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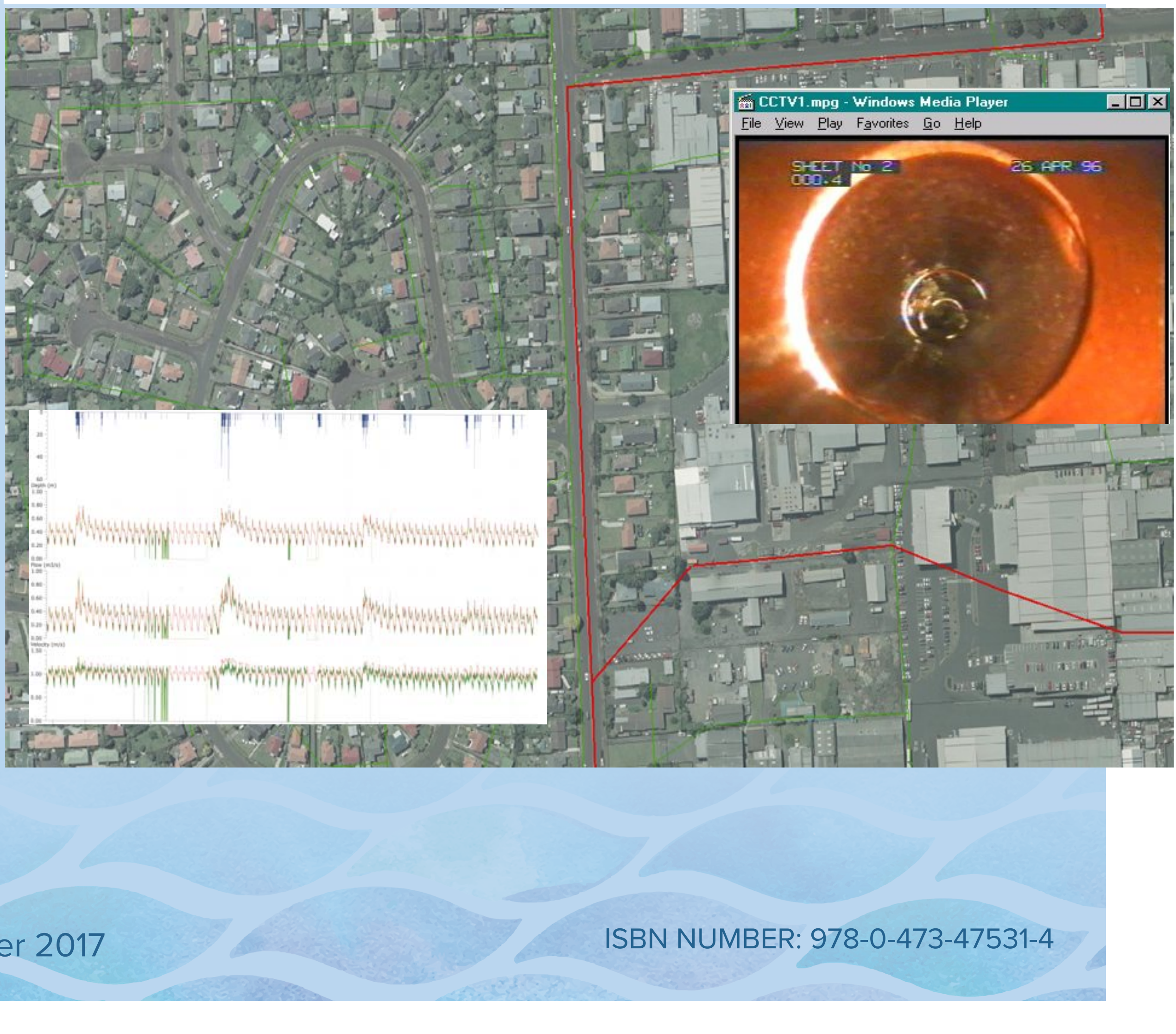
NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

WATER NEW ZEALAND MODELLING GROUP

National Modelling Guidelines

WASTEWATER NETWORK MODELLING



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Preface

This document constitutes final Version 1 Revision 5 of the Water New Zealand National Guidelines Module 1: Wastewater Modelling Guidelines. Version 1 Revision 4 was published in September 2008. Version 1 Revision 3 was published in June 2004. Version 1, Revision 2 was reviewed by Water New Zealand. Version 1, Revision 1 was released for industry consultation in the summer of 2003/2004. Draft Version 1, Revision 5 was released in April 2009.

Acknowledgments

It is acknowledged that many individuals have given up their time and resources in the production of these guidelines, since their inception in the summer of 2003/2004. On behalf of the Water New Zealand, Modelling Group, their contribution is recognised and greatly appreciated.

Further information on these draft guidelines is available from:

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1 Introduction

The purpose of these guidelines is to provide good practice protocols for undertaking wastewater (sewer) network modelling in New Zealand. In establishing these good practice protocols, the guidelines aim to progressively improve the development and use of models in New Zealand. The development of improved models will consequently improve the accuracy of modelling results for their use in the following activities:

- Asset management plans and Long-Term Planning,
- level of service assessments,
- engineering solution options,
- assessing environmental effects to support resource consent applications.

The guidelines contain information and recommended protocols on many aspects of wastewater network modelling including: the main types of models available and when to use them, the nature of input data required, and how to get the most accurate results for the level of assessment required. These guidelines have been developed to assist those relatively new to modelling techniques, and those involved in scoping and/or reviewing modelling outputs.

It should be recognised that modelling is a complex process and that some training in the form of formal training through workshops or courses is advisable before commencing modelling.

Once the decision to model has been made, these guidelines can help practitioners to determine the following:

- which model is most appropriate for the particular circumstances
- what data to put into the model (including asset data, flow data and meteorological data); and
- pitfalls to watch out for.

These guidelines are not intended to replace formal training or detailed user manuals that accompany specific modelling software. In addition, it should be recognised that the advice provided is not to be taken as an industry or national standard.

The guidelines provide practical advice for all parts of the modelling process (Sections 2 to 8) as well as advice on the audit and review process of wastewater modelling.

1.1 Generic Modelling Process

The generic modelling process is shown on Figure 1 on the following page.

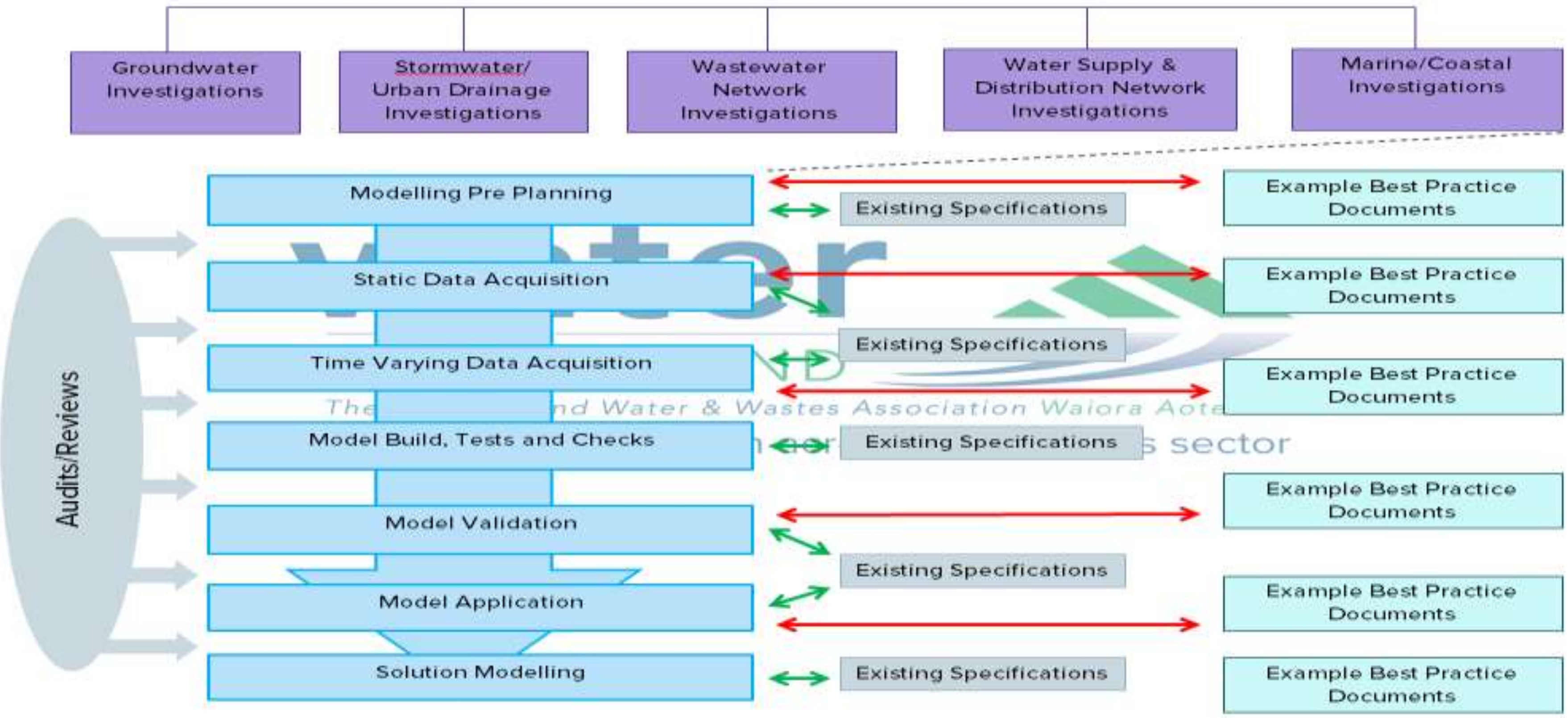

Figure 1: Generic Modelling Process

2 Initial Planning

Computer modelling is a complex, specialist task which needs to be appropriately planned. Planning will help ensure that the appropriate outcome will result from the project. Planning is essential as it assists in identifying tasks to be undertaken, as well as determining programme, key drivers, objectives to be met, budgets and justification for the modelling work.

It is recommended that the pre-planning work is undertaken and documented in the project plan. The project team, particularly the project manager may subsequently refer to this plan throughout the project.

2.1 Key Drivers

Identifying and understanding the key drivers for the modelling project will assist scoping and defining the project and the required outcomes. Some of the more common drivers for New Zealand modelling projects are summarised below.

Table 2.1 – Key Drivers for Modelling Projects

Driver Requirements	Components
• Activity Management Plans • 30 Year Strategies. • Long Term Plans (LTP) • Level of Service changes • Water and sanitary assessments	• Consultation – Community preferences and priorities • Current status • Growth planning • Solutions planning - Options (including non-engineering solutions) - Costs • - Implementation
• Resource consents • Assessment of Environmental Effects (AEE)	• Manhole discharges • Pipeline discharges • Sludge disposal • Pump station discharges • Environmental effects
• Population / growth • New development / network extensions • Identify impact on existing infrastructure	• Rate of growth • System performance – existing • System performance – growth • Identify key bottlenecks – distribution and trunk system
• Failure analysis • Resilience and criticality analysis • Risk mitigation planning	• Likelihood / consequence analysis

2.2 Objectives

Definition of the modelling objectives is a vital stage in any modelling project. It enables the best 'level of modelling' to be determined, which will influence the level of investment, project duration and level of accuracy of the deliverables relative to the desired outcome. Selecting the correct 'level of modelling' will ensure that a fit for purpose model can be developed at an economical cost. The two primary levels of modelling, strategic and catchment are defined in table 2.2.

Table 2.2 – Levels of Modelling

Typical Project Objectives	Model Type (Level)	Example Projects
• Bulk conveyance and treatment options • Impact assessment of major regional initiatives • Prioritisation plan for upgrading of catchments, trunk mains, major pump stations • Development of detailed planning and investigation programmes • Scenario development, assessment and costing for consultation purposes • 20-50 year cost estimates for upgrading programmes • Identification of high risk assets	• Level 1 - Strategic • Whole City, • Large parts of the City, • Significant catchments	• Project Storm II (Watercare Services) • Project Care (North Shore City) • Waitakere Wastewater Master Plan (Waitakere City) • Global Model (Metrowater) • Eastern Suburbs Model (Manukau Water) • Christchurch City Council
• Operational performance assessment • Establish cause of flooding/overflows • I/I control programming • Localised growth scenario planning • RMA compliance assessment and monitoring • Pump station upgrading options • Inter catchment transfers assessment • Improving level of services • Long term upgrading programme development	Level 2 - Catchment • Catchment management • Single large catchments • Adjoining catchments • Small parts of city	• Joint Catchment Studies (Watercare and Metrowater) • Waitakere City Council - New Lynn Modelling and I/I Investigations • North Shore City studies • Manukau Water studies • Metrowater Catchment Improvement Projects (CIPs) • Christchurch City Council

2.3 Model Attributes and Benefits

Table 2.3 – Level 1 Strategic Model Attributes

Typical Objectives	Typical Outputs	Typical Benefits	Model Complexity
• Bulk conveyance and treatment options • Impact assessment of major regional initiatives • Prioritisation plan for upgrading of catchments, trunk mains, major pump stations • Development of detailed planning and investigation programmes • Scenario development, assessment and costing for consultation purposes • 20-50 year cost estimates for upgrading programmes • Identification of high risk assets • High level assessment of large or significant catchments • High level impact of any significant proposed development initiatives	• Hydraulic impacts of significant trade waste sources • Treatment location options • Forward planning programmes ~ Prioritised catchments upgrade programme ~ Prioritised treatment upgrade programme ~ Prioritised trunk main upgrade programme ~ Prioritised pump station upgrade programme ~ Detailed planning programme ~ New asset construction programme • Cost projections for 20-50% for new infrastructure and upgrades • Consultation planning documentation	• Framework for more detailed studies • Prioritisation of future expenditure • Assists with consultation • Better understanding of future works programmes • Inputs to Asset Management Plan, LTCCP, Water Assessment • Least expensive • Relatively short timeframe to complete	• Can vary from simple static type models (inexpensive) to simple dynamic models (more expensive) • Simple static models can be done in-house on spreadsheet or with simple hydraulic software • The more complex simple dynamic models may be beyond the capability of in-house resources – does require modelling experience • Lower requirements in terms of asset data coverage and quality

Table 2.4 – Level 2 Catchment Model Attributes

Typical Objectives	Typical Outputs	Typical Benefits	Model Complexity
• Operational Performance Assessment and optimisation • Establish cause of flooding / overflows • I/I control programming • Localised treatment options analysis • Localised growth scenario planning • RMA compliance assessment and monitoring • Pump station upgrading options • Inter catchment transfers assessment • System optimisation for known rate of growth • Improving level of service for no growth • Long term upgrading programme development • Environmental impact assessment of discharges to environment • Impact assessment of any significant proposed development initiatives • Support detailed design	• Upgrading strategy ~ Long term upgrading programme for treatment, pipes, pump stations (costs and scope) ~ Mini-catchment prioritisation for I/I control programme ~ Overflow containment, treatment and monitoring strategy • New Infrastructure Planning • Continual improvement/monitoring programme • Improved asset inventory • Effluent quality assessment ~ Effluent characterisation at any point in network – wet and dry weather ~ Hydrographs and quality graphs to support design • Detailed designs ~ Upgrades for new developments ~ Optimisation of pump station operation ~ Containment structures • - Discharge treatment structures	• Linkage with renewal planning and prioritisation of renewals programmes • Improved confidence level in outputs for cost, nature and extent of works • Confirmation of operational problems and identification of previously unknown operational problems (e.g. manhole discharges) • Base model for more detailed studies • Base model for monitoring of trends or net impact of network improvements • Problem prioritisation – enables funds to be targeted at areas of specific and urgent need • Quantification of effluent discharge volumes/quality • Calibration of model against measured performance gives increased confidence in model output	• Medium to high level complexity requiring sophisticated software that makes use of time varying data to generate a dynamic model • Requires fairly extensive asset data of good quality • Requires experienced modellers with good understanding of engineering problems and solutions • External peer reviews advisable at key stages of project (typically model build; calibration; system performance) • Future use requires experienced in-house resources data management systems, investment in software and training

2.4 Data and Other Requirements

2.4.1 Model Extents

Regardless of the level of model selected, it is necessary to define the extents of the model and the key points in the network for which information is required.

Model extents and data collected are typically defined by the model level:

a) Pipe diameter (e.g. pipes smaller than 225mm diameters not modelled)
b) Location of known operational problems (e.g. flooding; manhole overflows; regular silt build-up)
c) Location of critical assets (pump stations, river crossings, major road crossings, estuary crossings, treatment plant, etc)
d) Location of planned significant regional initiatives
e) Location of planned significant localised development initiatives
f) Location of known operational devices (cross-connections; controlled overflow points; storage tanks; treatment devices)

Major network features and areas of concern should be accurately represented in the model. This may require additional data collection e.g. pipe size/material, elevations or pump make/model. Typical examples could include:

Key points in the network, where problems are known to occur or where problems could arise in the future.

Manholes with treatment or containment devices; controlled overflow devices (e.g. weirs); known surcharging or discharging problems; cross connections to other manholes in the network

a) Hydraulic boundary constraints such as pump stations; manholes as above, connections to large bulk conveyance systems
b) Low lying public areas where discharges could result in a public health hazard.

It should be noted however that the level of accuracy required should be commensurate with the required outcome from the model and it could be appropriate not to include some key points explicitly in the model, in say a Level 1 model.

2.5 Asset Data Requirements

Table 2.5 – Level 1 Strategic Model Data Requirements

Data Description	Level 1 Model – Strategic Planning			
	Source	Accuracy	Condition	Detail
Manholes	• GIS • As-built plans • Operational staff • Complaints database	• Contour plans (1m) • 0.2m, survey if necessary		• Lid levels, internal dimensions / volumes • Controlled overflow devices such as weirs, pipes • Uncontrolled overflows at manholes, via lid
Pipelines	• GIS • Coverage to suit model limits • Hydraulic textbooks • Design standards	Off GIS or as-built plans Data validate only	• Known operational problems such as roots, debris, fat, low gradients • Regular maintenance requirements • Material	• Diameter, length (typically exclude pipes smaller than Ø225mm) • Material • Gradients • Levels (especially if a drop manhole) • Pipe roughness
Pump stations	• GIS • Asset register • As-built plans	As-built plans	• Operational issues • Maintenance programme	• Pump delivery rate • Pump delivery head • Storage • Rising main details
Containment devices	• GIS • As-built plans	As-built plans	• Operational issues • Maintenance programme	• Levels • Capacity
Catchment boundary	• GIS • Contour plans	• 1 : 50000 scale plan	• N/A	• "Watershed" boundary line
Growth projections	• In-house projections • Census data	• Mesh block level	• Latest available estimates	• Population • Regional developments • Localised development initiatives

Data Description	Level 1 Model – Strategic Planning			
Known operational problems	• Operational staff • Significant problems only	• Location pin pointed	• Frequency and consequence established during discussion	• Hydraulic Bottlenecks • Discharges • Historical flooding
Flow and rainfall surveys (simple dynamic model only)	• Permanent monitors and rain gauges • Short term survey • Pump station flow meters			• Time varying flow and rainfall data • Data validate • Sample check

Table 2.6 – Level 2 Catchment Model Data Requirements

Data Description	Level 2 Model – Catchment Management Planning			
	Source	Accuracy	Condition/Other	Detail
Manholes	• GIS • Field survey • As-built plans • Operational staff • Complaints database	• As-built drawings or GIS = 0.1m • Survey where data is missing	• Inlet/outlet invert levels • Pipe length • Pipe diameter • Establish nature of receiving environment (parks, property, riparian margin, etc)	• Lid levels (lidar surveys) • Invert level at centre of manhole • Levels, internal dimensions/volumes • Data validate/sample check • Controlled overflow devices such as weirs, pipes • Data validate • Uncontrolled overflows at manholes, via lid
Pipelines	• GIS • Coverage to suit model limits • Hydraulic textbooks • Design standards • Site survey	• Off GIS or as-built plans • Survey where data is missing for key components	• Known operational problems such as roots, debris, fat, low gradients • Regular maintenance requirements • Review CCTV for key components	• Diameter, length • Material • Length • Gradients • Levels • Data validate and sample check • Pipe roughness

Data Description	Level 2 Model – Catchment Management Planning			
Pump stations	• GIS • Pump station database • As-built plans • Site survey	• Measure key elevations • Measure key dimensions of wet well • Confirm all operational levels	• Known operational problems • Maintenance programme • Confirm system operation design	• Pump delivery rate • Pump delivery head • Storage • Rising main details • Telemetry records • Flow meter records
Containment devices	• GIS • Pump station database • As-built plans • Site survey	• Measure key dimension of structure • Measure key elevations (inlet, outlet, overflow) • Confirm overflow details	• Known operational problems • Maintenance programme	• Level data • Tank dimensions • Outlet details • Overflow details • Sample check

Data Description	Level 2 Model – Catchment Management Planning			
	Source	Accuracy	Condition/Other	Detail
Catchment boundary	• GIS • Contour plans	• 1 : 5000 scale plan • Review connectivity plans	• N/A	• "Watershed" boundary line
Known operational problems	• Operational staff • Significant problems only	• Location pin pointed • Accurate survey and measurement • CCTV where appropriate	• Frequency and consequence established during discussion	• Hydraulic Bottlenecks • Discharges • Historical flooding
Flow and rainfall surveys	• Short term survey (6-12 weeks) • Permanent flow and rain gauges • Pump station flow meters	• Dry weather flow information required • Min 3 x significant wet events required • Good quality reliable data required	• The quality of data will have a big impact on outcome of study. Since the outcome could involve $m's, it is important that good quality data is obtained	• Location of monitors • Type of monitors • Raw and final (edited) data • Data to be recent as possible • Independent data audit (completed during survey)
Assessment of environmental effects	• Independent study			• Effect on receiving environment • Effluent quality/load • Assessment of "first flush"

3 Static Data Acquisition

3.1 General Asset Data

General asset data will typically be held in a Graphical Information System (GIS) and/or an Asset Management System (AMS). Operating manuals and ‘as-built’ plans may also be available for use in model development. It is important to focus on gathering (and improving where necessary) that data sets that are important to achieve a ‘fit for purpose’ outcome, as defined in the planning stage, and not necessarily those data sets which are interesting.

Typically this data will include:

- Asset data (pipes, manholes, pump stations, etc) and associated attributes (connectivity, levels, grades, diameters, etc)
- aerial photographs
- contours/lidar (catchment boundaries)
- roads
- cadastral / district plan (land use)
- impermeable area data
- population/rates data
- soil data (if available)
- connections to bulk conveyance systems operated by others.
- Design data associated with pump stations (inlet level(s), pump level, pump stop/start levels, pump performance curves, rising main system curves, wet well dimensions, overflow pipe details and levels)
- boundary conditions and configurations at hydraulic features/control points, e.g:
- temporary storage tanks
- weirs, screens
- controlled overflow points
- Water consumption data (at property level if available, otherwise from bulk meters but will require water supply zone details to be of any use). Large consumers need to be identified. Diurnal flow patters will be useful if these are available.

3.1.1 Data Validation

Where data is a low confidence or missing entirely, and in an area of concern, the data should be validated where possible e.g:

- up-sloping (negative) pipe gradients,
- diameters that reduce in the direction of the flow,
- missing dimensions, materials or elevations,
- network connectivity,
- catchment boundaries.

The extent and quality (confidence) of the asset data required for the model is dependent upon the Level of Modelling required (e.g. a Level 1 Strategic Model or a Level 2 Catchment Model).

3.1.2 Data Prioritisation

Having completed the data validation check, it should be possible to generate a *Missing Data Report* that will identify all missing asset data, highlight key missing data and provide a prioritised list of data to be collected for the model. It is suggested that a system for prioritising data capture be adopted as follows:

Top Priority - Essential for the building of the model

Such data is likely to be a key pump station or trunk main in the model system and every effort should be expended to obtain this data. E.g. elevations and diameters of a critical main, pump details or catchment boundaries anomalies.

Medium Priority - Important for the building of the model

Such data will be of assistance in the building of a model and could include manhole elevations, pipe diameter confirmation, CCTV of pipes with flat gradients (to assess silt build up).

Lower Priority - Non essential data (but nice to have)

Such information may help fine tune and improve the model performance but is generally beyond the level of detail required for the level of modelling selected. Also, it will not have a significant impact on the model hydraulics. E.g. collection of missing manhole diameters data in non-critical parts of the model.

3.2 Manhole Surveys

The primary purpose of manhole surveys is to gather missing information that is required for the building of the model. However, when visiting the site of a manhole, it is economical to collect (or confirm) as much information as possible about the manhole including condition information, location sketch (if difficult to find), and digital photograph showing its location.

A manhole survey will normally focus on a catchment and could involve a few manholes to hundreds of manholes depending on the extent of the catchment, the quality of records held by the authority and the desired outcome of the study. Generally the more manholes that have to be visited, the more effort there is to setting up the project. Typically the scope of works will involve:

3.2.1 Project Set-up

- Preparation of plans (with aerial back drop if possible) showing manholes to be visited, network layout and also layout of any other networks with manholes (e.g. stormwater).
- Advance notification of property owners. The objective here is to keep owners / tenants informed of the survey (and of unknown workers wandering around in their backyards) and to identify any access problems such as locked gates or guard dogs.
- Preparation of spreadsheet with relevant known manhole details (manhole number, street address, lid level, inverts level, etc) and with columns for unknown data.
- Preparation of manhole inspection sheets.
- Development of protocols for dealing with different scenarios such as:
  - Manholes with “frozen” lids
  - Buried manholes
  - Manholes posing an immediate health and safety risk (e.g. missing lids; manhole about to collapse, etc)
  - Manholes with significant defects that require urgent attention (e.g. severe root intrusion; severe infiltration; structural problems)
  - Manholes with minor defects
  - Manholes that cannot be located
  - New manholes not shown on the drawings
  - Illegal connections

3.2.2 Implementation

This can be undertaken using in-house resources (especially if the operator owns a maintenance company) or by contract. Regardless of who carries out the work, it is necessary to have a "client-side" project manager who can deal with any owner/tenant complaints, co-ordinate actions arising out of the survey (e.g. fix manhole urgently) and make arrangements for manholes to be located if these are buried (e.g. by way of CCTV). Generally the implementation phase will include:

a) Manhole location
b) Manhole inspection (condition; collect data on connecting pipes (diameter, level, house serviced, etc))
c) Survey of lid levels, measurement of depth, XYZ (if applicable)
d) Digital photographs showing location of manhole; manhole interior
e) Documentation of results
f) Independent data review (audit) and accuracy check

3.2.3 Close-out

The survey will generate a lot of new data on the assets and the "client-side" project manager should ensure that this is captured on the appropriate database systems (e.g. AMS, GIS, etc) for future use and record. The project manager will need to make sure that all buried manholes are raised and that defects are recorded on maintenance register for immediate or future action. An audit of a small percentage of the data collected is recommended.

3.3 Pump Station Data

Pump stations are hydraulic control points in wastewater systems. Since pump stations usually include some form of storage, the effect can be a discontinuity in flow with either positive or negative downstream effects depending upon whether the pumps are operating during peak flow or low flow conditions.

It can also be difficult to integrate the pump station into the model such that the model outputs accurately reflect reality. The better and more comprehensive the information is about the pump station, the more accurately the model can mirror the operation and performance of the pump station.

Ideally, during the verification stage of the model (when its outputs are being compared with reality – i.e. known circumstances and performance) an indication of the performance of the pump station is essential. When possible draw-down testing should be carried out for all pumps singly and in combination. These can be supplemented by flow gauge and pressure gauge readings if such devices are available.

Wherever possible it is recommended that pump performance curves are used and the model adjusted to reflect any differences theoretical and actual performance. It is recommended that these differences are understood and reported. E.g. low pump flow, in reality, due to increased head losses or the pump being in poor condition.

Essential information that will be required by the modeller will include:

- Location plan
- Elevations and sections
- Pipe work configuration and fittings

- Operational parameters (e.g. pump stop/start; alarms; pump duty/standby switching; dealing with overflows)
- Catchment size
- Available information from telemetry or other records
- Number, type and configuration of pumps
- Pump and/or system performance curves / design characteristics
- Actual pump performance
- Elevations (especially stop/start; centre of impellor; discharge point; highest point in rising main – if higher than discharge point)
- Rising main material, age, diameter, length (and horizontal and vertical alignment if available)
- Constructed overflow weir details
- Maintenance details such as frequency of de-silting; pump clogging; recurrent problems of a specific nature.

3.4 Operational Data

Operational records are an important source of information since they enable the output from the model to be verified and can assist the modeller in determining where any discrepancies are. Operations staff play a key role in the dissemination of this information and should be involved throughout the model building and verification process.

Typically, operational records should provide the following information:

a) Manhole spills, frequency and cause
b) Blockages; and cause (e.g. fat build-up; root infestation; pipe collapse)
c) Spot repairs
d) Stormwater flooding (which can manifest itself in the form of illegal stormwater connections to the wastewater network)
e) Rainfall data from rain gauges
f) Flow data from long term flow monitors

The information above can be augmented by the hands-on experience of operational staff. Nobody will know the network better than those who work on it every day. Operational staff are often able to supply information on network issues or undocumented infrastructure and solve problems where the data in the model does not add up. E.g.:

- undocumented operational problems (e.g. pipeline in an unstable zone where movement is occurring),
- undocumented changes to the system (new pipelines; deviations; new manholes; changed pumps; changed operational procedures that impact on flows),
- problem areas from a maintenance perspective (frequent manhole spills or blockages / flat gradients, silt / fat deposits),
- regular preventative maintenance activities (e.g. flushing of pipelines),
- confirmation of trade waste flows (location and magnitude),
- location of undocumented controlled overflow points,
- known capacity constraints.

3.5 Growth (Population) Data

Growth data is essential for modelling future demands and developing master plans that will underpin the Long Term Planning of a local authority or other water network owner. Population data is generally available from the local authority or Statistics NZ. This data will indicate trends that can be used in projecting future populations. However, local authority planners should be able to provide more accurate/targeted projections based on known planning constraints. Most authorities have projections, preferably, at mesh block level for the next 30 years for use in their 30 year strategy, and may have projections at a higher level (census area unit) for the next 50 years.

Growth data will typically be split between infill/densification and greenfield developments. Each of these may be handled in the model differently depending on the required outcomes of the model.

Since the magnitude and location of growth will have an enormous impact on the configuration and required capacity of the wastewater system - as well as the availability of funds to pay for upgrades. Therefore it is important that the local authority retains responsibility for developing the growth data used in the model as it will need to supply or agree to the many assumptions required.

3.5.1 Infill/Densification – The Existing Urban Environment

Infill or densification of the existing developed area will put additional pressure on the current infrastructure. Modelling a growth scenario can determine if there will be any additional capacity constraints or breaches of the adopted level of service in the future.

3.5.2 Greenfield - New Urban Environments

Greenfield sites that are planned for within and adjacent to existing catchments may be developed in the future is useful information for modelling projects. Where large-scale development is expected within the next 20 years then an estimate has to be made of:

a) location and sequencing (timing) of such development
b) expected housing density and associated population
c) expected commercial/industrial growth and consumption

Again, this information may be in the hands of the authorities' planners but, failing this, assumptions will have to be made, but will need to be clearly stated.

3.6 CCTV Surveys

CCTV data is a 'nice to have' data set and is not normally essential for the majority of modelling projects. A CCTV survey is normally required understand discrepancies between the modelled results and historical/measured records potentially caused by the following:

a) connectivity issues
b) live/dead status of pipelines
c) pipeline material/diameter
d) silt build up
e) the presence of hydraulic chokes (root intrusions; protruding laterals; debris; fatty deposits; etc)
f) stormwater cross-connections

Like the manhole surveys, a CCTV survey will generally require entry to private property and could cause concern to owners/tenants of properties. It is prudent to give such people advance notice and to establish potential entry constraints such as locked gates and dogs.

These surveys are best undertaken by companies specialising in CCTV inspections, and be conducted in general accordance with the NZ Pipeline Inspection Manual. It should be noted that this manual does require an element of forethought by the specifying authority, especially in respect of the delivery formats of the data to be collected.

Also, since access to a section of pipeline to be surveyed is normally via a manhole, it is also prudent to allow for a manhole condition inspection at the time a manhole is opened. Other data such as connections, depth could also be collected at the same time.

Client-side project management is required to respond to on-site problems (e.g. clearing of blockages), deal with owner/tenant complaints, audit of videos and project close-out (capture of information on database systems; dissemination of information to the modeller, etc).

3.6.1 Water Consumption Data

This data set is a 'nice to have' and is not essential for most modelling projects. Water consumption data should also be used cautiously as water demand, and the portion used for irrigation varies considerably for location to location.

Some authorities aim to reduce the average water consumption by introducing demand management strategies. This will have a corresponding impact on wastewater flow and will need to be considered. Water demand in New Zealand urban areas typically ranges between 150 and 200 litres per person per day, and corresponding wastewater flows are typically 200 to 300 litres per person per day depending on the levels of infiltration (ground water ingress) observed by the wastewater network.

4 Time Varying Data Acquisition

Time varying data such as flow and rainfall surveys are a complex and difficult component of the modelling project to manage. There is often a large number of staff involved for this work, across multiple companies which further adds to the complexity. As a significant portion of this work is performed underground, detailed pre-planning, support systems such as health and safety practices, and effective communications between all parties are crucial in ensuring these surveys are completed, well and without incident.

4.1 Flow and Rainfall Surveys

Even with separated wastewater and stormwater systems, wet weather can have a dramatic impact on the flow in the wastewater system. This is because of inflow and infiltration sources, which enable stormwater to gain access into the wastewater systems, substantially increasing flows and often resulting in the overloading of the system, and spills at manholes.

Inflow is generally via direct stormwater connections to the wastewater system (generally illegal and undocumented) such as Stormwater down pipe connections, low lying or defective private gulley-traps, cracked or defective manholes in low lying positions susceptible to flooding. The impact of inflow is generally fast (often referred to as fast-response) and also ceases relatively quickly following the cessation of a storm (depending of course on whether the inflow source is located in a flooded area, in which case the inflow will continue until the supply is exhausted).

Infiltration is generally related to the condition of the wastewater system, the nature of the soil and the antecedent moisture content of the soil. It is essentially the infiltration of groundwater into the system via cracks and other sub-surface defects. The impact of infiltration can take some time to mobilise (often referred to as *slow response*) and can continue for some time (often days) after a rainfall event.

The aim of flow and rainfall surveys is to establish the relationship between flows in the wastewater system and rainfall events. Such surveys will also provide information on base flows (flow in system during periods of low or "zero" demand) and diurnal flow characteristics during dry and wet weather. Long-term (often permanently) flow survey programmes will also provide information on seasonal variances in flow patterns and on growth trends in the flow.

4.2 Implementation

A flow and rainfall survey is generally an expensive undertaking since it requires a high degree of technical skill and input as well as regular (at least weekly for short term surveys) maintenance of the gauges. As a result, flow and rainfall surveys for the purpose of modelling are commonly, but not always short term (6-12 weeks) occurring preferably during the wet season when the probability and frequency of encountering significant rainfall events is at its highest. In some cases long term flow gauging is carried out to understand the variations in flow which occur over a long period of time, this will greatly enhance the quality of the model produced and the decision to commit to a long term flow gauging survey must be balanced against the cost of procuring one.

There are a number of stages in the implementation of a flow and rainfall survey and these are discussed below:

4.2.1 Gauging Network Design

The aim of this is to develop a robust layout for rain and flow gauges and involves:

a) desk top study to establish any existing gauges (generally rain gauges, pump station flow records) and availability/suitability of associated data;
b) assess system layout and topography to determine best spread of rain gauges;
c) assess known problem areas in the system and select suitable sites to cover these;
d) assess the preferred location of gauges in the wastewater system and eliminate those with poor hydraulic criteria (e.g. potential turbulence, susceptibility to surcharging etc);
e) assess possible alternative sites for each selected site (two or more if possible);
f) establish what sites are located in assets belonging to other authorities (e.g. a bulk collection authority) and whether these have any objection to the use of their assets as a gauging site (note – in such cases it is also necessary to establish any operational issues such as flushing programmes that need to be taken account of during the survey period).

Some broad guidelines for the selection of flow gauging sites include:

g) Monitor any branches that are entering from outside the catchment being monitored
h) Maximise the number of “leaf” gauge catchments (conversely minimise the number of “subtract” gauge catchments). A “leaf" catchment is a standalone catchment with no upstream inflows from adjoining gauge catchments. This is to reduce subtraction errors of one gauge flow to another.
i) Length of public wastewater pipelines in each gauge catchment – approximately three kilometres.
j) Dry weather flow depth for “HVQ” gauge ≥ 40 mm. Otherwise use a v-notch weir gauge as an alternative as these gauges provide better resolution of flow for slower and shallower flow depths.
k) Dry weather flow rate for “HVQ” gauge ≥ 0.3m/s.
l) Gradient of pipeline in which gauge installed ≤ 2%.
m) There should be no sudden hydraulic transitions at gauge sites (e.g. service lateral adjacent to gauge; major conveyance of pipelines at gauge manhole; drop connections into manhole; abrupt change in direction or gradient at manhole; imperfections in pipeline or manhole channelling).
n) Monitor locations of known existing problems
o) Controlled overflow points at manholes should be monitored.
p) The size of the selected gauging network should be appropriate to the level of modelling detail required and the desired outcome from the investigation.

Public Communications

Many of the flow and rain gauge sites will be located on private property. The survey process will involve multiple visits of varied duration and timing to each site and there is potential to disturb or annoy owners/tenants. However, during the gauge network design stage, a single visit to the site is generally sufficient. Consequently, it should only be necessary to advise owners/tenants of the proposed inspection (giving some background information and purpose of the flow and rainfall survey) and obtain any constraints to access such as locked gates and dogs. This should be undertaken at least a week in advance of any proposed inspections to give owners/tenants time to respond. The client-side project manager is generally the best contract person for this and should document any owner concerns or access constraints and manage the issues.

Field Check of Proposed Gauge Sites

It is best to confirm the suitability of the selected gauge sites well in advance of letting a flow and rainfall survey. This will allow time for adjustments to the gauging network (and these can occasionally be substantial adjustments) and minimise the risk of delays or associated claims from the flow-gauging contractor. It also enables the scope of the flow and rainfall survey contract to be clearly defined.

Flow gauging contractors will happily assist with the inspection of flow gauging sites (at a cost of course).

The aim of the field check is to confirm the suitability of each of the selected gauge sites. The desk study may have identified two or three possible locations for each site and each of these should be inspected and rated against each other. Where none of these is suitable, then the modeller may need to reconsider his layout and develop alternative proposals.

Photos and sketches should be made of each site inspected.

Gauge Network Report

Following the field check of sites, a gauge network report should be compiled giving the following information:

a) Overall location plan (flow gauge sites).
b) Overall location plan (rain gauge sites).
c) Table of flow gauge details (site identification number, site manhole number, physical address of site, length of upstream pipeline (site specific and accumulative), population served (site specific and accumulative), expected dry weather flows and associated depth of flow; preferred type of gauge (HVQ/weir); pipeline diameter; "subtract" or "leaf" gauge).
d) Table of rain gauge details (site identification number; physical address of site; whether existing or not).
e) Description of each gauge site (accessibility, flow regime at time of inspection, comments on suitability etc). This would include a completed sketch giving various details on the site such as manhole configuration, proposed location of gauge within manhole; direction of flow.
f) Any assumptions made.
g) Reasons for selection of the sites.

4.2.2 Flow and Rainfall Survey

The duration of the survey should be selected on the basis of when it will take place, the use to which the information will be put (modelling; infiltration/inflow studies or other) and the likelihood that the required number of significant rainfall events will take place during the survey. Consideration of timing in regards to population should also be undertaken for schemes with seasonal population fluctuations.

Because frequent access to the gauge site will be required during the survey period, it is usually prudent to serve notice to the owners/tenants of properties where sites are located. This should be undertaken prior to seeking tenders for the flow and rainfall survey.

Flow and rainfall gauging is extremely specialised work requiring very experienced and skilled technical staff. The information collected underpins the recommendations or outcome of any modelling study, which could subsequently result in the capital expenditure decisions. It is therefore imperative that the data collected is of the best quality possible. It is recommended that early involvement of an independent reviewer (auditor) is planned for with any flow survey. Data should be downloaded from the flow contactor on a weekly basis and checked as ‘fit for purpose’. The frequency of these checks can be reduced to fortnightly once there is a level of confidence in the data being collected and the gauging sites are producing good clarity of data profiles. The quality of the final edited data can be highly variable as a result and it is strongly advised that an experienced and independent auditor be appointed in advance of the award of any flow and rainfall survey contract in order to:

a) review the specifications
b) become familiar with the project
c) assist with the evaluation of tenders (especially in respect of technical issues and data formats)
d) supervise the flow and rainfall gauging contractor
e) review the regular reports by the contractor
f) audit the data collected by the contractor.

The role of the client, or the client-side project manager in the implementation of the flow and rainfall survey should not be under-estimated. It may include:

a) procurement of services (modeller, auditor, flow gauging contractor)
b) owner consent process and dealing with related problems
c) co-ordination of auditor and flow gauging contractor
d) ensuring that the reporting deadlines and requirements are met
e) arranging for cleaning of pipelines (prior to installation)
f) ensuring that auditor responses are timorously and appropriately met
g) taking decisions on the extension of the survey period
h) project closeout.

Successful implementation of any flow and rainfall project depends largely on good communication between Client/Auditor/Contractors especially during the early stages of the survey such as the installation phase and when early calibration measurements are taken. It is essential that the Contractor must comply with the requirements of the specifications and be able to demonstrate transparency in the development of his final edited data. This means that the auditor should be able to use all the information provided by the Contractor and generate the same result as the Contractor from the original raw data set.

The final data set should be provided in electronic format, together with a comprehensive final report.

5 Model Build, Test and Check

This section covers the development of the model data set, interpretation of asset data and the set-up of default modelling parameters that are often software specific.

5.1 Software Selection

The selection of software should be based on whether the model is fit for purpose, which in itself should be defined by the needs of the particular modelling study. It is recommended that in the case of Level 2 models that software containing a fully dynamic hydraulic solution be used. For Level 1 models less sophisticated hydraulic formulations such as a kinematic wave formulation can be used.

For level 2 models, a runoff model capable of representing long-term variations in Inflow and Infiltration is recommended. For level 1 model a simpler representation of the rainfall – runoff process could be appropriate. However, the chosen runoff model could be determined by the level of available data.

For all levels of model software capable of representing the following components of dry weather flows in a disaggregated manner is recommended.

- Base flow or Ground Water Infiltration
- Residential Flows
- Commercial / Industrial Flows.

In the design of new systems (rather than analysis of existing ones) a simplified runoff model or multiple of dry weather flow may be appropriate.

5.2 Model Build

5.2.1 Model Simplification and Un-Modelled Storage Volume

Models should be simplified to ensure that the model data set includes data essential in meeting the objectives of the modelling investigation being performed. Reference is made to the guidance provided in determining study asset data requirements in this regards. Where a large dataset is simplified to meet these guidelines care should be exercised to:

a) ensure that network low points are included in the simplified model data set
b) ensure that the hydraulic bottlenecks are explicitly included
c) ensure that network detail in 'problem' areas is maintained.

It is essential that if as a consequence of simplifying the model dataset the underground volume taken out be represented to ensure that the model does not fill prematurely. It is recommended that the unmodelled underground storage is included at manholes or nodes rather than in pipes / conduits. Adjustment of unmodelled additional underground should not be used as a calibration parameter.

5.2.2 Definition of Catchment Areas and Setting Initial Runoff Parameters

Having defined the level of coverage of the model, catchment boundaries are then defined. The extent of the catchment where the network drains to a specific node should be determined with reference to the full asset data. All catchments should fall in the range of specified maximum and minimum catchment area sizes. These specified maxima and minima would be determined by the required model detail.

When complete the catchments will be allocated to a loading node and population and trade discharges will be set up.

Initial catchment runoff parameters for each catchment will be set at this point.

5.2.3 Allowance for Presence of Silt

Where there is known to be encrusted silt this should be included in the model at the appropriate location. The recommended methods of modelling silt are:

a) some software allows the explicit inclusion of silt and the software calculates the new cross sectional pipe areas
b) user defined special shape including the silt
c) reduction of cross sectional area to reflect the carrying capacity of the silt-laden pipe.

5.2.4 Interpretation of Ancillary Data

It is likely that data concerning ancillaries (eg, pump stations, constructed overflows, penstocks, etc) will undergo some form of interpretation to ensure that the model truly represents the asset data. The method by which the data is interpreted is very software specific and use here should be made of the Software user manual and interpretation should be checked and reviewed by an experienced modeller.

Pipe Roughness – This will be based on the pipe material and its condition and where known appropriate pipe roughness values should be used.

Pipe / Manhole Head Losses – These will be based on hydraulic conditions in the manhole and be dictated and determined taking into account the geometry of the manhole including the change in angle of flow and change in pipe sizes and levels.

Wastewater Generation Rate – The per capita amount of wastewater discharged will be defined based on catchment conditions, geography, demographic/behaviour and other factors. If available, water consumption figures can be of use to determine or validate wastewater generation rates. Wastewater generation rates usually vary between 130 and 180 litres/person/day in New Zealand conditions. The use of figures outside this range should be justified.

Discharges from Manholes - The method of handling discharges from manholes should be set at this stage. It is possible that the status of some manholes (such as those which are sealed) will be changed at this stage.

Model Default Parameters - Model Default parameters will be set up at this stage.

5.2.5 Model Test and Check

When complete the model should be checked to ensure that it is functioning correctly. The model should be simulated with the full range of conditions that it is likely to be subjected to in its subsequent use. Checks should be performed to ensure that the model initialises correctly, that it is free from instabilities and that it conserves mass.

6 Model Calibration, Verification and Validation

This section covers the process that is undertaken to ensure that the model is capable of predicting the operation of the system being modelled.

6.1 Calibration and Verification

6.1.1 Short Term Flow Surveys

Calibration should be performed on dry weather conditions lasting typically between one day and one week. Whatever period is chosen should be as free of rainfall as possible order to distinguish between dry weather and wet weather effects.

The conditions experienced during a short term flow survey, typically lasting between 6 and 13 weeks do not always permit a two stage calibration / verification exercise due to the lack of suitable rainfall events in such a short period of time. It is recommended that calibration be carried out against at least three rainfall events of a reasonable size and length. Verification should be carried out with remaining events if available.

In cases where short-term surveys are used the runoff model at the onset of rainfall events must reflect the catchment antecedent (wetness) condition.

In all cases the calibration and verification comparison must be made against the results simulated by the hydraulic model. Comparison of the output from the runoff model only against the observed data can sometimes be misleading as throttling and attenuation of the system (simulated by the in the hydraulic model) is omitted from such comparisons.

Comparison of models predictions should be made against discharge (quantity), flow depth and flow velocity.

As an alternative to event based verification the whole period of the survey can be simulated and compared to validate the model.

6.1.2 Long Term Flow Surveys

The process to be used for data from long term surveys can be similar to that used for short term surveys, with the only difference being the amount of information available to use. A long term survey is likely to allow analysis of seasonal changes on the network.

Often long term gauging sites are fewer in number than temporary gauging sites and have often been used to supplement a short-term survey and to provide long-term validation.

6.1.3 General

The quality of calibration / verification can be expressed in terms of statistical variation of predicted flows from observed flows. It should be noted that this should only be carried out when data being compared with is suitably accurate.

Parameters altered during calibration should not be changed beyond reasonable bounds (often expressed as runoff model or per capita wastewater production parameter ranges) without adequate justification. Additional sources of justification can be obtained during site visits and usually relate to conditions existing which are different to those initially assumed in the model data set.

Parameters should not be changed outside these ranges solely to match flow data. This may mean that the statistical variation of the predictions from the observed data may go outside 'acceptable tolerances'. Where this occurs there should be an explanation of the reasons for this in the supporting documentation together with a description of the implications to the modelling study and a remedial action plan to find out the cause of the mismatch.

6.2 Validation

For the purposes of these wastewater network modelling guidelines, Validation is defined as the process of assessing model reliability by reviewing model predictions from data outside the calibration period i.e. a different dataset often operational records SCADA / reported data. While Verification is defined as the process of confirming the calibration performance by reviewing model predictions within the calibration data record period but outside events that have been calibrated against.

6.2.1 Level of Validation

There are various levels of validation that can and should take place. The level, which is undertaken, is dependent on the complexity of the model and its intended purpose. In all cases there should be a check with the operators of the system that the model's predictions are in line with expectations.

6.2.3 Ground Truth Check

This is the simplest check of the validity of a model and would typically seek to confirm that the models predictions of flows and overflows under wet weather are in line with historical records of the same. In some cases operators do not keep formal records of flows or overflows and in these cases the validation would be limited to the comparison of model results with anecdotal information from operators. This check is usually carried out as the final task in a model validation exercise. When calibration and / or verification have been performed this exercise is carried out afterwards. Should the ground truth test reveal anomalies the model dataset should be changed in line with better information or with the appropriate justification. The model dataset should not be changed without either of these things.

7 Model Application

This section describes the how the model can be applied to forecast current system configuration performance under a range of conditions (existing model) and to also forecast current system configuration performance under a range of conditions including increased dry weather loadings due to growth and changed wet weather loadings due to a deterioration in inflow and infiltration flows or the effect of sewer separation. (Future model).

7.1 Preparation of Existing Model

Appropriate changes should be made to the model that has just been calibrated. These changes are likely to be very small but if there is significant time between model validation and model application, the network may have changed which would require a change in the data set. Examples of changes are provided below:

a) cleaning away silt build up within pipelines
b) increased dry weather flows due to population growth
c) new infrastructure constructed or operational change since the time of calibration
d) sewer separation works completed upstream
e) significant deterioration or improvement in inflow and infiltration

7.2 Preparation of Future Model

At the model application stage a prediction of the current system's performance is made but with future loading conditions. This requires a future-loading model.

Under some circumstances a number of future models are developed, each with an assumed future loading condition and are often associated with a future population growth scenario. This and other likely changes to the future model are described below.

Future assumed population – increasing the population applied to the model increases the residential component of the flows. This information will have been gathered from the sources discussed in [Static Data Acquisition – Growth Data]. It should be noted that great care would have to be exercised if dry weather flows have not been disaggregated in the model building process.

Future assumed per capita wastewater production rate – There may be a need to increase the per capita rate to match an assumption that water usage will increase or there may be a need to decrease the per capita rate to match an assumption that water usage will decrease as a consequence of water demand management activities.

Future assumed increase in Inflow and Infiltration - Often the future condition will need to reflect a condition in 10 or more years from the present day where inflow and infiltration will have increased.

7.3 Simulations to be Performed

The existing and/or future model will be simulated to –

Predict dry weather flows. A dry weather flow simulation will be performed to examine the flows under dry weather. This is either carried out with a full weekday or weekend diurnal flow pattern to determine for the condition the maxima and minima of flow. This is often done to determine over-pumping requirements or to examine whether a self-cleansing velocity is obtained. Sometimes the dry weather flows are changed to average dry weather flows.

Predict the peak flow rate and surcharge / spill condition for a variety of return periods. Design storms of differing durations but with the same return period are simulated with the model and the worst condition of each return period determined. These gives an indication of the pipe full and spill condition level of service provided by each pipe element. Standard design storms have been developed for the Auckland Region and are available in Auckland Regional Council and Auckland City Council documents.

Predict wet weather response using continuous simulation. Long time series of rainfall can be used to simulate a continuous simulation of the network. There are a number of long time series of rainfall that have been produced in New Zealand to suite local conditions varying in duration from one year to seventeen years. Care should be exercised when using the longer time series, as the continuous simulation is very computer intensive. In selecting the length of the time series a balance should struck between the required accuracy of the results and the expended computer time.

8 Solution Modelling

This section describes the how the model can be used to determine solutions for remediation of problems identified during the course of the modelling study. The outcomes required from this part of modelling activities are very utility specific and as such these guidelines are not prescriptive.

8.1 Define Objectives

Prior to commencing the solution modelling exercise the desired performance objective of the network represented by the model should be defined. These objectives can cover all types of performance or Levels of Service indicators that can include:

a) the frequency of discharge from constructed overflows
b) the frequency of discharge from manholes
c) flows exceeding pipe design flow rate
d) flows not achieving self cleansing velocity
e) the return period at which single pipe elements surcharge.

Surrogates for these indicators can include:

- target level of Inflow reduction
- target Level of Infiltration reduction.

The objectives should be clearly stated in the project solutions or solution options report.

8.2 Test Solutions

After initial screening likely solutions to system performance deficiencies will be tested. This is likely to include a comparison between the results from the model that represents one or more solutions and the model that represents the existing network.

9 Audit and Review Programme

It is recommended that staged reviews and audits be performed and that for critical path activities that audits are carried out and recommendations acted upon prior to commencement of the next activity. This can be achieved by internal / external peer or expert review and the process of review should be established during the modelling project pre - planning stage.

The following outlines some of the key points throughout the modelling project where audits or reviews could be undertaken.

9.1 Model Project Pre-Planning

A review can be carried out of the pre-planning stage of the modelling project to ensure that the purpose of the project and that all relevant information has been gathered to permit conducting the project. The review will assess any specifications written for the purpose of conducting the project and outline where there is a divergence from the Water New Zealand modelling guidelines. A summary statement of the expected outcomes and the deliverables from the project will conclude the audit report.

9.2 Model Project Static Data Acquisition

This check could assess the data captured during the static data acquisition stage and confirm that any action taken in resolving anomalies is appropriate within the context of the scope of the modelling project.

In order to perform this audit the information required will be:

a) the static data acquisition review reports
b) the scope of the modelling project (and associated specifications)
c) model Build report.

Specifically, this audit could look at data capture and anomaly resolution from:

a) manhole surveys
b) CCTV data capture
c) population and growth data
d) pump station surveys
e) operational records
f) planning and configuration of flow/rainfall gauging sites
g) model Building, stability tests and validation
h) software selection
i) model extents definition and network simplification
j) inclusion of additional volume (network storage)
k) inclusion of silt build up
l) catchment area definitions
m) pipe roughness and network head loss calculations
n) dry weather flow representation (composite or segregated)

9.3 Model Project Time Varying Data Acquisition

In the course of conducting the flow and rainfall survey, a series of audits may be performed to ensure that the survey is conducted to achieve the very best data possible under the circumstances. Auditors may be appointed to undertake field validation of flow and rainfall measurement as well as review of the rainfall and flow data. It is recommended as a minimum that the following reviews be performed:

Periodic reviews of interim data. The interim data will be reviewed immediately after receipt from the field. For short-term surveys of less than 13 weeks it is recommended that interim data be received weekly. The data will be checked for consistency and accuracy and recommendations will be made (if appropriate) for swapping instruments or the relocation of flow gauging locations.

Review final data. The final data will be reviewed on its receipt.

Brief reports of the interim and the final reviews will be produced and in such a form that they can be consolidated with other similar audit reports.

The report should conclude with a statement confirming the fitness for purpose of the flow and rainfall data and any remedial actions required.

9.3.1 Rainfall and Flow Data

The rainfall data used as input to the model for model calibration should be evaluated for suitability. Specific points to be considered are:

a) number, variability and severity of storms
b) rainfall depth and intensity
c) spatial variability

The model will be checked for correct application of rainfall profiles to represent different rain gauges during calibration.

9.3.2 Observations on Individual Flow Sites

A review will be carried out at each flow site and, in conjunction with the Model Validation report the assessment of suitability will be made. Reference here will be made to specify tolerances between predictions and observed data. The review will also include an assessment of whether appropriate justification for model dataset changes has been provided in these cases and whether, in the cases of models not achieving tolerances that an appropriate level of data checking is documented. Comments made in the model validation documentation on the implications of not achieving tolerances in the model validation document will be reviewed.

9.3.3 Review of Ground Truth Check

A review of the ground truth check will be made to confirm that the model actually reflects reality and use here will be made of the anecdotal or historical data provided in the Model Validation report and the model's predictions.

The model validation audit report should conclude with a statement confirming the fitness for purpose of the model for its intended purpose and any remedial actions required.

A clear statement of limitations of model use is required, justified by reference to points covered in the detailed sections of the Model Validation Audit report.

9.4 Reproduction of Model Results

The client should be provided with a full set of modelling files (and results files as appropriate) including documentation on how to run the models and reproduce results. Key information includes time steps, simulation run-on times and simulation parameters at the start of the model run. Note - modelling files (including flow survey and results files) can be large in size and span multiple CDs or DVD disks).

10 Project Management

Project management is a process of techniques that enables its practitioners to perform to their maximum potential within the constraints of limited resources – point and case for the requirement of this process is on a computer modelling project. There is an old saying “Show me a modelling project that finishes on time, on budget and delivers what the client wants and I’ll show you a flying pig”. Modelling projects are notoriously difficult to deliver due to the vast qualities of data, the high level of technical expertise and the numerous opportunities for something to go wrong, given these first two factors.

The following doesn’t aim to replace formal project management training; it is purely aimed at providing some tips in the management of wastewater modelling projects, which have been learnt from a number of managers of modelling projects.

1. Understand the project objectives and task / cost breakdown and stick to it.
2. Understand the limitation of the available data and software, and be realistic on their impact on (1) above.
3. You will not be able to deliver a perfect job, so focus on project outcomes. Be prepared that tasks may have to be changed or repeated to suit the available data / resources.
4. Keep the communications between the provider and the client open, frank and regular.
5. Programme peer reviews throughout the process and not at the end – make sure the peer reviewer’s scope of work is focused and adds value.
6. As the project manager, don’t get caught up in the detail of the modelling – recognise difference between what is interesting and what is important.
7. Expect variations and budget appropriately, project costs don’t generally creep, they jump. A contingency fund is a good idea.
8. Consistency of methodology for multiple, like projects.

11 List of References

Table 12.1 – Reference Documents and Material

Document Title	Author / Source
Code of Practice for the Hydraulic Modelling of Sewer Systems	WAPUG
River data collection guide Version W01	WAPUG
River Modelling Guide: Version W01	WAPUG
NZ Pipe Inspection Manual- Second Edition	Water New Zealand
NZ Infiltration and Inflow Control Manual	Water New Zealand
Design guideline manual – Stormwater Treatment Devices – TP10	Auckland Council
Guidelines for the estimation of flood flows in the Auckland Region – TP 19	Auckland Council
Network analysis - a code of practice (Water Supply and Distribution)	WRC
Guidelines for Stormwater Runoff Modelling in the Auckland Region – TP108	Auckland Council
HIRDS (High Intensity Rainfall Design System)	NIWA
Design and Construction of Urban Stormwater Management Systems - MOP FD-20	WEF / ASCE

water
NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa
A consistent approach across the 3 waters sector