivery Ratio	Sed Cont Eff	Mitigated Soil Loss (tons)
West GB Ch21075 to Ch21800	3000	77	0.26	750	2.7	0.67	0.1	1	0.2	0.068	0.75	50%	0.026
Kimberley Grove to Olwyn Place C	2840	77	0.30	710	4.2	1.50	0.1	1	0.2	0.199	0.75	50%	0.075
112 George Deane Pl to 30 Wickla	1680	77	0.30	420	2.4	0.51	0.1	1	0.1	0.020	0.75	50%	0.008

Total 7,520 m2
0.75 ha

TOTAL (tons)	**0.29**	**0.11**

USLE Caluclation - Cut to Fill SH18

Constant R = Rainfall erosion index (J/hectare)

Reference: HIRDS Rainfall Data - National Institute of Water and Atmospheric Research (NIWA)

R = 0.00828 * P^2.2 * 1.7

Where: P = Rainfall for 6hr 2 year ARI storm event = 50.1
Multiplier to convert from imperial to metric units = 1.7

=> R = 77

Rainfall depths (mm)

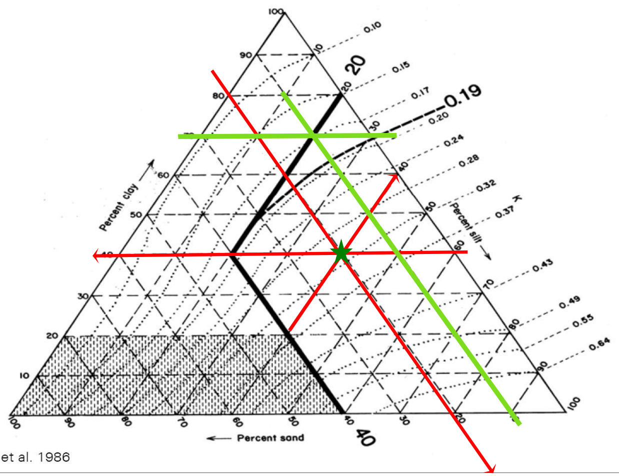
		Duration									
ARI (y)	aep	10m	20m	30m	60m	2h	6h	12h	24h	48h	72h
1.58	0.633	9.8	14.0	17.3	24.7	31.5	46.4	59.1	75.4	87.2	94.8
2.00	0.500	10.5	15.0	18.5	26.5	33.9	50.1	64.2	82.1	94.8	103.2
5.00	0.200	13.1	18.7	23.0	32.9	42.5	63.8	82.4	106.4	122.9	133.8
10.00	0.100	15.1	21.6	26.6	38.0	49.4	74.9	97.3	126.4	146.0	158.8
20.00	0.050	17.3	24.8	30.5	43.7	57.1	87.2	114.0	149.0	172.2	187.3
30.00	0.033	18.7	26.8	33.0	47.3	62.0	95.3	124.9	163.9	189.3	205.9
40.00	0.025	19.8	28.3	34.9	50.0	65.7	101.4	133.3	175.2	202.4	220.2
50.00	0.020	20.7	29.6	36.5	52.2	68.7	106.4	140.1	184.5	213.1	231.8
60.00	0.017	21.4	30.6	37.8	54.1	71.3	110.6	145.9	192.4	222.3	241.8
80.00	0.012	22.6	32.4	39.9	57.1	75.5	117.6	155.5	205.7	237.5	258.4
100.00	0.010	23.6	33.8	41.7	59.6	79.0	123.4	163.4	216.5	250.0	272.0

USLE Caluclation - Cut to Fill SH18

K = Soil erodibility factor (tonnes/unit of R)

Soil type:	**Silty Clay**	West GB Ch21075 to Ch21800		Clayey Silt
Estimated soil composition:				
Test Pit	From discussion with Geologist			
Clay	40 %			70
Silt	40 %			30
Sand	20 %			10
Estimated K value	0.30	(imperial)		0.17
Organic Content:	4 %			1
Correction factor:	-0.10	Refer to table below		0.06
Corrected K value	0.20	(imperial)		0.23
Convert to metric: (x1.32)	**0.26**			**0.30**

Figure 1: Triangular Nomograph for Estimating K Values



Goldman et al. 1986

Table 1: Correction Factor

Correction factor when percent organic matter is					
K value	0% (clay)	1%	2%	3%	4% (topsoil)
Greater than 0.40	+0.14	+0.07	0	-0.07	-0.14
0.20 - 0.40	+0.10	+0.05	0	-0.05	-0.1
Less than 0.20	+0.06	+0.03	0	-0.03	-0.06

USLE Caluclation - Cut to Fill SH18

LS = slope length and steepness factor (dimensionless)

Can use the following equation:

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065 \right) \times \left(\frac{l}{72.5} \right)^m$$

LS= topographic factor
l = Slope length, m
s = Slope steepness
m = Exponent dependent on slope steepness
0.2 for slopes<1%, 0.3 for slopes 1-3%. 0.4 for slopes 3.5-4.5%, and 0.5 for slopes > 5%)

LS Calculator:

Slope length (m)	750
Slope (%)	2.7
Slope Gradient Factor	**0.67**

Clarks Lane to Squadron Drive

Or use the following table based on the above equation:

Slope Ratio s, %	Slope Length, m												
	10	25	50	75	100	125	150	175	200	225	250	275	300
0.5	0.08	0.09	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15
1.0	0.09	0.12	0.15	0.17	0.18	0.20	0.21	0.22	0.23	0.23	0.24	0.25	0.26
2.0	0.14	0.19	0.23	0.26	0.29	0.31	0.32	0.34	0.35	0.37	0.38	0.39	0.40
3.0	0.21	0.27	0.33	0.38	0.41	0.44	0.46	0.48	0.50	0.52	0.54	0.56	0.57
4.0	0.26	0.37	0.49	0.57	0.64	0.70	0.76	0.80	0.85	0.89	0.93	0.96	1.00
5.0	0.31	0.48	0.69	0.84	0.97	1.08	1.19	1.28	1.37	1.45	1.53	1.61	1.68
6.0	0.39	0.61	0.86	1.06	1.22	1.36	1.49	1.61	1.72	1.83	1.93	2.02	2.11
7.0	0.47	0.75	1.06	1.29	1.49	1.67	1.83	1.98	2.11	2.24	2.36	2.48	2.59
8.0	0.57	0.90	1.27	1.56	1.80	2.01	2.20	2.38	2.54	2.70	2.84	2.98	3.11
9.0	0.67	1.06	1.50	1.84	2.13	2.38	2.60	2.81	3.01	3.19	3.36	3.35	3.68
10.0	0.78	1.24	1.75	2.15	2.48	2.77	3.04	3.28	3.51	3.72	3.92	4.11	4.30
11.0	0.91	1.43	2.02	2.48	2.86	3.20	3.51	3.79	4.05	4.29	4.53	4.75	4.96
12.5	1.10	1.74	2.46	3.02	3.48	3.89	4.26	4.61	4.92	5.22	5.51	5.77	6.03
15.0	1.47	2.32	3.28	4.02	4.64	5.19	5.68	6.14	6.56	6.96	7.34	7.69	8.04
16.7	1.74	2.76	3.90	4.77	5.51	6.16	6.75	7.29	7.79	8.27	8.71	9.14	9.55
20.0	2.34	3.70	5.23	6.40	7.39	8.26	9.05	9.78	10.45	11.09	11.69	12.26	12.80
22.0	2.73	4.32	6.11	7.49	8.65	9.67	10.59	11.44	12.23	12.97	13.67	14.34	14.98
25.0	3.38	5.34	7.55	9.25	10.68	11.94	13.08	14.12	15.10	16.01	16.88	17.70	18.49
30.0	4.56	7.21	10.19	12.48	14.41	16.12	17.95	19.07	20.39	21.62	22.79	23.90	24.97
33.3	5.41	8.55	12.09	14.80	17.09	19.11	20.93	22.61	24.17	25.64	27.03	28.34	29.61
35.0	5.86	9.26	13.10	16.05	18.53	20.71	22.69	24.51	26.20	27.79	29.30	30.73	32.09
40.0	7.25	11.47	16.22	19.86	22.93	25.64	28.09	30.34	32.43	34.40	36.26	38.03	39.72
45.0	8.71	13.78	19.48	23.86	27.55	30.80	33.74	36.45	38.96	41.33	43.56	45.69	47.72
50.0	10.22	16.15	22.84	27.98	32.31	36.12	39.57	42.74	45.69	48.46	51.08	53.57	55.95
55.0	11.74	18.56	26.25	32.15	37.13	41.51	45.47	49.12	52.51	55.69	58.71	61.57	64.31
57.0	12.35	19.53	27.62	33.83	39.06	43.67	47.84	51.68	55.24	58.60	61.77	64.78	67.66
60.0	13.27	20.98	29.67	36.34	41.96	46.91	51.39	55.51	59.34	62.94	66.35	69.59	72.68
66.7	15.29	24.18	34.20	41.88	48.36	54.07	59.23	63.98	68.40	72.55	76.47	80.20	83.77
70.0	16.27	25.73	39.63	44.57	51.46	57.53	63.03	68.08	72.78	77.19	81.37	85.34	89.13
75.0	17.72	28.03	39.63	48.54	56.05	62.67	68.65	74.15	79.27	84.08	88.62	92.95	97.08
80.0	19.13	30.25	42.78	52.39	60.50	67.64	74.10	80.03	85.56	90.75	95.66	100.33	104.79
85.0	20.49	32.39	45.81	56.11	64.78	72.43	79.34	85.70	91.62	97.18	102.43	107.43	112.21
90.0	21.79	34.45	48.72	59.67	68.90	77.03	84.38	91.14	97.43	103.35	108.94	114.25	119.33
95.0	23.03	36.41	51.50	63.07	72.83	81.42	89.19	96.34	102.99	109.24	115.15	120.77	126.14
100.0	24.21	38.28	54.14	66.31	76.57	85.61	93.78	101.29	108.29	114.85	121.07	126.98	132.62

Slope length (m)	710
Slope (%)	4.2
Slope Gradient Factor	**1.50**

Kimberely Grove to Olwyn Place

Slope length (m)	420
Slope (%)	2.4
Slope Gradient Factor	**0.51**

112 George Deane Place to 30 Wicklam Lane

USLE Caluclation - Cut to Fill SH18

Constants C & P

C = Cover factor
Ratio of soil loss under specified conditions to that of a bare site
C factor is reduced when soil is protected against erosion

P = Erosion Control Practice Factor
Reflects the roughness of the earthworks surface

Treatment	C factor	P factor
Bare soil		
- compacted and smooth	1.0	1.3
- tracked walked on contour	1.0	1.2
- rough irregular surface	1.0	0.9
- disked to 250mm depth	1.0	0.8
Native vegetation (undisturbed)	0.0	1.0
Pasture (undisturbed)	0.0	1.0
Temporary grass	0.1	1.0
Temporary cover crop	0.5	1.0

* Reference:
Modified from Goldman SJ, Jackson K, Bursztynsky T 1986. Erosion and Sediment Control Handbook.

TP108 Peak Flow Rate Calculations

TP108 Worksheet

Project: North Harbour No.2 Watermain

Project No.: 42073300

Task: Run-off Calculations for pipe bridge - Oratia Stream

Calculated: W. Ouyang **Signature:** **Date:** 25-Nov-15

Reviewed By: K. Healy **Signature:** **Date:**

Approved By: **Signature:** **Date:**

A) Runoff Parameters and Time of Concentration

1. Catchment Details

Total Area (ha)	1636.44	Ref Data Sheet
Pervious Area (ha)	1334.87	Ref Data Sheet
Impervious Area (ha)	301.57	Ref Data Sheet
Channel^{n} factor **C**	0.80	0.60 - Piped System , 0.80 - Grass Channel
Catchment length **L** (km)	5.393	Refer Sc Calc Sheet
Catchment slope **Sc**	0.041	Refer Sc Calc Sheet

Assumptions (if any):
MPD Scenario
tc - changed - used tc from Mike 11 Model
Rainfall values changed as per those used in model 10yr-124, 50yr-169, 100yr-189.

2. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil Name and Classific.	Area identifier, cover description (cover type, treatment and hydrological condition)	Curve number CN*	Area	Product CN x Area
A	1 - Impervious	98	301.57	29,553.4
A	2 - Pervious	39	1334.87	52,060.1
	* from Appendix B	**Total**	**1636.44**	**81,613.5**

CN (weighted) = $\frac{\text{total CN x A}}{\text{total area}} = \frac{81{,}613.5}{1{,}636.4388}$ = **49.9**

Ia (weighted) = $\frac{\text{5 x pervious area}}{\text{total area}} = \frac{6{,}674.4}{1{,}636.4388}$ = **4.1**

3. Time of Concentration

Runoff Factor = $\frac{CN}{200 - CN}$ = 0.332

tc = 0.14C x L0.66 x [CN/(200-CN)]-.55 x Sc-0.30 = **1.627** hrs Note: tc = 10 min = 0.17hrs

SCS Lag for HEC-HMS "tp" = 2/3 x tc = 1.085 hrs

TP108 Peak Flow Rate Calculations

B) Graphical Peak Flow Rate

1. Catchment Area (km^2) = 16.364388

2. Calc storage, S = 25.4 x [(1000/CN - 10)] = 255.298

	2year	10year	20year	100year
3. Annual Recurrence Interval (ARI)	**2year**	**10year**	**20year**	**100year**
4. 24 hour rainfall depth, P_{24} (mm)	80	121	142	204
5. Compute c* = $\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$ (mm)	0.123	0.181	0.208	0.278
6. Specific flow rate q* (from Fig. 6.1 below)	0.014	0.020	0.022	0.030
7. Peak flow rate, q_p = q^*AP_{24} (m^3/sec)	18.236	39.635	51.194	100.346
8. Runoff depth, Q_{24} = $\frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S}$ (mm)	17.2	36.8	48.5	88.1
9. Runoff Volume, V_{24} = 1000 x $Q_{24}A$ (m^3)	282,130	601,887	793,536	1,441,294

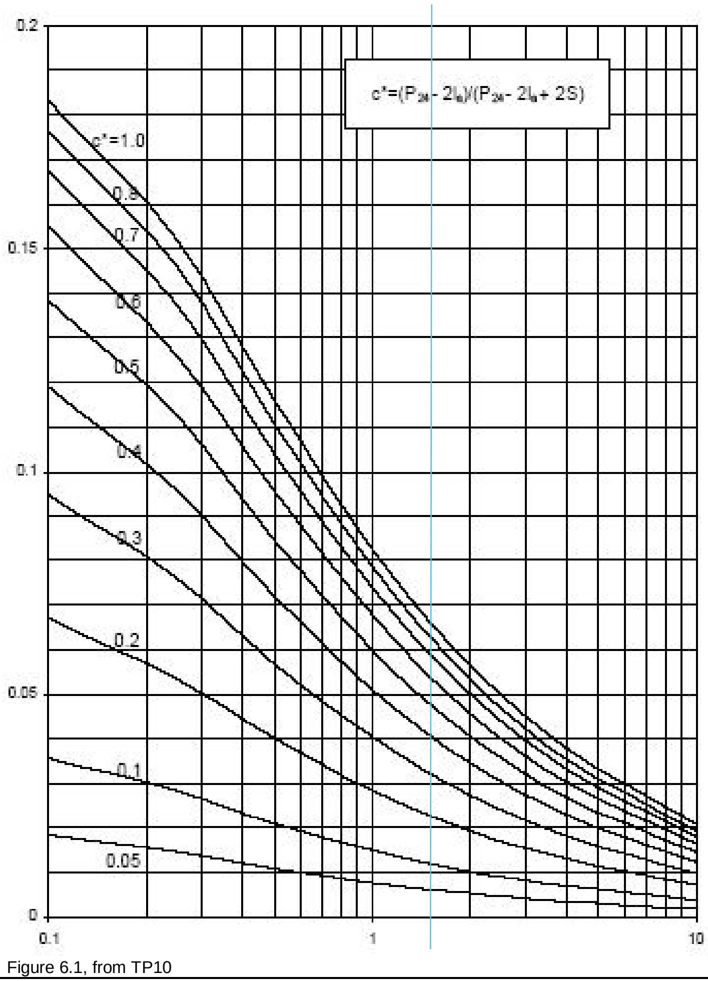


Figure 6.1, from TP10

TP108 Peak Flow Rate Calculations

TP108 Worksheet

Project: North Harbour No.2 Watermain

Project No.: 42073300

Task: Run-off Calculations for pipe bridge - Opanuku Stream

Calculated: W. Ouyang **Signature:** .... **Date:** 25-Nov-15

Reviewed By: K. Healy **Signature:** .... **Date:** ....

Approved By: .... **Signature:** .... **Date:** ....

A) Runoff Parameters and Time of Concentration

1. Catchment Details

Total Area (ha)	2225.30	Ref Data Sheet
Pervious Area (ha)	2080.21	Ref Data Sheet
Impervious Area (ha)	145.09	Ref Data Sheet
Channel^n factor **C**	0.80	0.60 - Piped System , 0.80 - Grass Channel
Catchment length **L** (km)	3.543	Refer Sc Calc Sheet
Catchment slope **Sc**	0.038	Refer Sc Calc Sheet

Assumptions (if any):
MPD Scenario
tc - changed - used tc from Mike 11 Model
Rainfall values changed as per those used in model 10yr-124, 50yr-169, 100yr-189.

2. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil Name and Classific.	Area identifier, cover description (cover type, treatment and hydrological condition)	Curve number CN*	Area	Product CN x Area
A	1 - Impervious	98	145.09	14,218.8
A	2 - Pervious	39	2080.21	81,128.1
	* from Appendix B	**Total**	**2225.30**	**95,346.9**

CN (weighted) = $\frac{\text{total CN x A}}{\text{total area}} = \frac{95,346.9}{2,225.2968} =$ **42.8**

Ia (weighted) = $\frac{\text{5 x pervious area}}{\text{total area}} = \frac{10,401.0}{2,225.2968} =$ **4.7**

3. Time of Concentration

Runoff Factor = $\frac{\text{CN}}{\text{200 - CN}}$ = 0.273

tc = 0.14C x L0.66 x [CN/(200-CN)]-.55 x Sc-0.30 = **1.406** hrs   Note: tc = 10 min = 0.17hrs

SCS Lag for HEC-HMS "tp" = 2/3 x tc = 0.937 hrs

TP108 Peak Flow Rate Calculations

B) Graphical Peak Flow Rate

1. Catchment Area (km^2) = 22.252968

2. Calc storage, S = 25.4 x [(1000/CN - 10)] = 338.810

	2year	10year	20year	100year
3. Annual Recurrence Interval (ARI)	2year	10year	20year	100year
4. 24 hour rainfall depth, P_{24} (mm)	80	121	142	204
5. Compute c* = $\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$ (mm)	0.094	0.141	0.164	0.224
6. Specific flow rate q* (from Fig. 6.1 below)	0.012	0.018	0.020	0.028
7. Peak flow rate, q_p = q^*AP_{24} (m^3/sec)	21.229	48.467	63.243	127.358
8. Runoff depth, Q_{24} = $\frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S}$ (mm)	13.5	29.7	39.7	74.1
9. Runoff Volume, V_{24} = 1000 x $Q_{24}A$ (m^3)	301,214	661,608	882,478	1,648,324

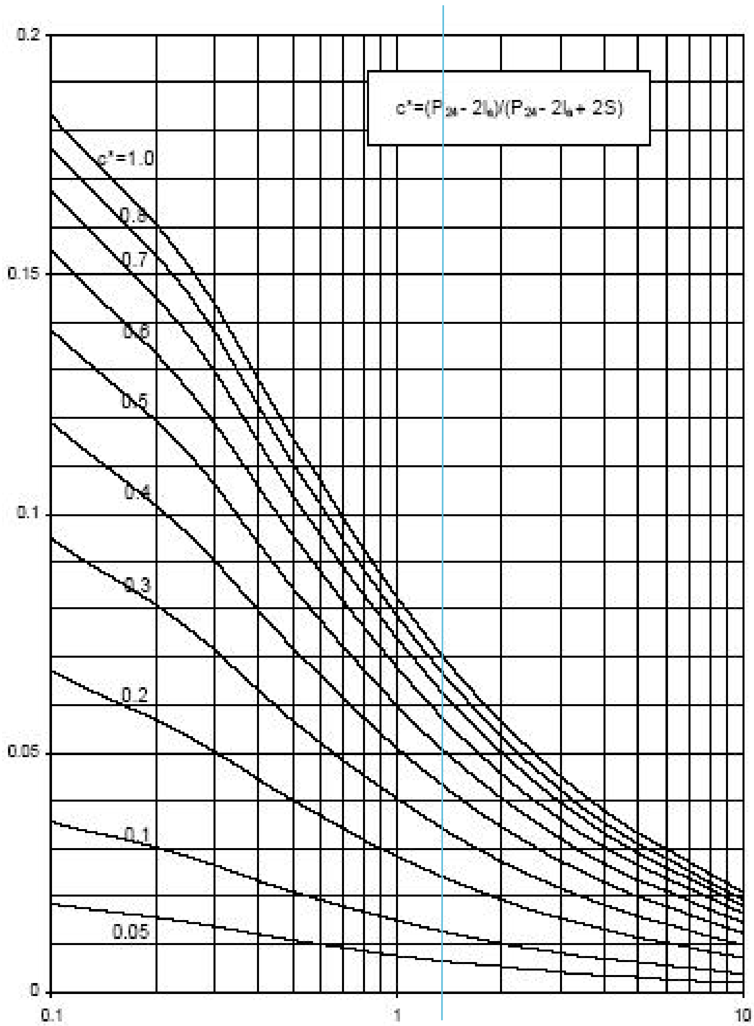


Figure 6.1, from TP10

TP108 Peak Flow Rate Calculations

TP108 Worksheet

Project: North Harbour No.2 Watermain

Project No.: 42073300

Task: Run-off Calculations for pipe bridge - Paremuka Stream

Calculated: W. Ouyang **Signature:** **Date:** 25-Nov-15

Reviewed By: K. Healy **Signature:** **Date:**

Approved By: **Signature:** **Date:**

A) Runoff Parameters and Time of Concentration

1. Catchment Details

Total Area (ha)	232.44	Ref Data Sheet
Pervious Area (ha)	130.07	Ref Data Sheet
Impervious Area (ha)	102.37	Ref Data Sheet
Channel^{n} factor **C**	0.80	0.60 - Piped System , 0.80 - Grass Channel
Catchment length **L** (km)	1.948	Refer Sc Calc Sheet
Catchment slope **Sc**	0.039	Refer Sc Calc Sheet

Assumptions (if any):
MPD Scenario
tc - changed - used tc from Mike 11 Model
Rainfall values changed as per those used in model 10yr-124, 50yr-169, 100yr-189.

2. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil Name and Classific.	Area identifier, cover description (cover type, treatment and hydrological condition)	Curve number CN*	Area	Product CN x Area
A	1 - Impervious	98	102.37	10,032.7
A	2 - Pervious	39	130.07	5,072.7
	* from Appendix B	**Total**	**232.44**	**15,105.4**

CN (weighted) = $\frac{\text{total CN x A}}{\text{total area}}$ = $\frac{15,105.4}{232.4440}$ = **65.0**

Ia (weighted) = $\frac{\text{5 x pervious area}}{\text{total area}}$ = $\frac{650.3}{232.4440}$ = **2.8**

3. Time of Concentration

Runoff Factor = $\frac{\text{CN}}{\text{200 - CN}}$ = 0.481

tc = 0.14C x L0.66 x [CN/(200-CN)]-.55 x Sc-0.30 = **0.687** hrs Note: tc = 10 min = 0.17hrs

SCS Lag for HEC-HMS "tp" = 2/3 x tc = 0.458 hrs

TP108 Peak Flow Rate Calculations

B) Graphical Peak Flow Rate

1. Catchment Area (km^2) = 2.32444

2. Calc storage, S = 25.4 x [(1000/CN - 10)] = 136.858

	2year	10year	20year	100year
3. Annual Recurrence Interval (ARI)	2year	10year	20year	100year
4. 24 hour rainfall depth, P_{24} (mm)	80	122	143	206
5. Compute c* = $\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$ (mm)	0.215	0.299	0.335	0.423
6. Specific flow rate q* (from Fig. 6.1 below)	0.038	0.049	0.054	0.066
7. Peak flow rate, q_p = q^*AP_{24} (m^3/sec)	7.102	13.918	18.000	31.603
8. Runoff depth, Q_{24} = $\frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S}$ (mm)	28.1	55.6	71.2	121.4
9. Runoff Volume, V_{24} = 1000 x $Q_{24}A$ (m^3)	65,271	129,319	165,616	282,240

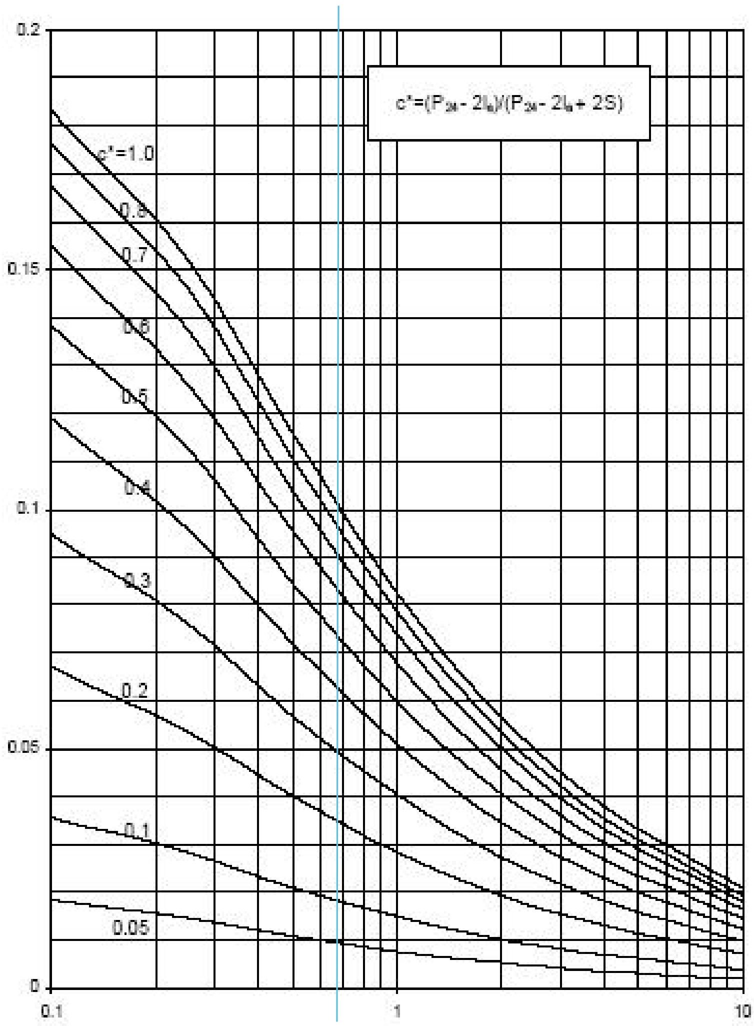


Figure 6.1, from TP10

TP108 Peak Flow Rate Calculations

TP108 Worksheet

Project: North Harbour No.2 Watermain

Project No.: 42073300

Task: Run-off Calculations for pipe bridge - Oteha Stream

Calculated: W. Ouyang **Signature:** .... **Date:** 25-Nov-15

Reviewed By: K. Healy **Signature:** .... **Date:** ....

Approved By: .... **Signature:** .... **Date:** ....

A) Runoff Parameters and Time of Concentration

1. Catchment Details

Total Area (ha)	962.70	Ref Data Sheet
Pervious Area (ha)	735.33	Ref Data Sheet
Impervious Area (ha)	227.38	Ref Data Sheet
Channel^n factor **C**	0.80	0.60 - Piped System , 0.80 - Grass Channel
Catchment length **L** (km)	3.282	Refer Sc Calc Sheet
Catchment slope **Sc**	0.035	Refer Sc Calc Sheet

Assumptions (if any):
MPD Scenario
tc - changed - used tc from Mike 11 Model
Rainfall values changed as per those used in model 10yr-124, 50yr-169, 100yr-189.

2. Runoff Curve Number (CN) and Initial Abstraction (Ia)

Soil Name and Classific.	Area identifier, cover description (cover type, treatment and hydrological condition)	Curve number CN*	Area	Product CN x Area
A	1 - Impervious	98	227.38	22,283.2
A	2 - Pervious	39	735.33	28,677.7
	* from Appendix B	**Total**	**962.70**	**50,960.9**

CN (weighted) = $\frac{\text{total CN x A}}{\text{total area}} = \frac{50,960.9}{962.7048} =$ **52.9**

Ia (weighted) = $\frac{\text{5 x pervious area}}{\text{total area}} = \frac{3,676.6}{962.7048} =$ **3.8**

3. Time of Concentration

Runoff Factor = $\frac{\text{CN}}{\text{200 - CN}}$ = 0.360

tc = 0.14C x L0.66 x [CN/(200-CN)]-.55 x Sc-0.30 = **1.176** hrs   Note: tc = 10 min = 0.17hrs

SCS Lag for HEC-HMS "tp" = 2/3 x tc = 0.784 hrs

TP108 Peak Flow Rate Calculations

B) Graphical Peak Flow Rate

1. Catchment Area (km^2) = 9.627048

2. Calc storage, S = 25.4 x [(1000/CN - 10)] = 225.833

	2year	10year	20year	100year
3. Annual Recurrence Interval (ARI)				
4. 24 hour rainfall depth, P_{24} (mm)	87	134	158	230
5. Compute c* = $\frac{P_{24} - 2Ia}{P_{24} - 2Ia + 2S}$ (mm)	0.149	0.218	0.249	0.329
6. Specific flow rate q* (from Fig. 6.1 below)	0.020	0.030	0.034	0.043
7. Peak flow rate, q_p = q^*AP_{24} (m^3/sec)	16.655	38.556	51.586	95.005
8. Runoff depth, Q_{24} = $\frac{(P_{24} - Ia)^2}{(P_{24} - Ia) + S}$ (mm)	22.2	47.3	62.3	112.8
9. Runoff Volume, V_{24} = 1000 x Q_{24}A (m^3)	213,319	455,395	599,730	1,085,955

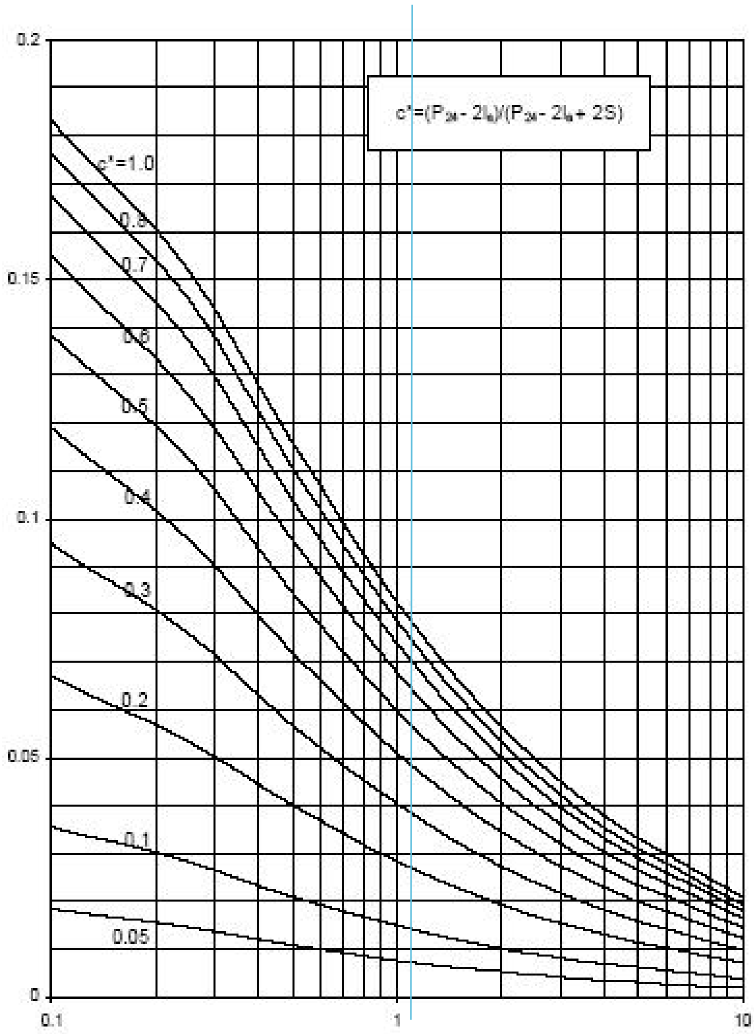


Figure 6.1, from TP10