Good Engineering Practice for Northern Water and Sewer Systems

Second Edition

Government of
Northwest Territories

Good Engineering Practice for Northern Water and Sewer Systems

Second Edition

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Government of
Northwest Territories

GOOD ENGINEERING PRACTICE for NORTHERN WATER and SEWER SYSTEMS

Second Edition

The material presented in the *Good Engineering Practice for Northern Water and Sewer Systems* guidebook has been prepared in accordance with generally recognized engineering principles and practices, and is to be used for general information only. It encompasses the state of the art as known to authors at the time the guidebook was prepared. However, the Department of Municipal and Community Affairs, Government of the Northwest Territories does not accept responsibility for errors and omissions in the guidebook. Users are responsible for ensuring that information extracted from this guidebook is suitable and correct for their particular application. The mention of the names of manufacturers, products, service companies, or consultants does not imply endorsement; however, it does indicate the Government's proven preferences.

Department of Municipal and Community Affairs
Government of the Northwest Territories

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TO THE READER

Water and sanitation services are a core function of any community government, and adapting these systems to a changing climate is crucial in the sensitive northern environment of the Northwest Territories. As part of our mandate to support the communities of the NWT, the Department of Municipal and Community Affairs is pleased to present this Second Edition of *Good Engineering Practice for Northern Water and Sewer Systems*.

It is the hope of the Department of Municipal and Community Affairs that this newly updated and expanded version of *Good Engineering Practice for Northern Water and Sewer Systems* will help guide the design of water and sanitation projects for the benefit of all of our communities.

I would like to thank the staff of the Department of Municipal and Community Affairs, Water & Sanitation Section for their hard work, and extend my appreciation to everyone who contributed their time to provide input on the draft of the Second Edition.

Caroline Cochrane

The Honourable Caroline Cochrane
Minister
Municipal and Community Affairs
Government of the Northwest Territories

TO THE READER (FOR FIRST EDITION)

The Northwest Territories' climate and environment present special challenges to designers and builders of water and sewer systems in the NWT. In recognition of these special challenges, the Department of Public Works and Services of the Government of the Northwest Territories has developed the *Good Engineering Practice for Northern Water and Sewer Systems* guidebook.

Therefore I am pleased to present this guidebook, which is intended to assist all stakeholders involved in designing, constructing and operating quality water and sewer systems in the NWT.

In developing the guidebook, Public Works and Services relied on the experiences and contributions of a wide variety of people and businesses. The Department and I thank those individuals – without their participation this guidebook could not have been produced.

The Honourable Floyd K. Roland
Minister
Public Works and Services
Government of the Northwest Territories

FOREWORD TO THE SECOND EDITION

When the First Edition of *Good Engineering Practice for Northern Water and Sewer Systems* was published in 2004, it filled a critical need for northern-specific guidance on water and sewer systems. The same northern challenges that led to the development of the First Edition still exist today, and NWT communities now face additional pressures from climate change and new, more stringent regulations. The Department of Municipal and Community Affairs has produced this updated and expanded Second Edition of the *Good Engineering Practice for Northern Water and Sewer Systems* in order to support communities in meeting the challenge of provide safe, clean drinking water and sanitary services for their residents.

Several sections have been newly created or expanded for the Second Edition.

- *Cold Regions Design Considerations* – The north is a challenging environment for infrastructure. This section has been added in order to highlight a few key northern considerations for designers new to the region.

- *Wastewater Treatment Technologies* – Following the publication of the *Canada-wide Strategy for the Management of Municipal Wastewater Effluent*, Northern-specific research is beginning to emerge on the topic of wastewater treatment. This section was created to begin compiling some of the new scientific recommendations along with ideas that have worked well in a northern context.

- *Intakes* and *Buildings* – Truckfill stations throughout the NWT are being replaced with water treatment plants that include filtration and other technologies. Therefore, the former section on truckfill stations has been greatly expanded and split into separate sections on Intakes and Buildings.

With the publication of the Second Edition, we are confident that *Good Engineering Practice for Northern Water and Sewer Systems* will continue to be a valuable tool in helping designers and communities to achieve their goals in delivering quality services to residents of the NWT.

Eleanor Young

Eleanor Young
Deputy Minister
Municipal and Community Affairs
Government of the Northwest Territories

FOREWORD TO THE FIRST EDITION

Building water and sewer systems in the North presents different challenges than building water and sewer systems in more temperate climates. The *Good Engineering Practice for Northern Water and Sewer Systems* guidebook is intended to help northern builders meet those challenges by providing a comprehensive set of guidelines for the design, construction and operation of water and sewer systems in the North.

Good Engineering Practice was developed through input from northern engineering firms, NWT communities, and Public Works and Services and client department staff, who worked together to achieve a consensus regarding practices for northern water and sewer systems that are appropriate, economic and realistic. Simple, straightforward examples are used to illustrate and validate the practices.

The guidelines are intended to supplement codes and regulations, particularly where the GNWT feels that:

- higher standards should be applied relative to those in the *National Building Code*, the *NWT Public Health Act*, the *NWT Public Water Supply Regulations*, the *NWT Public Sewage System Regulations*, or relative to the standards and guidelines recommended by the American Water Works Association, or those in the local municipality's bylaws;
- code requirements should be expanded upon;
- historical experience has shown that conditions in remote northern communities require an approach different than that typically used in southern water and sewer practice; or
- historically proven preferences for specific methods, systems or products should continue to be employed.

We are confident that all northern designers and builders will find *Good Engineering Practice for Northern Water and Sewer Systems* to be a valuable guidebook, and we encourage users to continue to contribute towards its improvement in the next edition.

D. Bruce Rattray, P. Eng.
Deputy Minister
Public Works and Services
Government of the Northwest Territories

ACKNOWLEDGEMENTS FOR SECOND EDITION

The original edition of the *Good Engineering Practice for Northern Water and Sewer Systems*, published in 2004, gathered together a wealth of accumulated knowledge from projects throughout the north and provided valuable guidance to northern engineers. Since that time, responsibility for water and sanitation has shifted to the Department of Municipal and Community Affairs (MACA), and many new lessons have been learned. This Second Edition of *Good Engineering Practice for Northern Water and Sewer Systems* has been completely updated to reflect regulatory changes and practical experience gained over the intervening 13 years, and expands on the work done in the original document. New sections reflect the replacement of small truckfill systems with full water treatment plants across the NWT, as well as the evolving science of northern wastewater treatment.

MACA would like to specially acknowledge Jaime D. Goddard, P.Eng., Senior Technical Officer, Water & Sanitation. As the lead writer and project lead for the Second Edition, Jaime tackled the difficult task of actually putting words on paper. She also spent many hours bringing the material from the First Edition up to date, researching new sections, and considering every comment from the reviewers. MACA would also like to acknowledge Justin Hazenberg, P.Eng., Engineering Team Lead Water & Sanitation. As the lead reviewer for the project, Justin provided detailed feedback on the technical content and helped to identify information that needed more clarification or explanation.

We would also like to extend our thanks to the many individuals who took the time to review the draft document and either provided written feedback or attended the review workshop: AlecSandra Macdonald (GLWB), Bob Boon (AECOM), Chucker Dewar (GNWT MACA), D. Farrell McGovern, David Hatto (GNWT INF), Erica Janes (MVLWB), Heather Scott (MVLWB), Iqbal Arshad (GNWT MACA), Jeanne Arsenault (GNWT ENR), Jeremy Roberts (formerly GNWT HSS), John Clark (GNWT INF), Justine Lywood (Sanikiluaq Development Corporation), Ken Johnson (Stantec), Mark Cronk (GNWT INF), Mark Peer (GNWT INF), Ron Kent, and Simon Doiron (GN). Their comments and questions helped us to produce a much stronger final product.

Grace Lau-a
Director
Community Operations Division
Department of Municipal and Community Affairs

ACKNOWLEDGEMENTS FOR FIRST EDITION

In preparing *Good Engineering Practice for Northern Water and Sewer Systems* (First Edition), the Department of Public Works and Services has drawn upon the assistance of numerous individuals from within the Department and from engineers and technical specialists in the private sector. Many of them contributed technical writing and comments to this guidebook. *Good Engineering Practice for Northern Water and Sewer Systems* became a reality because of their participation, and I hope this kind of shared learning experience and cooperative effort can continue during the production of the second edition.

Special acknowledgements are due to staff in the Department of Public Works and Services' Water and Sanitation Section: Kim Philip, Senior Engineer; Vincent Tam, Senior Engineer; Olivia Lee, Water and Sanitation Intern Engineer; and Loretta Ransom, Water Quality and Environmental Specialist.

Many thanks are expressed to Rob Given, Policy Officer, for project coordination and editorial assistance, and to John Dick for consolidating the sections of the guidebook and producing it in its current form. We also thank Richard Cracknell, Senior Mechanical Technical Officer and Laurie Holmes, Sr. Administrator. Thanks are also extended to Artur Zajdler, Facility Planner, for his assistance in designing the cover.

Finally, our appreciation is extended to Sukhi Cheema, Manager, Technical Support Services, who initiated and coordinated the overall production of this guidebook.

Joe Auge
Director
Asset Management Division
Department of Public Works and Services

SPECIAL ACKNOWLEDGEMENTS FOR FIRST EDITION

The publication of this first edition of the *Good Engineering Practice for Northern Water and Sewer Systems* guidebook was made possible only through the generous financial contribution provided by the Department of Municipal and Community Affairs of the Government of the Northwest Territories.

At this time, we would also like to express our sincere appreciation to two northern architectural and engineering consulting firms – Earth Tech Canada Inc. and FSC Architects & Engineers – which provided significant technical contributions towards the guidelines and information appearing in *Good Engineering Practice*.

This 'co-sponsorship' and 'co-ownership' provided by our public sector partner – the Department of Municipal and Community Affairs – and our private sector contributors – Earth Tech Canada Inc. and FSC Architects & Engineers – is an excellent example of northern partners working synergistically together to achieve a goal that would have, if it were attempted individually, been unattainable.

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PREAMBLE

Introduction

The *Good Engineering Practice for Northern Water and Sewer Systems* (*GEP*) guidebook contains performance guidelines, preferred materials and methods, and logistical considerations for the design and construction of northern water and sewer systems. Over time, certain products and approaches to constructing water and sewer systems have proven successful and have been adopted by design consultants and builders working in the NWT. It is hoped that your comments and opinions will lead to further revisions and additions that will keep the guidebook current and relevant.

Criteria for Good Engineering Practice

These technical guidelines are not intended to supplant mandatory codes or regulations, but to supplement those contained in the *Cold Climate Utilities Monograph*, *National Building Code of Canada*, the *NWT Public Health Act*, the *NWT Water Supply System Regulations*, the *NWT Public Sewerage System Regulations*, the standards and guidelines recommended by the American Water Works Association, and those in the local municipality's bylaws. The guidelines are recommended where the GNWT believes that:

- more stringent requirements should be applied relative to those of the *National Building Code*, local municipality, etc.;
- there is a need to augment or clarify code requirements;
- its experience has demonstrated that conditions peculiar to remote northern communities require an approach different from typical Canadian building industry practice; or
- specific products, systems or methods have been developed and have been found to be superior for northern conditions.

Application of Guidelines

Good Engineering Practice has been prepared as suggested guidelines for obtaining good value and quality water and sewer systems. The *GEP* is applicable to renovations to existing systems or new systems.

Development of Good Engineering Practice

These guidelines evolved from studying the typical water and sewer systems found in most communities in the NWT. The new guidebook incorporates guidelines from the *Cold Climate Utilities Monograph*, plus collected observations from designers, builders, and system operators and users. Further information was gathered by staff of the Water and Sanitation Section, in consultation with other stakeholders in the utilities industry.

Revisions

Periodic reviews will be undertaken to reconfirm, revise or update the content of *Good Engineering Practice*. Your comments and suggestions are invited. Proposed changes or additions should be submitted to:

Engineering Team Lead Water & Sanitation,
Community Operations Division,
Department of Municipal and Community Affairs, GNWT,
#500, 5201 – 50th Avenue, Yellowknife, NT, X1A 3S9
Phone: (867) 767-9164
Fax: (867) 873-0584   E-mail: GEP@gov.nt.ca (attach additional pages if necessary)

Referenced section # and section name:

___

A brief description of your proposed change or addition:

___

___

___

Rationale (relate experiences that have led you to make this recommendation):

___

___

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___

___

___

___

Your name: ___ Occupation / position: ___

Organization / firm / department: ___

Mailing address: ___

Phone (work): ___ Fax (work): ___

Date: ___ E-mail: ___

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COLD REGIONS DESIGN CONSIDERATIONS

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1.0 COLD REGIONS DESIGN CONSIDERATIONS

1.1 INTRODUCTION

Northern conditions often require a different approach to design than what is commonly used in Southern Canada. This section introduces some Northern-specific challenges and conditions. It is intended to highlight some of the differences between Northern and Southern areas, but is not comprehensive and is not a substitute for experience, research, and site-specific investigations. There are a number of textbooks available on frozen ground engineering and permafrost. Designers should ensure that they are familiar with the issues pertinent to their discipline or area of expertise.

1.2 FROZEN GROUND, PERMAFROST, AND CLIMATE

The Northern climate presents a number of unique challenges in infrastructure design.

1.2.1 Definitions

Permafrost	*Ground that stays below zero degrees Celsius for two winters and the intervening summer. Depending on the conditions, the ground may be entirely frozen, partially frozen, or completely unfrozen and still meet the definition of permafrost. The term 'permafrost' does not give any indication of the soil type or engineering properties of the ground.*
Active Layer	*The top layer of ground that freezes and thaws seasonally. It is sometimes referred to as seasonally frozen ground.*
Talik	*A layer or region within a permafrost zone where the temperature reaches above zero degrees Celsius. It may extend through the permafrost, or be encapsulated by permafrost.*

1.2.2 Timing of Investigations

The temperature of the ground surface fluctuates with changes in air temperature. These temperature changes take time to propagate down through the ground, leading to a lag between the timing of air temperature changes and ground temperature changes at depth. Because of this, the deepest thaw is seen not in the summer, but generally around September or October, even though the top of the ground may be starting to freeze again. It is a mistake to drill boreholes in the spring and assume that any frozen ground encountered is permafrost; there may be several meters of thaw yet to come.

Recommendation	*Rationale*
If depth to permafrost is needed for design, recommend scheduling drilling for the time of deepest thaw, if practical.	*Drilling at other times can lead to inaccurate conclusions about the depth and extent of permafrost. However, site access may be restricted during the thawed season, depending on the location and surface conditions.*

1.2.3 Ground Temperature Profile

Figure 1.1 is a typical “trumpet curve” for a region of continuous permafrost illustrating how temperature extremes reduce with depth below ground surface.

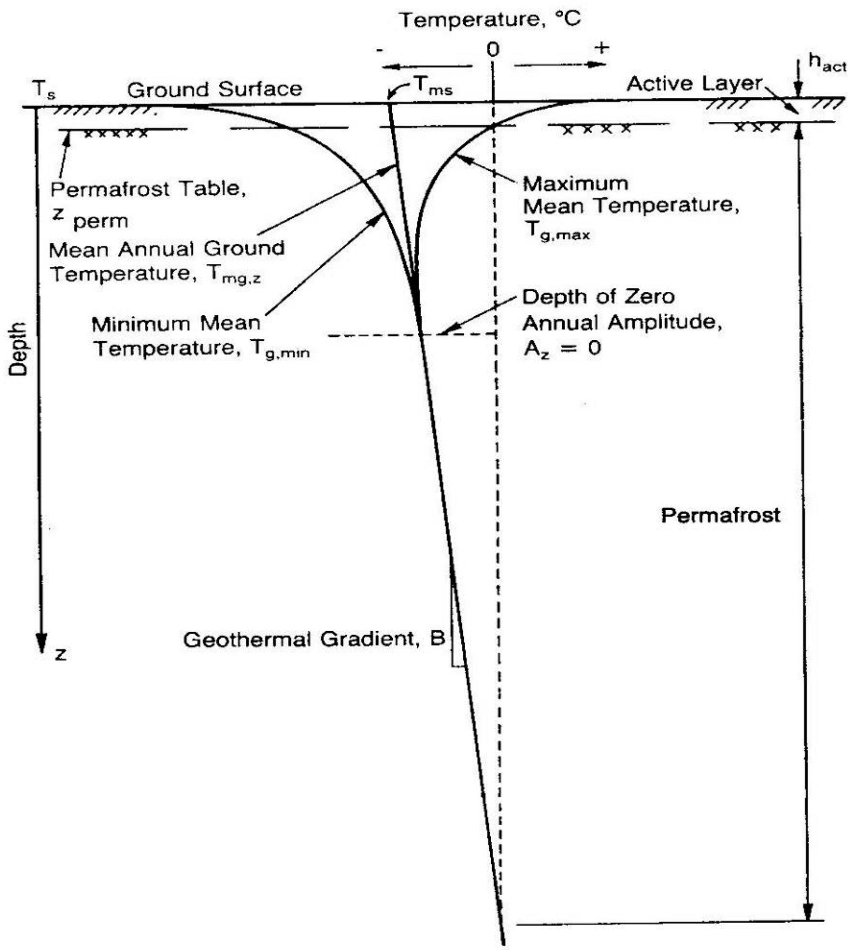

Figure 1.1 – Schematic Ground Temperature “Trumpet Curve”

1.2.4 Frozen Ground Ice Features

Frozen ground can contain regions of nearly pure ice ranging from ice coatings on individual soil grains, to thin layers or ice lenses to massive ice several meters thick. Ice lenses are formed as the ground freezes and water is drawn to the freezing front via capillary action. Ice lens growth is controlled by both the soil type and the availability of water. Massive ice can be formed in place or can be the buried remnants of glacial ice. Pingos are a form of massive ice that grows in place and creates a hill with a core of ice. Ice wedges are vertical wedges of ice formed by ice growth in a crack, and can extend for several meters. Frost heave caused by the seasonal growth of ice lenses, in combination with the frozen bond between the ground and any structures anchored in it, can push piles, pipe supports, and posts right out of the ground over time.

Figure 1.2 – Sewage Truck Discharge with Pingos in the Distance

1.2.5 Salinity

Salinity has a significant effect on the freezing of the ground. With a sufficiently high salt concentration, the freezing point of water can theoretically be depressed down to -21.1°C. At typical salinities found in the polar regions, seawater has a freezing point of approximately -2°C. As the water freezes, salt is rejected from the frozen portion and forms concentrated pockets of unfrozen brine trapped within the frozen ground. These pockets of brine lead to considerable variability in the strength of the ground, as it may be only partially frozen even though it meets the definition of permafrost based on temperature.

1.2.6 Thaw Stability

The thaw-stability of an area of frozen ground depends on the materials it is composed of. Well-drained gravel may not be affected by thawing, while ice-rich silt can undergo significant settlement on thawing and can turn into a slurry and lose strength completely if the amount of water generated by melting exceeds the capacity of the soil to absorb it. Large subsidences can result from the thawing of massive ice features or from the consolidation of ice-rich soil as the ice melts, reducing the volume, and the water drains away, allowing the soil skeleton to settle into a new equilibrium.

Changes to the natural state of a site during construction including removal of vegetation or the insulating organic layer of ground, excavations, and running or standing water can all initiate thaw deep into the permafrost. Storage reservoirs or lagoons create a body of standing water that can cause a large thaw bulb below and around their footprint.

Buildings are often raised off the ground to provide a ventilated space between the floor and the ground in order to avoid thaw. Other options for building foundations include thermosyphons or thermopiles. For infrastructure such as piping, tanks, and reservoirs, it is usually not practical to include measures to keep the ground frozen. In these cases, it may be necessary to remove thaw-sensitive materials and replace them with engineered fill.

1.2.7 Buried Piping Considerations

In Southern areas, buried pipes are generally placed below the depth of seasonal frost to protect them from freezing. In the North, this approach is usually either impossible due to the year-round presence of frozen ground below the seasonal frost zone, or impractical due to the depth of seasonal frost. Instead, insulated piping is placed either above ground or underground and the water is heated and kept continuously circulating. More detailed discussion of underground piping is provided in Sections 3, 4, 8, and 11.

1.2.8 Climate Change

Impacts from climate change in the NWT include changes in ice conditions, changes to precipitation patterns, permafrost degradation, and changes to flora, fauna and fire risk due to warming temperatures. Related research and publications by the GNWT can be found on the Department of Environment and Natural Resources (ENR) website under their Climate Change program.

The Engineers Canada Public Infrastructure Engineering Vulnerability Committee (PIEVC) has developed the PIEVC Engineering Protocol, which can be used to assess the vulnerability of infrastructure to climate change. This information can help guide engineering decisions on design, operation, or maintenance changes for climate change adaptation. The Protocol is available from Engineers Canada at no charge.

The Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists (NAPEG) has adopted Engineers Canada's document *Model Guideline for Engineers Canada Constituent Associations – Principles of Climate Change Adaptation for Professional Engineers* as a guideline. This document is available on NAPEG's website.

1.3 REMOTE LOCATION LOGISTICS

In addition to the technical challenges associated with cold weather and frozen ground, the remote location of many northern communities brings additional factors into play when planning and executing projects in this region. Access to many Northern communities is by air and either winter road or annual barge. In the NWT, approximately half of the communities have all-season roads. Some of these roads include ferry or ice crossings that are impassable while the ice is forming or melting. Construction materials and heavy equipment for most communities need to be brought in by winter road or barge, as airlifting is prohibitively expensive.

Historical opening and closing dates for winter roads and ferry crossings, along with current road status information, is available from the GNWT Department of Infrastructure website.

The construction season is short in Northern communities. Weather or high demand for a small amount of available equipment can impact schedules. Planning for projects in communities without year-round road access may need to begin one to two years ahead of the intended construction start date.

Figure 1.3 – Ferry Crossing

Recommendation	*Rationale*
Plan construction activities around barge and/or winter road schedules.	*Flying in materials is very expensive. Allow enough time when tendering projects to order materials for delivery to the barge before the cutoff date or for shipping on the winter road. If these shipping windows are missed, the project will normally be delayed by a full year.*
Plan for construction to be completed in time to remove heavy equipment on the barge or winter road at the end of the project.	*If equipment misses the window to be shipped out, it will be stuck for an additional year and incur additional charges.*
Check flight schedules at the planning stage, and ensure accommodations are available before booking flights.	*Many communities only have a few flights each week and limited accommodations, which may govern scheduling of inspections or the ability to fly in expert help.*

1.4 APPROPRIATE TECHNOLOGIES

Technologies selected for remote areas should ideally be suited to extreme temperatures and be simple to operate and maintain.

Recommendation	*Rationale*
Minimize the need for expert help and specialty trades during operation and maintenance.	*This type of expertise is generally not available in remote communities and it can take several days to have an expert flown in, at great expense.*
Plan for freeze-recovery for outdoor infrastructure.	*Outdoor infrastructure is likely to be frozen at least once during its operating lifetime. Where possible, choose materials that can be thawed and put back into service after freezing, such as HDPE rather than PVC for pipelines.*
Select the simplest process that will provide suitable drinking water.	*There is high turnover of operators in many communities. Experience and educational backgrounds vary. Select treatment technology based on ease of operation to minimize difficulties for new operators.*
Touchscreen Human-Machine Interfaces (HMIs) are recommended where Programmable Logic Controllers (PLCs) are used for plant control.	*Provides an easy-to-use visual interface that is familiar to anyone who uses a smartphone.*
Consider providing an internet connection to allow for remote monitoring. Protect connections with up-to-date security systems.	*Remote monitoring and logging of instrument readings helps with troubleshooting.*

Consider internet service via the cellular network where available.	*At the present time, cellular network internet connections are often more reliable than dialup landline connections in NWT communities.*
Consider various means of providing phone service.	*Some means of voice communication should be provided, particularly for remote plants. This need not be a landline phone. Note that cell reception tends to be poor inside plants, but a signal booster may be suitable in place of a landline.*

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2.0 GENERAL UTILITY OBJECTIVES

The primary objective of *Good Engineering Practice for Northern Water and Sewer Systems* (GEP) is to provide a technical reference guidebook to help builders produce the best value in their respective utilities for the North. Utilities should be designed specifically for the northern climate and other physical parameters of the site, as well as to minimize the overall capital costs plus the life cycle operating and maintenance costs. The objective is to encourage improvement over time, based on proven methods and materials, while supporting improved utility performance and new technology.

2.1 GENERAL GOALS AND PRINCIPLES

The goals and principles governing utilities design in the North include:

- Protecting public health and safety;
- Protecting the environment;
- Effectiveness and efficiency;
- Community acceptance;
- Compliance with all relevant legislation and regulations; and
- Following accepted good engineering practices.

2.2 USE OF LOCAL RESOURCES

2.2.1 General

Promoting and actively assisting communities to take on greater responsibility for their economic and social well-being is an important objective of the GNWT. Construction projects provide important opportunities for communities to become involved in their own development.

2.2.2 Local Knowledge

Residents of a community can provide valuable information related to site conditions such as snowdrifting patterns, preferred orientations, anticipated use patterns and examples of successful materials or methods.

2.2.3 Local Labour

To maximize local involvement, materials and methods used in utilities construction should be suitable for broad application that will enable training applicable to future projects. To work towards achieving maximum local involvement, avoid the use of specialized products or installations.

2.2.4 Local Equipment

The use of local equipment benefits the community and can reduce construction costs, as bringing equipment into most remote communities is extremely expensive. Utility design and construction methods should be suitable for available equipment.

2.2.5 Local Suppliers

Specifications should not restrict local or northern suppliers. Locally available products should be incorporated where possible in new utilities.

2.2.6 Operation and Maintenance

Installations should be completed by a certified tradesperson and annual inspections should be carried out by either a certified tradesperson or a Licenced Professional Engineer registered to practice in the jurisdiction where the work is taking place.

Given the limited number of experienced tradespeople in the NWT, there is both a need and an opportunity to train and develop utility maintainers in every community. Operator training should be a component of any new system construction or major upgrades.

Operation and maintenance procedures should be written in plain language so that they are easily understood and carried out. Readily available maintenance products and equipment should be specified.

2.3 LIFE CYCLE COSTS

Wherever alternative designs are considered, the alternative with the lowest life cycle cost should be selected. Wherever alternatives are shown to have the same life cycle costs, the alternative with the lowest capital cost should be selected. The life cycle costing should be based on the expected design life of the utility and its systems. In some circumstances, other considerations may overrule: for example, where direct benefits to the community will be realized (e.g., incorporating locally available materials), or where a product preference is stated in these guidelines.

2.4 ENERGY MANAGEMENT

Minimizing the energy consumption of public utilities is important in the NWT where energy costs are extremely high; electricity is usually diesel generated, and fuel must be transported annually to remote locations.

See Section 2.6.7 *The National Energy Code* for comments on the *National Energy Code*.

2.4.1 Heating and Ventilation

Recommendations for energy efficiency have been integrated in the applicable sections of the *Good Building Practice for Northern Facilities* guidebook. Water Treatment Plants in particular are generally not occupied for the full day, and building heat may be primarily intended for equipment freeze protection. Particular consideration should be paid to ventilation requirements for chemical mixing and storage areas. For more information, consult the SDS (Safety Data Sheet) for the chemical of concern.

2.4.2 Lighting

Recommendations for energy efficiency have been integrated in the applicable sections of the *Good Building Practice for Northern Facilities* guidebook.

2.4.3 Water Systems

NWT water systems incorporate freeze protection and thus consume substantial fuel and electrical energy to heat, distribute and circulate the water. System designs must carefully consider energy requirements related to system needs.

2.5 APPROPRIATE TECHNOLOGY

To achieve the previously described goals, several basic principles have evolved. These principles can help guide utility choices, to ensure they are appropriate for conditions in the NWT.

2.5.1 Simplicity and Efficiency

Utility design should:

- be kept simple to improve the speed of installation and to offer greater opportunity for employment of local skills;
- incorporate materials and methods that will permit quality construction under adverse environmental conditions and a limited construction season; and
- limit the variety of materials to minimize the number of specialized trades required on the project.

2.5.2 Reliability

Essential utility systems and system components like water heating and fire protection must be reliable, and remain accessible, in the harsh winter conditions of the NWT. Installations that facilitate quick repairs are an essential characteristic of utility systems. Standby equipment must be provided for all essential system components to ensure uninterrupted operation. Spare parts should be provided for commonly expendable parts to facilitate emergency repairs.

Utility components, including interior and exterior finishes, must also be rugged enough to withstand the conditions they are exposed to without the need for frequent or specialized repairs. Any equipment or system that either needs servicing by specialized tradespeople, or that contains parts that are difficult to obtain, is not desirable, though at times may be necessary.

Expert assistance and specialized trades are generally not available in small NWT communities, and, due to flight schedules, they usually cannot get to site to assist until at least the next day. This delay can have serious impacts on community infrastructure.

2.5.3 Standardization

The intent of the GEP guidebook is to standardize system elements based on proven successes, so that the systems are cost effective, energy efficient, readily operable and maintainable by local people. Given the vast size and regional variation within the NWT, utilities must respond to differences in:

- community settings
- climatic zones
- transportation systems
- site conditions

Variations to recommendations reflecting local or regional differences and preferences are noted in this guidebook, where applicable.

2.6 CODES, REGULATIONS AND GUIDELINES

2.6.1 Public Health Act

The NWT *Public Health Act* is the governing legislation for water and sewer utilities in the NWT. Under the *Public Health Act*, there are various regulations that pertain to water and sewer utilities, including:

- *Water Supply System Regulations* (see also section 2.6.2)
- *Public Sewerage Systems Regulations*
- *General Sanitation Regulations*
- *General Sanitation Exemption Regulations*

2.6.2 Water Supply System Regulations

Some of the requirements of the *Water Supply System Regulations* include:

- Approval of water supply systems by the Chief Public Health Officer before operation.
- Approval of any planned system modifications or construction by the Chief Public Health Officer before construction starts.
- Certification of water treatment plant operators to the level of the plant they are operating.
- Cleaning and disinfection of systems, including water trucks.

2.6.3 Guidelines for Canadian Drinking Water Quality

The *Guidelines for Canadian Drinking Water Quality* (GCDWQ) are developed by the Federal-Provincial-Territorial Committee on Drinking Water. The Guidelines specify maximum acceptable limits, interim limits, and aesthetic objectives substances and conditions that affect the quality of drinking water. Changes to the current limits and additional chemicals are added regularly. A summary of these limits can be viewed on Health Canada's website:

http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php

The GCDWQ turbidity guidelines state that generally, minimum treatment of surface water or groundwater under the direct influence of surface water should include filtration (or technologies providing an equivalent log reduction credit) and disinfection. The guidelines do allow for a system to be exempt from filtration requirements under specific circumstances. The primary objective is to reduce the risk of microbial contamination due to protozoa. Currently there is no numerical GCDWQ for protozoa due to the difficulties in measuring and analyzing protozoa. Turbidity monitoring, along with monitoring of disinfectant residual, *Escherichia coli* (*E. coli*), heterotrophic plate counts (HPC), and total coliforms, is used as an indicator of the microbiological quality of water. The GCDWQ provide maximum acceptable concentrations (MACs) for turbidity based on the type of filtration being used.

In the NWT, the Department of Health and Social Services adopts the *Guidelines for Canadian Drinking Water Quality* as a regulation. Therefore, all drinking water supplied in the NWT must meet these guidelines.

2.6.4 Workers' Safety and Compensation Commission

The Workers' Safety and Compensation Commission of the Northwest Territories and Nunavut (WSCC) is responsible for processing claims, conducting workplace safety inspections, and administering the *Workers Compensation Acts*, *Safety Acts*, *Explosives Use Acts* and the *Mine Health and Safety Acts*.

2.6.5 Water Licences

In the NWT, water licences are issued by the regional water boards to both municipal and non-municipal water users, and are generally required for withdrawal or discharge of water. Some specific activities, such as fire-fighting and domestic water use, do not require a licence. Water licences set out the effluent quality objectives for wastewater discharge, and may limit timing or quantity for water use or discharge. Most of the regional boards also issue Land Use Permits, which may be required for water and sewer projects depending on the nature of the work. Details of licensing requirements and the application process can be found on each board's website.

All current and past water licences and applications are publically available on the online registry for the board having jurisdiction. The communities in each board's region are listed below. The Hamlet of Aklavik is included under two boards at this time; the water supply system is licensed under the Gwich'in Land and Water Board and the solid waste and sewage facilities are under the Inuvialuit Water Board.

Figure 2.1 – Land and Water Board Jurisdiction

Board	Communities In Region
Mackenzie Valley Land and Water Board	Dettah, Enterprise, Fort Liard, Fort Providence, Fort Resolution, Fort Simpson, Fort Smith, Hay River, Hay River Reserve, Jean Marie River, Kakisa, Lutsel K'e, Nahanni Butte, Sambaa K'e (Trout Lake), Wrigley, Yellowknife
Sahtu Land and Water Board	Colville Lake, Deline, Fort Good Hope, Norman Wells, Tulita
Wek'èezhìi Land and Water Board	Behchoko, Gameti, Wekweeti, Whati
Gwich'in Land and Water Board	Aklavik, Fort McPherson, Inuvik, Tsiigehtchic
Inuvialuit Water Board	Aklavik, Paulatuk, Sachs Harbour, Tuktoyaktuk, Ulukhaktok

2.6.6 National Building Code of Canada

The most recent version of the *National Building Code of Canada* (NBCC) was published in 2015. The NBCC has been adopted in the NWT as a regulation under the *Fire Prevention Act*. The authority having jurisdiction is the Fire Marshal of the NWT. The Office of the Fire Marshal is a division of Emergency Services, Municipal and Community Affairs, GNWT, located in Yellowknife.

2.6.7 The National Energy Code

The most recent edition of the *National Energy Code of Canada for Buildings* was published in 2015, but it has not been adopted by the NWT. The Energy Code includes prescriptive and performance requirements. The Energy Code with associated software, including a construction and energy cost database, is available to allow an evaluation of the performance of the design. Designers and Project Managers are therefore encouraged to become familiar with the Energy Code. Local codes may exceed the *National Energy Code*.

2.6.8 The National Plumbing Code

The latest edition of the *National Plumbing Code* was published in 2015. The Plumbing Code specifies the minimum requirements for:

- Drainage systems for water-borne wastes and storm water for buildings to the point of connection with public services,
- Venting systems,
- Water service pipes, and
- Water distribution systems.

The *National Plumbing Code* has been adopted under the NBCC.

2.6.9 Municipal Bylaws

All municipal bylaws and acts must be adhered to in the design and construction of facilities in the NWT.

2.6.10 Standards and Guidelines

Standards and guidelines used in utilities design include, but are not limited to:

• American Water Works Association	-	AWWA
• American Society for Testing and Materials	-	ASTM
• Canadian Council of Ministers of the Environment	-	CCME
• Canadian Standards Association	-	CSA
• Canadian General Standards Board	-	CGSB
• Underwriter Laboratories of Canada	-	ULC
• Capital Standards and Criteria	-	Municipal and Community Affairs, GNWT
• Cold Regions Utilities Monograph	-	American Society of Civil Engineers/ Canadian Society of Civil Engineering
• Water Supply for Public Fire Protection	-	Fire Underwriter's Survey
• NWT Fire Protection Study, 1993	-	GNWT
• Guidelines for Canadian Drinking Water Quality	-	Federal/Provincial Subcommittee on Drinking Water
• Water Supply System Regulations	-	GNWT
• Freshwater Intake End-of-Pipe Fish Screen Guideline	-	Department of Fisheries and Oceans
• Good Building Practice for Northern Facilities	-	Infrastructure (formerly Public Works and Services), GNWT

2.6.11 Design Professionals

The practice of engineering is regulated by the Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists, under the authority of the *Engineering and Geoscience Professions Act* of the Northwest Territories.

2.6.12 SI Metric Requirements

All new construction for the GNWT must be designed in SI metric units; the actual materials may be designated in metric or imperial, and soft conversion to metric is acceptable.

2.7 GNWT STANDARD DRAWINGS

The GNWT has developed standard drawings for water and sewer service work. These are in Appendix A.

2.8 ROLES AND RESPONSIBILITIES

Several Federal and Territorial (GNWT) government departments play specific roles in providing safe drinking water. The roles and responsibilities of GNWT departments and of Federal departments are presented in Figure 2.2 and Figure 2.3 respectively.

Figure 2.2 – Roles and Responsibilities of GNWT Departments

Department	Roles and Responsibilities
Health and Social Services	Sets the standards for drinking water quality and supplies, based on legislation and GCDWQ, then monitors, regulates, and inspects water systems, and enforces the regulations.
Municipal and Community Affairs	Provides funding, research, and policy development in water and wastewater. MACA’s enabling legislation allows communities to provide water delivery services. Provides technical expertise, training and operational assistance for water supply infrastructure. MACA’s School of Community Government provides training for water and sewer system operators.
Environment and Natural Resources	Responsible for monitoring, inspecting and regulating the discharge of contaminants to the environment. Assists in development of Source Water Protection Plans. Monitors compliance to the water licences granted by the various boards

Figure 2.3 – Roles and Responsibilities of Federal Departments

Departments	Roles and Responsibilities
Department of Fisheries and Oceans	Responsible for protecting and ensuring the quality of fish habitat.
Water Boards	Responsible for the water licensing process in the NWT.
Indigenous and Northern Affairs Canada	Responsible for the protection of inland waters.
Health Canada	Recommends drinking water criteria and standards to provincial and territorial jurisdictions.
Environment Canada	Responsible for reducing the discharge of contaminants. Comments on water licence applications before the water licences are granted.

2.9 CONTACTS

Contacts for technical advice or emergency situation guidance are listed in Figure 2.4 and Figure 2.5 respectively.

Figure 2.4 – Contacts for Technical Advice

Department	Contact	Phone No.
Municipal and Community Affairs (MACA)	Water and Sanitation - Yellowknife	867-767-9164 ext. 21078
Health and Social Services (HSS)	Environmental Health – Yellowknife	867-767-9066 ext. 49262
	Environmental Health – Hay River	867-874-6596
	Environmental Health – Inuvik	867-777-4840 or 867 777-4841

Figure 2.5 – Contacts for Incidents and Emergency Situations

Department	Contact	Phone No.
Municipal & Community Affairs (MACA)	Water and Sanitation - Yellowknife	867-767-9164 ext. 21078
Municipal & Community Affairs (MACA)	24/7 Emergency Measures Office - Yellowknife	867-920-2303
Health and Social Services (HSS)	Environmental Health - Yellowknife	867-767-9066 ext. 49262 during business hours 867-920-8646 outside of business hours
Environment and Natural Resources (ENR)	Manager, Environmental Protection	867-767-9236 ext. 53184
Environment and Natural Resources (ENR)	24-Hour Spill Report Line	867-920-8130

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3.0 PIPING

3.1 DEFINITION OF UTILIDOR

The word “utilidor” is used for a variety of structures, ranging from utility tunnels large enough to walk through, to any buried piping located in the North. In some areas, the term is used informally to refer to all piped systems. For the purposes of this document, “utilidor” means one or more pipes that are enclosed in an insulated box rather than having insulation applied directly to the pipes. A utilidor may be aboveground or buried. Utilidors in Canada’s North are generally just large enough to contain the piping, and not for human access. In Alaska, these structures are commonly referred to as “utilidettes”, and the term “utilidor” means a structure large enough to walk through.

3.2 HISTORY OF NORTHERN PIPED WATER SYSTEMS

Municipal piping systems in Canada’s North have a relatively short history. One of the earliest examples was a system using wood-stave pipe installed in Dawson City, Yukon in 1904. In the NWT and Nunavut, the earliest systems were installed in 1948/49 in Yellowknife and during World War II in Norman Wells as part of the Canol pipeline.

In the NWT and Nunavut, the piping systems developed in different ways in different areas.

In the southern Mackenzie (Yellowknife, Hay River, Fort Simpson, etc.) buried pipes, similar to those in the south, have been in use since the first systems were installed and continue to be used to the present. The major changes have been to utilize modern pipe types and polyurethane insulation, as they became available. Prior to the availability of polyurethane insulation, there was little use of insulated pipes, although early Yellowknife pipes were surrounded by peat in an attempt to limit heat loss.

More remote areas, such as Iqaluit, Rankin Inlet and Inuvik, initially utilized a mix of buried and aboveground utilidors. The utilidors were initially insulated wood or metal framed structures containing not only water and sewer but also, in many cases, heating lines that conveyed high temperature hot water from a central heating plant for building heat. These utilidors had high maintenance costs and high heat loss. Current practice is to utilize individually-insulated pipes, in both buried and aboveground applications, and to limit the use of aboveground pipes to areas of sensitive soil conditions, such as ice-rich permafrost. Utilidors remain in service in many locations, but new or replacement sections are generally individual pipes. The major central heating plants in Iqaluit and Inuvik have been abandoned in favour of individual building heating systems.

3.3 MATERIALS IN USE

A variety of pipe types have been used, including:

▪ Asbestos Cement (both water and sewer)	No longer manufactured for sale in Canada, due to health concerns for workers handling the pipe. Asbestos cement piping is not recoverable after freezing. The brittle nature of the material can lead to breakage if disturbed and the release of asbestos fibres may cause a health hazard for workers during field evaluation or repair work. Piping that is removed from service will require appropriate disposal. Asbestos is hazardous if

inhaled, but the GCDWQ states that there is “no evidence of adverse health effects from exposure through drinking water”. See *GCDWQ Guideline Technical Document – Asbestos* for background data.

Historical use in Behchoko (Edzo), Yellowknife (for services only), Inuvik and Iqaluit (in box utilidors), Fort Smith, Fort Simpson, Hay River.

- Cast Iron

  No longer produced. Production ceased when ductile iron became available. Cast iron remains in use in Yellowknife and Hay River.

- Corrugated HDPE Pipe

  Alternative to CMP for stormwater applications, such as culverts.

- Corrugated Metal Pipe (CMP) for Sanitary Sewers

  Installed as sanitary sewers in Yellowknife from 1948-1977. Maximum service life is 30 years due to significant corrosion.

Figure 3.1 - Corroded Corrugated Metal Pipe

- Corrugated Metal Pipe (CMP) for Storm Sewer

  Routinely installed for storm sewers and for drainage culverts.

- Copper (water services)

  Extensive use in water services in most communities. Copper pipe can typical withstand at least a few freeze/thaw cycles.

- Cross-Linked Polyethylene (PEX)

  PEX pipe is used for interior plumbing and heating piping. It can handle higher temperatures than standard polyethylene pipe, but is typically not UV resistant.

  The City of Yellowknife is considering pre-insulated dual-line PEX-Flex pipe for service lines, but this has not been tested yet.

▪ Ductile Iron	Currently used in Yellowknife and Behchoko for new construction.
▪ High Density Polyethylene (HDPE)	In use as buried piping since the mid-1970s in Behchoko (Rae), Yellowknife (limited), Rankin Inlet, Iqaluit, Resolute Bay, Norman Wells, Inuvik (limited) and Fort McPherson. Limited use in utilidors in Behchoko (Rae) and Fort McPherson. Pre-insulated HDPE piping is routinely used for potable water intakes. It is available with heat trace pre-installed in channels under the insulation and with polyethylene or aluminum jackets for buried or aboveground installations. HDPE pipe is typically treated with carbon black to provide UV resistance.
▪ Lead (water services)	There are significant health concerns with lead pipes and they are no longer used. There has been some historic use in Yellowknife.
▪ Polyvinyl Chloride (PVC)	Available since the mid-1970s. Used for mains and sewer services in Fort Smith, Hay River, Fort Simpson and, in limited amounts, in Yellowknife. Pipe becomes brittle in the cold and can shatter when frozen. PVC is not recommended for use where there is a chance of the pipe being exposed to freezing conditions.
▪ Welded Steel	Utilidors in Norman Wells are unlined steel. More recent utilidors in Inuvik are cement-lined steel to limit interior corrosion.
▪ Wood-stave	Limited historical use in Yellowknife and Pine Point. No longer in use.

Major problems have been corrosion of CMP used for sewer mains in Yellowknife (approximately 30-year life span) and ovalling failure of thin-walled HDPE in older sewer systems.

3.4 ABOVE OR BELOW GRADE INSTALLATION

The trend, since the late 1970s, has been to utilize buried pipes wherever possible. To this end, only three communities (Inuvik, Norman Wells, and Fort McPherson) construct new aboveground systems. Norman Wells does, where possible and practical, utilize buried utilities. Inuvik's soil conditions preclude buried pipes, except for isolated areas. Fort McPherson's system is mainly buried, but has aboveground service connections.

Recommendation | *Rationale*

3.4.1 Buried Pipes

Buried pipes are the recommended alternative, where possible.

Buried pipes are not subject to extremes of ambient temperature, do not disrupt lots and roadways and are not subject to vandalism.

3.4.2 Aboveground Construction

Aboveground pipes should only be contemplated where soil conditions preclude buried pipes.

Installation above grade safeguards thaw-sensitive soils.

Figure 3.2 - Typical Aboveground Pipes in Inuvik

3.4.3 Seasonal Aboveground Pipes

Temporary pipes can be laid on the ground surface to supply water to buildings that normally have trucked service.

Seasonal aboveground piping is used to supply water to houses in Yellowknife's Old Town during the summer. The piping is not insulated and is drained in the fall. It has been noted that sewage pumpout volumes increase when the summer lines are in place.

3.5 PIPE MATERIAL SELECTION CRITERIA

Selection of the pipe to use in a particular situation requires knowledge of the soil conditions on the project. The pipe selected should closely meet the needs of the project and the end user. Designers must recognize that the "perfect all-purpose pipe" does not exist.

Selection criteria should include:

- Corrosion Resistance — Where water is aggressive, corrosion of metal pipe interior walls can be substantial. Exterior corrosion, primarily on uninsulated pipes, may also be a concern if soils are aggressive.
- Roughness co-efficient (long term) — A smooth pipe interior increases pipe capacity and decreases pump energy requirements.
- Soil Conditions — Buried pipes generally rely on bedding for support. Loss of support can result in pipe collapse. Loss of

	support can also lead to movement of reaction blocks and separation of bell and spigot fittings.
▪ Beam Strength	Where pipe must span between piles, (as in the case of aboveground pipes) or areas of thaw-induced settlement, the pipe must have sufficient strength to carry the loads.
▪ Freeze-Back Forces	Excessive pore water pressure trapped between the permafrost layer and winter frost layer can deform or collapse pipe.
▪ Potential Freeze Damage	Pipes should, if freezing risk is high, be capable of being thawed and returned to service without loss of strength.
▪ Overall Cost	Pipe selection should consider both the capital cost (purchase plus installation) and the long term operations and maintenance costs:
(i) Capital Cost	▪ Purchase price. ▪ Special joining techniques add to installation costs and costs of future repairs. ▪ Purchase price is affected by the wall thickness of pipe that is selected. Designers must calculate the required wall thickness for each project.
(ii) O & M Costs	▪ Where a municipality has standardized on one pipe type, using a different type increases their O & M costs and parts inventory.

Recommendation	*Rationale*

3.5.1 High Density Polyethylene (HDPE)

HDPE is preferred where there is a high risk of freezing.	*HDPE can normally be thawed and returned to service without damage to the pipe. It is corrosion resistant and not affected by extreme cold. HDPE is commonly used in areas of continuous permafrost such as Rankin Inlet, Iqaluit, Resolute Bay and Fort McPherson.*
.1 HDPE design should generally follow the recommendations of the Plastics Pipe Institute (PPI) *Handbook of PE Pipe*, except where otherwise indicated.	*Industry standard. Northern conditions require some additional considerations, as indicated throughout this document.*
.2 Thermal Expansion	*HDPE has a high coefficient of thermal expansion which needs to be taken into account if a wide range of temperatures is expected. This could be during the service life, or due to the change from construction to operating conditions.*

.3 Minimum Wall Thickness

A maximum DR (DR =diameter/wall thickness) of 17 is recommended.

Experience has shown that larger DR pipes (i.e. pipes with thinner walls relative to their diameter) are prone to collapsing due to freeze-back forces. Analysis is needed to select an appropriate DR. Figure 3.3 illustrates a collapsed pipe and ice in the space between the pipe and insulation.

Figure 3.3 - Collapsed HDPE Pipe

.4 Butt-Fused Joints

Thermal butt fusion provides leak-free joints with the same or higher strength than the pipe. Butt fusing does require a specialized machine and trained operators.

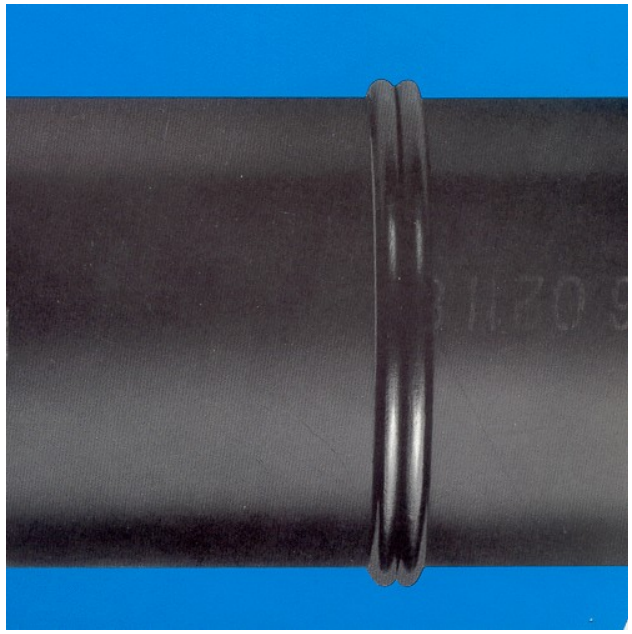

Figure 3.4 - Butt-Fused Joint

.5	Electrofusion Joints	*Also provides leak-free joints by fusing on a coupler, but without needing special equipment. Designers should verify that the couplers are available in the size required before specifying, as the availability of couplers is increasing.*
.6	Socket-Fused Joints	*Requires socket-fusion equipment, generally only used on small pipes (<50 mm sizes).*
.7	Reaction Blocking of Bends Not normally required.	*Concrete reaction blocks are not required as fused pipe takes up reaction forces at bends.*
.8	For insulated pipe, recommend factory-insulated rather than field-insulated.	*Factory application gives a high-quality, consistent result.*

3.5.2 Polyvinyl Chloride (PVC)

PVC is preferred where soil conditions are competent to support the pipe and the pipe can be buried to depths unlikely to experience freezing temperatures.

PVC is not subject to corrosion, is light, easy to install and similar in cost to HDPE. PVC is commonly used in Fort Smith, Hay River and Fort Simpson. PVC becomes brittle when exposed to extreme cold temperatures.

.1 Bell and Spigot Joints

Recommended for underground use.

For ease of installation. Allows some movement pipe to pipe at each bell.

.2 Reaction Blocking of Bends

Required to transmit reaction forces to soil.

.3 Joint Restraints

Recommended where soil conditions will not or may not withstand reaction forces.

Where thrust blocks can or may move, joint restraints are required to prevent bends and fittings separating from pipe.

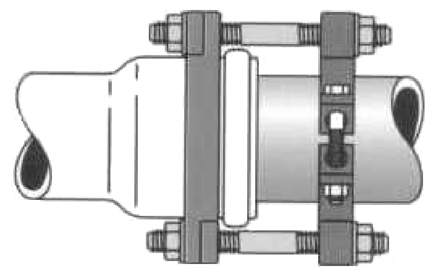

Figure 3.5 - Joint Restraint Harness for PVC

.4 Minimum Dimension Ratio

A separate calculation is recommended for each installation.

Changing soil conditions, depth of burial or service pressures may dictate different DRs.

3.5.3 Ductile Iron (Cement Lined)

Ductile iron is preferred where there is thaw settlement potential and/or where pipe bedding support is marginal.

Ductile iron is a rigid pipe and can, at normal installation depth, withstand settlement forces and loss of bedding support. Typically used in Yellowknife where thaw-induced settlement is common.

.1 *Bell and Spigot Joints*: Recommended for underground use.

For ease of installation. Allows some movement pipe to pipe at each bell.

.2 *Reaction Blocking of Bends*

Required to transmit reaction forces to soil.

.3 *Joint Restraints*: Recommended where soil conditions will not or may not withstand reaction forces.

Where thrust blocks can or may move, joint restraints are required to prevent bends and fitting separating from pipe.

.4 *Pressure Class Selection*: A separate calculation for each area is recommended.

Changing soil conditions, depth of burial or service pressures may dictate different pressure classes

.5 *Conductivity Straps*

Designers should verify the need for conductivity devices based on soil conditions at each site.

Figure 3.6 - Buried Mains – Pipe Comparison

Attribute	Ductile Iron	PVC	HDPE
Corrosion Resistance	Good if Cement Lined	High Resistance	High Resistance
Retains Interior Smoothness	Moderate if Cement Lined	High	High
Withstands Poor Bedding or Loss of Bedding	High Tolerance	Moderate Tolerance	Low Tolerance
Beam Strength	High	Moderate	Low
Resists Ground Forces During Freeze-back	High Resistance	Moderate Resistance	Low to Moderate Resistance Depending on Pipe Wall Thickness
Resists Damage When Contents are Frozen	Fails When Frozen	Fails When Frozen	Best, Can be Thawed and Returned to Service
Ease of Installation	Moderate	Simplest	Most Difficult
Economical Purchase Price	Highest Price	Low Price	Low Price

3.5.4 Steel (Cement Lined)

Welded steel is primarily used for utilidor piping.

Welded steel provides the beam strength necessary to span between pile supports on utilidors.

.1 Welded or Flanged Joints

Required to ensure pipe acts as a beam between pile supports.

.2 Expansion Loops and/or Fittings

Temperature changes result in large length changes in pipe, which must be accommodated.

.3 Reaction Blocking of Bends

Not required.

Welded joints or flanged joints allow reaction forces to be taken up in the pipe.

3.6 ABOVEGROUND PIPING

Aboveground pipes are generally used where the soils are sensitive to thawing and trenching for buried pipe installation would create thaw settlement problems.

Aboveground pipes are disruptive as buildings must be above the pipes to achieve gravity drainage, and roadways must cross over gravity sewers.

Recommendation	*Rationale*

3.6.1 Boxed Utilidors (pipes not individually insulated)

Not recommended.

Heat loss is a function of the insulated wall area, the level of insulation provided and the temperature gradient between the liquid in the pipe and the ambient temperature. The wall area is extensive in box utilidor construction. Additionally, it is difficult to seal these structures against moisture and air currents. Insulation tends to get wet, reducing its effectiveness, or fall out of place. The lack of an air barrier leads to convective heat loss.

Figure 3.7 - Old Box Utilidor in Iqaluit

3.6.2 Individually-Insulated Pipes

Recommended.

The wall area is minimized by insulating just the pipe. Factory-installed insulation is normally jacketed for protection. Individually-insulated pipes are easier to seal against water and air infiltration.

Figure 3.8 - Aboveground Piping in Inuvik Using Individually-Insulated Pipes

3.6.3 Pipe Support

Pile supports are recommended.

Properly installed piles are not subject to seasonal movement as would be surface-mounted supports. A span calculation should be done to ensure sufficient support.

3.6.4 Lateral Pipe Movement on Supports

Pipe supports must allow lateral movement.

Thermal expansion and contraction forces should not be transmitted to the support piles.

3.6.5 Thermal Expansion/Contraction

Suitable expansion loops or expansion joints are recommended.

Thermally induced movements must be controlled. Generally, certain points are fixed so all expansion occurs toward the expansion loops or expansion joints.

3.6.6 Longitudinal Movement

Consider the need for longitudinal restraint on long aboveground piping runs.

There may be a need to restrain piping from movement due to gravity and thermal forces, especially for piping installed along a slope.

3.7 PIPE BEDDING

Buried pipes rely on the subgrade and the pipe bedding to withstand both the load of the backfill and, at shallow depths, the live load of vehicle traffic. Further, where pipes are installed in the active layer, the bedding must also work to resist freeze-back forces. Figure 3.9 indicates how pipe deformation mobilizes resistance of bedding material. Figure 3.10 shows a typical GNWT cross-section. Designers should refer to pipe sizing guidelines, GNWT and community standards for appropriate bedding configurations.

In some cases, it is desirable to raise the bottom of the active layer above the top of the piping in order to encase the pipe in permafrost for stability. This is usually achieved by placing rigid foam board insulation as part of the backfill system. Timing of construction with regard to ground temperature is an important consideration to achieve freeze-back in this situation.

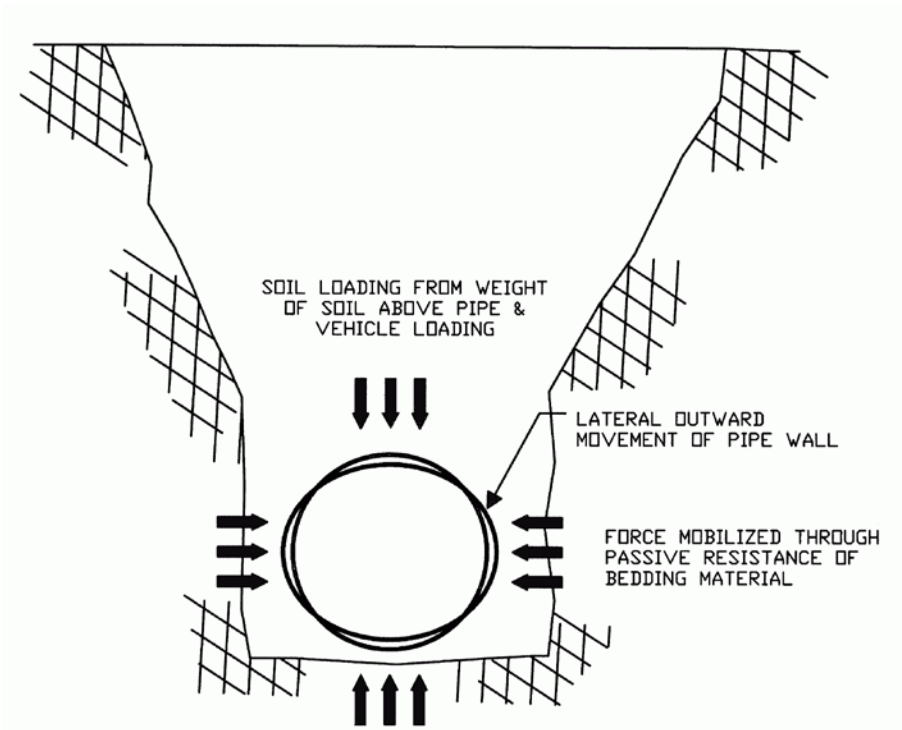

Figure 3.9 - Mobilization of Enveloping Soil through Pipe Deformation

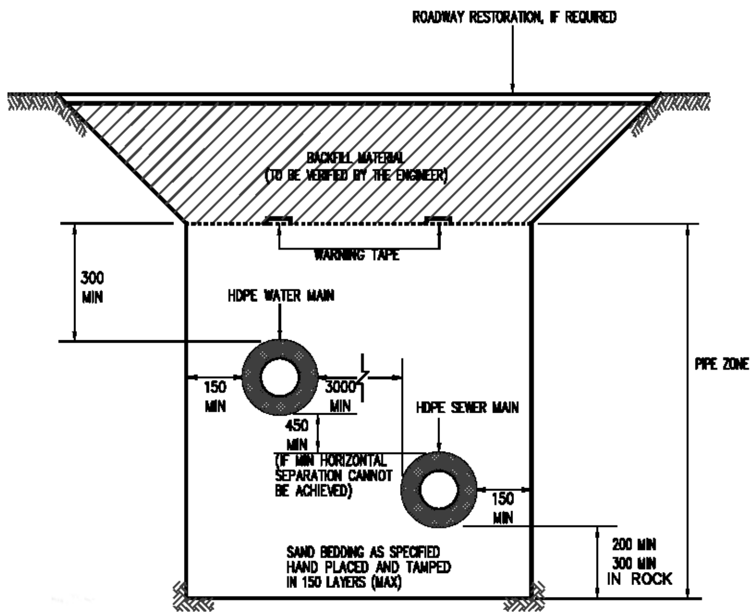

Figure 3.10 - Typical GNWT Standard Trench Detail

Recommendation	*Rationale*
3.7.1 Clean Sand Bedding	
Clean sand bedding is preferred.	*Sand provides the least potential damage to pipe insulation coating and is readily compacted around the pipes.*
3.7.2 Crushed Gravel	
Crushed gravel (maximum 25 mm) is an alternate to clean sand bedding.	*Gravel is better suited to poor trench conditions. It is utilized where local sand sources are limited or non-existent.*
3.7.3 Screened Pit Run Gravel	
Screened pit run gravel (maximum 25 mm) may be used as bedding material if sand or crush is not available.	*In some communities, sand or crush may not be available.*

3.7.4 Warning Tape

Warning tape should be placed on top of the bedding.

Tape identifies pipes in future excavations and minimizes damage.

Water - Blue
Sewer - Green
Imprinted Wording:
"Caution: Buried Water (or Sewer) Below".

3.7.5 Separation Distances for Water and Sewer Mains

Where possible, lay water mains a minimum of 3 m from sewer mains.

Minimize risk of cross-contamination.

Where 3 m horizontal separation cannot be achieved, the bottom of the water main should be at least 450 mm higher than the top of the sewer.

Where water and sewer mains cross, the bottom of the water main should be at least 450 mm higher than the top of the sewer for the portion of the water main located within 3 m of the sewer, measured horizontally.

Where these distances cannot be achieved, pipes should be designed as pressure pipes and leak tested.

3.8 CONNECTIONS TO STRUCTURES

Care must be taken in connecting pipes to buildings, manholes or access vaults as differential movement can damage the pipes.

Recommendation — *Rationale*

3.8.1 Flanges

Flanged connections should only be considered if the joint is supported.

Rigid flanges experience high stress loads when subjected to differential movements. They are prone to failure if not properly supported.

.1 Gaskets

Gaskets shall be full face neoprene.

Partial gaskets are difficult to install properly. Fabric-reinforced gaskets do not seal properly on flat-faced flanges.

3.8.2 Differential Movement Connections

Pipe connections should allow movement of the pipe relative to the structure.

Relative movement of buried objects is common and connections must allow this movement without pipe damage.

.1 PVC or Ductile Iron

Two couplings or bell-and-spigot joints are recommended.

Two joints allow full differential movement without stressing adjacent pipe.

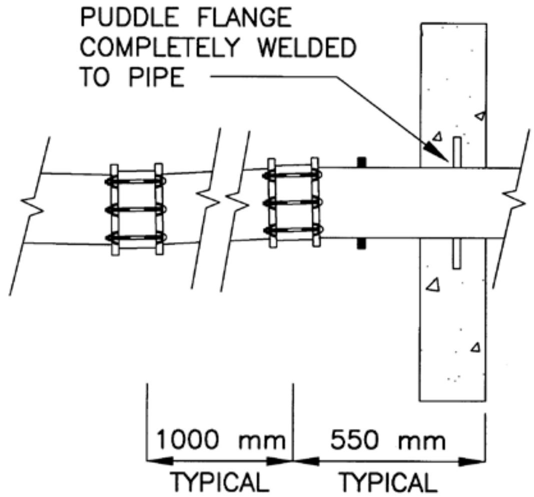

Figure 3.11 - Differential Movement Connection

.2 High Density Polyethylene

One coupling with a stainless steel insert is generally sufficient.

HDPE is a flexible pipe and thus, together with one coupling, generally allows necessary movement. A stainless steel insert approximately 60% of the coupling length is used to ensure the coupling, when tightened, compresses the coupling seal. If the insert is not used, the flexible HDPE deforms and the coupling seal does not compress properly.

Figure 3.12 - Couplers on HDPE Pipe

3.9 FREEZE PROTECTION

Unless piping can be installed below the seasonal frost line, some form of freeze protection is mandatory. Designers must undertake a cost benefit analysis to determine the appropriate thickness of insulation for a particular application. Such analysis should compare the capital cost of the installation to the cost of heating the water over the life of the piped system.

Freeze protection includes both passive protection (insulation) and active protection (heat trace, water heating, circulation and bleeding to waste).

Recommendation	*Rationale*
3.9.1 Polyurethane Pipe Insulation	
Factory-applied polyurethane is recommended for both buried and above grade pipes.	*Polyurethane is closed-cell insulation, which effectively reduces heat loss from mains. It is suitable for buried and above grade uses, provided it is properly sealed.* *See also Section 4.0 Insulation.*
3.9.2 Heat Trace	
Heat trace is not recommended for general use as a freeze protection device, but can be useful in limited areas, such as locations that are difficult to drain.	*Power costs are high in the North and power consumption makes general use of heat trace cost prohibitive. Replacement on failure is generally expensive.*
.1 *Maximum Sheath Temperature*: Maximum sheath temperature must be controlled by proper cable selection.	*Some heat trace can generate higher temperatures than HDPE and PVC can withstand.*
.2 *Constant Wattage Heat Trace*	*Applies a constant wattage along the cable, regardless of the temperature. In order to save power, constant wattage heat trace should be thermostatically controlled rather than always on. Generally recommended for pre-insulated pipe.*

.3	*Self-Limiting Heat Trace*	*The wattage applied decreases as temperature increases (i.e., colder areas get more heat, warmer areas less heat). Generally not recommended for pre-insulated pipe with a heat trace channel, as it will heat the channel and switch off before sufficient heat is transferred to the water.*
.4	*Replacement Provision*: The heat trace should be in a channel or tube.	*If the heat trace is in a channel or tube, it can normally be easily replaced by exposing both ends. When it is directly applied to the pipe, under the insulation, replacement is very difficult. Ice or other blockages of the channel can cause problems with replacement.*
.5	*Control*: A control system for operation and, on non-metallic pipe, for high limit shutdown is recommended.	*The heat trace should be shut off when the heated pipe is above the desired temperature to conserve power. High limit shutdown is required to protect non-metallic pipes. Caution is required during system design as sensors monitor only one point, which may not be the point of most extreme temperatures on the pipe. Heat trace may also be flow-controlled.*
.6	Recommend self-regulating heat trace for freeze-protection of inclined shaft intakes.	*In an inclined shaft intake, the heat tape is typically in a copper tube and not surrounded by insulation. Therefore, it is typically able to heat the entire casing pipe before shutting off due to high temperature.*
.7	Recommend power-limiting heat trace for pipelines.	*In pipelines, self-regulating heat tape will heat up the plastic channel and then shut off before transferring much heat to the water pipeline. A power-limiting heat tape that turns on/off based on the temperature of the water is more effective in this situation.*
.8	Recommend considering hydronic heat-trace in applications where a boiler is in use and there is no potential for cross-contamination of the water lines.	*Can be more cost-effective. Should not be used where a leak could allow contamination of the raw or treated water with glycol; however, heat exchangers can be used to transfer heat to process water lines and hydronic heat trace can be used for wastewater tanks.*
.9	Recommend primary and backup heat trace for intakes.	*Failure of heat trace in winter conditions can lead to rapid freezing as in most systems the intake has no flow most of the time. Provide a backup to prevent freezing until repairs can be made.*
.10	Heat trace should be approved for use in buried and wet installations.	*Heat trace used in water systems is usually exposed to these conditions.*

3.9.3 Water Heating

It is often necessary to raise the water temperature prior to entering the mains.	*Water at the source is generally near 0ºC in the winter and must be heated for treatment and/or to account for*

heat loss in storage or mains.

.1 Water Temperature

Calculation must be done to determine the extent of water heating required.

Designers must determine what heat loss is occurring in storage and in the main system. They must also determine the factor of safety the maintainers require prior to sizing boilers, storage insulation, pipe insulation, circulation rates, etc. The required temperature is usually not high, as it is only necessary to keep the return water above freezing.

.2 Temperature Drop

Calculation must be done to ensure the temperature drop along the pipeline is acceptable.

The Cold Regions Utilities Monograph recommends that as a general rule the temperature drop along a pipeline should be less than 5°C, preferably less than 2.5°C. Significant temperature swings are inefficient and can cause thermal expansion issues and ground thaw.

3.9.4 Water Circulation

Piped potable water systems should be designed such that water is continually moving in each pipe and returning to the pumphouse.

Circulation allows monitoring of the return water temperature and adjustment of the water heat to maintain desired system and return temperatures.

.1 Circulation Rate

Calculation must be done to determine optimum circulation rate.

Circulation rates are usually set based upon temperature depression; the water must get back to the reheat facility before the temperature drops below a safe level. The cost of pumping is usually low relative to the cost of heating.

3.9.5 Bleeding Water to Waste

Bleeding water as a means of freeze protection is strongly discouraged.

Bleeding water is generally uneconomic considering the costs of obtaining, treating, heating, pumping and delivering water. It also increases the costs associated with transporting the sewage to treatment facilities and treatment of higher sewage volumes.

3.10 THAW RECOVERY

A means of readily accessing water and sewer mains is required so that recovery of a frozen main is practical, as in the case of HDPE pipe.

Recommendation | *Rationale*

3.10.1 Sewer Manholes/Access Vaults

Sewer manholes and/or access vaults are generally spaced no more than 100 m apart.

This maximum spacing is determined by the maximum length that the thawing machines, sewer cleaning or rodding apparatus available in the community can accommodate.

3.10.2 Sewer Access Portals

Access portals are recommended on long runs of sewers or forcemains when manholes or vaults are not required.

Portals provide a means to introduce thawing and cleaning devices. Maximum spacing is generally the same as for sewer manholes/access vaults.

.1 Where the main is under pressure, portals should only be used on HDPE mains.

Liquid in the top of the portal stub can freeze, damaging PVC or metal mains.

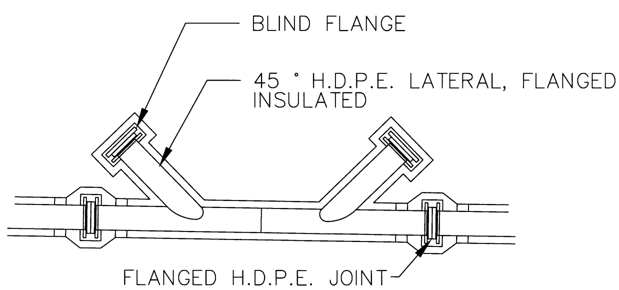

Figure 3.13 - Sewer Portal Schematic

Figure 3.14 - Sewer Portal

3.10.3 45° Valved Nipples (50 mm)

Where access vaults or water manholes are utilized, 45° valved nipples are recommended.

Valved nipples allow the insertion of a thawing device. The 45° angle is required to divert the device down the pipe.

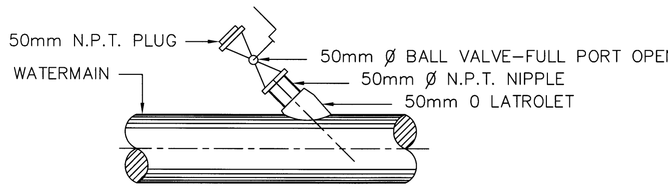

Figure 3.15 - Valve Nipple Schematic

3.10.4 Pipe Draining

All pipes are to be graded to drain to access points.

When a portion of the system is out of service for repair or a main is frozen, adjacent mains may have to be drained to prevent freezing.

3.10.5 Steam Thawing

Recommended for metal pipes only.

Steam can damage HDPE and PVC pipes. Note that the cement lining and seal coat of ductile iron pipes may not be able to withstand steam temperatures; consult the manufacturer.

3.10.6 Hot Water Thawing

Recommended for HDPE and PVC pipes.

The temperature of hot water is low enough to be safe for use on HDPE and PVC pipe. Typical HDPE and PVC formulations can handle operating temperatures up to 60°C. The pressure rating for PVC is de-rated above 23°C. Positive gradient towards the point where thaw water is injected is required.

3.10.7 Electric Thawing

Recommended only if the equipment is approved for use by Canadian Electrical Code.

Welding machines can easily thaw metal lines, but can cause electrical fires or damage in other buildings besides the unit being thawed.

3.10.8 Thawing With Heat Tape

HDPE pipe can be safely thawed with electric heat tracing tape.

When thawing HDPE pipe with heat tape, the Plastics Pipe Institute recommends wrapping the affected area with pressure sensitive metallic tape over which is wrapped temperature-limited (49°C maximum) heat tracing tape. The metallic tape helps distribute heat evenly over the pipe surface. Typical northern intakes have the heat trace contained inside a copper tube; this configuration can also be used for thawing.

3.11 PIPE TESTING

A comprehensive testing program should be specified for all installations. Designers must be aware that different procedures exist for different pipe types, and must specify the correct procedures for the pipe type selected.

Recommendation	*Rationale*
3.11.1 Flushing	
Recommended for all new installations at a minimum of 0.75 m/sec or by power flusher.	*Removes sand, gravel and construction debris. Scouring velocity (i.e., greater than 0.75 m/sec) is required to move material.*
3.11.2 Ball Test	
Recommended for all new sewer mains when video inspection equipment is not available.	*Drawing a ball with a diameter of 80% of the pipe diameter reveals deformed pipe or construction debris blockage. Normally done if video inspection equipment is not available.*
3.11.3 Video Inspection	
Recommended for new sewer mains.	*Video inspection, after flushing, can determine grade problems, pipe deformation, service penetrations and the presence of debris, which can cause blockages. Video inspection can also reveal infiltration problems.*
3.11.4 Pressure Test	
All pressure pipes should be tested to AWWA standards and to manufacturer's standards.	*Pressure testing reveals defective joints, pipe or fittings. Testing pressure must be limited to the rating of valves and fittings.*
3.11.5 Leakage Tests	
All pressure pipes should be subjected to a sustained period of leakage tests to AWWA standards and to the manufacturer's recommendations.	*Sustained leakage tests, primarily on bell and spigot joints, are required to ensure leakage is within allowable limits.*
3.11.6 Infiltration/Exfiltration Test	
Gravity pipes should be tested for rates of infiltration or exfiltration.	*Gravity pipes do not generally have fittings to allow pressure tests. Infiltration/exfiltration tests are required to ensure all joints and service saddles are properly sealed.*

3.11.7 Bacteriological Testing

All potable water mains and services must be chlorinated in accordance with AWWA C651. Bacteriological testing must be undertaken to prove there are no total or faecal coliforms present prior to the watermain being placed in service.

No water from potable water mains can be considered safe for human consumption until it can be demonstrated that the water complies with current Health Regulations and the Guidelines for Canadian Drinking Water Quality.

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INSULATION

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4.0 INSULATION

4.1 INTRODUCTION

The need for insulation on water and sewer piping was recognized from the earliest piping systems in the NWT and Nunavut. Unlike southern installations, most northern piping cannot be installed below the seasonal frost penetration line, and in many cases, pipes are installed in permafrost or above grade. Lack of insulation led to excessive freezing problems or excessive water heating requirements to prevent freezing.

4.2 MATERIALS IN USE

A variety of insulating materials have been utilized on northern piping systems, including:

▪ Peat Moss	Early buried pipes in Yellowknife were bedded in peat moss.
▪ Fibreglass Batts	Wood box utilidors in Iqaluit and Inuvik.
▪ Mineral Wool	Wood box utilidors in Iqaluit and Yellowknife.
▪ Zonolite® (loose fill, pour in place, vermiculite insulation)	Wood box utilidor and wood-boxed buried services in Yellowknife. Aboveground utilidors in Iqaluit. Some vermiculite insulation dating from approximately the mid-90's or earlier has been found to contain asbestos.
▪ Polystyrene Beads	Service boxes and fire hydrants, both buried and on utilidors.
▪ Expanded Polystyrene	Wood box utilidors.
▪ Asbestos	High temperature heating lines in utilidors in Iqaluit and Inuvik.
▪ Polyisocyanurate	Generally limited to half shells or fitting cover kits.
▪ Polyurethane	Half shells on buried and above grade pipes and factory applied to buried and above grade pipes. Also available as field-applied foam. Factory-insulated pipe is available with channels for heat trace.
▪ Extruded Polystyrene	Routine use on buried, flat-faced structures.

4.3 SELECTION CRITERIA

With the exception of extruded polystyrene and polyurethane, all of the above insulation materials will readily absorb moisture, and hence, lose their effectiveness as insulation materials.

Recommendation	*Rationale*
4.3.1 Extruded Polystyrene	
Recommended for flat-sided, below grade structures.	*Available as sheet stock in a variety of thicknesses.*
Recommended for flat areas with high soil loadings.	*Commercially available in a variety of compressive strengths.*
Recommended use of shiplap edges.	*Overlapping shiplap edges are more effective at joints than butt edges, which often have a gap.*
4.3.2 Polyurethane	
Recommended for factory application on pipes.	*Commercially available applied to pipes in a variety of thicknesses.*
Recommended for half-shell covers for pipe joints and fittings.	*Commercially available as half-shell kits.*

4.4 WATERPROOFING

Both extruded polystyrene and polyurethane are closed cell materials. Over time, however, moisture can penetrate either material to a certain extent. Where practical, it is prudent to seal these products to minimize access by moisture and subsequent loss of insulation value. Sealing is generally not practical on flat sheet stock; hence, the following section pertains to piping insulation.

Recommendation	*Rationale*
4.4.1 Bare Insulation Ends	
Recommend sealing with heat shrink sleeve.	*Seals the exposed insulation to limit moisture access.*
4.4.2 Insulation Covering	
Recommend a polyethylene jacket extruded directly onto the polyurethane foam.	*Provides effective waterproofing throughout the length of the pipe. Jacket is bonded to the foam. Jacket thickness should be appropriate to the size of the pipe and the installation type (above or below grade).*
Recommend a 1.27 mm thickness or two layers of spirally wrapped high density polyethylene tape, hot applied, counter wound, overlapping 15% on each tape seam.	*Provides effective waterproofing throughout the length of the pipe.*
4.4.3 Half Shells and Fitting Cover Kits	
Recommend pre-fabricated rigid polyisocyanurate or polyurethane with fully bonded polymer coating.	*Shells are less prone to breakage during shipping and handling.*

Recommend coating with two coats of waterproofing asphaltic mastic.

Seals the insulation to limit moisture access.

Recommend covering with heat-shrink sleeves for regular shapes.

Provides a moisture barrier joined to pipe insulation jacket.

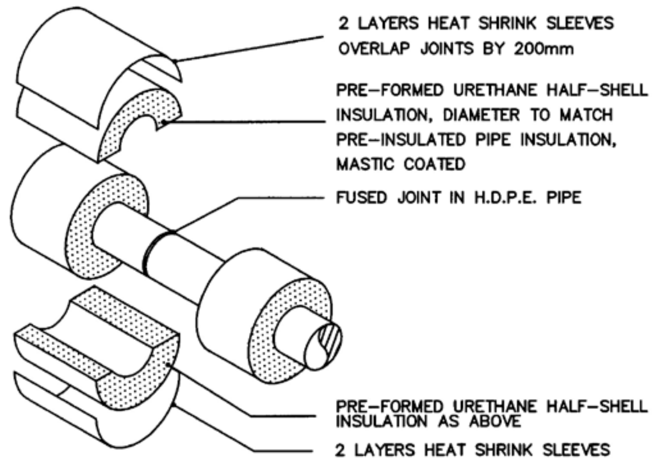

Figure 4.1 – Typical Half Shells

Recommend covering with two layers of heat-shrink tape on all irregular-shaped surfaces, counter wound, with 15% overlap at seams.

Tape will allow coverage of irregular-shaped surfaces.

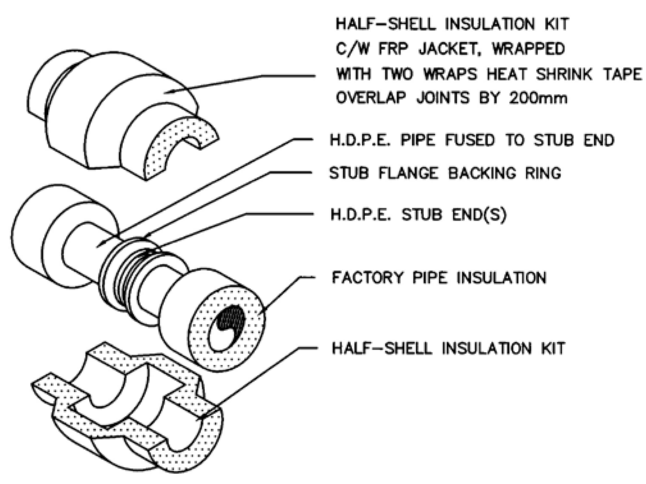

Figure 4.2 – Typical Flange Cover Kit

4.5 FIELD-APPLIED FOAM

In any insulated piping installation, there will be pipe insulation damage or areas where half shells or kits do not fit precisely.

Recommendation	*Rationale*
4.5.1 Insulation Repairs and Gaps	
Recommend replacing lost insulation and gaps at half shells or cover kits with field-applied foam.	*Restores full insulation value.*
Recommend two wraps of heat-shrink tape over repair.	*Seals out moisture.*

4.6 INSULATION THICKNESS

Insulation is available in a variety of thicknesses.

Recommendation	*Rationale*
4.6.1 Thickness	
Recommend that a separate calculation be undertaken for each application.	*Insulation is expensive and the designer must ensure the optimal level is specified, consistent with economics and service goals.*
Recommend 50mm thick insulation on pipes unless calculation or experience shows otherwise.	*50mm thickness is commonly available on pre-insulated pipes and has been found to provide a balance between the thermal resistance and the surface area for heat loss.*

4.7 ULTRAVIOLET AND MECHANICAL PROTECTION

Insulated pipe installed above grade is subject to both ultraviolet (UV) radiation and mechanical damage.

Recommendation	*Rationale*
4.7.1 Metal Jacketing	
Recommend galvanized spiral-wrapped jacketing in minimum 22 gauge metal.	*Provides UV protection and is resistant to normal mechanical damage.*

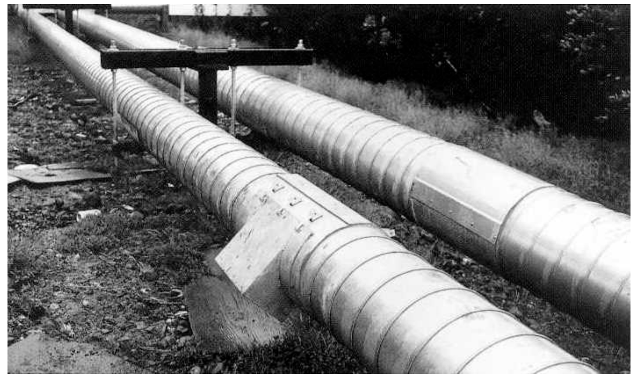

Figure 4.3 – Metal-Jacketed Pipes

4.7.2 HDPE Jacketing

Recommend as an alternate to metal jacket, generally on buried piping where bedding material is not ideal.

Protects the insulation from sharp bedding. Use above grade may result in long term UV damage to the jacket.

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ACCESS VAULTS AND MANHOLES

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5.0 ACCESS VAULTS AND MANHOLES

5.1 INTRODUCTION

Manholes are used extensively in sanitary and storm sewers in southern Canada to allow workers access to pipes for cleaning and for pipe maintenance.

In Canada's Arctic, manholes were initially installed to southern standards for the same reasons. In the discontinuous permafrost zones, these transplanted southern standards are still in use today.

Further north, it quickly became apparent that heat loss was unacceptably high and that a sheltered, insulated chamber was required for system maintenance in extreme weather conditions. Further, manholes were required on the water system to allow access to valves, access to the watermains for thawing/or draining, and access to fire hydrants for maintenance and repair in severe winter conditions. A mini service centre access vault, generally larger than southern manholes, was developed that was easily accessible, insulated and heatable.

The terms "manhole" and "access vault" are often used interchangeably in the communities. For this publication, the following convention is used:

Manhole:	Access chamber for sanitary sewer or storm sewer only.
Access Vault:	Access chamber for multiple utilities in one chamber or for water system valves and fire hydrants.

See Appendix A for GNWT water and sewer standard drawings.

5.2 MATERIALS IN USE

A variety of materials are in use for vault construction, including:

▪ Cast-in-Place Concrete	Routine use in Yellowknife for hydrant access vaults, valve access vaults and larger (Greater than 600 mm diameter) storm sewer manholes. Insulated cast-in-place access vaults were used in Behchoko (Rae), Rankin Inlet and Iqaluit.
▪ Corrugated Metal Pipe (CMP) Barrels	Existing CMP manholes and access vaults are in use in various communities, but are not currently specified due to difficulties in insulating and sealing against groundwater infiltration.
▪ Insulated Double-Walled or Triple-Walled HDPE	Access vaults in Iqaluit, Rankin Inlet, Resolute Bay and Fort McPherson.
▪ Insulated Double-Walled Steel	Routine use for access vaults in Behchoko (Rae), Fort McPherson, Rankin Inlet and Iqaluit.
▪ Pre-cast Concrete Barrels	Routine use in Fort Smith, Hay River, Fort Simpson, Yellowknife and Behchoko (Edzo) for sanitary sewer manholes, catch basins, and storm sewer manholes (pipe diameter less than 600 mm).

▪ Wooden Structure	Very limited use in specific instances.

5.3 MANHOLE AND ACCESS VAULT SELECTION CRITERIA

The selection of the manhole or access vault type to use in a specific community or situation requires knowledge of the system and the standards adopted by the municipality.

Selection criteria should include:

▪ Groundwater Infiltration Tolerance	Generally, the objective is to have no groundwater infiltration.
▪ Anticipated Service Life	Timber crib manholes or access vaults may be suitable for temporary situations.
▪ Available Local Materials	Quality concrete is often difficult to make in isolated communities.
▪ Prefabrication	Prefabrication allows higher quality control and workmanship as units are constructed in a controlled condition.
▪ Shipping Costs	Prefabricated units are costly to ship as they occupy more volume than do components.
▪ Construction Season	A short construction season may necessitate prefabricating units.
▪ Local Standards	Municipalities may have standards that dictate manhole or access vault types.
▪ Streetscape Layout	Some manhole or access vault types may not fit the urban streetscape.
▪ Insulation Requirements	Round manholes or access vaults are difficult to properly insulate with board insulation.
▪ Ease of Installation	Type selected should consider the capacity of local equipment. Prefabricated units can be quite heavy.

<u>Recommendation</u>	<u>*Rationale*</u>

5.3.1 Wooden Access Vaults

Wooden vaults may be preferable for temporary projects.	*Wood is low cost and vaults can be built by unskilled labour.*
Wooden vaults are normally not recommended for permanent installations.	*Wooden manholes or access vaults are subject to decay and cannot be effectively sealed against groundwater infiltration.*

5.3.2 Pre-cast Concrete Barrels (1200 mm diameter)

Recommended for use on sanitary sewers and storm sewers under 600 mm diameter and catch basins in the discontinuous permafrost area.

Pre-cast barrels are cost efficient and generally perform well with no insulation. Pre-cast barrels are generally produced in a manufacturing plant with access to good quality aggregate and concrete.

Not recommended for watermains.

Pre-cast barrels are difficult to seal at pipe penetrations.

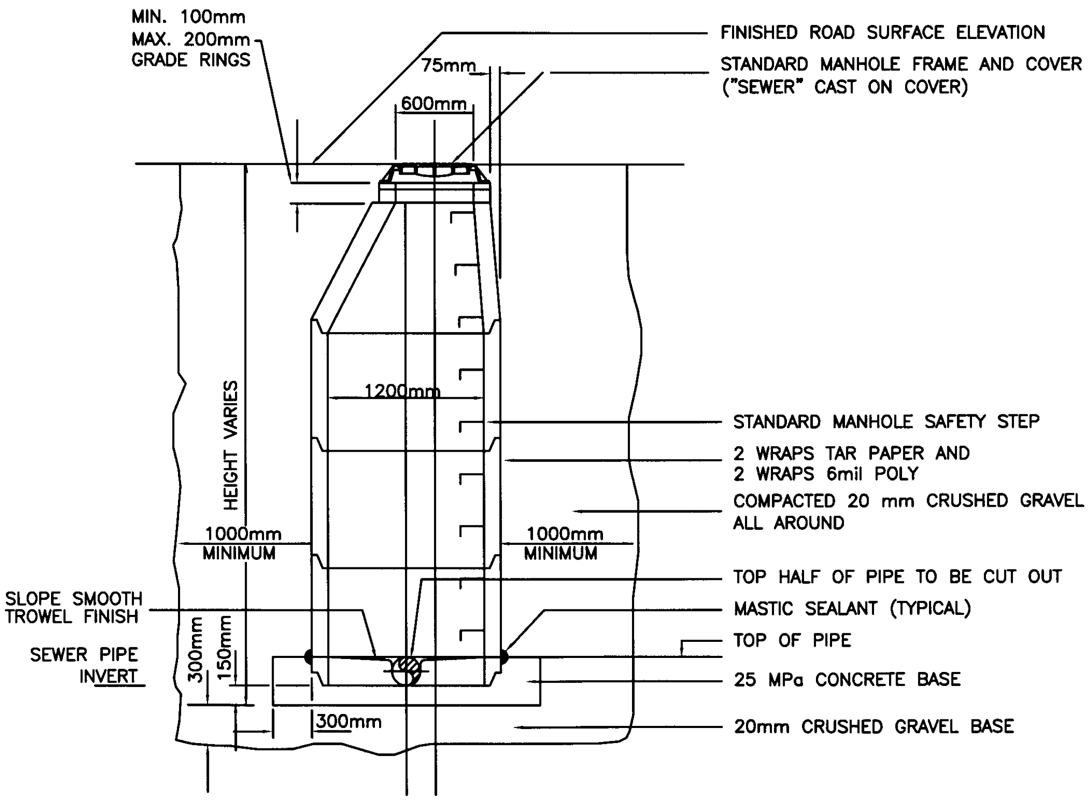

Figure 5.1 - Pre-cast Manhole c/w Cone Top

.1 Recommend use of cones rather than flat tops.

Cones resist frost-jacking forces. (See also Section 5.5.)

Figure 5.2 - Pre-cast Sanitary Manhole c/w Cone Top and Polyethylene Wrap

5.3.3 Cast-in-Place Concrete

Recommended for sanitary or storm sewer pipes over 600 mm diameter.

Pipes over 600 mm diameter result in excessive material being removed from 1200 mm diameter manhole barrels.

Figure 5.3 - Cast-in-Place Storm Sewer Vault

Recommended for water valve and fire hydrant access vaults beneath roadways.

Concrete tops can be reinforced to withstand vehicle loadings.

Figure 5.4 - Cast-in-Place Hydrant Vault

.1 Recommended insulation is extruded polystyrene sheets.

Square or rectangular access vaults are easily insulated with sheet stock.

.2 Recommend flat sides rather than round.

Flat sides can be easily formed and insulated with board insulation.

5.3.4 Prefabricated Insulated Double-Walled Steel

Recommended for water and sewer access vaults where vaults are not subject to traffic loads.

Cost-prohibitive to reinforce access vault tops to withstand vehicle loads.

Figure 5.5 - Hydrant Access Vault

.1 Recommend vault tops be 450 mm above grade.

Vaults remain accessible and visible and are not subject to surface runoff entering the vault.

.2 Recommend sewer and water access be in separate vaults or

In the currently used style of combined vaults, the sewer cleanout is sometimes left open, leading to a risk of combined vaults designed to segregate the two systems. | *contamination of the water line.*

.3 Recommend both interior and exterior be sandblasted and epoxy coated. | *To protect metal surfaces from corrosion.*

5.3.5 Prefabricated Insulated Double-Walled HDPE Vaults

Recommended for smaller access vaults in lieu of double-walled steel. | *Less expensive than steel versions. Lighter in weight and not subject to corrosion.*

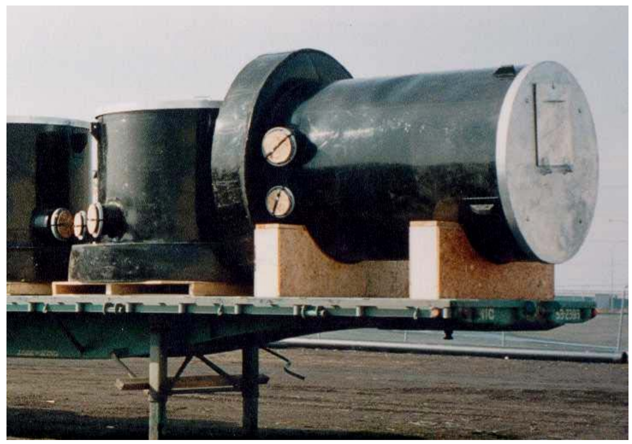

Figure 5.6 - HDPE Access Vaults

5.4 STRUCTURAL DESIGN

Regardless of the vault type selected, the designer must ensure that the vault will have sufficient strength to withstand the loadings that will be imposed on it.

5.5 ACCESS VAULT/MANHOLE LOCATION

Access vaults and manholes are normally installed at locations where they are required for system maintenance.

Recommendation	*Rationale*
5.5.1 Sanitary and Storm Sewers Access Vaults/Manholes	
Recommended at pipe intersections.	*To allow access for maintenance.*
Recommended at locations of pipe grade changes.	*Grade changes can result in solids deposition requiring cleaning.*
Recommended at bends in pipe alignment.	*Bends are difficult to traverse with sewer rods and cleaning and thawing equipment.*

5.5.2 Water Access Vaults/Manholes

Recommended at pipe intersections.	*To allow access to water valves.*
Recommended at watermain high points.	*To allow release of air from mains via installed valves.*
Recommended at watermain low points.	*To allow draining of the mains to prevent freezing.*
Recommended at fire hydrants where direct bury hydrants are not utilized.	*To allow access to valving and below-grade portion of the hydrants.*

5.5.3 Spacing

Sewer manholes and/or access vaults are generally spaced no more than 100 m apart for 150 to 450 mm mains or 150 m for mains over 450 mm.	*The maximum spacing is determined by the maximum length that the thawing machines, sewer cleaning and/or rodding apparatus available in the community can accommodate.*

5.6 ACCESS VAULT BEDDING

All vaults, regardless of type, require a well compacted base to support the structure.

<u>Recommendation</u>	<u>*Rationale*</u>

5.6.1 Bedding

A 300 mm minimum thickness of bedding material is recommended, compacted to a minimum of 95% Standard Proctor.	*To provide a uniform load-bearing surface. (See Section 3.7 for bedding types.)* *Note: Board insulation may be placed above the bedding to insulate the access vault base. Designers must determine the proper insulation strength for the application.*

5.7 PREVENTION OF FROST-JACKING

During ground freezing, substantial vertical forces can be applied to the access vaults or manholes in a phenomenon called frost-jacking. In simple terms, moist frost-susceptible soils expand as they freeze, the soil can only expand upwards, and any structures in the freezing layer are subjected to this upward force.

<u>Recommendation</u>	<u>*Rationale*</u>

5.7.1 Granular Backfill

Granular backfill is recommended for 1.0 m around the access vault/manhole.	*Granular backfill is non-frost-susceptible.*

5.7.2 Wrapping

Concrete manholes and access vaults should be wrapped with tar paper and two layers of 10 mil polyethylene.	*The wrapping prevents the backfill freezing to the rough concrete surface and provides a 'slip plane'.*

5.8 PREVENTION OF FLOATATION

Access vaults or manholes are subject to floatation forces when the groundwater table is above the base of the access vault or manhole.

<u>Recommendation</u> *<u>Rationale</u>*

5.8.1 Base Extensions

Base extensions are recommended.	*Extending the base mobilizes the weight of backfill material to resist floatation. Calculations are required on each project to determine the extent of the base extension required.*

5.9 PREVENTION OF GROUNDWATER INFILTRATION

Regardless of vault types, groundwater should be prevented from entering a manhole or access vault. Such entry adds to the volume of sewage to be handled by mains, lift stations and sewage treatment facilities. In water access vaults, groundwater prevents ready access to the valves in an emergency. Further, flooded access vaults containing both water and sanitary sewer piping pose a higher risk of cross-contamination of the water pipe.

Modifications to existing access vaults are challenging to design, and can result in leakage.

<u>Recommendation</u> *<u>Rationale</u>*

5.9.1 Pre-cast Concrete Barrels

A Ram-Neck™ gasket is recommended between barrels.	*Gaskets are more leak proof than simple mortared joints.*
Lower benching concrete should extend at least 150 mm below pipes and above all pipes entering manhole.	*To provide strength and sufficient concrete to deter leakage.*
The exterior benching/barrel interface should be beveled and mastic filled.	*To limit groundwater path at the interface.*

5.9.2 Cast-In-Place Concrete

Steel pipes penetrating walls should have 150 mm wide puddle flanges at mid-wall.	*Increases flow path and reduces leakage. (See Figure 5.7 – Puddle Flange.)*

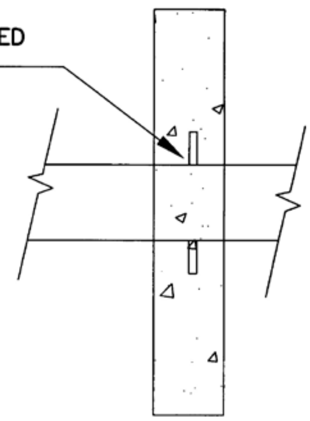

Figure 5.7 - Puddle Flange

All concrete joints should be keyed and have waterstop installed.

Reduces infiltration potential.

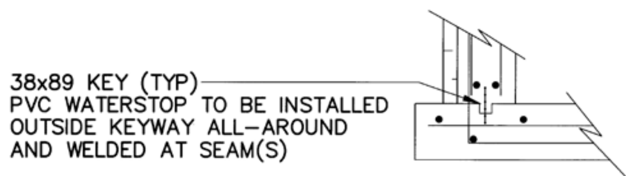

Figure 5.8 - Waterstop and Key

5.9.3 Double-Walled Access Vaults – Steel and HDPE

All joints should be welded.

Provides leak-free joints.

All pipe entry to access vaults should be welded to walls.

Provides leak-free joints.

5.9.4 Gasketed Pipe Entries

The use of Link-Seal™ or similar sealant methods where pipes pass through vault walls is not recommended.

Over time, ground movement often results in pipe movement. This stresses the seal and results in leakage.

5.10 MECHANICAL COMPONENTS

Manhole and access vaults provide a means to access sewer and water pipes and appurtenances in a dry environment that is, in some cases, heatable in severe weather conditions. The pipes, valves and fittings in the access vault must also be maintained. Valves, in particular, must be readily removable for replacement.

The manhole or access vault must be sized to accommodate all components and must have a suitable allowance for removal and replacement of components.

Recommendation	*Rationale*
5.10.1 Pre-cast Barrels	
Sanitary sewer and storm sewer pipes should be the same material as the mains.	*Minimizes pipe stock and coupling types in maintenance stock.*
5.10.2 Cast-in-Place Concrete	
Sanitary sewer and storm sewer pipe should be the same type as the mains.	*Minimizes pipe stock and coupling types in maintenance stock.*
Water pipe penetrating through the walls should be epoxy-coated steel.	*To allow welding of puddle flanges to minimize infiltration and to absorb pipe thrust. Epoxy coating minimizes pipe corrosion.*
5.10.3 Double-Walled Steel Access Vaults	
Water and sewer pipes must be steel and be welded to the vault wall.	*Welding is required to prevent groundwater infiltration.*
5.10.4 Double-Walled HDPE Access Vaults	
Water and sewer pipes through the wall must be HDPE.	*Pipes must be welded to the walls to prevent groundwater infiltration.*
5.10.5 Fittings in Access Vaults	
Fittings inside water vaults should be grooved and coupled. (Victaulic™, Couplox™, etc.)	*Pipes can be disassembled and replaced as required. With flanged fittings, it is very difficult to remove one fitting and then replace it with new gaskets.*
5.10.6 Sewer Cleanouts in Access Vaults	
Sewer pipe access (cleanout) in the access vaults must be bolted shut and gasketed.	*To prevent sewage entering the access vault in the event of a sewage backup. Such backups could lead to cross-contamination of water pipes.*

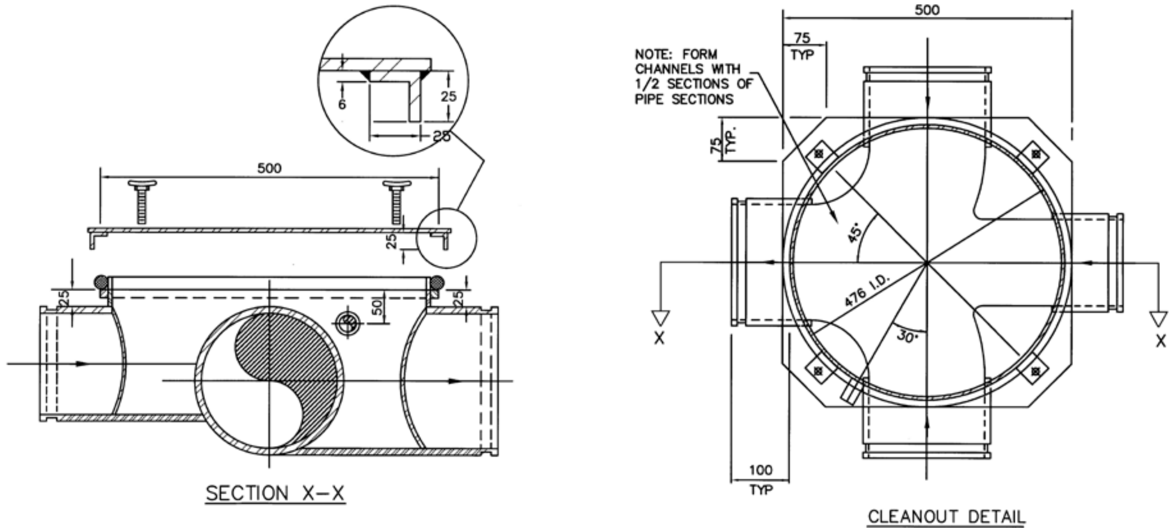

Figure 5.9 - Closed Sewer Cleanout

5.10.7 Water Valves in Access Vaults

Resilient seated gate valves to AWWA specifications are a recommended alternative.

Valves are strong and durable, but require more space than butterfly valves.

Resilient seated butterfly valves are a recommended alternative.

Butterfly valves take up less space than gate valves.

.1 Lug body valves only should be used.

Piping can be removed from one side of the valve while maintaining pressure on the other side.

.2 Geared operators should be used on 150 mm and larger valves.

Considerable torque is required to activate valves under high main pressures.

5.10.8 Drain Valves

Drain valves are recommended on all water pipes entering vaults.

Provides a means to remove water from lines for maintenance or in an emergency drain.

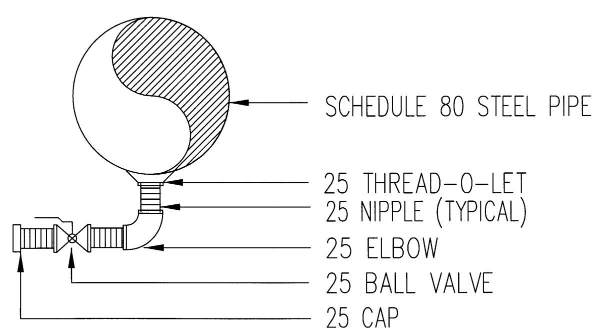

Figure 5.10 - Drain

5.10.9 Air Release Valves

Manual air release valves are recommended at all mains that slope up to a vault.

Provides a simple means to check for and remove air from a line. (See also 5.10.10.)

5.10.10 45° Valved Nipples (50 mm)

Where access vaults or water manholes are utilized, 45° valved nipples are recommended for use on watermains inside access vaults.

Valved nipples allow manual air release or the insertion of a thawing device. The 45° angle is required to divert the thawing device down the pipe.

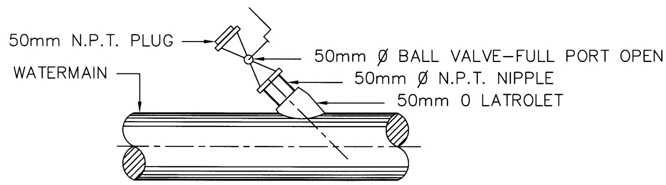

Figure 5.11 - Valve Nipple Schematic

5.11 MARKER POSTS

Marker posts or bollards may be desirable to indicate vault locations and/or to provide a measure of protection from vehicle traffic.

<u>Recommendation</u>	*<u>Rationale</u>*

5.11.1 Location

.1 Marker posts are recommended for steel and HDPE vaults (see drawing TD-3 in Appendix A).	*Vaults are installed with tops 450 mm above grade and are subject to damage if struck by vehicles or snow-clearing equipment.*
.2 Marker posts are recommended adjacent to high risk fire hydrants (see drawing TD-3 in Appendix A).	*To provide protection to the hydrant from vehicles.*

5.12 TESTING

All access vaults and manholes should be tested to ensure that groundwater infiltration is at or below acceptable limits.

<u>Recommendation</u>	*<u>Rationale</u>*

5.12.1 Concrete Manholes

Recommend plugging sewer lines and filling manhole with water for at least two hours. Leakage should not exceed 0.3% of volume per hour.	*Demonstrates effective seal of manhole components.*

In areas of high groundwater, recommend no visible infiltration to manhole.	*Demonstrates effective seal of manhole components.*

5.12.2 Prefabricated Steel or HDPE Access Vaults

Recommend filling access vault shell with water after piping has been welded into place, but prior to placing insulation.	*Any leakage at welded joints can be observed and corrected.*

5.12.3 Water Piping

Recommend testing with mains testing. (See Section 3.11.)	*Any leakage can be observed and corrected.*

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6.0 FIRE PROTECTION

6.1 INTRODUCTION

Fire hydrants are installed on northern piped systems in the same spacing and distribution as on southern systems. Special precautions are required to provide freeze protection. The majority of this section focuses on fire hydrants, though pumps for fire flow in piped distribution systems are also discussed. Water storage for fire protection is discussed in Section 16.

6.2 FIRE HYDRANT TYPES IN USE

There are two types of fire hydrants in use: off-line and in-line.

Off-line hydrants are installed only where the watermains are below the seasonal frost line and not subject to freezing. Off-line hydrants are in use in Fort Smith, Hay River and Fort Simpson. Generally the off-line installation includes a line size by 150 mm tee, 150 mm pipe from the main to the hydrant location, an isolation valve and the hydrant assembly.

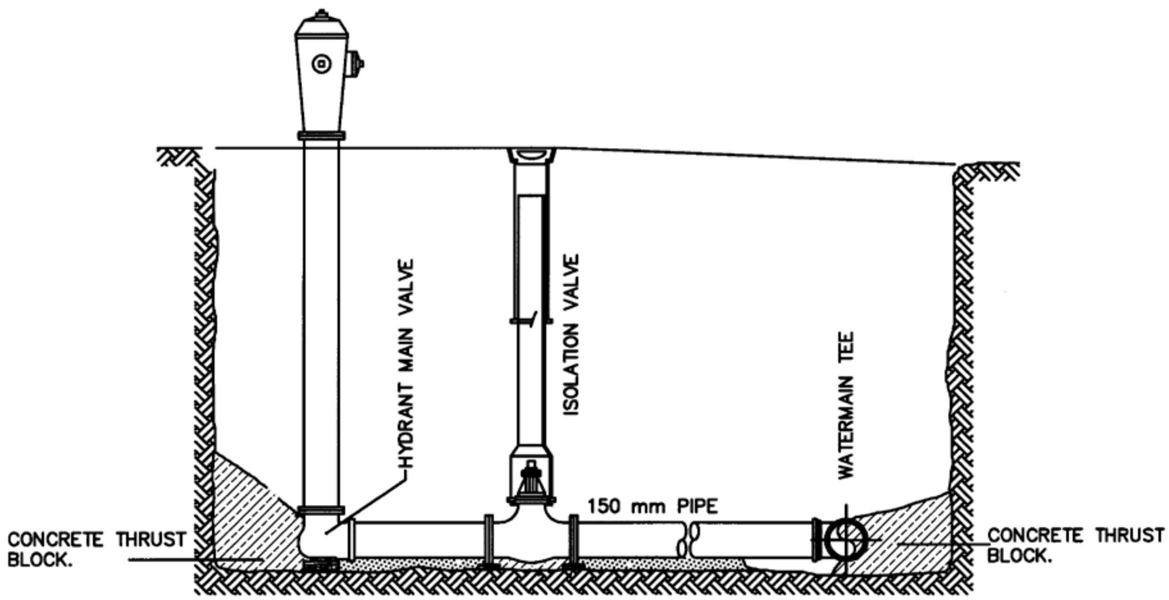

Figure 6.1 - Typical Off-line Hydrant

In-line hydrants have a 150 mm flanged spool piece in place of the conventional hydrant elbow. This allows the hydrant to be mounted directly on a tee on the watermain, so that water circulation through the tee prevents freezing of the hydrant main valve. Variations of in-line hydrants have been either direct buried, on utilidors or installed in access vaults.

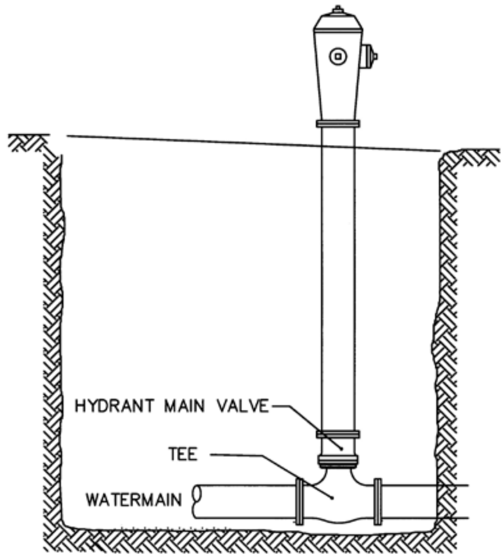

Figure 6.2 - Typical In-line Hydrant

In systems that use access vaults, the fire hydrants are typically installed in the access vaults. This is shown in the GNWT standard drawings for insulated double-walled steel access vaults.

6.3 FLOW REQUIREMENTS

Systems must be designed to provide recommended fire flows at minimum design pressures, while still providing maximum day system demand.

Recommendation	*Rationale*
6.3.1 Residential	
Minimum recommended fire flow for residential areas is 3,600 L/min for 90 minutes.	*Minimum recommended by NWT Technical Committee on Fire Protection, NWT Fire Protection Study, 1993 – Recommendation 12-6.*
6.3.2 Non-residential	
Consultation with the local fire department, Fire Marshal and MACA is recommended prior to selecting design fire flows for non-residential areas.	*Fire protection in remote areas can be challenging and a customized approach may be required.*

6.4 DISTRIBUTION

Fire hydrants should be situated so that they are readily accessible and provide the coverage required for the fire flows anticipated.

Recommendation	*Rationale*
6.4.1 General Guidelines	
.1 Maximum spacing in single family residential areas is 180 m.	*From Water Supply for Public Fire Protection. (Fire Underwriter's Survey).*
.2 Maximum spacing in multiple-family residential areas is 90 m.	*From Water Supply for Public Fire Protection. (Fire Underwriter's Survey).*
.3 Determine average area covered by each hydrant based on fire flow required.	*From Water Supply for Public Fire Protection. (Fire Underwriter's Survey).*
.4 Locate hydrants at roadway intersections.	*For ease of access.*
.5 Locate hydrants at entrance to cul-de-sacs.	*Fire trucks can connect as they enter the cul-de-sac.*
.6 Do not place hydrants on rear lot lines or in lanes.	*Difficult to access.*
.7 Consultation with the community is mandatory.	*Individual communities may have more stringent requirements than published in the standards.*

6.5 FREEZE PROTECTION

Unless the hydrant base can be installed below the frost line, some form of freeze protection is mandatory.

Recommendation	*Rationale*
6.5.1 In-line Hydrants	
In-line hydrants are recommended where the watermains are in the seasonal frost zone.	*Continuous flow through the watermains prevents freezing.*
6.5.2 Draining	
.1 Hydrant drain holes must be plugged in areas of high groundwater. (Direct bury hydrants only.)	*Groundwater will enter the hydrant barrel and freeze.*
.2 Hydrants with plugged drain holes must be pumped out after each use and propylene glycol added to the hydrant.	*If hydrants are not pumped out, the barrel will freeze. Antifreeze is required as all of the water cannot be removed. Non-toxic propylene glycol antifreeze is essential as the antifreeze can enter the main if pressure is lost and the hydrant is opened.*
.3 Hydrants in access vaults and manholes should have the drain holes open.	*Water in the barrel can drain into the vault after hydrant use. Water should be pumped out of the vault after use.*

6.5.3 Nipples

The length of nipples between the tee and hydrant main valve should be minimized.

Any lateral piping, where flow is not maintained, must be as short as possible to reduce the risk of freezing in the non-flowing piping.

6.6 ISOLATION

Valves are required to isolate the hydrant from the system for maintenance. For the majority of northern systems, the removal of a hydrant from service must not interfere with the circulation in the watermain system, or freezing of mains can occur.

Recommendation — *Rationale*

6.6.1 Direct Bury Hydrants

For direct bury hydrants in the seasonal frost zone, a three-valve arrangement is recommended.

Hydrant can be valved out of service without interrupting system flow. (Used in previous years in Yellowknife.)

6.6.2 Hydrants in Access Vaults

Fire hydrants in vaults should utilize a three-valve arrangement (Yellowknife standard) or a single isolation valve immediately below the hydrant main valve (GNWT standard).

Hydrant can be valved out of service without interrupting system flow.

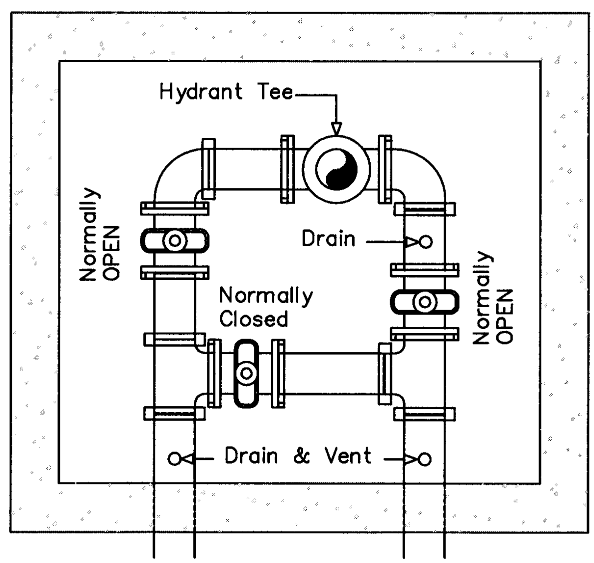

Figure 6.3 - Typical Three-Valve Assembly

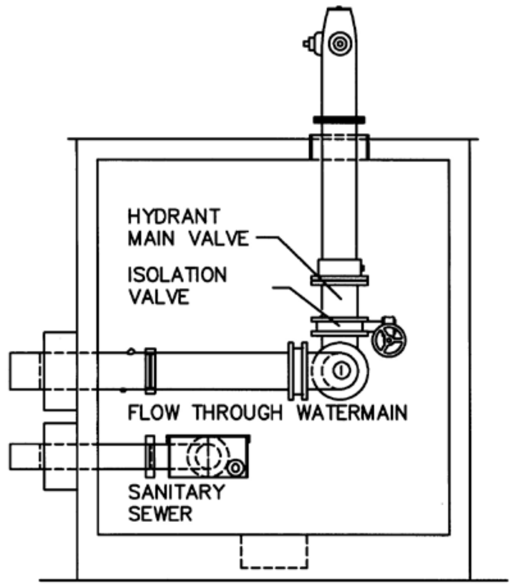

Figure 6.4 - Single Isolation Valve on Hydrant

6.6.3 Utilidors

Fire hydrants on utilidors should have a valve immediately before the Siamese hydrant.

Hydrant can be valved out of service without interrupting system flow.

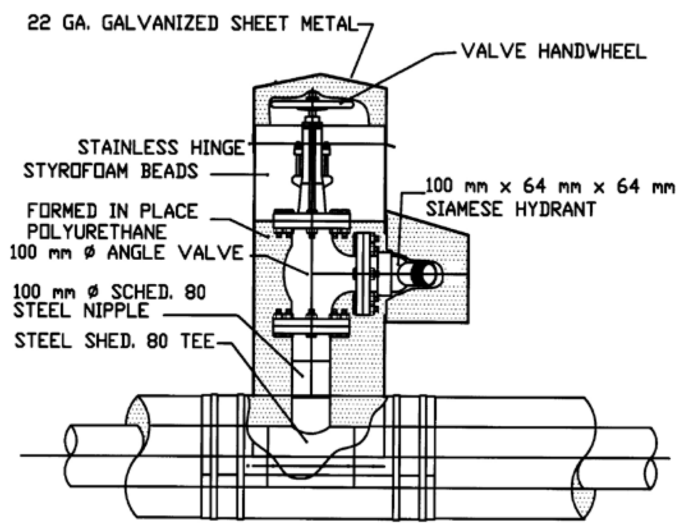

Figure 6.5 - Typical Utilidor Hydrant

6.7 OUTLETS

The outlets provided on the hydrant are utilized for connection of fire hoses and for suction hose connections for pumper trucks.

Recommendation	*Rationale*
6.7.1 Outlets	
.1 The outlet thread provided must be confirmed with the community fire department.	*Different communities use different threads on hydrant outlets.*
.2 Hydrants should have two 65 mm outlets (confirm with community).	*From Water Supply for Public Fire Protection (Fire Underwriter's Survey).*
.3 Hydrants should have a pumper connection to community size and thread standards.	*To allow connection of a pumper truck.*

6.8 CONSISTENCY

To the extent possible, hydrants should be consistent throughout the community.

Recommendation	*Rationale*
6.8.1 Miscellaneous	
.1 The community must be consulted prior to specifying fire hydrants.	*Most communities have standardized on a make and model of hydrant to minimize inventory requirements of spare parts.*
.2 All hydrants should open in the same direction.	*To avoid confusion and errors.*
.3 Threads provided must match existing.	*To allow connection by standard hose couplings.*

6.9 WATER STORAGE FOR FIRE PROTECTION

See Section 16.7 for piped systems and Section 16.8 for trucked systems.

6.10 PIPED SYSTEM PUMPS FOR FIRE FLOW

Dedicated pumps for fire flow are utilized on piped systems only. Trucked systems rely on the normally used truckfill pumps.

Recommendation	*Rationale*
6.10.1 Flow Rates	
Recommend initial fire flow rates be determined from "Water Supply for Public Fire Protection" as published by Fire Underwriter's Survey.	*Recognized standard for fire protection.*
Recommend pump(s) be capable of delivering design fire flow plus maximum day demand.	*Recommended by Fire Underwriters.*
6.10.2 UL/FM-Rated Fire Pump	
Recommend owner or operating agency be consulted in regard to selecting a UL/FM-rated fire pump.	*Many municipalities elect to provide fire flow without using UL/FM-rated pumps.*
6.10.3 Number of Pumps	
Recommend more than two pumps only if system serves over 25,000 people.	*As recommended by Fire Underwriters.*

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7.0 INTAKES

7.1 INTAKE TYPES

An intake system can take many forms. In northern Canada, a simple inclined shaft system was developed and refined, and has been successful. While the inclined shaft is the predominant intake system for municipal water supplies, other forms of intakes, such as wetwells with gravity intake lines, are also in use.

7.1.1 Inclined Shaft Intake

Casing Pipe	*Pipe which contains the intake pump and discharge pipe. Usually insulated and jacketed to 1m below maximum ice depth. Typically 300 – 350 mm in diameter. Terminates in a fish screen. Other end terminates just inside the water plant.*
Discharge Pipe	*Pipe attached to the intake pump inside the casing pipe. Water drawn in by the intake pump flows through the discharge pipe. Not insulated. Typically 75 – 100 mm in diameter.*

In an inclined shaft intake, an insulated casing pipe (typ. 300-350mm in diameter plus 50mm of polyurethane insulation) extends from the water treatment plant or storage tank into the water source. The casing pipe terminates in a fish screen that meets the Department of Fisheries and Oceans requirements for intakes. A submersible well pump and discharge pipe along with electric heat trace in copper conduits are inserted into the casing pipe just far enough that the pump is safely below the maximum depth of ice in the water source. This ensures that the pump is in water that never freezes. The check valve is normally removed from the pump, allowing the discharge pipe to drain after use so that the heat trace only needs to prevent freezing in the portion of the pipe passing through the ice. All piping is typically HDPE.

This design has been used and refined over many years across the North. In most cases, it is simple to construct and works well. The pump and discharge pipe can be pulled out of the casing for repairs without assistance from divers or specialized trades.

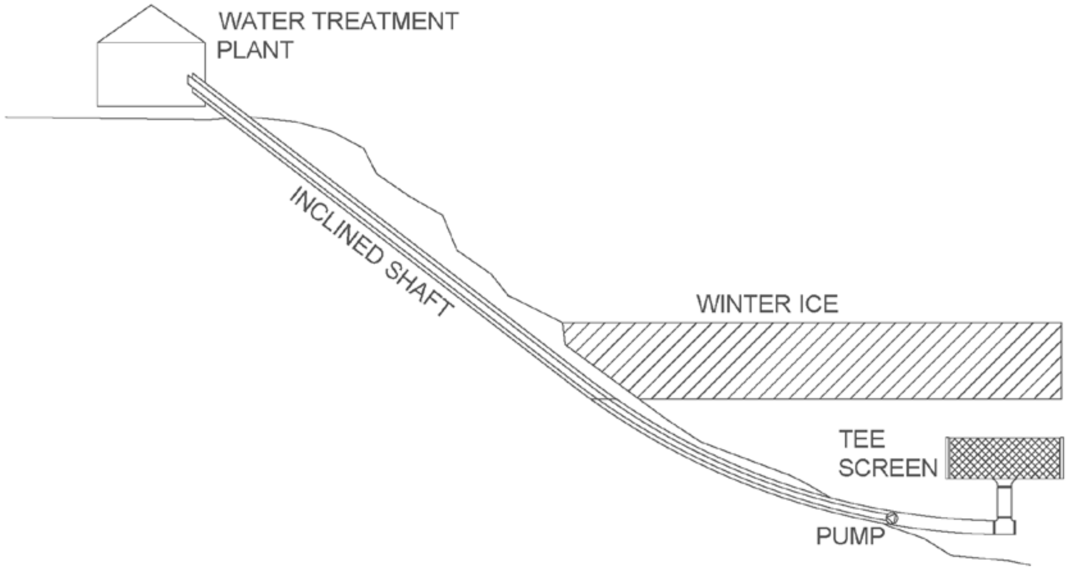

Figure 7.1 - Typical Inclined Shaft Intake

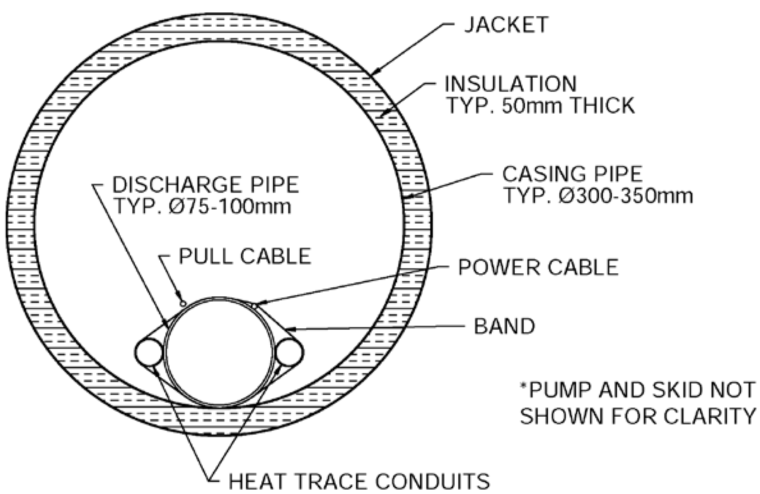

Figure 7.2 - Typical Inclined Shaft Intake Cross-Section

<u>Recommendation</u>	*<u>Rationale</u>*
Recommend inclined shaft intake be the first choice where practical.	*Proven design in the north. Normally simple to operate and has a low cost of installation. Contractors and workers are generally familiar with these systems.*

7.1.2 Wet Well Intake

Wet well intakes consist of a vertical well connected to a screened intake in the water source. The well is filled by gravity flow from the intake, and water is drawn from the well to the water treatment plant or storage tank using a submersible well pump, similar to the inclined shaft intake in Section 7.1.1. The pump can be pulled vertically out of the wet well for repairs.

This intake style is useful in locations where inclined shaft intakes tend to be damaged by river and ice action, as it is less exposed. Care should be taken in siting the wet well to ensure that river ice does not pile up on top of it, preventing access to the pump during the winter.

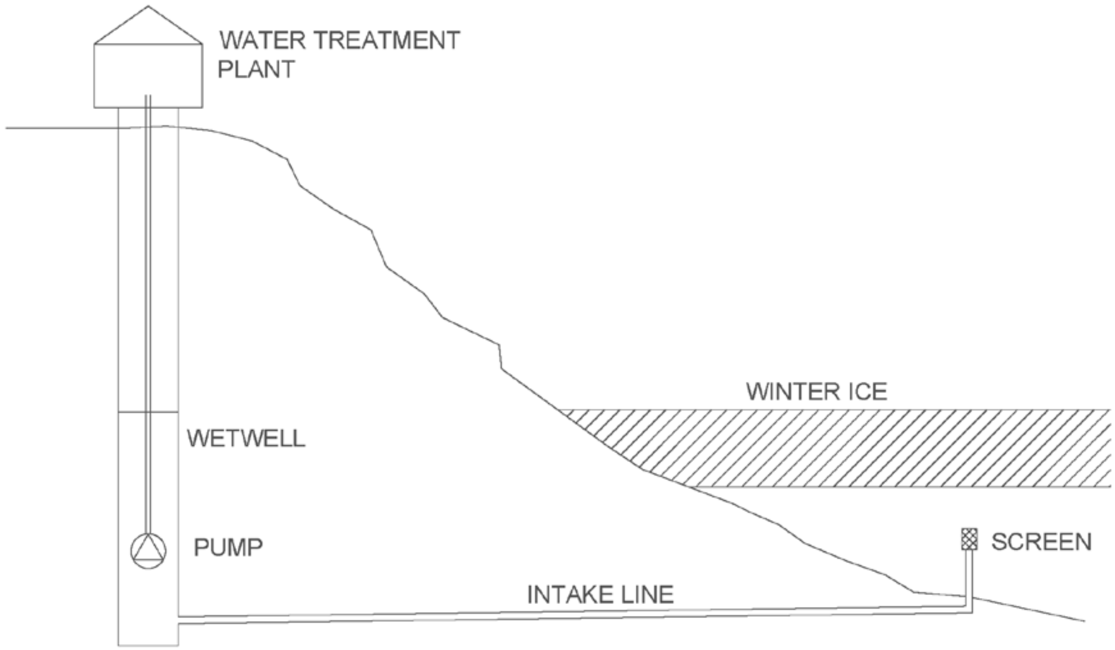

Figure 7.3 - Typical Wetwell Intake

Recommendation	*Rationale*
Recommend where inclined shaft intakes are not practical due to mechanical damage concerns.	*Minimizes intake exposure to ice and boulders.*
Ensure wetwell is accessible year-round.	*Buildup of ice pushed ashore by river currents can render wetwells inaccessible for several months at a time, which means the pumps cannot be accessed for repairs.*

7.1.3 Infiltration Galleries

Infiltration galleries may be an option for locations where the intake pipe needs to be buried for protection.	*Infiltration galleries tend to be prone to plugging up due to silt, but may be suitable depending on conditions.*

7.1.4 Temporary and Seasonal Surface Intakes

Recommend using surface intakes that can be removed from the water after use for seasonal reservoir fills or other temporary uses.	*Intakes for short term, emergency, or seasonal use do not require permanent structures and are cheaper to build. They are removed from the water during freeze-up and break-up. Surface intakes can be floating or installed through the ice in winter.*
For winter use of surface intakes, recommend an insulated shack with heating.	*Some heat is needed to keep the hole in the ice from freezing over.*
For intakes that will be used off and on throughout the year, recommend an analysis of the lifecycle costs of a permanent intake vs repeatedly setting up a temporary intake.	*Temporary intakes can take considerable labour to deploy and remove. Depending on the site conditions and the frequency of use, it may or may not be preferable to move to a permanent intake.*

7.2 MATERIALS

Materials for northern intakes need to function well in extreme winter temperatures. Preferably, they should be easy to repair or replace without expert assistance.

Recommendation	*Rationale*

7.2.1 Concrete Structures

Recommend avoiding use of cast-in-place structural concrete in isolated communities.	*Generally good quality aggregate or aggregate of proper dimensions is not available.*

7.2.2 Casing Pipe

Recommend insulation of casing pipe for all areas above the level of lowest ice formation.	*Minimizes heat loss from the casing pipe.*
Recommend insulation and heat trace do not continue more than 1m vertically past the level of lowest ice formation.	*Insulation beyond this point is not thermally useful, and makes the pipe more buoyant, requiring heavier weights to hold it down and increasing the chances of a floating intake.*
Recommend use of high density polyethylene (HDPE) as a casing pipe.	*Eliminates corrosion potential. Can be field bent as required to follow intake grades.*
Recommend choosing a pipe strong enough to withstand soil, ice, and construction loads.	*Although the casing is not a pressure pipe, it needs to withstand the loads from being buried in soil or ice, as well as other loads that may occur during construction, without being crushed.*

Consider removal of fusion beads from inside of casing pipe.

Prevents pump skid from catching on fusion beads. Not necessary in all installations, but may be helpful in some situations, such as long intakes where it is more difficult to slide the pump back down the casing.

7.2.3 Securing Heat Trace and Cables to Discharge Pipe

Recommend stainless steel bands or heat shrink wrap instead of tape when needed to secure heat trace, power cables, or other items to the discharge pipe.

Most types of tape eventually fall off in cold, wet conditions and get pulled into the intake pump causing damage or plugging the intake. Ensure that the chosen product is abrasion-resistant and has a reasonably smooth outer surface to avoid interfering with sliding the discharge pipe into the casing pipe.

Figure 7.4 - Intake Pump With Tape

Ensure bands are a large enough size to fit around the cables, heat trace conduits, and, where applicable, insulation.

Specifying the band size matching the pipe size results in the bands being too short to fit.

Do not secure pull cable to discharge pipe.

Pulling on the cable will break the bands. Cable should be attached only to the pump skid.

7.2.4 Submersible Pump

Recommend submersible pumps of appropriate size be installed to below the level of maximum ice formation.

Submersible pumps operate well in inclined shafts. The pump must be below the level of ice formation to prevent damage if the intake freezes.

Recommend no check valve be installed at the pump, where possible.

Allows the discharge pipe to drain after a truck-loading operation to prevent freezing of the intake and truckfill pipes. Even if the pumps have been ordered without check valves, they are sometimes received with check valves. Verifying this before installation avoids having to immediately pull the pump, or having the intake freeze in the first winter because the mistake went unnoticed.

	Draining the intake is the preferred method to avoid freezing. Some designs may require the intake to be kept primed. An air release valve may be needed for some designs.
Recommend pump be locked out while intake is draining back.	*Prevents damage to pumps from starting them while they are spinning backward as the intake drains. This is generally only an issue when filling two trucks back-to-back.*

7.2.5 Discharge Pipe

Recommend the discharge pipe from the pump to the treatment plant be HDPE.	*Eliminates corrosion potential. Generally does not rupture if frozen.*

7.2.6 Electric Heat Trace

Recommend two heat trace per casing pipe be installed - one duty, one standby.	*Should one heat trace fail, the backup unit can be used to prevent freezing. Thawing an intake takes considerably more power than keeping it from freezing. Two heat traces running at the same time can reduce thawing time.*
Recommend a controller be utilized to maintain the casing pipe temperature.	*Minimizes energy costs.*
Recommend controller include high temperature shut-down feature.	*Heat trace may cause overheating to the point of intake damage.*
Recommend heat trace be installed in watertight metal tubes.	*Metal tubing ensures ready transfer of heat to the water/ice in the casing pipe.*
Recommend heat trace be approved for use in wet conditions.	*Intake heat trace is likely to be exposed to water.*

7.2.7 Pump Skid

Recommend the pump be mounted on a skid with smooth, non-corrosive runners.	*Prevents the pump from catching on the casing pipe joints.*
Ensure that the skid provides sufficient clearance between the casing pipe and all flanges or other protruding components.	*Prevents gouging casing pipe during pump removal or insertion.*

Figure 7.5 - Flange Gouging Casing Pipe

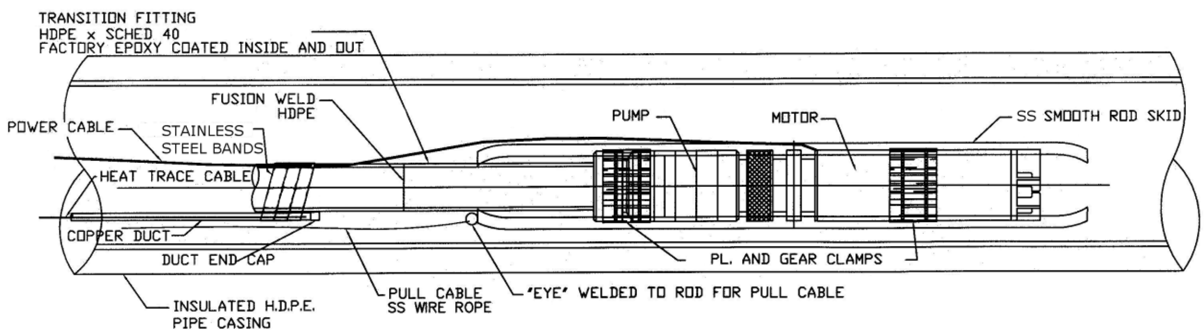

Figure 7.6 - Typical Submersible Pump in a Casing Pipe

7.2.8 Pull Cable

Recommend an aircraft grade stainless steel cable be attached to the pump skid for removal purposes.

Pulling directly on the HDPE discharge pipe can result in breakage. The pull cable should not be attached to the discharge pipe, only to the skid.

Recommend cable clips be installed with U-bolt over dead end of cable and saddle on live end and tightened according to manufacturer's instructions.

Clips are ineffective if they are installed backwards, leading to the cable disconnecting from the pump skid when pulled.

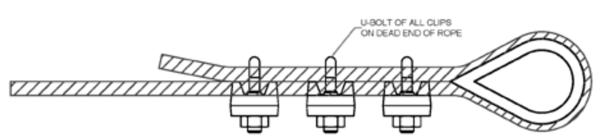

Figure 7.7 - Cable Clip Installation

Recommend bitter end be cut short to avoid catching on casing pipe fusion beads, where applicable.	*Prevents catching on fusion beads when pump is sliding through casing pipe.*

7.2.9 Intake Screens

Recommend stainless steel screens.	*Minimizes corrosion.*
Size screens based on Department of Fisheries and Oceans *Freshwater Intake End-of-Pipe Fish Screen Guideline*.	*Legislative requirement.*
Consider sizing screen to allow for blockage by sediment over time.	*In source water with a high sediment load, screens may become gradually blocked. Consider a larger screen to keep the approach velocity within Department of Fisheries and Oceans guidelines between screen cleanings.*

7.2.10 Pipe Weights

Recommend pipe buoyancy calculations include insulation and air volume when designing weights.	*Insulation and air add significantly to the buoyancy of the pipe.*
Recommend precast concrete weights to hold down intakes.	*Strong material, resistant to mechanical damage. Better quality control than site-mixed concrete.*
Recommend geotextile saddlebag weights as an alternative to concrete weights.	*Lightweight and compact for shipping. Can be filled onsite using local labour. Ensure a source of suitable granular fill is available prior to specifying; shipping in granular material for this purpose is impractical. Note that saddlebag weights can be challenging to install in the winter and are more prone to mechanical damage while in service.*
The use of loose granular material (sand, gravel, 50 mm minus, etc.) to hold down intakes is not recommended.	*Insulated HDPE floats easily. Gravel can shift over time, particularly in rivers, and allow the intake to float.*
Recommend checking floatation forces on shallow-buried sections of casing pipe near shore and providing weights where needed.	*The weight of cover material may be insufficient to prevent insulated HDPE from floating in saturated soils. Over time, backfill tends to flow around the pipe due to pump vibration and cannot prevent floatation.*

7.3 SITING AND DESIGN

Intakes should be sited to avoid mechanical damage and siltation.

Recommendation	*Rationale*
7.3.1 In-River Work	
Gather local knowledge and talk with experienced divers prior to planning work in rivers.	*In some rivers, visibility for divers can be zero due to turbidity. According to experienced divers, some NWT river locations are not suitable for diving due to dangerous conditions. Banks are unstable in some areas.*
7.3.2 Intake Protection	
Recommend considering the need for protection from boulders and ice damage as well as wave and river action during siting and design.	*Spring breakup of river ice in some locations can drag blocks of ice along the river bottom, damaging intakes located on the river bed, or even buried in the river bed.*
7.3.3 Intake Length	
Recommend keeping intakes as short as practical.	*Long intakes are more exposed to freezing conditions and damage.* *Considerably more labour is involved in pulling and reinstalling pumps in a longer intake.*
7.3.4 Intake Screens	
Recommend screens be a minimum of 1.0 m above the bottom of the river or lake.	*Clearance from the bottom is required to avoid the intake of bottom sediment. Sediment can plug the intake screen and allow the intake pump to draw the casing pipe dry; the buoyancy of the air-filled casing pipe may then exceed the ability of the pipe weights to prevent floatation.*
Recommend screens be a minimum of 1.0 m below the maximum winter ice cover.	*To prevent ice damage, and minimize frazil ice buildup.*
Recommend the lowest water level of the source be determined.	*Lake or river levels can vary substantially.*
7.3.5 Number of Intakes	
Recommend choosing single or dual intakes based on site conditions.	*Historically, dual intakes have been recommended. The GNWT has found that in most cases a single intake with a spare pump on hand is adequate. Dual intakes may be justified in some cases, for example where the intake is particularly vulnerable or difficult to access for repairs, or where frequent pump breakdowns are anticipated (such as for sources with high sediment load). In these cases, it is preferable to be able to switch to another intake and complete repairs at a convenient time.*

	Fire protection requirements should be taken into account; for example, a second intake may be justified for a system that does not have fire storage.
Recommend a fire flow bypass within the plant if fire flow is to be drawn directly from the source.	*Less expensive than a dedicated fire intake (also see below). If the treatment system throughput rate does not meet the required fire flow rate and fire storage is not provided, it is recommended that the design allow the treatment system to be bypassed (with the exception of chlorination) in an emergency so water can be drawn directly from the intake to the truckfill. Also see Section 16.8.1.*
Dedicated fire intakes are not recommended.	*Separate fire intakes that are rarely used may not be maintained and failures may only be discovered in an emergency situation. If two intakes are installed, they should be alternated in service.*
If two intakes are installed, recommend truck drivers have the ability to switch to the second intake.	*Valuable time can be lost in a fire situation if an operator must be found before a switch to the second intake can be made.*

7.3.6 Casing Pipe and Intake Screen Cleaning

If intake screen cleaning is expected to be frequent, recommend airburst system.	*Clears screen more effectively than using the intake pumps to backwash, and can be helpful if the screen is expected to plug up, for example due to sediment in the source water. The air burst system should be piped to the screen to avoid filling the casing pipe with air and causing floatation.*
Casing backwash systems using the intake pumps are not recommended.	*Achieving scouring velocity in a 300 – 350 mm pipe takes larger pumps than the intakes are normally equipped with. Using the intake pumps for backwash is not effective in clearing debris or sediment from the casing.*

7.3.7 Intake Installation

For summer construction, recommend installation using the “float-and-sink” method, where practical.	*Refer to Chapter 10 of the Handbook of PE Pipe published by the Plastics Pipe Institute for information on marine installation of PE pipe. Note that insulation adds considerable buoyancy that is not accounted for in the Handbook.*

For winter construction, recommend using the ice as a working platform where practical.	*The ice provides a large, stable working platform for construction and diving work, eliminating the need for a boat or barge. Ice conditions should be checked carefully prior to starting work; localized thin or weak areas can be present even when most of the ice is solidly frozen. The GNWT Department of Infrastructure publication "Guidelines For Safe Ice Construction" outlines some of the recommended safety practices for working on ice.*

7.4 SELF-DRAINING CAPABILITY

In the life of a facility, it is quite probable that heat will be lost. To the extent possible, all water piping should drain, when not in use, to minimize freeze damage potential.

Recommendation	*Rationale*
7.4.1 Check Valves	
Recommend check valves not be used unless required for system functioning.	*Allows piping to drain when not in use.*
7.4.2 Pipe Grading	
Recommend piping be graded to drain.	*Allows piping to drain when not in use.*
7.4.3 Drain Valves	
Recommend solenoid drain valves be used on trapped low points on piping. Ensure solenoid valves flow water at zero pressure.	*De-energizing solenoids allow(s) draining of pipes when not in use.*
7.4.4 Air/Vacuum Valves	
Recommend use of air release/vacuum release valves when required where some piping cannot be drained.	Allows air release on start-up and air entry when piping drains.

7.4.5 Dual Intakes

Where two intakes are installed, a Tech Taylor® or similar valve is recommended.

Allows two intakes to feed one overhead fill arm while still being self-draining.

Figure 7.8 - Tech Taylor Valve Diagram

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WATER SERVICES

Table of Figures

8.0 WATER SERVICES

8.1 INTRODUCTION

Water services perform the vital function of conveying the water from the mains to the building being served.

See Appendix A for GNWT water and sewer standard drawings.

8.2 MATERIALS IN USE

See Section 3.3.

8.3 DESIGN CRITERIA

Material selection and sizing of services must be done early in the design process.

Recommendation	*Rationale*
8.3.1 Service Sizing	
Recommended minimum single-family service size is 20 mm.	*Smaller sizes, although used in the past, can see substantial pressure drops during water use in the house.*
For Arctic communities, consider minimum 25 mm for single-family service.	*Freeze protection.*
For large buildings, obtain a recommendation on service sizing from the building mechanical design engineer.	*Fixture counts in the building and the need for sprinkler fire protection, if any, must be determined by the building mechanical engineers.*
On large services, recommend return line sizing, including a life-cycle cost analysis.	*On a two-line system, the circulation pump will run continuously for a large part of the year. The designer must determine the most economic combination of pump size and service line size.*
8.3.2 Material Selection	
Recommend obtaining municipal standards prior to material selection.	*Many municipalities have standards regarding service material types and only stock repair pipe and fittings for these types.*
8.3.3 Isolation Valves	
Recommend consulting with municipality prior to specifying isolation valves for services.	*Municipalities may, as is the case in Yellowknife, not require nor desire a surface operator for buried service isolation valves on smaller (50 mm or less) service lines.*

8.4 FREEZE PROTECTION

Any water service, except those installed below the seasonal frost line, must have an active freeze protection mechanism. Reference Section 3.9 for general freeze protection means, including:

- pipe insulation;
- electric heat trace;
- water circulation; and
- 'bleeding water to waste'.

Recommendation	*Rationale*

8.4.1 Aqua-Flo®

Aqua-Flo® units are sometimes used on single service lines.

Aqua-Flo® units require routine maintenance (check valve and orifice wear) and can be quite noisy during operation.

Aqua-Flo® units that are shut off for extended periods may introduce undesirable elements into the water system, if they are not cleaned prior to re-start.

Figure 8.1 – Aqua-Flo® Unit

Recommendation | *Rationale*

8.4.2 Water Circulation

A two-line pump system is recommended.

This system is simple to operate and maintain. Since the smallest commercial pumps generally produce more than sufficient flow, power costs are minimized.

A pit orifice system is not recommended.

The velocity in the watermain must be kept at a relatively high level requiring higher municipal power costs.

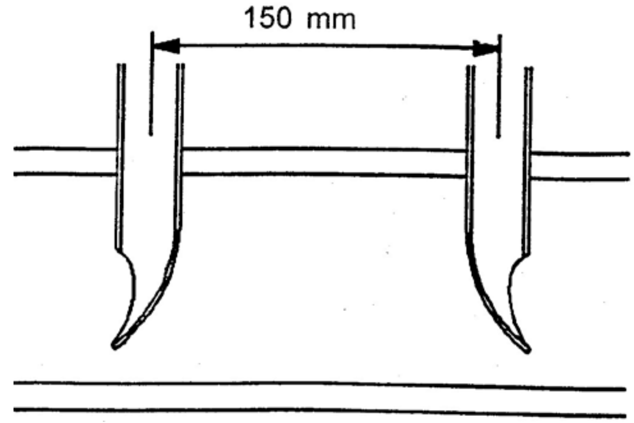

Figure 8.2 - Schematic of Pit Orifices in Main

A two-line (supply/return) watermain system and house orifice is not recommended, except for small systems.

Two watermains are required in the street, raising capital costs.

Orifices wear, reducing available pressure differential.

Homeowners can remove orifices, which severely reduces pressure differential and endangers other services.

Once the system expands past a critical point, there is not effective pressure differential at the end services.

Recommendation | *Rationale*

8.4.3 Service Water Pump

Recommend the pump be as small as possible.

Minimizes building electrical costs.

Figure 8.3 - Typical Circulation Pumps

Recommend pump sizing be calculated on each project.

Pump size must be optimized to service length, size and heat loss.

Recommend pumps be bronze fitted or stainless steel.

Cast iron bodies generally suffer severe corrosion or iron bacteria buildup.

8.4.4 Heat Trace

May be utilized as a secondary freeze protection device.

Circulation pumps generally use less power; heat trace can be activated by a flow switch if flow stops.

See also Section 3.9.

8.5 THAW RECOVERY

Any service installed in permafrost, or in the seasonal frost layer, relies on active freeze protection and, almost inevitably, such active freeze protection will fail. A means must be in place to thaw a frozen water service. Generally, small diameter single family services are much more prone to freezing than larger multi-family or commercial services. Larger insulated services have a much larger time from flow stopping to freezing, and water demand alone may change the water sufficiently to prevent freezing.

Recommendation	*Rationale*

8.5.1 Thaw Pumps

Recommend municipal staff or private contractors have thaw pumps that allow injection of hot water to thaw services.

Municipal staff or private contractors can respond to problems in a timely manner.

8.5.2 Heat Trace

Electric heat trace can, if installed, be utilized to thaw a frozen service. This can, however, be a lengthy process.

Heat trace is generally sized to provide sufficient heat to prevent freezing. Considerably more heat is required to thaw a frozen service.

8.5.3 Electric Welders

Electric welders should never be used to thaw service pipes.

Use of electric welders can cause electrical fires in buildings, often several buildings away from the unit being worked on.

8.5.4 Electric Thaw Devices

Electric thaw devices may be utilized, provided they are built specifically for the purpose and have functioning safeguard controls.

Similar to an electric welder, commercial units have safeguard controls to prevent loss of current and the risk of damage to buildings.

8.6 VALVING, CONNECTION TO MAINS

All service lines, regardless of size, are valved at the connection point to the main. The actual connection means is a function of the pipe type(s) in use in the system.

Recommendation — *Rationale*

8.6.1 Direct Tap Main Stops

Recommend direct tapping of ductile iron or PVC mains when sizes are within manufacturer's recommendations.

Both ductile iron and PVC can be drilled and tapped for direct insertion of a main stop, within size ranges recommended by the pipe manufacturer.

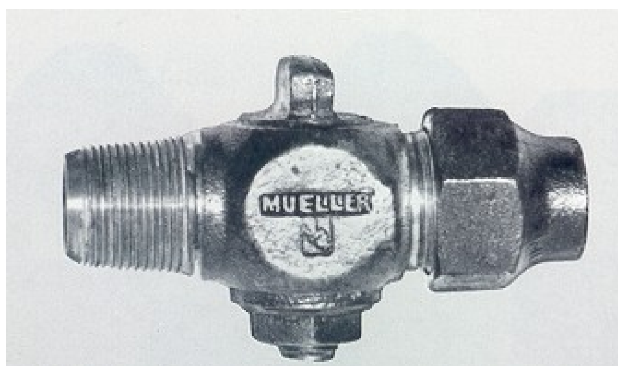

Figure 8.4 - Typical Main Stop

8.6.2 Service Saddles

Recommend use of service saddles for larger direct taps in ductile iron and PVC.

If the service size exceeds the manufacturer's recommendation for a direct tap, there will be insufficient threads in the pipe wall to retain the main stop.

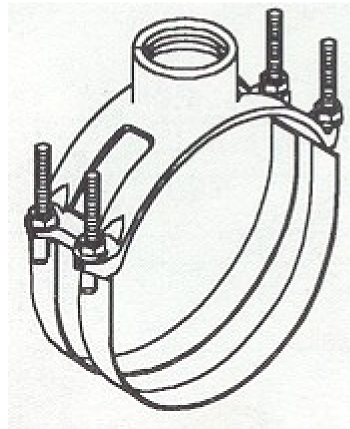

Figure 8.5 - Typical Service Saddle

Recommend use of saddles on HDPE pipe.

Choose saddles specifically designed for use on HDPE pipe.

Recommendation

Rationale

8.6.3 Threadolets

Recommend threadolets be welded to steel pipe for insertion of main stops.

Threadolets are made to be welded directly to steel. Using a threadolet instead of a service saddle minimizes the amount of factory-applied insulation that must be removed. A service saddle requires insulation be removed from the full circumference of the main.

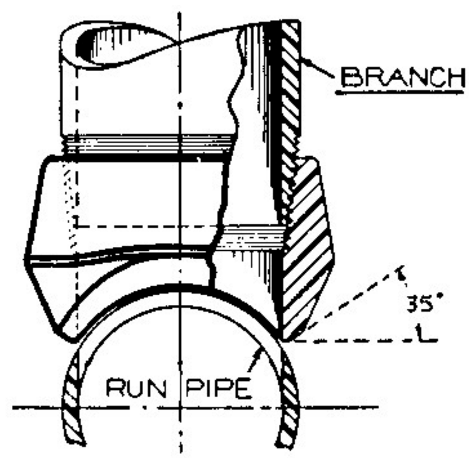

Figure 8.6 - Threadolet

8.6.4 Main Stops

Recommend brass main stops for services 50 mm and less.

Main stops can be closed during service installation or service maintenance.

Recommend AWWA thread (when available) for direct tapped main cocks.	*Provides a tapered thread, which is more effective than straight male iron pipe thread.*
Recommend either AWWA or male iron pipe thread for HDPE service saddles.	*Provide whatever is the municipal standard to minimize need for spares stock.*

8.6.5 Main Stop to Pipe Connections

Recommend compression fittings where service is not subject to potential freezing or pipe is HDPE.	*Compression fittings are readily available.*
Recommend stainless steel inserts in HDPE pipe at compression fittings.	*Stainless steel inserts allow trapping of the HDPE between the insert and compression fitting, providing a better long term seal.*
Recommend flared fittings if copper services are used and may be frozen.	*Freezing action can pull copper pipe from compression fittings.*

8.6.6 Services Over 50 mm

Recommend use of prefabricated tees.	*Main cocks are not generally available over 50 mm.*
Recommend, if acceptable to the municipality, use of gate valve and service box operable at road surface.	*Allows ready access to valve for isolation.*
Alternatively, the service line can be connected at a nearby access vault.	*Connection may be easier at an access vault, depending on the system. This is general practice in Nunavut for services larger than 50mm.*

8.6.7 Goosenecks

Recommend horizontal loop in copper service pipe at main stop connection.	*Allows differential movement of service versus main without stressing copper to main stop connection.*

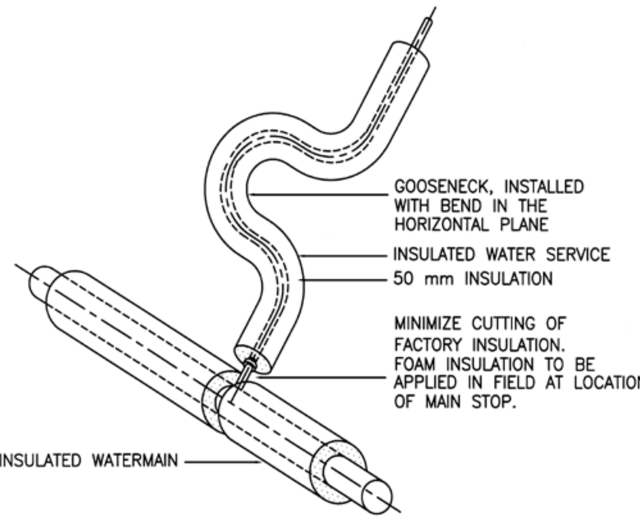

Figure 8.7 - Typical Gooseneck

8.7 CURB STOPS

A separate curb stop and surface actuator are placed at the property line, on a service installed below the frost line, to allow a service to a building to be shut off. Such a shut off may occur during construction, renovation or building damage, or may result from non-payment of utility bills.

Recommendation	*Rationale*
8.7.1 Placement	
Recommend municipal standards be obtained.	*Some municipalities have eliminated the surface-operated curb stop as being too problematic.*
Recommend placement immediately adjacent to main, if used, and if service is subject to freezing.	*The service will freeze if there is any appreciable distance between the main and curb stop.*
Recommend installation that prevents frostjacking of curb stops.	*Some municipalities wrap layers of plastic around the vertical pipe where it is located in seasonally frozen ground.*

8.8 BUILDING CONNECTION

A building connection includes the water service entry, circulation pump, heat trace controller (if used), water meter (if used) and building water connection.

Recommendation	*Rationale*
8.8.1 Isolation Valve	
Recommend each service line entering a building have an isolation valve.	*Provides means to shut off water to building for maintenance of plumbing.*

Recommend isolation valves on both sides of pump and meter.

Allows meter and pump replacement with minimum water spillage.

8.8.2 Sealing

Recommend all pipe entries be insulated and sealed.

For buried services, groundwater must be blocked from entering building.

On above grade entries, pipe entry must be properly weather-sealed to prevent building heat loss.

8.8.3 Circulation Pump Orientation

Recommend pump be oriented so that building demand does not decrease flow through the pump.

If building demand decreases flow through the pump, any flow switches may nuisance-trip.

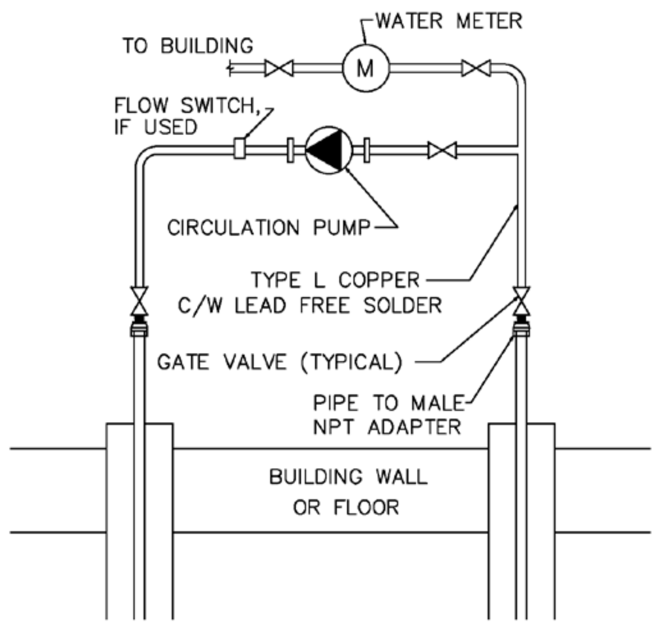

Figure 8.8 - Typical Service in Home

8.8.4 Flow Switch

Recommended if system is to be alarmed or if a back-up heat trace is installed.

Flow switch will activate alarm or heat trace in a low flow condition.

Recommend using flow-switch controlled alarms and/or heat trace only in installations where a high risk of freezing justifies the additional complication.

Flow switch selection can be challenging and there have been issues with switch sensitivity in previous installations.

Recommendation	Rationale
Recommend matching flow switch to system design parameters.	*If flow switch is not properly selected, it may not operate as intended.*

<u>Recommendation</u> *<u>Rationale</u>*

8.8.5 Water Meter

Recommend use of municipality's standard meter.	*Most municipalities have standardized on a specific type of meter and remote reader. Unmetered services are not recommended, as they do not allow for volume accounting.*

8.8.6 Unions

Recommend unions be installed at pump and meter.	*Sufficient unions are required to allow ready replacement of pump and meter.*

8.9 INSTALLATION AND REPLACEMENT

Installation of water service pipes should follow good pipe-laying procedures as outlined in Section 3.7 and be pressure tested as outlined in Section 3.11. Other specific requirements are contained herein.

<u>Recommendation</u> *<u>Rationale</u>*

8.9.1 Depth of Bury

Recommend a minimum of one metre bury for underground water services outside the building footprint.	*Generally ensures work on the lot will not damage the service.* *At one metre depth, the soil temperature adjacent to the pipe is much warmer than winter air temperatures.*

8.9.2 Grade

Recommend water services slope from the main to the building.	*Eliminates potential for trapped air, which can reduce pumping efficiency.*

8.9.3 Uninterrupted Length

Recommend that each service line be one uninterrupted length of pipe or, where this is not possible, a minimum number of joints be used.	*The fewer joints, the less leakage potential.*

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SANITARY SEWER SERVICES

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9.0 SANITARY SEWER SERVICES

9.1 INTRODUCTION

Sanitary sewer services serve to convey sewage from the building to the sewer mains.

See Appendix A for GNWT water and sewer standard drawings.

9.2 MATERIALS IN USE

See Section 3.3. Sanitary sewer service lines are normally HDPE.

9.3 DESIGN CRITERIA

Material selection and sizing of sewer services must be done early in the design process.

Recommendation	*Rationale*
9.3.1 Service Sizing	
Recommended minimum single-family service size is 100 mm.	*Good practice. 100 mm will service the majority of single-family homes.*
Recommend obtaining a size direction from building mechanical engineering designers for large buildings.	*Fixture counts in the building and the National Plumbing Code of Canada will dictate the service size.*
9.3.2 Material Selection	
Recommend obtaining municipal standards prior to material selection.	*Many municipalities have standards regarding service material types and only stock repair pipe and fittings for these types.*
9.3.3 Minimum Grades	
Recommended minimum grade on a 100 mm sewer service is 2%.	*Good practice.*
Minimum grade on services over 100 mm should provide a minimum velocity of 0.75 m/sec when the pipe is flowing full.	*Good practice.*

9.4 INSTALLATION

Installation of buried sewer service pipes should follow good pipe laying procedures as outlined in Section 3.7.

Recommendation | *Rationale*

9.4.1 Depth of Bury

Recommend a minimum of one metre bury for underground sewer services outside the building footprint.

Generally ensures work on the lot will not damage the service. At one metre depth the soil temperature adjacent to the pipe is much warmer than severe air temperature. However, this is a minimum recommendation and one metre of cover is not adequate to prevent freezing in all NWT communities.

9.4.2 Basement Services

Recommend a minimum depth of 2.45 m at property line if homes with basements are contemplated.

A 2.45 m depth will generally allow full gravity service from a home basement.

9.5 MAIN CONNECTION

The means of connection to the main will vary, depending on the pipe materials in use.

Recommendation | *Rationale*

9.5.1 Service Saddles

Recommend use of a service saddle on all 100 mm services.

Provides a leak-free joint between service line and main.

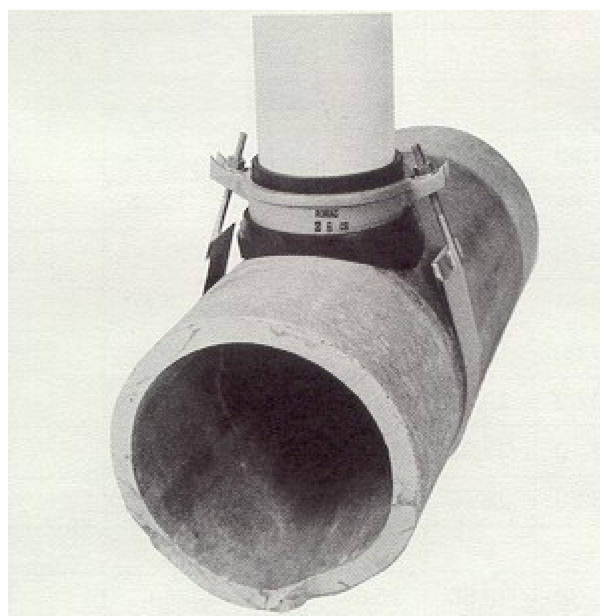

Figure 9.1 - Typical Sewer Saddle

Recommend use of a 150 mm service saddle only if the main sewer is 250 mm or larger.

Pipe wall is weakened if a 150 mm ø opening is cut in a 200 mm diameter (or smaller) pipe wall.

Recommend use of prefabricated "T" where service size is 200 mm or greater.

Commercial saddles generally are not available for services larger than 150 mm.

Recommend opening in main line be cut using a round coring saw.	*Provides the proper round opening.*

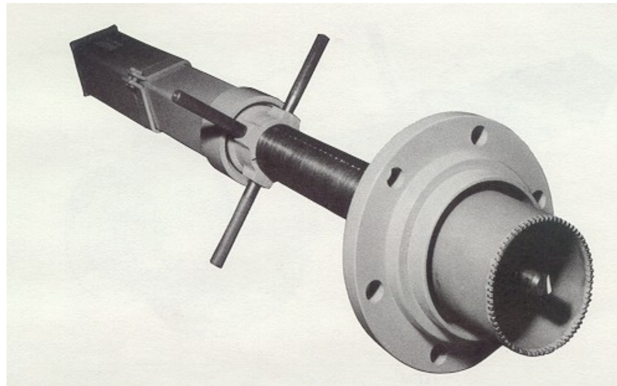

Figure 9.2 - Typical Service Saw

Square cut or rough free hand cut openings are prone to leakage and can accumulate paper and debris leading to blockages.

9.5.2 Service Entry to Main

Recommend connection be at 10:30, 12:00 or 1:30 position on the main.	*Connecting on the upper portion of the main ensures there is no backup of sewage in the service when the main is running near capacity.*
Recommend use of a 45° bend on the service (10:30 or 1:30 connection) or a 90° bend (12:00 connection).	*Realigns sewer service to desired grade.*
	Use of a bend adjacent to the main provides a means to allow some movement of the main relative to the service without failure of the joint.

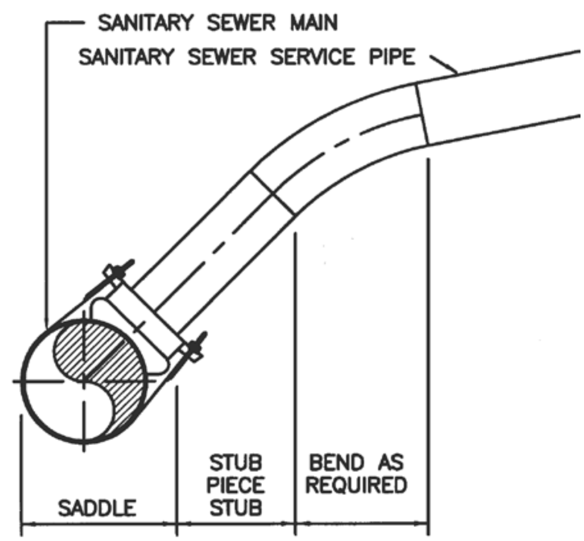

Figure 9.3 - Sanitary Service Entry

9.6 FREEZE PROTECTION

Sanitary sewer services generally convey relatively warm sewage (showers, dish washing, laundry, etc.); however, they are in use on an infrequent basis and may experience no flow for a high percentage of the day. Blockages due to freezing can occur due to wetting during use and subsequent freezing or by frost buildup as warm moist air from the mains is drawn towards building vent stacks and contacts the cold pipe.

Recommendation	*Rationale*
9.6.1 Insulation	
Recommend all above grade sewer service pipes and all service pipes within 1.5 m of ground surface be insulated.	*Minimizes freezing.*
Recommend design calculations be undertaken to determine need for insulation on service pipes with more than 1.5 m of cover.	*Ground temperatures may, at 1.5 m depth or lower, be such that insulation is not warranted.*
Recommend designers determine the insulation thickness required for each project.	*Insulation is expensive and the best cost/benefit should be achieved.*
9.6.2 Heat Trace	
Recommend use only where conditions are such that insulation alone will not prevent freezing.	*Power costs are high and the majority of sewer services do not require active freeze protection.*
9.6.3 Bleeding Water to Waste	
Recommend systems are not designed to use bleeding as a means of freeze-protection.	*'Bleeding to waste' increases water supply costs and sewage treatment/disposal costs and should only be done if unavoidable.*

9.7 THAW RECOVERY

Sewer services can be blocked by freezing.

Recommendation	*Rationale*
9.7.1 Building Sewer Access	
Recommend each building have a sewer cleanout or access point that is accessible and close to the service exit from the building.	*Provides a ready access point to insert steam or hot water thaw devices. Required by National Plumbing Code of Canada.*
9.7.2 Portable Steamers	
Recommended for thawing steel, ductile iron or other non-plastic services.	*Provides relatively quick thawing of a frozen sewer service.*

Recommend local private contractors or municipal staff have portable steamers.

Municipal staff or private contractors can respond to problems in a timely manner.

9.7.3 Portable Hot Water

Recommended for thawing PVC or HDPE services.

Both PVC and HDPE can be damaged by overheating with steam during thawing.

Recommend local private contractors or municipal staff have portable hot water devices.

Municipal staff or private contractors can respond to problems in a timely manner.

9.7.4 Heat Trace

Electric heat trace can, if installed, be utilized to thaw a frozen service. This can, however, be a lengthy process.

Heat trace is generally sized to provide sufficient heat to prevent freezing. Considerably more heat is required to thaw a frozen service.

9.8 BUILDING/PLUMBING CONNECTION

Generally the sewer service is connected outside the building, or beneath the building, using a coupler suitable for joining the pipe types in use.

<u>Recommendation</u> | *<u>Rationale</u>*

9.8.1 HDPE Service – Above Grade Building

Recommend use of connection detail for above grade buildings developed by the GNWT, with due consideration to potential seasonal frost heave.

The GNWT connection detail is both comprehensive and proven, but there may be seasonal frost heave on the vertical riser.

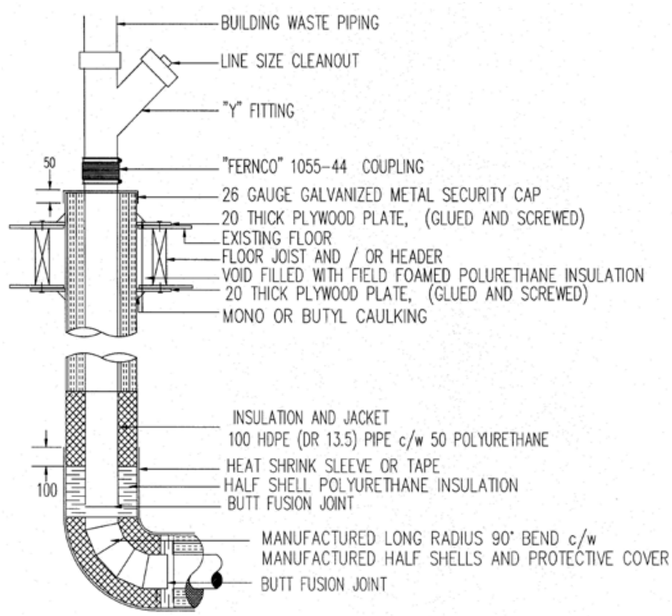

Figure 9.4 - Sewer Service Riser

9.9 SEWER SERVICE PUMPS

Sewer service pumps may be required when gravity service from all or a portion of the building is not possible.

Recommendation	*Rationale*
9.9.1 Pump Use	
Sewage service pumps should only be considered where gravity service is not possible.	*Pumps and starting devices require maintenance. Most homeowners are not equipped or prepared to deal with sewage pumps.*
9.9.2 Sump	
Sewage service pumps require a sump.	*Pumps cannot run continuously; a sump is required to collect sewage prior to periodic pumping.*
Sumps must be sealed during use.	*To prevent sewage gas and odours from entering the home.*
Sumps must have a vent to the house vent stack.	*To allow air to escape as the sump fills and to allow air to re-enter as the sewage is pumped out of the sump.*
9.9.3 High Level Alarm	
An audible and visible high level alarm is recommended.	*Alerts the building occupants of a problem before sewer backup occurs.*

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TRUCKED SERVICES

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10.0 TRUCKED SERVICES

10.1 INTRODUCTION

Due to the high cost of installing and maintaining piped water and sewer systems in the north, the majority of communities in the NWT rely on trucked services.

Truckfill facilities are of two main types:

- dedicated truckfill operations directly from a source or storage tank; or
- truckfill operations from an existing watermain.

10.2 TRUCKED WATER DELIVERY DESIGN CONSIDERATIONS

Recommendation	*Rationale*
10.2.1 Minimum Flow Rate	
A minimum flow rate of 1,000 L/min. is recommended.	*For trucks up to 12,000 L capacity, 1,000 L/min generally provides an acceptable fill time. Also see Section 16.8 for fire flow requirements.* *Per MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993) – see Appendix B.*
A higher flow rate may be desirable with large capacity vehicles.	*If bulk water hauling by larger vehicles is desired, fill rate should be set to allow filling in around 10 minutes to maximize haul efficiency.*
Treatment system throughput rate and/or treated water storage design should allow for filling two trucks within a reasonable time.	*In communities with multiple delivery trucks, it is common for both trucks to arrive around the same time at the start of the delivery day. It is generally more economical to increase throughput rather than storage size.*
10.2.2 Flow Rates - Watermain Feed	
Recommend a system analysis if the truckfill is fed from a piped watermain system.	*The truckfill operation is a large demand on a system which, if not properly designed, will result in large system pressure loss and/or pump requirements.*
Recommend rechlorination at truckfill.	*To ensure sufficient chlorine residual in household tanks.*

10.2.3 Household and Other Building Tanks

Refer to Section 14 *Household and Other Building Storage Tanks* for information on household tanks.

10.2.4 Couplings

Recommend not using a system that relies on hose couplings or similar connections.

Hose couplings are difficult to handle in cold weather and are prone to ice buildup.

10.2.5 Articulating Arms

The use of articulating arms is not recommended.

The seals in the arms freeze when not in use and must be broken free. The useful life of the seals is short.

10.2.6 Overhead Fill Arm

The use of an overhead fill arm connected to an open hatch on the tank is recommended.

Does not require coupling the fill pipe to the tank. Overhead arms are easily graded to promote self-draining.

Recommend an insulated, self-draining truckfill arm with heat trace.

To prevent freezing. Electric heat trace can be activated at the discretion of the operator.

Recommend adjustable two-piece fill hose.

One-piece fill hoses are very stiff when frozen and difficult to maneuver into the tank hatch.

Figure 10.1 – Overhead Fill Arm

Consider implications of spilled water in design.

Ice buildup can be dangerous. Also see Section 13.7.1.

10.2.7 Activation Pushbuttons

Recommend truckfill activation buttons be mounted on the overhead fill arm.

Allows truck operator to start/stop filling operation from the top of the truck.

Figure 10.2 – Truck Filling in Progress

If truckfill activation buttons are mounted on the outside of the truckfill station, recommend a locked panel.	*To prevent vandalism.*
Recommend pushbuttons be rated for -50°C.	*Oil-tight or covered pushbuttons will not operate at extreme temperatures.*
Recommend pushbuttons be useable even if the operator is wearing heavy mitts or gloves.	*Operators must be able to utilize the pushbuttons in extreme weather conditions.*
If a publically-accessed fill point (for RV's, etc) is included, recommend it be a separate system from the municipal fill arm.	*To ensure municipal system is accessible at all times and prevent public access to the municipal and fire flow systems.*

10.2.8 Automatic Shutoff of Truckfill

Timers or flow totalizers can be used for filling trucks.	*Allows truck operator to pre-set fill time or volume and have filling stop automatically, rather than overflowing the truck tank.*

10.2.9 Lighting

Recommend at least one light on the overhead fill arm.	*Operator safety.*

10.2.10 Truck Access

Refer to section 13.7.2.

10.3 TRUCKED SEWAGE COLLECTION DESIGN CONSIDERATIONS

<u>Recommendation</u>	*<u>Rationale</u>*

10.3.1 Truck Unloading Point

Recommend using GNWT detail for sewage truck unloading point.	*Simple, cost-effective design. Detail may be modified for site conditions.*

10.3.2 Household and Other Building Tanks

Refer to Section 14 *Household and Other Building Storage Tanks* for information on household tanks.

10.4 WATER TRUCKS

10.4.1 Water Truck Selection

<u>Recommendation</u>	*<u>Rationale</u>*
Recommend a caged ladder and fall-protection railing.	*Climbing and walking on the truck can lead to serious falls. Trucks are now available with railings that can be easily raised when the operator reaches the top of the truck.*

10.4.2 Cleaning Water Trucks

<u>Recommendation</u>	*<u>Rationale</u>*
Drinking water haul trucks must be cleaned and disinfected at least yearly.	*Ensures contamination is not introduced to treated water during transport.*
Follow the *Instructions for Cleaning and Disinfecting a Water Delivery Truck Tank* document available through MACA or HSS.	*Standard procedure developed specifically for northern communities.*
Ensure water is dechlorinated prior to disposal.	*To avoid environmental impacts from discharge of water with a high concentration of chlorine.*
In addition to annual cleaning, clean and disinfect fittings and hoses whenever they contact the ground.	*Fittings and hoses pick up contaminants if they are dropped or dragged on the ground during use. Contaminants may then be introduced into the water delivered to households or into regulatory samples.*

10.5 SAMPLING AND TESTING

10.5.1 Sampling From Trucks

<u>Recommendation</u>	*<u>Rationale</u>*
Chlorine testing should be done 3 times/day on every delivery day.	*Ensure all water delivered meets the minimum requirements for free chlorine. If fewer than 3 truckloads are delivered, 1 test per truck is sufficient.*

Follow the *Steps to Follow for Chlorine Testing at Truckfill Stations* document available from MACA.	*Standard procedure based on NWT regulatory requirements.*
Recommend obtaining samples from the top hatch rather than the delivery hose, unless otherwise directed by the Environmental Health Officer.	*Delivery hoses are sometimes a source of contamination. Samples taken from the top hatch are usually more representative of the water being produced by the treatment system.*
The minimum acceptable free available chlorine level for truck delivery from plants without storage is 0.4 mg/L after 20 minutes. For plants with storage, or for trucks that have sat full overnight, 0.2 mg/L is acceptable.	*Water that has sat in the truck overnight has had a longer contact time with the chlorine. Plants with storage provide sufficient contact time prior to the truckfill.*
Recommend bacteriological sampling from each truck at least once per month.	*To ensure representative sampling of the water treatment and distribution system.*

10.5.2 Sampling From Buildings

Recommendation	*Rationale*
For bacteriological sampling, recommend sampling at public buildings rather than private homes.	*Tank cleaning at private homes is the responsibility of the homeowner and the person taking the samples is usually not aware of the condition of the tank. A dirty tank can lead to positive bacteriological tests that are not representative of the quality of the water being delivered.*
Recommend disinfecting tap prior to taking samples.	*The tap can be a source of contamination and can lead to positive bacteriological tests that are not representative of the quality of the water being delivered.*

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11.0 WATER MAINS

11.1 INTRODUCTION

Water distribution mains serve to provide sufficient flows for two purposes, delivery of water from the source to the various consumers, via building water services, and sufficient flows to fire hydrants for fire protection purposes.

11.2 MATERIALS IN USE

See Section 3.0 *Piping*.

11.3 DESIGN CRITERIA

The waterworks system is to be designed as part of the overall community water distribution system. The design manual of the American Water Works Association (AWWA) is the guide for this design. The system should be capable of delivering the maximum day demand, plus fire flow or the peak hour flow, whichever is greater.

Recommendation	*Rationale*
11.3.1 Velocity	
Maximum velocity should not exceed 3.0 m/sec.	*High velocities result in excess head losses in the pipes and increase the risk of water hammer damage.*
11.3.2 Demands	
Design average demands should be calculated based on published MACA criteria and should be compared to actual community use records.	*Published criteria represent reasonable assumptions; however, individual communities may experience higher or lower actual use rates.*
Maximum daily design demands should be at a minimum of 2.0 x average demand.	
Peak hour design demands should be at a minimum of 3.0 x average demand.	
11.3.3 Fire Flows	
Design fire flows should be determined in consultation with the Office of the Fire Marshal and the funding agency.	*Establishing the design fire flow criteria is the responsibility of the Fire Marshal in consultation with the funding agency.*
11.3.4 Pipe Size	
Minimum pipe diameter should be 150 mm.	*Smaller mains cannot adequately service fire hydrants.*

11.3.5 System Pressures

Recommendation	Rationale
The minimum system pressure under normal system demands should be greater than 200 kPa.	*Pressure below 200 kPa results in excessive customer complaints and may not be sufficient for operation of home equipment.*
The minimum system pressure under fire flow conditions should be 140 kPa.	*To ensure fire flows do not result in negative pressures that could lead to pipe collapse and damage to building equipment.*
The maximum system pressure should be less than 700 kPa.	*Providing excessive pressures requires additional energy consumption. Pressures over 700 kPa may damage building piping equipment.*

11.3.6 Thermal Performance

Recommendation	Rationale
Recommend an analysis of the thermal performance of the water system.	*Thermal performance of the watermain system can be critical to ongoing serviceability.*

11.4 VALVING

Sufficient valving is required to ensure watermain servicing or repair can be undertaken without undue disruption to serviced buildings.

11.4.1 Criteria

Recommendation	*Rationale*
Valves on distribution mains should be no more than 200 m apart.	*Minimizes disruption area.*
Sufficient valves should be in place to limit the number of lots cut off from water to 25 lots, when a section is isolated.	*Minimizes disruption area.*
No more than one hydrant should be out of service when a section of main is isolated.	*Maintains fire protection capacity.*
Where valving occurs in vaults, valving should be in place such that no hydrants are removed from service when a main is isolated.	*Maintains fire protection capacity.*

11.5 THRUST BLOCKING

Bell and spigot style of pipes require thrust blocking or restrained joints at all bends and tees to transfer the resultant forces to the soil without separation of the joints.

Recommendation	*Rationale*
11.5.1 Location	
Provide appropriate sized concrete thrust blocks at all bends, tees, wyes, reducers, plugs, valves and direct bury hydrants.	*To prevent joint separation.*
11.5.2 Joint Clamping	
Where soil conditions are marginal and thrust blocks may move, clamp enough joints on each side of the fitting to prevent movement.	*Clamped joints can transfer reaction forces to pipe to prevent movement.*

11.6 CONNECTION TO STRUCTURES

See Section 3.0 *Piping*.

11.7 FIRE HYDRANTS

See Section 6.0 *Fire Protection*.

11.8 INSULATION

See Section 4.0 *Insulation*.

11.9 TESTING

See Section 3.11 *Pipe Testing*.

11.10 LEAK DETECTION

Watermain system operators should be undertaking routine checks to ensure any leaks are located and promptly repaired. Leaks, particularly in small systems, can severely impact the ability of the treatment facilities to produce sufficient water.

<u>Recommendation</u>	*<u>Rationale</u>*
11.10.1 Meter Comparisons	
Monthly or weekly water production should be compared against historical data.	*Sudden increases may be the result of a leak.*
Where water is metered to the buildings, the meter readings should be compared against monthly water production.	*While meter inaccuracies will result in these numbers never agreeing, leakage or other water loss would be indicated if plant production is more than 115% of building meter readings.*
Flow totalizer readings on supply mains, less flow totalizer readings on return mains, should be compared against building monthly readings.	*If the supplied volume less the return volume is more than 115% of building meter readings, leakage or other water loss is indicated.*
11.10.2 Leak Detection Program	
Where leakage or other water loss is indicated, a leak detection program is recommended.	*Reducing water loss and eliminating leaks reduces the amount of water required and the operations costs.*

11.11 WATERMAIN REPLACEMENT

Watermain replacement requires planning and organization to ensure success.

<u>Recommendation</u>	*<u>Rationale</u>*
11.11.1 Main Sizing	
Where a substantial portion of a watermain is to be replaced, the designer should determine if the existing size and pressure rating is appropriate for long term use.	*Over time, fire flow requirements or system demands may have increased. Main replacement with a larger size may be warranted.*
11.11.2 Repair Criteria	
The type and pressure rating of the existing main should be determined.	*Equivalent or compatible repair materials must be on hand. Any repair couplings must be sized to suit the pipes to be joined. Different types of pipes have different outside diameters.*
Isolation valves adjacent to the repair area should be exercised.	*Valves must be operational so that the repair section can be isolated.*

Potential repair materials should be itemized and checked against current spares stock.	*All materials must be on hand to complete the repair in a timely manner.*
Equipment and manpower needs must be defined and scheduled.	*To ensure equipment and personnel are available.*
Buildings that will be affected by a watermain shutdown should be identified, and the occupants notified.	*Building occupants may have to reschedule activities if no water is available.*
The need for temporary water services should be defined.	*Where repair work will exceed a few hours, temporary water services may be required.*
System circulation patterns should be checked.	*Isolation of a main will affect the circulation patterns. This could result in frozen mains if the isolation period is lengthy.*
Replaced portions of watermains must be disinfected according to AWWA C651.	*To ensure the water system is not contaminated.*

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12.0 SANITARY SEWERS

12.1 INTRODUCTION

Sanitary sewers serve to carry sewage waste from buildings to either sewage lift stations or directly to waste treatment facilities.

12.2 MATERIALS IN USE

Refer to Section 3.0 *Piping*.

12.3 DESIGN CRITERIA

The sanitary sewer system should be designed to service the projected population of potential development areas. The sewer system must be capable of conveying the peak hourly sewage contribution plus an allowance, where applicable, for groundwater infiltration.

Design criteria should include:

Recommendation	*Rationale*
12.3.1 Slope	
The minimum slope used should provide a velocity of 0.75 m/sec when the pipe is at 100% capacity.	*Sufficient velocity must be present to provide scouring when the pipe is at capacity to move solids.*
The minimum grade of the highest leg of a run of sanitary sewer should be 1.0%.	*There is little flow in the upper section of sewers. The 1.0% grade assists in movement of solids in the sewage.*
12.3.2 Peak Flows	
Peak hourly flows should be calculated at average flow rates multiplied by a peaking factor. The minimum peaking factor should be:	*Empirical formula in common use.*
Peak Factor = $1+\frac{14}{4+\sqrt{P}}$	
Where P = population in thousands.	
12.3.3 Minimum Diameter	
The minimum sewer main diameter should be 200 mm.	*Best practice.*

12.3.4 Curved Sewers

Curved sewers should be allowed given the approval of the utility owner.

Some municipalities may not allow curved sewers.

Curved sewers should have a grade at least 50% greater than the minimum grade required on a straight run of sewer.

Higher grade increases velocity and decreases probability of solids being deposited on the inside of the curve.

12.3.5 Transitions

Where pipes of equal diameter traverse a manhole, the outlet invert must be 0.025 m below the inlet invert.

To ensure grade through the manhole and to prevent solids deposition.

Where the sewer pipe diameter changes in a manhole, 80% of pipe diameter should be the minimum match point.

To ensure grade through the manhole and efficient hydraulics where pipes are operating full.

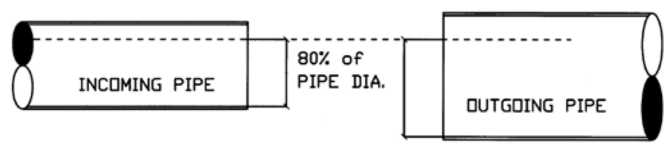

Figure 12.1 - 80% Diameter

Incoming sewers should not meet outgoing sewer mains at an angle greater than 90°.

Excessive benching is required to turn the flow and direct it to the outgoing sewer.

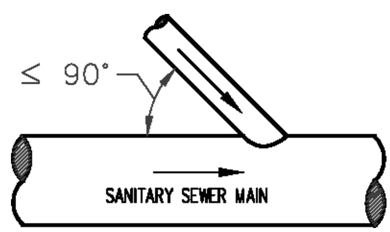

Figure 12.2 - Sewer Angle

12.3.6 Thermal Performance

Recommend an analysis of the thermal performance of the sanitary sewer system.

Thermal performance of the sanitary sewer main system can be critical to ongoing serviceability. Sections with low flow are especially vulnerable to freeze.

12.4 TESTING

See Section 3.11 *Pipe Testing*.

12.5 CONNECTION TO STRUCTURES

See Section 3.8 *Connections to Structures*.

12.6 INSULATION

See Section 4.0 *Insulation*.

12.7 SEWERMAIN REPLACEMENT

Sewermain replacement requires planning and organization to ensure success.

Recommendation	*Rationale*
12.7.1 Main Sizing	
Where a substantial portion of a sewermain is to be replaced, the designer should determine if the existing size is appropriate for long term use.	*Over time, system demands may have increased. Main replacement with a larger size may be warranted.*
12.7.2 Repair Criteria	
The type and pressure rating of the existing main should be determined.	*Equivalent or compatible repair materials must be on hand. Any repair couplings must be sized to suit the pipes to be joined. Different types of pipe have different outside diameters.*
Potential repair materials should be itemized and checked against current spares stock.	*All materials must be on hand to complete the repair in a timely manner.*
Equipment and manpower needs must be defined and scheduled.	*To ensure equipment and personnel are available.*
Buildings that will be affected by a sewermain shutdown should be identified and the occupants notified.	*Building occupants may have to reschedule activities if no water is available.*
Pumps should be in place to pump sewage around the replacement area and to remove any sewage in the trench.	*To minimize the volume of sewage in the trench.*
Health standards should be reviewed with all personnel.	*There will be a certain amount of sewage in the trench from adjacent buildings. Workers must practice good hygiene.*

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BUILDINGS

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13.0 BUILDINGS

13.1 INTRODUCTION

Buildings for northern water facilities generally house intake equipment, water treatment process equipment, pumps for piped systems or truckfills, and backup power generation equipment. Treated water storage may also be located inside the building. All equipment must be simple and reliable in extreme weather conditions.

Figure 13.1 – Typical Water Treatment Plant Building

13.2 BUILDING ENVELOPE

Recommendation	*Rationale*
13.2.1 Insulation	
Recommend obtaining minimum thermal resistance values for roof, walls and floor from GNWT Infrastructure (formerly Public Works and Services) *Good Building Practice for Northern Facilities*.	*Minimize heating costs.*
Recommend that building insulation levels be determined on a case-by-case basis.	*A higher insulation level than the minimum may be warranted.*
Recommend polyurethane sandwich panels for smaller buildings, if possible.	*Pre-finished and minimal site labour required.*

13.2.2 Interior Finish

Recommend splash and corrosion-resistant finishes.	*Low maintenance.*

13.2.3 Exterior Finish

Recommend weather and animal-resistant materials.	*Low maintenance. Woodpeckers have been known to make holes in wood cladding and damage the insulation.*

13.2.4 Floor

Recommend concrete floor topping, if possible.	*Fuel and/or water spillage is a high probability and must be contained.*
Where concrete is not possible, recommend water-resistant, fuel-resistant flooring that provides traction when wet.	*Contain spills and prevent slip and fall accidents.*

13.2.5 Door Hardware

Recommend heavy duty door hardware.	*Lower maintenance.*
Recommend padlocks with a hasp or security bar for security.	*Prevent unauthorized access, easy to change lock if needed. Standard hardware on manufactured buildings is often easy to force open.*

13.2.6 Windows

Recommend minimal or no windows, particularly on remote stations.	*Minimizes vandalism and reduces heat loss.*

13.2.7 Foundation

Recommend obtaining the advice of a geotechnical engineer.	*Many sites are on permafrost and site-specific or specialized foundations may be required.*
Recommend skid-mounted buildings on gravel pad where practical.	*Allows levelling of building if foundation settles. May allow building to be moved and reused during future upgrades. Minimizes sitework for foundation. May allow building to be prefabricated in a shop to save time on site during the short construction season.*

13.2.8 Grounding

Recommend electrical grounding design be based on the recommendations of GNWT Infrastructure (formerly Public Works and Services) *Good Building Practice for Northern Facilities*, section E5.	*Frozen ground and buildings not connected by grounded water mains can make grounding challenging. Good Building Practice for Northern Facilities, section E5 provides grounding options based on the experience of the GNWT Department of Public Works and Services.*

13.3 BUILDING LAYOUT/FLOORPLAN

Recommendation	*Rationale*
13.3.1 Working Space	
Recommend that layout design take maintenance into consideration.	*Maintenance is simplified when parts such as cartridge filters, UV bulbs, and meters needing cleaning or calibration are easily accessible, preferably without a ladder.*
Where practical, provide built-in steps, ladders, or catwalks for equipment or hatches located too high to reach.	*Stepladders are inconvenient to store and to move around a water plant. If only a stepladder is provided, operators often end up standing on chairs, pails, or other less safe alternatives.*
13.3.2 Room For Future Expansion	
Recommend that the site selected allow for future expansion. Recommend that the treatment process, as well as the structure itself, be designed with the anticipation of future additions to the treatment process.	*Due to continuous research in the area of water quality and the development of new water treatment methods, the standards and guidelines for drinking water quality are continually revised. As a result, treatment processes and truckfill stations/pump houses often require upgrades and expansions to meet the new regulations.*
It is not recommended that buildings be designed larger than required for current operations.	*It is generally not economical to maintain and heat the additional space for several years before it is needed.*
13.3.3 Lab Requirements	
Recommend space for a water quality and monitoring test station be incorporated into the layout of the building.	*Daily tests are performed on chlorine residual, turbidity, and, in some locations, other parameters such as iron and manganese or aluminum. A test station provides the operator with a designated area to store the testing equipment and space to perform the required tests.*
Recommend that provisions for a sink or wash basin be included in the design of the water quality and monitoring test station.	*The cleanliness of the testing equipment affects the accuracy of the results. A sink allows the operator to keep the test station and test equipment clean.*
Recommend providing both hot and cold domestic water.	*Warm water is desirable for cleaning glassware and washing hands.*

13.3.4 Washrooms

Provide washroom when there are two or more full-time employees. Consider providing a washroom when a single employee is expected to be at the plant all day and there is no washroom nearby.

NWT General Sanitation Regulations require a washroom for two or more employees. In some cases, water plants are be located far from town, and a washroom may be advisable even for a single employee.

13.4 WASTEWATER

See Section 15.8.

13.5 STORAGE

Recommend separate storage space for pails or barrels of chlorine and other chemicals.

Avoids corrosion of electrical and other equipment from chlorine vapours. Avoids cluttering process areas and blocking eyewash stations or safety showers. Storage should be easily accessible when chemicals need to be replenished, preferably without going outside or carrying pails up or down stairs. If chemical storage is unheated, provide space in main plant to allow pails to thaw without being in the way.

For larger plants, consider a loading dock or other access for equipment.

Helps in handling of large chemical barrels or totes.

Recommend storage space for tools, spare parts, standby pumps, cleaning supplies, manuals, logbooks, testing equipment, safety gear, and hanging up winter coats while working in the plant.

Keeps parts and equipment organized and accessible. Avoids cluttering process areas and blocking eyewash stations or safety showers.

13.6 MECHANICAL/ELECTRICAL SYSTEMS

Building mechanical and electrical systems should follow the *Good Building Practice for Northern Facilities* guidelines.

Water utility buildings may have high humidity and/or chlorine vapours, requiring ventilation and protection of components.

Recommendation — *Rationale*

13.6.1 Interior Water Piping

Recommend use of non-corrosive piping, such as PVC, inside the building.

Uncoated steel piping is subject to corrosion.

Do not use PVC pipe in areas at high risk of freezing during a power outage.	*PVC pipe can shatter when the water inside freezes.*

13.6.2 Truckfill Arm Piping

Recommend use of coated steel piping on the exterior truckfill arm.	*Exterior piping must withstand extreme temperatures and forces generated when trucks strike a frozen discharge hose.*
Recommend exterior truckfill arm be insulated and electrically heat traced.	*Ensures blockage potential due to ice buildup inside pipe is minimized.*
Recommend exterior truckfill arm be graded to allow water to drain back after use.	*Reduces risk of freezing by ensuring piping is empty when not in use. Gravity drainage, rather than automated valves, is preferred where possible to minimize maintenance.*

13.6.3 Heating/Ventilation/Lighting

Refer to Section 2.0 *General Utility Objectives*.

13.7 SITE GRADING

Site development needs to address issues of drainage, vehicle access and pump removal.

Recommendation	*Rationale*

13.7.1 Drainage

Recommend area of truckfilling operation be sloped away from the building.	*Water spillage during truckfill operation is common. Ponding leads to slippery and dangerous conditions in winter. Ice buildup under the truckfill arm also reduces the clearance above the truck.*
Avoid excessive grades where possible.	*Ice is inevitable in truckfill areas and steep grades increase the chance of slip and fall accidents.*
Recommend a hard-surfaced splash pad be provided, if practical, in the truckfilling area.	*Water spillage during truckfill operation is common and can cause erosion.*
Recommend surface drainage be directed away from the building and intake location.	*Minimizes ponding and erosion potential*.

13.7.2 Truck Access

Recommend water truck path incorporate a straight access to the fill point.	*Difficult to position truck properly in the middle of a curve.*

Recommend turning radiuses be for largest truck contemplated.	*Larger trucks may be obtained over the life of the facility.*
Recommend using larger turning radiuses than the 'minimums' published.	*Difficult for drivers to deal with 'minimums' on a routine basis.*
Recommend centre of turning bulb be filled to road grade.	*Open centres are drainage problems and present a vehicle hazard.*
Recommend a design that does not require trucks to back up, where practical.	*Large trucks are difficult to back up safely.*

13.7.3 Parking

Recommend providing parking space for at least two vehicles.	*Station operators can block the water truck's access if no parking is provided.*

13.7.4 Protection of Building

Recommend providing mechanical protection, such as bollards.	*Prevents vehicle damage to buildings.*

13.7.5 Pump Removal

Recommend a straight, unobstructed route be available for pump removal if an inclined shaft intake is used.	*A route must be available to remove the complete length of discharge piping when removing the pump. The route should allow for the use of heavy equipment for pulling and rollers or barrels to support the pipe.*

Figure 13.2 – Intake Pipe Supported by Barrels During Pump Pull

13.8 LINE POWER

Recommendation	*Rationale*

13.8.1 Economic Analysis

Recommend line power be brought to any new systems, unless there is a significant economic disadvantage.	*Line power requires less involvement by the plant operator than full-time on-site power generation.*
Recommend obtaining a quote from the power company for installation of line power to a remote site.	*Costs for running a power line to a remote site in the north can be very high and have a significant impact on the economic analysis.*

13.8.2 3-Phase Power

If line power is being brought to site, consider providing 3-phase power.	*Many types of water treatment equipment require 3-phase power. It may be cheaper to provide 3-phase upfront than to upgrade the power lines later when the plant is upgraded, particularly if trenching is required (e.g. at runway crossings).*

13.9 SITE-GENERATED POWER

On occasion, the water source is remote from the community and commercial power is not available.

Recommendation	*Rationale*

13.9.1 Load Management

Recommend electrical loads be carefully reviewed during design of site-generated power.	*Careful load management is required to minimize generator size and fuel burn.*

13.9.2 Alternative Energy

Solar, wind, and other types of alternative power sources may be attractive due to the high cost of energy in remote communities; however, caution is recommended when adding these systems.	*Alternative power sources have O&M requirements outside the scope that most water plant operators are familiar with, and are more suitable for a broader application in the community rather than just the water plant.*
Bio-mass systems can be considered for systems where water is heated for process or distribution.	*Bio-mass boilers, such as wood pellet boilers, can provide heating at a reduced cost and provide environmental benefits.*

13.10 EMERGENCY POWER

Recommendation	*Rationale*
13.10.1 Emergency Power	
Emergency power is required for all water treatment plants.	*Water treatment plants are considered post-disaster buildings under the National Building Code of Canada and therefore require emergency power.*

13.11 SAFETY AND SECURITY

Recommendation	*Rationale*
13.11.1 Fire Extinguishers	
Ensure fire extinguishers do not pose a risk when combined with the chemicals present in the water treatment plant, such as chlorine.	*Some extinguishers react explosively with chlorine. Refer to the National Fire Code and NFPA 10 – Standard for Portable Fire Extinguishers.*
13.11.2 Building Security	
Recommend that the access door be equipped with a lock and that the door remain locked when there is no operator present.	*Sensitive equipment and hazardous chemicals are used and stored in the building. Keeping the door locked reduces the chances of exposure to hazardous materials by community members, and helps minimize vandalism and tampering with equipment. The health of the entire community depends on proper equipment setting and functioning.*
Recommend the outside operator's panel be locked and the fire department be provided with a key.	*The fire department staff will have access to the water supply in the event of a fire.*
Recommend the fire department and the SAO or Band Manager be provided with a spare key to the truckfill or pump house and that they be taught how to turn the water supply on and off.	*If the outside operator panel has been shut off by accident, the fire department will have access to the building and the ability to turn on the water supply in the event of an emergency.*
Recommend that all hazardous materials be stored in a secure container or area, be well labeled, and that the SDS be kept in the truckfill station or pump house.	*Public and operator safety.*
It is recommended that "Hazardous Materials Storage Area" be posted on the outside door of all water treatment plants and pump houses.	*Helps to deter vandals and acts as a reminder to the operators and the public that caution should be taken while in the building.*

13.11.3 Reservoir

Recommend that the access gates to the reservoir be closed and locked at all times when the operator is not present.	*To minimize the risk of humans or animals falling into the reservoir and hurting themselves and/or contaminating the reservoir.*
Recommend providing a means of escape for small animals that fall into a lined reservoir, such as an inclined ladder or a liner that is textured for traction.	*To help prevent drowned animals decaying in the reservoir.*

13.11.4 Alarms

Recommend providing alarms for fire, intrusion, low temperature, process interruptions, and other conditions requiring operator attention.	*To ensure prompt response to alarm conditions. Water utility buildings are not staffed 24/7.*
Recommend a combination of audible alarm, outdoor light, alarm condition on HMI screen, and/or auto-dialer to announce major alarms.	*To ensure someone is notified of alarms.*

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14.0 HOUSEHOLD AND OTHER BUILDING STORAGE TANKS

14.1 WATER STORAGE TANKS

Water storage tanks may become contaminated if they are not properly installed or maintained. For step-by-step procedures on how to clean household tanks, contact the regional MACA office or the GNWT Department of Health and Social Services. A video on cleaning household water tanks can be found on the GNWT website http://www.nwtdrinkingwater.ca.

Recommendation	*Rationale*
14.1.1 Tank Selection	
Tanks should be designed and located so one can clean them easily without entering the tanks. Care should be taken to avoid “blind spots” that cannot be reached from the cleaning port.	*To facilitate regular cleaning. For safety reasons, tanks should not be entered for cleaning.*
Refer to the mechanical section of the most recent edition of *Good Building Practice for Northern Facilities* for specific information on tank design and location.	*GNWT standards.*
Tanks should ideally be clear or semi-transparent and located inside the house (not a crawl space).	*To facilitate regular visual checks of the tank’s condition.*
Public buildings, such as schools, should be equipped with separate tanks for fire protection and drinking water supply, in accordance with *Good Building Practice for Northern Facilities*.	*A separate, smaller tank for drinking water means a faster turnover rate. Advantages of a faster turnover rate include:* ▪ *Helps maintain chlorine residual.* ▪ *Less potential for taste and odour problems caused by stagnant water.* *A separate, smaller tank facilitates more regular cleaning of the drinking water supply tank. A smaller tank is easier to clean, and the school would not have to be shut down due to lack of fire protection.*
14.1.2 Maintenance	
Water storage tanks should be thoroughly cleaned at least once a year.	*Recommended by the Department of Health and Social Services. Regular cleaning will reduce the risk of bacteria re-growth and help the water maintain chlorine residual.*

14.2 SEWAGE STORAGE TANKS

Refer to the mechanical section of the most recent edition of *Good Building Practice for Northern Facilities*.

14.3 TANK LOCATION

Recommendation	*Rationale*
14.3.1 Municipal Bylaws	
Locate tanks in accordance with municipal bylaws.	*Legal requirement.*
14.3.2 Cross-contamination	
Where there is no municipal bylaw governing tank location, recommend arranging tanks to prevent cross-contamination during filling operations.	*Health concern. Avoid running water truck fill hose through an area where sewage may be spilled.*

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15.0 WATER QUALITY AND TREATMENT

15.1 INTRODUCTION

Water supply sources in the Northwest Territories (NWT) are abundant and less threatened by the types of contaminants found in more populated areas of Canada. However, most raw water contains some contaminants that are colourless, odourless, and tasteless and that can have harmful effects on humans. Organisms that can cause harmful effects are referred to as pathogenic.

Water for drinking, bathing, and domestic uses should be free of pathogenic organisms, deleterious chemical substances and radioactive matter, and should be palatable, aesthetically appealing, and free of questionable colour. Water should also have non-corrosive characteristics and low potential for scale formation.

15.2 CODES, REGULATIONS AND STANDARDS

See Section 2.0 *General Utility Objectives*.

15.3 WATER SOURCE SELECTION

When considering source water quality, it is important to know all of the potential sources of contamination entering into the watershed. Watershed management varies, depending on the watershed size, the land use, and treatment. To properly manage a watershed, it is important to know the characteristics of the watershed, map out and describe the land use patterns in the watershed, implement water quality, land use, and water use monitoring programs, and have a method for assessing new land uses.

<u>Recommendation</u>	*<u>Rationale</u>*

15.3.1 Water Source Selection

Recommend selecting a water source that meets, or comes close to meeting, the *Public Health Act (Water Supply System Regulations)*, and the *Guidelines for Canadian Drinking Water Quality.*	*Good source water quality requires less treatment and fewer chemicals, which reduces treatment cost and simplifies the operations and maintenance requirements.*
Recommend discussions with community at the source selection stage.	*To obtain background information and address any concerns the community has with a particular source, such as historical issues, recreational use, or water quality concerns. Some of these may be mitigated in the selection of treatment process if there is no other suitable source available.*

For surface waters, recommend selecting a water source:	
.1 That is located in a reliably managed watershed.	*Any discharges to the watershed would be required to meet the regulations and standards and, in addition, watershed water quality data may already be available.*
.2 Where there is minimal recreational use, or where recreational use will not impact water quality.	*Reduced chances for contamination of the source water with pathogenic organisms.*
.3 With minimal periods of high turbidity and seasonal variation.	*Highly turbid water is aesthetically unappealing and protects pathogenic organisms from disinfection; additional treatment is required.*
For groundwater, recommend selecting a source that is free of surface water influence or, if not, that the influences are predictable and manageable.	*Groundwater sources that are not influenced by surface waters are generally better protected from pathogenic micro-organisms.*
Recommend selecting a water source that replenishes itself at a sufficient rate and returns sufficient water to supply the community population far beyond the planning period.	*To minimize the risk of loss of supply or the requirement to relocate the facility. A source that replenishes quickly helps by flushing and diluting contaminants.*
Recommend considering aesthetic qualities such as taste, odour, and oily appearance in tea.	*Aesthetic concerns can lead to rejection of safe treated water by the community.*

15.3.2 Baseline Water Quality Data

Collect baseline water quality data over a period of at least one year on all potential drinking water supply sources.	*Baseline data will help to select the appropriate treatment process, and to prepare for events that affect water quality, such as spring runoff, storms, and algae blooms.*
Baseline water quality data should be extensive and include the full chemical, physical, and microbiological tests required by Health and Social Services. Pay close attention to the following parameters:	*Experience has shown that raw water quality in the NWT is generally free of chemical contamination associated with industrial activity. The following parameters have been found to exceed the GCDWQ in some raw water sources. Optimizing these parameters will help to provide safe drinking water that tastes, smells, and looks appealing.*
.1 Microbiological indicators	*Gives an indication of whether or not pathogenic organisms may be present.*

.2 Turbidity	*Particles present in turbid water help to protect viruses and bacteria from chlorine disinfection and may make the water aesthetically unappealing.*
.3 Colour	*Colour often comes from organic matter and dissolved elements, which may also contribute to taste and odour problems.*
.4 Total/Dissolved Organic Carbon	*Organic matter may cause taste and odour problems, and may form undesirable disinfection by-products when combined with chlorine.*
.5 Iron and Manganese	*In addition to taste problems, iron and manganese promote the growth of autotrophic organisms that form layers of slime inside storage tanks and pipes. The slime layers consume chlorine and can harbour pathogenic micro-organisms, as well as contribute to colour problems, which can stain plumbing fixtures.*
.6 Hardness and Alkalinity	*Hard water causes scale build-up in pipes, while soft water causes corrosion in pipes.*

15.4 TREATMENT PROCESS SELECTION

The primary objective of treatment process design is to ensure that drinking water is free of all pathogenic organisms, making it safe for human consumption. Since most pathogenic organisms are killed through the disinfection process, all treatment methods must include disinfection. Current NWT regulations require a chlorine residual in all systems for the purposes of distribution. Chlorine is typically used for primary disinfection as well.

The *Guidelines for Canadian Drinking Water Quality* require filtration and set numerical guidelines for turbidity. Turbidity is used as an indicator of both potential contamination and treatment efficiency. Details are provided in the document entitled *Guidelines for Canadian Drinking Water Quality Guideline Technical Document Turbidity*. An exemption from the filtration requirement is permitted under certain conditions; however, this is not the GNWT’s preferred option in system designs.

The primary objective of filtration is to reduce the risk of microbial contamination due to protozoa. Currently there is no numerical maximum allowable concentration (MAC) in the GCDWQ for protozoa because of the difficulty in measuring and analyzing protozoa. The GCDWQ includes a treatment goal of minimum 3-log removal and/or inactivation of cysts and oocysts for *Giardia* and *Cryptosporidium*.

The selection of additional treatment processes depends on the baseline water quality data for the selected source. Treatment methods currently used in the NWT include:

- Conventional treatment (coagulation/flocculation/sedimentation/filtration) & disinfection;
- Cartridge filtration & disinfection;
- Granular media filtration & disinfection;
- Greensand filter & disinfection;
- Membrane filtration & disinfection;
- Screen & dual-disinfection; and
- Disinfection alone.

Currently, all disinfection-only systems in the NWT are being upgraded and replaced with systems that include some form of filtration to meet current guidelines. NWT water treatment plant operators have mandatory certification requirements and are supported by MACA's circuit rider program; more complex technologies can therefore be used where needed to meet new, more stringent guidelines. The use of membrane filtration has become common in the NWT in recent years as the technology has become simpler and more cost-effective to operate.

Some treatment technologies currently in use in the NWT are discussed below, along with typical maintenance tasks, and issues that have been experienced or concerns specific to the North.

15.4.1 Chlorination

All NWT treatment plants use chlorine for disinfection and to provide a disinfectant residual in the piped or trucked distribution system (other disinfection technologies are sometimes used in addition to chlorine). Chlorine is also occasionally used for pre-oxidation of iron and manganese ahead of the filtration system or to reduce slime growth in cartridge filters. Liquid 12% sodium hypochlorite is the most commonly-used form of chlorine. Solid calcium hypochlorite has been used at several plants, but it requires mixing and is more difficult to handle; it is therefore not a preferred option despite advantages in shipping and shelf-life. Gaseous chlorine is generally cheaper and is used in larger centers, but has safety risks that require additional training and safety procedures.

Chlorine can also be generated onsite from salt. This technology has the potential to avoid some of the handling, shipping and shelf life issues of solid and liquid chlorine; however, it has not yet been proven in small northern communities. The City of Yellowknife started using onsite generation of sodium hypochlorite in 2015.

Chlorine disinfection is typically calculated using the CT concept. CT is the product of the residual concentration of disinfectant (C), measured in mg/L at the outlet of the contact chamber, and the disinfectant contact time (T), measured in minutes. The required CT value depends on the target microorganism, pH, and temperature.

For disinfection, chlorine is typically injected at the end of the treatment train using a dosing pump. Plants with treated water storage may have an additional injection point on the truckfill pipe to top up the chlorine when a truck is being filled. For piped systems, the chlorine dosage should be sufficient to maintain a measurable chlorine residual at the end of the return line.

Maintenance includes periodic disassembly and cleaning of the dosing pumps, replacement of worn parts such as gaskets, and keeping chlorine stocked.

Due to the risks of corrosion, chlorine should be stored separately from process equipment and electrical equipment such as the backup generator. Powdered chlorine can react with oils and cause fires.

15.4.2 Coagulation/Flocculation/Sedimentation (Conventional Treatment Plants)

There are many plants in the NWT that use coagulation and granular media filtration. In addition, many of the NWT's membrane filtration plants have the capability to add a coagulation pre-treatment step in the event of higher turbidity or other fluctuations in raw water quality that the membranes cannot handle.

Maintenance includes backwashing filters, periodic removal of sludge from the settling tank, and keeping chemicals stocked.

Some plants have experienced difficulty in adjusting the coagulant dosage for changing raw water conditions, resulting in high treated-water aluminum levels, complaints of water that feels slippery, and floc accumulation in building tanks. However, this technology has generally worked well to treat high-turbidity source water, such as Mackenzie River water. Jar testing is needed in order to optimize chemical dosages as conditions change. Measuring aluminum levels in the plant effluent can also be helpful in adjusting coagulant dosages.

15.4.3 Membrane Filtration

Many of the newly-installed plants in the NWT in the past few years have been membrane filtration plants. This technology has previously been considered too complex to be successfully used in the North, but with mandatory operator certification and training programs as well as ongoing support from MACA's circuit rider program, it appears to work well. These plants are generally controlled by a Programmable Logic Controller (PLC) with a touchscreen Human Machine Interface (HMI) and can include the capability to implement coagulation ahead of the filters when needed.

Membrane plant maintenance includes backwashing, chemical cleaning of the membranes, and replacement of worn-out or damaged filter tubes.

15.4.4 Ultraviolet (UV) Disinfection

UV disinfection is used in some plants as a primary disinfectant. Chlorine is still required in order to provide a residual in the storage tanks and/or distribution system. UV disinfection does not work well in the presence of high turbidity, and must therefore be preceded by turbidity removal unless the source water turbidity is consistently low. The Public Health Agency of Canada states that UV is effective in inactivating *H. pylori*; for chlorine disinfection, these bacteria require a 45-minute contact time at 1.1 mg/L residual chlorine, which is much higher than the normal target for northern water plants. Additional details can be found on the Public Health Agency of Canada webpage entitled "Helicobacter Pylori – Pathogen Safety Data Sheet – Infectious Substances".

Maintenance involves cleaning and changing bulbs.

15.4.5 Cartridge Filters

Cartridge filters are used in some communities. They are not suitable for high-turbidity source water, such as most rivers, and the replacement filters are bulky to store and transport. However, they are simple to maintain and can be sized to strain out *Giardia* and *Cryptosporidium*.

Maintenance consists of replacing filter cartridges when sediment builds up to the point that the pressure loss is too high for efficient operation of the system. It is important to ensure that the appropriate filter pore size is specified when ordering replacements in order for the system to achieve the treatment level it was designed for.

Cartridge filters can be overwhelmed by sediment from high-turbidity water, but they can work well with suitable source water. It is recommended that the selected filters are validated under the challenge testing protocol outlined in the USEPA's Long Term 2 Enhanced Surface Water Treatment Rule. The USEPA requires product-specific testing for cartridge filtration due to differences in filter design and manufacturing. The whole system, including the housing, piping, and fittings, must be validated.

15.4.6 Greensand Filters

Greensand filters are used in the NWT in locations where groundwater high in dissolved iron and manganese is used as a drinking water source.

Maintenance includes backwashing with potassium permanganate to restore the oxidizing ability of the greensand media. Greensand+ filter media is also available, and does not require the use of potassium permanganate.

15.4.7 Softening

NWT surface waters are generally soft, but where groundwater is used as a drinking water source, water softeners are used to reduce hardness.

Maintenance mainly consists of topping up the salt in the brine tank and running a backwash cycle to regenerate the softener when it becomes less effective due to the buildup of removed minerals.

15.4.8 Granular Media Filters

Several NWT plants use granular media filtration, where the raw water is either pumped or gravity fed through sand and/or granular carbon.

Maintenance consists mainly of backwashing to remove buildup from the media and topping up the media level as needed. If the media being used is changed from what the plant was designed for, the backwash rate may also need to be adjusted to prevent excessive media loss.

Recommendation	*Rationale*
15.4.9 Treatment Process Selection	
Consider implementing a pilot study for challenging water sources.	*It is a reliable and cost-effective method to evaluate different processes, to optimize chemical selection, doses and sequence of addition prior to full scale implementation.*
Recommend that chlorine be used as the primary disinfectant.	*Chlorine leaves a residual that is available to combat potential bacteriological contamination in the distribution system or in building water storage tanks.*
Free available chlorine residual in plants with treated water storage should be above 0.2 mg/L after 20 minutes of contact time, to be considered safe to deliver. For plants without treated water storage, the residual should be 0.4 mg/L after 20 minutes.	*Regulatory requirement of the NWT Public Health Act.*
All chemicals used in water treatment need to be approved by the Department of Health and Social Services.	*Regulatory requirement of the NWT Public Health Act.*
Minimize chemically assisted treatment, except for chlorination.	*Minimize safety hazards and operational costs. However, chemically assisted treatment should not be avoided at the cost of meeting guidelines.*
Filtration and disinfection shall be practiced for water supplies that use surface water or groundwater under the influence of surface water.	*In general, filtration removes relatively large protozoan pathogens and may remove smaller bacteria and viruses depending on the filtration method used. It also reduces turbidity and chlorine demand. Finally, chlorination kills any remaining pathogens and leaves a protective residual in the water distribution and storage system.*

Select a simple process.	*To minimize operation and maintenance requirements, community capacity and training requirements, and life cycle costs.*
See Figure 15.1 for assistance with process selection.	*This table lists processes available to treat common problems in NWT waters.*

Figure 15.1 – Best Available Technologies and Applications in the NWT

Parameter	**Technology**
Algae	Filtration, coagulation/flocculation
Colour	Membrane filtration, coagulation/flocculation, Powdered Activated Carbon (PAC), Granular Activated Carbon (GAC)
Corrosion (microbiological)	Disinfection, filtration, coagulation/flocculation
Corrosion (chemical)	Chemical addition (lime, soda)
Hardness (calcium, magnesium)	Ion exchange, membrane filtration (Nanofiltration & Reverse Osmosis (RO))
Hydrogen sulphide	Aeration, oxidation
Iron and manganese	Oxidation/filtration, greensand ion exchange & ion exchange
Micro-organisms (bacteria)	Disinfection, filtration, coagulation/flocculation
Micro-organisms (viruses, protozoa)	Disinfection, filtration, coagulation/flocculation
Organic contaminants	Aeration, oxidation, coagulation/flocculation, PAC, GAC, filtration
pH	Acid or base addition (also influenced by coagulation and aeration)
Taste, odour	Coagulation/flocculation, PAC, GAC, biofiltration, aeration, oxidation
Total dissolved solids	Ion exchange, membrane filtration
Total organic carbon	Coagulation/flocculation, PAC, GAC, biofiltration & membrane filtration (Nanofiltration & RO)
Trihalomethane	Reduce precursors prior to chlorination, reduce chlorine concentration and contact time
Turbidity	Filtration, coagulation/flocculation/sedimentation

15.5 DISINFECTION SYSTEM

Unless the water is pre-chlorinated in storage, or in a watermain, a means of providing the appropriate chlorine dosage is required.

Recommendation | *Rationale*

15.5.1 Pump Activation

For small, simple systems, recommend a flow switch be used to activate the chlorine pump.

Chlorine is only supplied if flow is present in the fill pipe.

Figure 15.2 – Typical Chlorine Dosing Pump

Recommend the flow switch activate a wall plug.

Pump can be quickly changed without an electrician.

For larger systems, recommend the chlorine pump be controlled by the PLC.

Allows dosage control and alarm functions.

15.5.2 Chlorine Solids

Use of powdered or granular chlorine is not recommended.

The GNWT has observed increased reliability in plants that have switched to liquid chlorine.

Powdered chlorine is prone to caking if moisture is present.

The fine dust from powdered chlorine can be hazardous to operators.

Plants that have used solid chlorine have experienced considerably more corrosion than other plants.

Additional storage and handling facilities and procedures are needed, along with operator training and Personal Protective Equipment.

15.5.3 Liquid Chlorine

For smaller communities, recommend liquid chlorine be used if possible.

Simplifies operation and maintenance requirements. Historically, there has been hesitation to use liquid chlorine due to the shipping costs. However, operations have been much smoother in communities that have switched to liquid chlorine.

15.5.4 Gaseous Chlorine

Gaseous chlorine may be considered only for larger centres.	*Safe handling of gaseous chlorine requires additional training and qualifications not normally available in small communities.*

15.5.5 Chlorine Pump

Recommend pump be sized to suit chlorine strength, residual required and fill flow rate.	*All three parameters impact pump rate required. Newer dosing pumps can handle low flow rates, eliminating the need to dilute chlorine.*
Pump service kits, spare injection points, and tubing should be provided.	*Chlorine pumps are prone to clogging. Regular maintenance reduces expenditures for replacement pumps.*

15.5.6 Spare Pump

Recommend one or more spare pumps be kept on site.	*A failed pump means no chlorine is applied. Without an accessible spare, the operator must add chlorine liquid to the tank directly (batch chlorinate).*

15.5.7 Chlorine Contact Time

Recommend a minimum CT value of 12 min-mg/L.	*To achieve 4-log virus removal and other pathogen inactivation.*

15.6 WATER QUALITY MONITORING

Water quality monitoring is performed for regulatory purposes and for process control purposes. The Department of Health and Social Services ensures that the *NWT Health Act* and the *Water Supply System Regulations* are met. Bacteriological samples as well as annual chemical samples are mandatory. The sampler should be concerned with training, sampling procedures, sampling frequency, and where the analysis of the sample is performed.

Verification that the water treatment processes are working is necessary. Water quality monitoring is a process control measure used to evaluate the effectiveness of the water treatment and disinfection processes. Samples are taken and tests are performed in order to verify the effectiveness of the treatment processes.

Recommendation	*Rationale*

15.6.1 Regulatory Monitoring

Recommend using an accredited laboratory to perform the analysis.	*Good practice and also for reporting purposes.*
Recommend that sampling personnel be properly trained.	*Minimize potential for false results due to sampler mishandling.*
Follow sampling procedures provided by the laboratory or Health and Social Services.	*Not following procedure may alter the sample and reduce the accuracy of the results.*
Follow sampling frequency specified by the Department of Health and Social Services.	*Manner and frequency of sampling to be determined by the Environmental Health Officer.*

15.6.2 Regulatory and Process Control Monitoring

.1 Chlorine Residual

Recommend monitoring the chlorine residual concentrations with the frequency specified by the Department of Health and Social Services.	*Process validation and control. Chlorine residual must be properly maintained as per the Water Supply System Regulations.*
In addition to regulatory sampling, free chlorine should be continuously monitored by an inline chlorine meter.	*Best practice. Useful as an indication of water quality changes or equipment failures.*

.2 Turbidity

Recommend monitoring the turbidity before and after the treatment process, with the frequency specified by the Department of Health and Social Services.	*Process validation and control. Testing before and after treatment provides an indicator of the effectiveness of the treatment process .*

.3 *E.coli* and Total Coliforms

Recommend sampling with the frequency specified by the Department of Health and Social Services.	*Process validation and control. E.coli and Total Coliform sampling is used as an indicator of the effectiveness of the treatment process or of contamination. Samples can be sent to a lab or processed in-house. Several communities currently use the Colilert system for in-house testing (see Section 15.6.4.5). Quantification testing is not required under current regulations.*

.4 Trihalomethanes (THMs)

Recommend testing with the frequency specified by the Department of Health and Social Services.	*Verification of THM levels to provide guidance on process adjustments. THM levels vary with seasonal water quality changes and tend to be higher after reservoir fills or during the spring freshet.*

.5 Annual Chemical Sampling

Perform annual sampling of the chemical and physical parameters required by HSS.	*Regulatory requirement.*

15.6.3 Additional In-House Characteristics Monitoring

.1 Iron and Manganese

In locations where iron and manganese treatment is implemented, recommend monitoring before and after the treatment process.

Process validation and control. Testing before and after treatment is an indicator of the effectiveness of the treatment process.

.2 pH

If treatment processes include chemical coagulation, monitoring the pH is recommended.

Process validation and control. When using chemical treatment, the pH of the water is altered and it is important to monitor and maintain pH levels to ensure that the treatment process is functioning properly.

.3 Colour

In communities where colour is an issue, recommend monitoring the colour before and after treatment.

Process validation and control. Monitoring colour before and after treatment will indicate whether or not the treatment process is working properly.

15.6.4 Monitoring Equipment

.1 Hand-held Monitoring Equipment

Recommend that all hand-held equipment be digital as opposed to other, more subjective equipment, such as a colour wheel.

Good practice. Digital equipment provides more precise and accurate results.

.2 In-line Monitoring Equipment

Recommend in-line monitoring equipment for chlorine residual and turbidity.

Process control. Increased monitoring frequency is recommended for larger systems. In-line monitoring can be continuous or intermittent (every 5 min for example) and can be used to alert the operator if the treatment process fails.

.3 Selecting Monitoring Equipment

Recommend considering calibration requirements as well as expiration/shipping/availability of calibration standards and reagents when selecting equipment.

It is preferable to select equipment that can be calibrated in-house using simple procedures. Where practical, select equipment that does not require calibration, such as DPD chlorine analyzers for systems with piped wastewater service where the waste stream is not an issue.

.4 Maintenance

Equipment should be selected to minimize maintenance.

Maintenance of in-line monitoring equipment can be a challenge in small communities. Operators may not have experience with this equipment and often have limited time to spend on maintenance.

.5 In-house Coliform Testing

Recommend Colilert or similar system if in-house coliform testing is implemented.	*Several communities are currently using the Colilert system for in-house E. coli and total coliform presence/absence testing in order to eliminate shipping and hold-time issues.* *To test with the Colilert system, a reagent is added to each sample jar and the samples are incubated for 24 hours. Development of a yellow colour indicates the presence of coliforms. Development of fluorescence under UV light indicates the presence of E. coli. A comparator is provided to help assess the results.* *Quantitative testing (Most Probable Number) can also be done with the addition of Colilert "Quanti-Trays" and a sealing unit, but is not currently required under NWT regulations and has not been implemented in the NWT.*

15.7 CHEMICAL HANDLING AND STORAGE

Chemical storage and handling are the major workplace safety issues associated with water treatment.

Recommendation	*Rationale*
15.7.1 Chemical Storage	
Recommend a cool, dry storage facility be provided for all chemicals. Follow the storage instructions listed on the SDS.	*For employee safety and to optimize the chemical shelf life.*
15.7.2 Chemical Handling	
Recommend that all employees be properly trained for chemical handling and that all the required personal protective equipment listed on the SDS be supplied by the plant, be properly maintained, and be available for use at all times.	*For employee safety and to reduce the number of preventable accidents.*

15.8 PROCESS WASTEWATER

Wastewater may be produced during water treatment processes. Disposal of this waste is a regulatory requirement of the community water licence.

Recommendation | *Rationale*

15.8.1 Wastewater Disposal

Waste residual should be disposed of according to community water license requirements, preferably directly to the sewage system. If returned to the water source, residuals must be disposed of downstream or otherwise separated from the intake by 90 m and must be approved by the authority having jurisdiction.

To avoid potential contamination of the drinking water supply.

Consider separate disposal for contaminated and uncontaminated wastewater streams.

Uncontaminated water, such as membrane backwash water, may be able to be disposed of overland, rather than filling up the wastewater tank.

15.9 RECORD KEEPING AND REPORTING

Regular recording and reporting is a requirement of the Department of Health and Social Services.

Recommendation | *Rationale*

15.9.1 Records and Reporting

Recommend keeping records on:

.1 Water quality and consumption

.2 Preventative maintenance

.3 Repairs

.4 Operational changes and procedures

.5 Changes to the plant process and/or equipment.

To track the preventative maintenance program, maintain manufacturers' warranties, fulfill water licence requirements, and to ensure the Department of Health and Social Services has the information necessary to determine if the community health needs are being met, and to quickly eliminate the water supply system as the source of the problem in the event of a community health crisis.

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16.0 WATER STORAGE AT TREATMENT PLANTS

16.1 INTRODUCTION

Water storage may be required:

- to satisfy seasonal demand when no year-round water source exists or where the source is of poor quality for a portion of the year;
- for emergency purposes if the source is extremely remote from the community and access may be interrupted;
- to ensure sufficient quantities of water are readily available for fire-fighting purposes;
- to provide equalization where the supply or treatment process flow rate is lower than the required truckfill flow rate;
- to provide water for backwashing or other in-plant uses; or
- to provide chlorine contact time.

In NWT communities where water is stored to satisfy seasonal demand, it is often raw water stored in large open earthen reservoirs. Water stored for equalization or in-plant uses is normally treated water stored in closed tanks. These tanks may be un-insulated tanks located inside the treatment plant, or insulated outdoor tanks. Water stored for other purposes may be treated or untreated depending on the situation.

Tanks in households or other buildings are discussed in Section 14.

16.2 DESIGN CRITERIA

The primary factors to consider in water storage design are the population and water use projections. The average day demand is used to calculate seasonal and emergency storage requirements. The maximum day demand (average day demand times the maximum day factor) is used to calculate equalization storage requirements. Seasonal, emergency, equalization and fire protection storage requirements are discussed in later subsections. In many communities, the overriding factor is the time between truck fills. Chlorine contact time requirements may also impact the required storage volume.

The document *MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993)* referenced below is appended to this document for reference.

<u>Recommendation</u>	*<u>Rationale</u>*
16.2.1 Population Projection	
Recommend obtaining population projections from the GNWT Bureau of Statistics.	*Authoritative source.*
Recommend consultation with the funding agency and community prior to finalizing a design population.	*Local conditions may necessitate modifications to population projections.*

16.2.2 Water Use Projections

Recommend obtaining historical water use records from the community and/or current facility operations.	*An understanding of community water use patterns is essential in preparing projections.*
Recommend projecting water use based on historical patterns and on standard MACA formulae.	*Historical water use may indicate higher or lower projections than standard formulae.*
Recommend designing for a residential water use of at least 90 L/person/day for trucked systems, regardless of historical use.	*MACA minimum service standard. Water use tends to increase as more appliances are installed.*

16.2.3 Maximum Day Factor

Recommend obtaining historical data on maximum day factors on piped systems.	*Maximum day factors can vary on a community-to-community basis. In the absence of historical data, refer to MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993) for guidance.*
Recommend obtaining historical data on maximum day factors on trucked systems.	*The trucking patterns in a community can impact the maximum day factor substantially if the hauls are not balanced on a day-to-day basis. In the absence of historical data, refer to MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993) for guidance.*

16.2.4 Time Between Trucks

Recommend designing to allow two trucks to be filled within a reasonable timeframe.	*Ensures efficient operations. If sufficient treated water is not available for the second truck, drivers may use the fire flow bypass to fill the truck rather than waiting for treated water to be available. For larger communities, where there may be more than two trucks in use, a maximum of 20 minutes between trucks is suggested as a design basis.*

16.3 MATERIALS IN USE

A variety of water storage reservoir and tank types have been used, including:

▪ Wood-stave, lined and insulated	Limited historical above-ground use in Ft. McPherson and Inuvik.
▪ Bolted steel, lined and insulated	Limited historical above-ground use in Aklavik.
▪ Welded steel, epoxy coated and insulated	Common usage where below grade is not practical; examples in Ft. McPherson, Aklavik and Norman Wells.

Figure 16.1 – Aklavik Water Tank

▪ Welded or bolted steel, epoxy coated	Common usage inside buildings for small storage volumes.
▪ Concrete	Currently used below grade in Yellowknife, Behchoko, Ft. McPherson, Hay River, Ft. Simpson, Ft. Providence, Ft. Smith, Iqaluit, and Ft. Liard.
▪ Earthen, lined	Used for seasonal storage in Ft. Good Hope, Tuktoyaktuk, Wrigley, Jean Marie River, and Trout Lake.
▪ Fiber composite	Limited use inside buildings for smaller volumes, for example, in Tulita.
▪ Aluminum	Recently installed membrane plants in Jean Marie River, Wrigley, Lutsel K'e, Trout Lake, and Fort Good Hope have indoor aluminum tanks for treated water. Several of these tanks have experienced corrosion, requiring the installation of sacrificial anodes.

16.4 FREEZE PROTECTION

Recommend providing some form of freeze protection for outdoor storage tanks.	*Freeze protection for tanks may include electrical or hydronic heat tracing, or circulation of heated water. These methods should be combined with insulation to limit heat loss. Where boilers are used for building heating, consider using the same boilers for heating water. An energy cost analysis can be used to determine the most efficient system.*

Recommendation	Rationale
Recommend insulating larger tanks directly rather than constructing a building specifically to house tanks.	*More efficient use of heat; avoids cost of heating a building in addition to the tank. Avoids construction cost for a building.*

16.5 FOUNDATION

Recommend obtaining the advice of a geotechnical engineer on tank and reservoir foundations.	*A full water tank exerts a considerable load on the foundation. Settlement or movement of the tank can cause problems with piping. Earthen reservoirs can also lead to thawing of permafrost.*

16.6 SEASONAL STORAGE

Water from local rivers or lakes may be difficult to treat during certain portions of the year, necessitating seasonal storage. Further, some northern communities do not have a year-round water source. Local streams or rivers may cease to flow in the fall, or local lakes may be shallow and freeze completely in the winter. Filling of seasonal storage reservoirs is normally done with temporary intakes, often through a hole drilled in the ice.

Recommendation	*Rationale*
16.6.1 Storage Period	
Recommend a cost-benefit analysis comparing the cost of constructing a larger reservoir vs filling several times per year.	*Reservoirs may be filled annually, or several times each year where conditions permit.*
Recommend consultation with community regarding stream or river flow periods.	*River flow rates vary throughout the year.*
Recommend analysis of historical water quality data.	*Water quality varies throughout the year. Refills should be timed to obtain the best quality water to the extent this is practical. Turbidity is generally lower in winter, but other parameters should be considered as well.*
16.6.2 Ice Cover	
Recommend a dynamic drawdown model of ice growth and water use.	*A winter reservoir will have a substantial water volume in the form of ice cover, which will not be available to the community.*
16.6.3 Water Contamination	
Recommend reservoir building materials be tested to ensure leachate will not contaminate the water.	*Sands and gravels or quarried bedrock may contain deleterious substances.*

16.6.4 Liner

Recommend reservoir be lined to minimize any potential leakage.	*Any leakage can, over the winter, result in a shortfall in water.*
Recommend considering the potential for gas or water buildup below artificial liners.	*Gas or water accumulation can cause a liner to float.*
Recommend not constructing earthen reservoirs below the groundwater table.	*Groundwater accumulation under a liner can float the liner when the water level in the reservoir is drawn down below the groundwater level.*
Recommend textured liners for safety.	*Textured liners provide better traction to prevent slip and fall accidents.*
Ensure liner is certified for potable water use.	*Liners that are not certified for potable water may leach deleterious substances.*
Recommend a liner that is tested to at least -40°C.	*Some liners do not remain flexible and can crack at cold temperatures.*

16.6.5 Fencing

Recommend open-water reservoirs be protected by fencing.	*Limits wildlife and human access to the reservoir.*

16.7 PIPED SYSTEM STORAGE CAPACITY

Storage capacity should be determined after consultation with the operating agency or department. Initial criteria are contained below.

Recommendation	*Rationale*

16.7.1 Fire Storage – Piped System

Recommend initial storage requirements be determined from "Water Supply for Public Fire Protection" as published by Fire Underwriters Survey.	*Recognized standard for fire protection.*
Recommend consultation with Fire Marshal and funding agencies prior to finalizing flow and storage requirements.	*Local conditions may necessitate modification to flow and storage.*

16.7.2 Equalization Storage

Recommend 25% of Maximum Day Demand (Average Day Demand times Maximum Day Factor).	*Allows for reservoir fluctuation when demand exceeds supply.* *Per MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993).*

16.7.3 Emergency Storage

Recommendation	Rationale
Recommend a minimum of 30% of Average Day Demand.	*Provides a time interval to effect repairs to the supply to the reservoir.*

16.8 TRUCKED SYSTEM STORAGE CAPACITY

Storage capacity should be determined after consultation with the operating agency or department and after an analysis of the trucking pattern of the community. Initial criteria are contained here.

Recommendation	*Rationale*

16.8.1 Fire Storage – Trucked System

Recommend a minimum truckfill rate of 1,000 L/min. This can be achieved using a fireflow bypass that bypasses the treatment system to achieve higher flow rates.	*Per MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993).*
If a fireflow bypass is used, chlorine shall be added when filling a truck from the bypass.	*Prevents contamination of water truck.*
Recommend a minimum of 60,000 L fire storage, if loading at 1,000 L/min cannot be done directly from the source.	*Per MACA, NWT Fire Protection Study (1993).*
Recommend consultation with the Fire Marshal and funding agencies prior to finalizing loading rate and storage.	*Local conditions may necessitate modifications to flow and storage.*

16.8.2 Equalization Storage

Recommend storage be equal to maximum projected haul day less eight hours of supply pump(s) or water treatment plant output.	*During the course of the hauling day, the supply pump(s) or water treatment plant will reduce the total volume needed in storage.* *Per MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993).* *Note that for smaller communities, the truck delivery schedule may govern the amount of storage needed.*
Recommend considering an increase to plant throughput rather than increasing storage.	*May be more cost effective to increase plant production rates than to build and maintain large storage tanks. Water quality may also be impacted by longer storage time in larger tanks.*

16.8.3 Plant Requirements

Recommendation	Rationale
Recommend storage include all water required for plant use, including backwash requirements, if any.	*Backwash requirements can be considerable and will, if not accounted for, reduce the water available for delivery.*

16.8.4 In-town Storage

Recommendation	Rationale
Recommend in-town storage if the water source is more than 3.2 km from the community.	*Water sources that are remote from a community increase the risk that lengthy delays in water delivery may be encountered, if roads are damaged or blocked due to storms. The time to cycle trucks fighting a fire becomes excessive as distances increase.* *Per MACA, Water and Sewage Facilities, Capital Programs: Standards and Criteria (July 1993).*

16.9 IMPACTS OF STORAGE ON WATER QUALITY

It is important that water quality issues be considered when selecting water storage methods and products. The length of time water is stored, water circulation, disinfection regimes, and storage tank accessibility can all have an impact on water quality.

Recommendation	*Rationale*
16.9.1 Impacts of Storage on Water Quality	
For tank storage, recommend:	
.1 Proper tank sizing based on risk and economic analysis.	*Tanks must be adequately sized, but excessive retention times may cause problems with stagnant water and bacterial re-growth.*
.2 Proper location of baffles and inlet/outlet piping to promote good circulation.	*Prevents biological activity that occurs under stagnant conditions. Ensures adequate CT for disinfection by preventing short circuiting.*
.3 Chlorinate to maintain a residual in the storage tank.	*Chlorination reduces biofilm growth and bacteria-enhanced corrosion of steel tanks.*
.4 Chlorinate during truckfill to achieve the minimum chlorine residual required by Health and Social Services.	*Regulatory requirement of the NWT Public Health Act. Water must contain a minimum residual to be considered safe for delivery.*

16.10 MAINTENANCE

16.10.1 Treated Water Tanks

Recommend monitoring chlorine in the treated water tank.	*A rapid loss of free chlorine can indicate biological activity within the tank.*
Recommend cleaning treated water tank annually as per AWWA Standard C652: Disinfection of Water Storage Facilities.	*To maintain good water quality.*
Recommend biological water sampling of newly cleaned tank prior to return to service.	*Ensure tank has been properly disinfected.*
Recommend regular visual inspections of all tanks for leaks.	*Ensures leaks are detected and repaired in a timely fashion.*
Recommend visual inspection of outdoor tank foundations for signs of erosion and settlement.	*Allows preventive maintenance to be done before settlement causes problems.*
Recommend inspections of the internal coating of tanks at a frequency recommended by AWWA standards.	*Ensures damage or degradation of internal coating is detected and repaired in a timely fashion.*
Provide easy access for cleaning and dual tanks if possible. Baffles and tank geometry should allow for cleaning.	*Storage tanks must be cleaned at least once a year to reduce potential for bacteria contamination. For larger systems, dual tanks are one option to ensure some storage is available during cleaning.*
Recommend draining, removing sediment from, and inspecting raw water reservoirs prior to refill.	*Sediment removal maintains reservoir volume. Inspection of liner allows preventive maintenance and repairs.*

16.10.2 Raw Water Reservoirs

Recommend maintaining water level in outdoor reservoirs at least 2m above the intake screen throughout the winter.	*To prevent ice damage to intake screens.*
Recommend removal of vegetation from berms.	*Prevent root damage to liners. Chemical weed treatments are not recommended around drinking water.*

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WASTEWATER TREATMENT TECHNOLOGIES

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17.0 WASTEWATER TREATMENT TECHNOLOGIES

17.1 INTRODUCTION

Northern wastewater treatment is most often done using lagoons and wetlands. Lagoons are either decanted at a set time (usually annually) or designed to continuously discharge. There has historically been little scientific data on wetland treatment in northern climates, but recent research is beginning to provide guidance for treatment system design and operation.

17.2 RECENT RESEARCH

Several research papers on northern lagoon and wetland systems have recently been published. The guidelines that have been produced based on this research have not been adopted by the GNWT and may not be applicable in all situations.

17.2.1 Dalhousie University

The Government of Nunavut engaged Dalhousie University's Centre for Water Resources Studies to conduct research into the performance of lagoon and wetland systems in Nunavut. Two design guidelines have been published under this research program and may be of assistance to designers.

- Jamieson, R., & Hayward, J. (2016). *Guidelines for the Design and Assessment of Tundra Wetland Treatment Areas in Nunavut.*
- Jamieson, R., Ragush, C., & Hayward, J. (2017). *Guidelines for the Process Design of Wastewater Stabilization Ponds in Nunavut.*

These guidelines, as well as detailed background reports, are available in PDF format through the Centre for Water Resources Studies at Dalhousie University in Halifax, Nova Scotia (http://centreforwaterresourcesstudies.dal.ca/).

17.2.2 Fleming College

The Centre for Alternative Wastewater Treatment at Fleming College has conducted research on several wetlands in Nunavut, and has published a report and wetland modelling software based on the results.

- Chouinard, A., Balch, G.C., Jørgensen, S.E., Yates, C.N., & Wootton, B.C. (May 2014). *Tundra Wetlands: the treatment of municipal wastewaters - RBC Blue Water Project: performance and predictive tools*.

This report is available in PDF format through the Centre for Alternative Wastewater Treatment (CAWT) at Fleming College in Lindsay, Ontario (http://cawt.ca/resources/). The modelling software, Subwet 2.0, is provided at no charge by the United Nations Environment Programme – Division of Technology, Industry and Economics (a link is provided from CAWT's website).

17.3 REGULATIONS

The Canadian Council of Ministers of the Environment (CCME) *Canada-Wide Strategy for the Management of Municipal Wastewater Effluent*, published in 2009, provided a 5-year window to determine performance standards specific to Canada's Far North. A Northern Working Group, including the governments of the Northwest Territories, Nunavut, Québec, Newfoundland and Labrador, and Canada, was formed to research these standards. To date, the Northern Performance Standards Project Team (formerly the Northern Working Group) has completed preliminary work on adapting the Strategy's risk level criteria for the North by taking into account Northern-specific challenges and costs. The CCME Water Management Committee (WMC) is currently responsible for overseeing further development of Northern Performance Standards.

In the NWT, effluent quality criteria for wastewater discharge are determined by the Land and Water Board having jurisdiction and are laid out in each community's water licence. The *Waters Act* gives the Land and Water Boards the authority to set limits on waste discharge. Parameters for effluent quality objectives for municipal wastewater discharge may include, but are not limited to:

- pH
- Biochemical Oxygen Demand (BOD_5) (Note: BOD_5 is gradually being replaced by CBOD in NWT water licences)
- Carbonaceous Biochemical Oxygen Demand (CBOD)
- Suspended Solids (SS) or Total Suspended Solids (TSS)
- Oil and Grease
- Fecal Coliforms
- Ammonia-N (NH_3-N)
- Phosphorus

Water licence parameters are monitored through Surveillance Network Program (SNP) sampling. SNP points are typically located at and downstream of the lagoon discharge point. Their locations and sampling frequencies are listed in the water licence. The point of compliance is often set at the lagoon discharge point, as this is considered the last point of control. For systems that rely on a wetland downstream of the lagoon as part of the treatment system, the Land and Water Board may consider both the lagoon and wetland system in determining the effluent quality criteria and point of compliance.

17.4 LAGOON AND WETLAND SITING

Wastewater treatment systems should be located where they are least likely to impact the environment or disrupt users of land and water resources. In the north, typical systems include lagoons and wetlands. Wetlands may be natural or enhanced.

Recommendation	*Rationale*
Avoid choosing wetlands or discharge point locations near areas traditionally used for hunting, fishing, harvesting, or recreation.	*Minimize human contact with effluent. If an alternate location cannot be chosen, community education about avoiding these areas during the treatment season may be needed.*
Avoid choosing wetlands or discharge point locations near or upstream of municipal drinking water intakes or locations where individuals collect water or ice for personal use.	*Avoid contamination of water sources. In some communities, individuals collect untreated water and ice for personal use from traditional sources that may differ from those designated for the municipal water supply.*

Consider tidal cycles and/or flow characteristics of receiving waters at final discharge point.	*Affects area of influence of effluent, impact on water quality during discharge. May require specifying discharge timing (e.g. discharge only during high tides).*
Maintain separation distance from airports, where practical.	*Lagoons attract birds which can interfere with aircraft operations. Refer to Part III of the Transport Canada document TP 1247 - Aviation - Land Use in the Vicinity of Aerodromes. A bird hazard study may be required where separation distance cannot be achieved.*
Consider the cost of road construction, as well as the time required for trucks to drive to the site.	*Road construction in remote NWT communities can exceed $1 million per kilometer. Where regulatory and other considerations allow a choice of sites, the cost of access road construction, as well as the lifecycle costs of added personnel time and vehicle wear and tear resulting from a longer driving distance, may justify the choice of a closer site even if the up-front costs of facility design, studies, or site construction may be higher than the other available sites.*
Where possible, prevent wastewater effluent from combining with landfill runoff or leachate.	*Assists in determining the source of any non-compliance issues.*
Avoid siting lagoons in floodplains, where practical.	*Flooding can damage lagoon structures, and may fill them beyond capacity, leading to emergency decant of water that does not meet effluent quality criteria.*

17.5 GENERAL DESIGN CONSIDERATIONS

17.5.1 Target Effluent Criteria

The following criteria set by the National Performance Standards in the *Canada-Wide Strategy for the Management of Municipal Wastewater Effluent* are recommended as an initial target for treatment system design. However, it is recognized that this may not be practical for all systems, and a customized approach may be needed.

- Carbonaceous Biochemical Oxygen Demand ($CBOD_5$) – 25 mg/L
- Total Suspended Solids (TSS) – 25 mg/L (the National Performance Standard allows TSS to exceed 25 mg/L if the exceedance is caused by algae)
- Total Residual Chlorine (TRC) – 0.02 mg/L (not generally applicable in the NWT)

17.5.2 Lagoons

Due to their simple design and operation, lagoons are the default form of primary treatment in Canada's north.

<u>Recommendation</u>	<u>*Rationale*</u>
Recommend a minimum of two treatment cells.	*Improves treatment efficiency and simplifies maintenance. Deep cells promote sedimentation and retention of solids. Shallow cells increase dissolved*

	oxygen and allow for radiative heating, increasing temperatures and promoting biological growth treatments; however, they may lead to an increase in TSS due to algae growth. Combining multiple cells allows for more effective treatment, and minimizes mixing of fresh wastewater with partially treated wastewater. Recent studies have demonstrated that a single cell lagoon in the north cannot reliably meet the current benchmarks for treatment.
Recommend lined cell for primary treatment.	*Allows measurement of treatment level in primary cell.*
Recommend sizing the overall treatment system to hold a full year's volume of wastewater.	*Minimal treatment happens in winter. Decant and exfiltration structures are normally frozen. Note that the primary cell alone does not need to hold the full year's volume.*
Recommend plug flow design for continuous flow lagoons if practical.	*Maximizes retention time and minimizes short-circuiting, resulting in improved treatment efficiency.*
Recommend using a CSP culvert for the sewage truck discharge point.	*Simple, cost-effective design. The added cost of ramps and retaining walls is generally not justified.*
Where practical, extend truck discharge culvert through fence.	*Eliminates the need for drivers to open and close a gate. Avoids having a break in the lagoon fencing.*

Figure 17.1 - Sewage Truck Discharge Culvert

Consider an emergency discharge overflow pipe at an elevation that prevents damage to the structural integrity of the berm from overfilling, ideally located as high as possible to allow freeboard to be maintained.	*Prevents damage to berm.*

Recommend designing for 1 m minimum freeboard at maximum capacity.	*Standard requirement by water boards in the NWT. Less freeboard may be accepted with justification from the design engineer. Freeboard targets should consider both structural integrity and a margin of safety for accidental discharge.*
The shape and dimensions of the lagoon should facilitate sludge removal as much as practical.	*Simplifies long-term maintenance.*
Recommend consideration of cold temperature and short treatment season in design.	*Cold temperatures reduce treatment efficiency. The majority of treatment in the lagoon occurs during the summer and fall, when the lagoon is thawed and the hours of sunlight are longer.*
Recommend discharging overland or to wetland if possible, rather than directly to the receiving waters.	*Provides additional treatment prior to effluent entering water body.*
Recommend continuous discharge to the environment from mid-summer to late fall if practical. However, if the compliance point is at the lagoon decant point, decant should not begin until effluent quality criteria are met.	*Allows time for vegetation to become productive and water temperatures to rise. Avoids high flows from melting water. Decreases loading rate on wetland.*
Recommend fencing and signage around lagoons.	*Prevent humans and wildlife from falling into lagoon.*
Consider sludge depth in volume calculations.	*Sludge reduces the operational depth of the lagoon. Allow space for several years of sludge accumulation to reduce O&M.*
Consider including a sludge drying bed in the design.	*Provides a location to manage sludge.*
Choose simple designs with few moving parts where possible.	*Ice can damage or prevent operation of valves and other moving parts. Simpler designs are easier to repair.*
Obtain the advice of a geotechnical engineer.	*Northern soil conditions can be challenging. Expert advice should be obtained particularly regarding permafrost, as well as loads on retaining walls from loaded sewage trucks. Additional discussion on frozen ground and permafrost considerations can be found in Section 1.2.*
Recommend minimum 1 m separation between high groundwater level and base of liner or lagoon system.	*Groundwater can float liners or cause infiltration issues when lagoons are excavated into the groundwater table. Building berms up above ground level can help avoid this.*

17.5.3 Wetlands

Wetlands, whether natural or constructed, have been proven to provide excellent treatment of wastewater effluent. Recent research has demonstrated that natural wetlands are an appropriate technology for northern Canadian communities.

Recommendation	*Rationale*
Recommend assessing flow patterns at various times of the year for natural wetlands.	*The flow through natural wetlands can vary substantially between seasons and particularly during the spring freshet. Flow paths, inlet and outlet locations, and wetland size may vary during the year. The hydraulic retention time and treatment efficiency provided by the wetland may vary.*
Recommend consideration of growing season when determining timing of discharge to wetland.	*If wetland treatment is used to achieve effluent quality compliance, discharging throughout the growing season provides a lower loading rate and maximizes treatment in the wetland.*
Recommend signage around treatment wetlands and communication with the public about the location of these systems.	*Keep humans out of treatment wetlands, where water quality may exceed effluent quality criteria.*
Consider access to potential monitoring sample points during design.	*Avoid having future monitoring take place in areas that are difficult to access.*

17.6 MECHANICAL PLANTS

Mechanical wastewater treatment plants are relatively rare in the North; the NWT has only one mechanical system. Some of the advantages and disadvantages of mechanical treatment as compared to lagoons and wetland systems are summarized below.

Figure 17.2 - Advantages and Disadvantages of Mechanical Wastewater Treatment

Advantages	**Disadvantages**
• Takes up less land area • Clear point of compliance for regulatory agency • Can be located closer to community • Fewer aesthetic concerns	• Higher capital and O&M cost • More complex to operate • Operators with sufficient expertise usually not available in the North • Mechanical parts require maintenance and replacement • Uses more electricity • More frequent sludge handling and disposal • Plants with low loading rates are vulnerable to process shock

Recommendation	*Rationale*
Recommend avoiding mechanical wastewater treatment plants unless circumstances preclude using a lagoon system.	*Mechanical systems are more difficult to operate and maintain. Experienced operators are not available in the North. Relatively moist indoor air conditions cause ventilation issues in extreme winter temperatures.*

APPENDIX A

TYPICAL GNWT WATER AND SEWER DRAWINGS

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TYPICAL GNWT WATER AND SEWER DRAWINGS (cont.)

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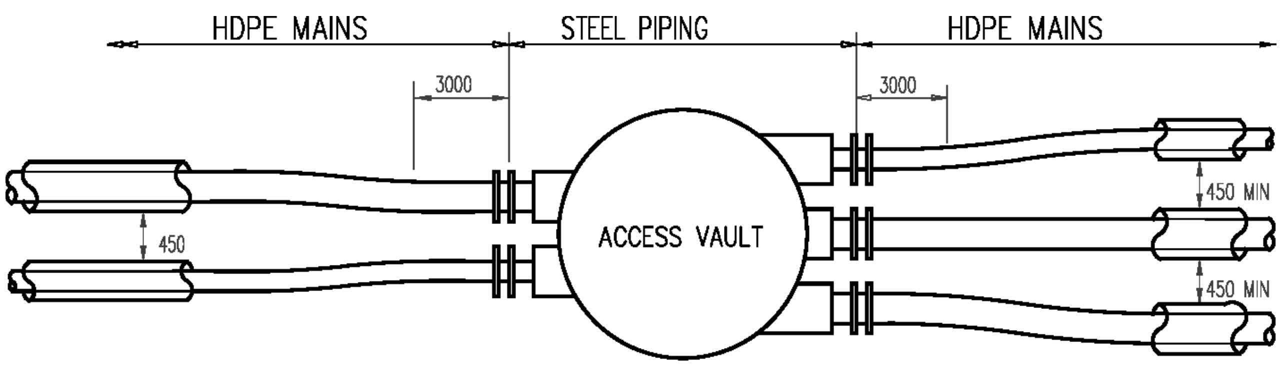
TD-1 TYPICAL SEPARATION OF MAINS OUTSIDE ACCESS VAULT



NOTES:

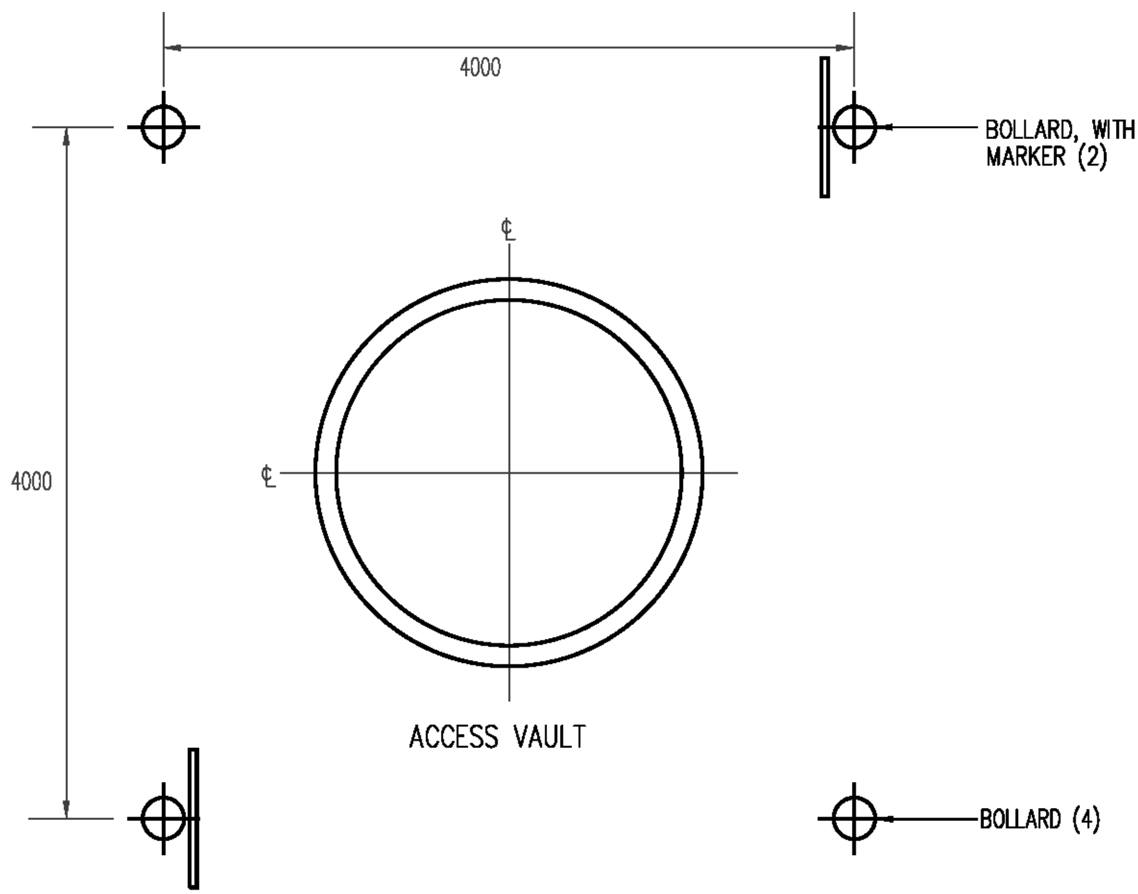
1. ALL CURVES SHALL BE SMOOTH WITH A RADIUS AS RECOMMENDED BY THE PIPE MANUFACTURER.
2. PROVIDE MIN 450 CLEARANCE BETWEEN PIPE INSULATION TO ALLOW ROOM FOR TAMPING EQUIPMENT.
3. HDPE PIPING WITHIN 3 000 OF A FLANGED STUB END SHALL NOT BE CURVED. THESE 3 000 SECTIONS SHALL BE BACKFILLED PRIOR TO CURVING ADJACENT PIPE.
4. INSULATION REMOVED FROM MAINS FOR CLARITY.

DRAWING TD–1 TYPICAL SEPARATION OF MAINS OUTSIDE ACCESS VAULT

ALL DIMENSIONS ARE IN mm

APPENDIX A

TD-2 BOLLARD/MARKER LOCATION LAYOUT

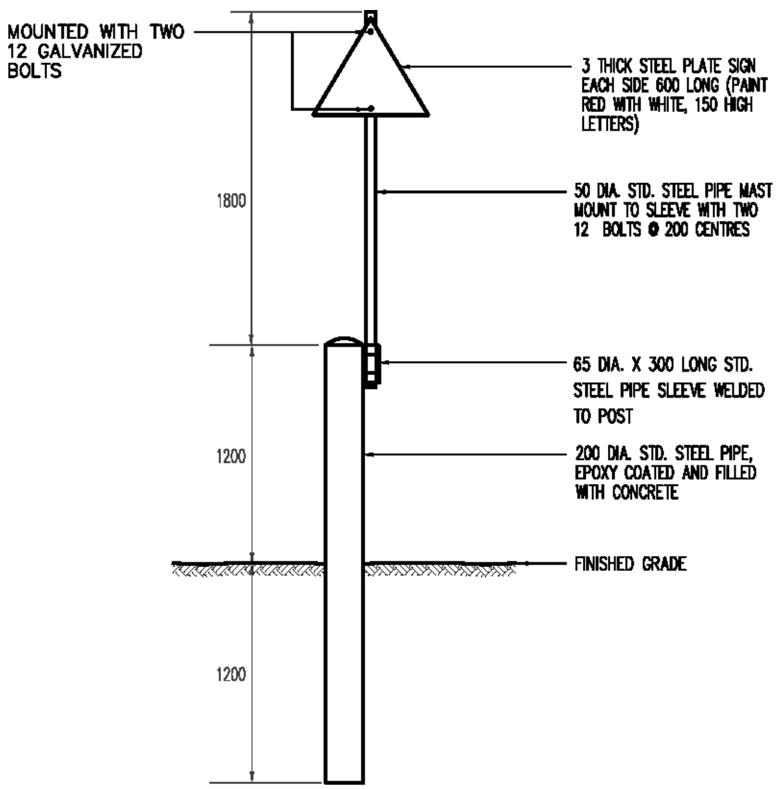


DRAWING TD-2 BOLLARD/MARKER LOCATION LAYOUT

ALL DIMENSIONS ARE IN mm

APPENDIX A

TD-3 BOLLARD MARKER POST



NOTES:

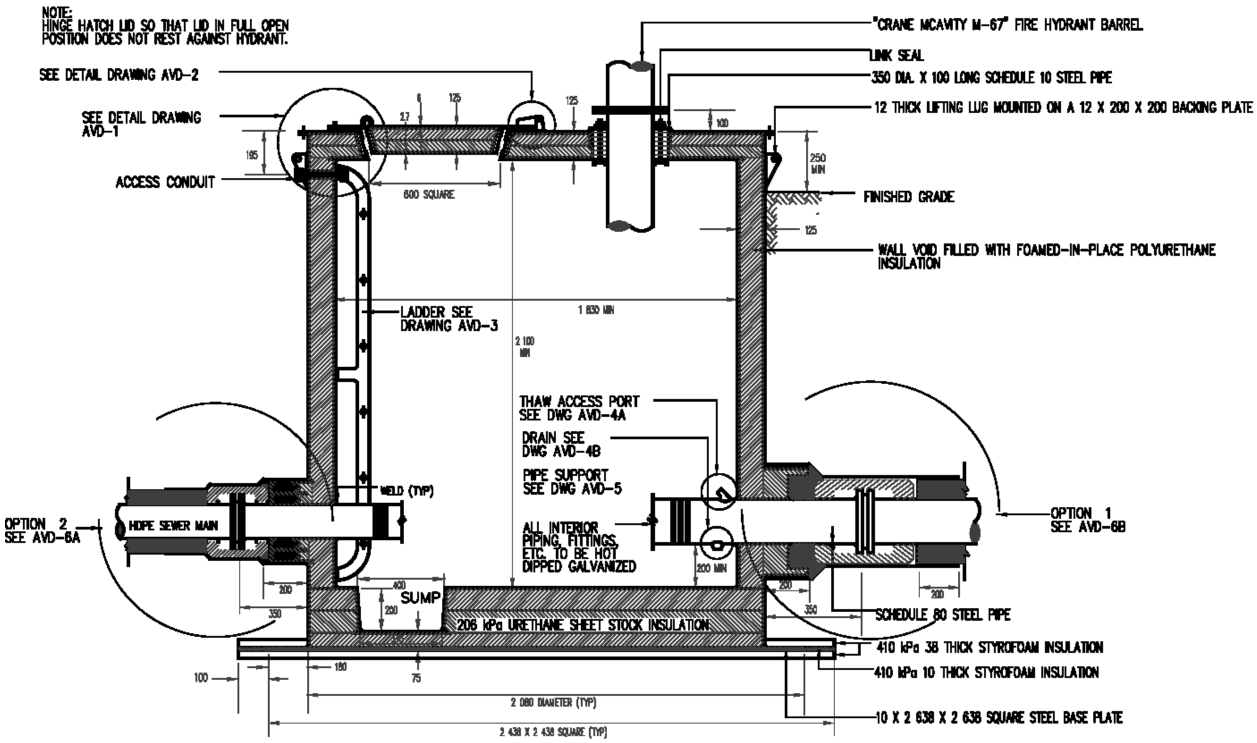
1. TWO MARKER SIGNS, COMPLETE WITH BOLLARDS, ARE REQUIRED FOR EACH ACCESS VAULT.
2. TWO ADDITIONAL BOLLARDS, WITHOUT MARKERS, ARE REQUIRED FOR EACH ACCESS VAULT.
3. BOLLARDS, SLEEVES AND MASTS TO BE PAINTED RED AFTER FABRICATION.

DRAWING TD-3 BOLLARD/MARKER POST

ALL DIMENSIONS ARE IN mm

APPENDIX A

AV-1 TYPICAL ACCESS VAULT



NOTES:

1 ACCESS VAULT TO BE FABRICATED FROM 6 THICK STEEL PLATE (EXCEPT BASE PLATE WHICH IS 10 THICK), CONTINUOUSLY WELDED CONSTRUCTION.

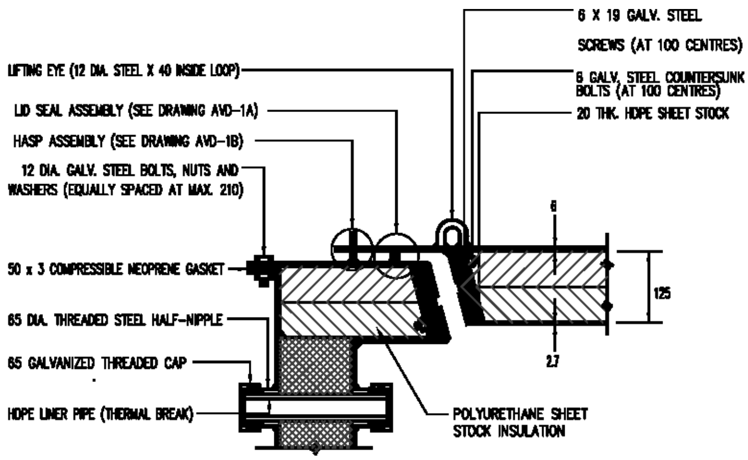
2 INTERIOR, EXTERIOR AND NON-GALVANIZED ITEMS TO BE PAINTED WITH TWO COATS OF INDUSTRIAL GRADE EPOXY PAINT. EXTERIOR COLOUR TO BE GREY INTERIOR COLOUR TO BE WHITE.

DRAWING AV-1 TYPICAL ACCESS VAULT

ALL DIMENSIONS ARE IN mm

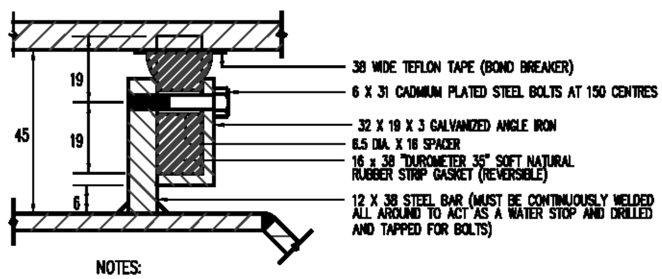
APPENDIX A

AVD-1 HATCH DETAIL and AVD-1A HATCH SEAL DETAIL



DRAWING AVD-1 HATCH DETAIL

ALL DIMENSIONS ARE IN mm



NOTES:

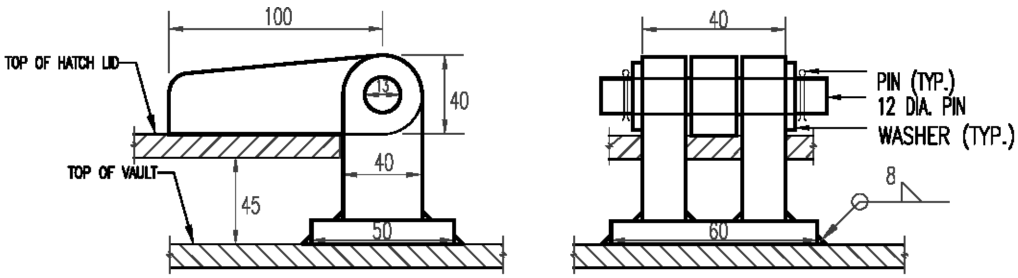
1. SEAL ASSEMBLY IS TO BE CONTINUOUS ALL AROUND COVER OPENING.
2. LID AREA TO BE COVERED BY TEFLON TAPE, SHALL BE SMOOTH AND THOROUGHLY CLEANED TO REMOVE ALL DIRT, GREASE AND OTHER CONTAMINANTS BEFORE APPLYING TAPE.

DRAWING AVD-1A HATCH SEAL DETAIL

ALL DIMENSIONS ARE IN mm

APPENDIX A

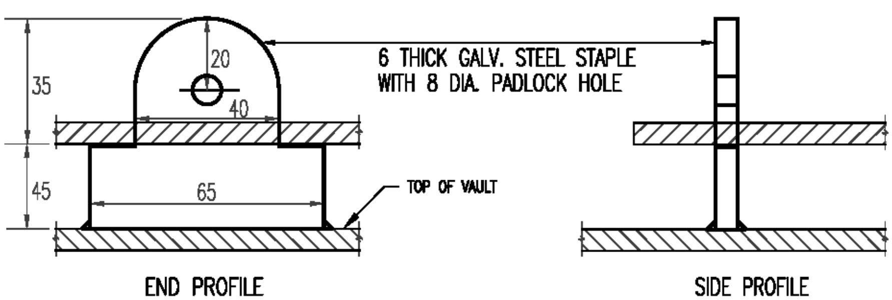
AVD-1B HINGE DETAIL and AVD-2 HASP DETAIL



NOTE: HINGES CONSTRUCTED FROM 12 THICK STEEL PLATE, TWO HINGES SPACED AT 400 CENTRES.

DRAWING AVD–1B HINGE DETAIL

ALL DIMENSIONS ARE IN mm

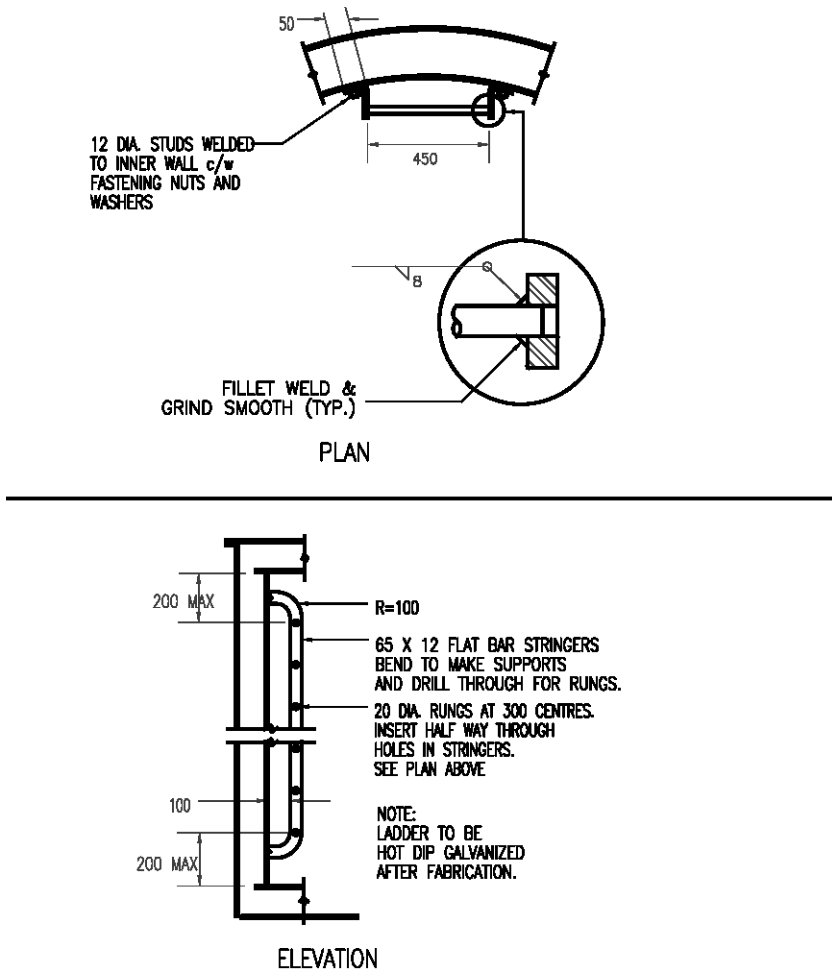


DRAWING AVD–2 HASP DETAIL

ALL DIMENSIONS ARE IN mm

APPENDIX A

AVD-3 ACCESS VAULT LADDER DETAIL – PLAN AND ELEVATION

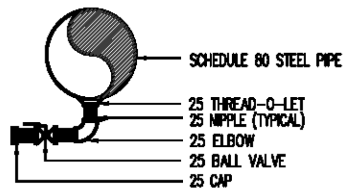


DRAWING AVD-3 ACCESS VAULT LADDER DETAIL

ALL DIMENSIONS ARE IN mm

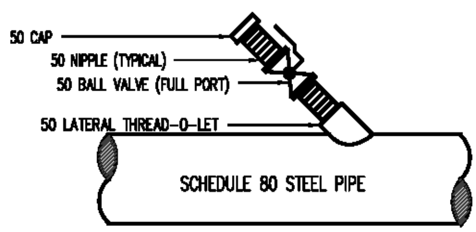
APPENDIX A

AVD-4A DRAIN DETAIL, AVD-4B THAW ACCESS PORT DETAIL, and AVD-5 AV PIPE SUPPORT DETAIL



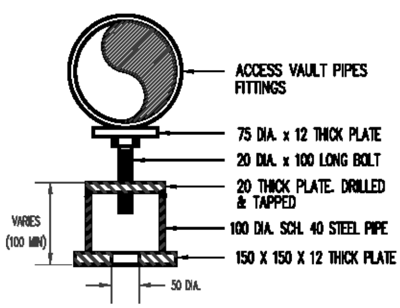
DRAWING AVD-4A DRAIN DETAIL

ALL DIMENSIONS ARE IN mm



DRAWING AVD-4B THAW ACCESS PORT DETAIL

ALL DIMENSIONS ARE IN mm



NOTES:

1. SUPPORTS ARE REQUIRED UNDER HYDRANTS, CLEAN-OUT ASSEMBLIES & CONNECTION POINTS FOR BRANCH LINES (ONE SUPPORT MIN. PER LINE).

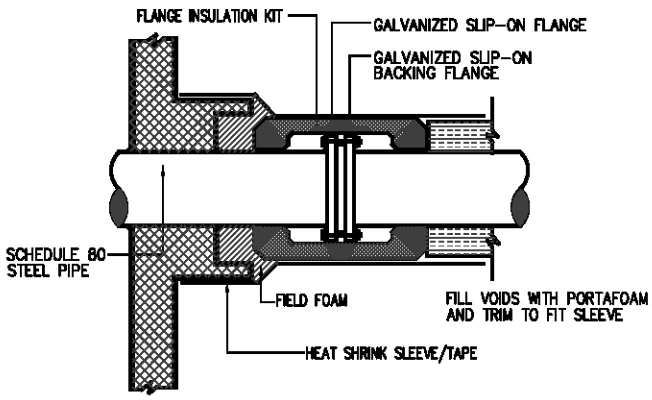
2. SUPPORTS SHALL BE HOT-DIPPED GALVANIZED AFTER FABRICATION.

DRAWING AVD-5 AV PIPE SUPPORT DETAIL

ALL DIMENSIONS ARE IN mm

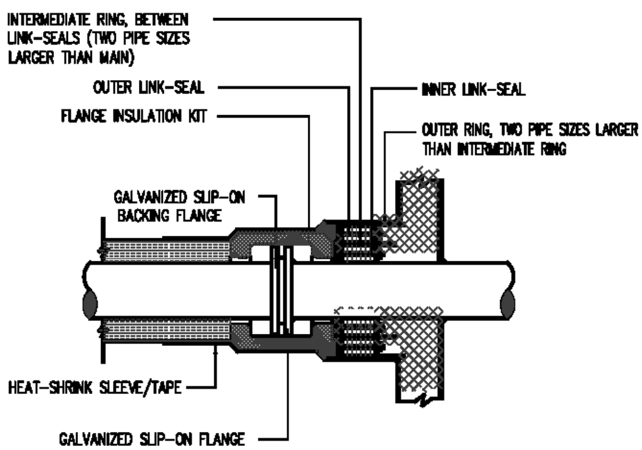
APPENDIX A

AVD-6A OPTION 1 and AVD-6B OPTION 2



DRAWING AVD-6A OPTION 1

ALL DIMENSIONS ARE IN mm



DRAWING AVD-6B OPTION 2

ALL DIMENSIONS ARE IN mm

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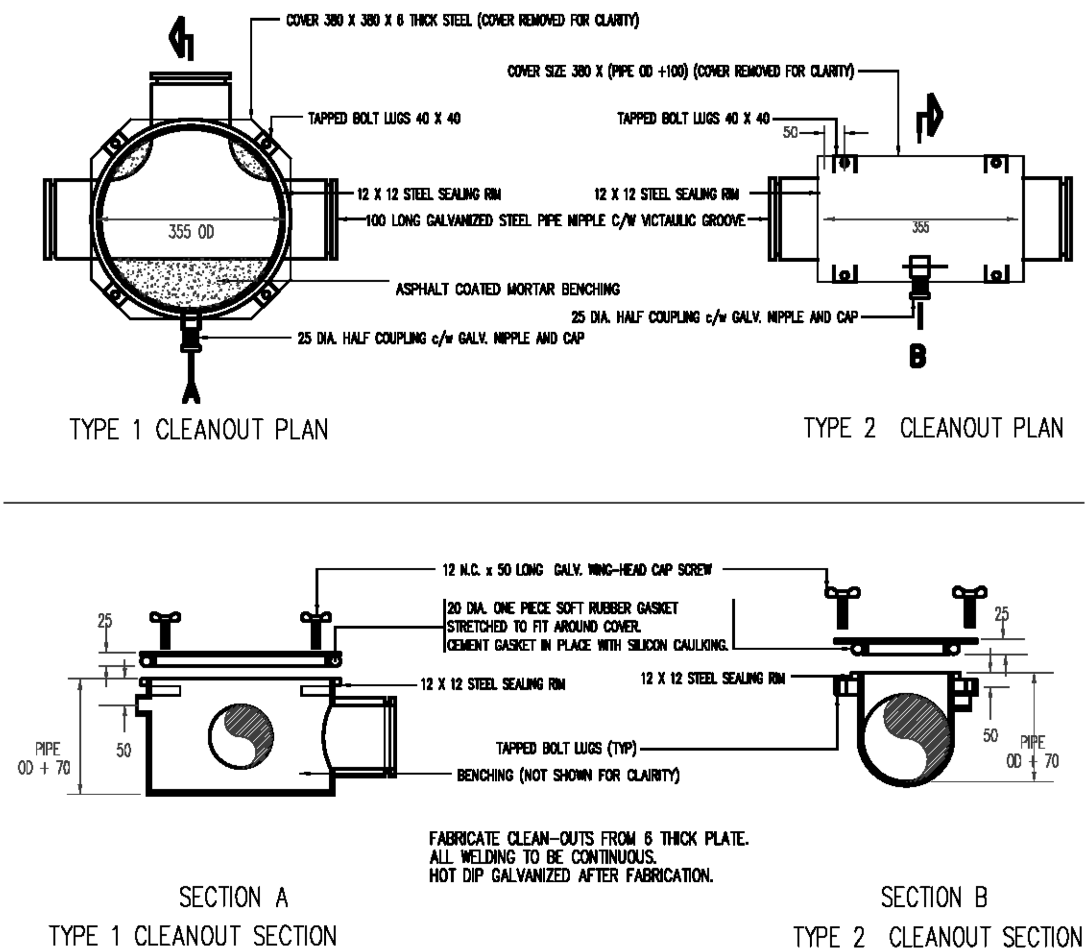
AVD-7 TYPE 1 AND 2 CLEANOUT

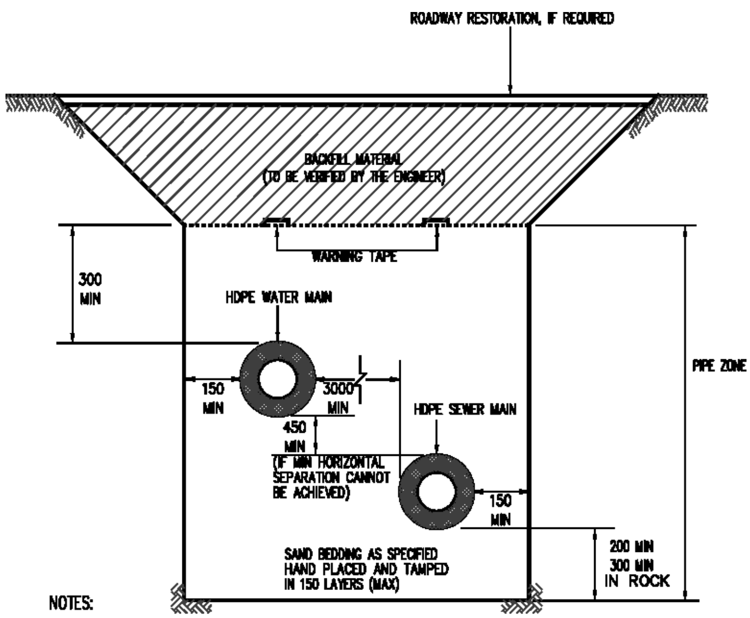


DRAWING AVD-7 TYPE 1 AND 2 CLEANOUT

ALL DIMENSIONS ARE IN mm

APPENDIX A

WSM-1 TYPICAL CROSS-SECTION OF MAINS



NOTES:

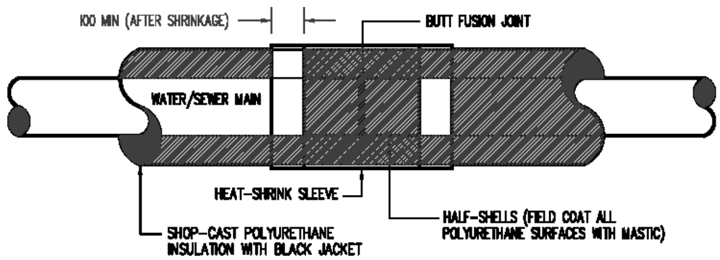
1. BEDDING MATERIAL SHALL BE COMPACTED TO 95% STANDARD PROCTOR DENSITY.
2. MAINTAIN A MINIMUM COVER OF 600 UNDER ROADWAY AND 400 UNDER LOT.
3. WARNING TAPE FOR WATER SERVICE LINES SHALL BE BLUE IN COLOUR AND HAVE FACTORY APPLIED MARKINGS AT ONE METRE INTERVALS, i.e., "CAUTION – BURIED WATER SERVICE LINE".
4. WARNING TAPE FOR SANITARY SEWER LINES SHALL BE GREEN IN COLOUR AND HAVE FACTORY APPLIED MARKINGS AT ONE METRE INTERVALS, i.e., "CAUTION – BURIED SANITARY SEWER LINE".
5. ALL FUSION JOINTS SHALL BE MADE BY A QUALIFIED AND LICENSED JOINTING TECHNICIAN.
6. TRENCH LIMITS SHOWN ARE MINIMUM. LIMITS SHALL CONFORM TO SAFETY REGULATIONS GOVERNING SUCH TRENCHES.
7. THE TRENCH SIDE SLOPES ARE SITE SPECIFIC AND SHALL BE AS REQUIRED BY SAFETY REGULATIONS, OR AS SPECIFIED BY THE ENGINEER.

DRAWING WSM–1 TYPICAL CROSS–SECTION OF MAINS

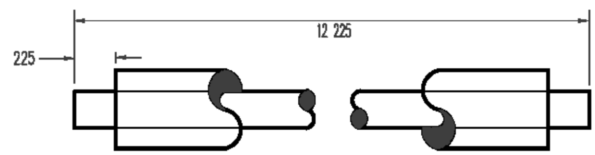
NOT TO SCALE ALL DIMENSIONS ARE IN mm

APPENDIX A

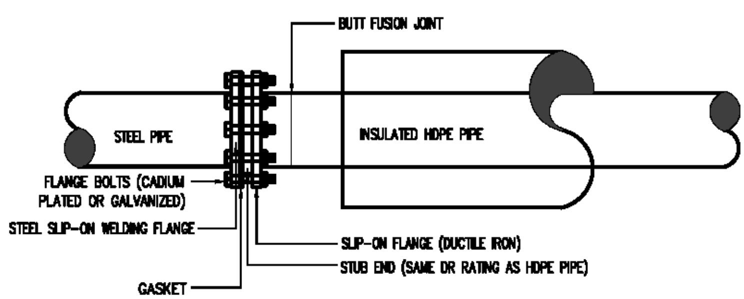
WSM-2 BUTT FUSION JOINT, WSM-2 TYPICAL PIPE LENGTH, and WSM-2 TYPICAL FLANGED JOINT



DRAWING WSM-2 BUTT FUSION JOINT
ALL DIMENSIONS ARE IN mm



DRAWING WSM-2 TYPICAL PIPE LENGTH
ALL DIMENSIONS ARE IN mm



DRAWING WSM-2 TYPICAL FLANGED JOINT
ALL DIMENSIONS ARE IN mm

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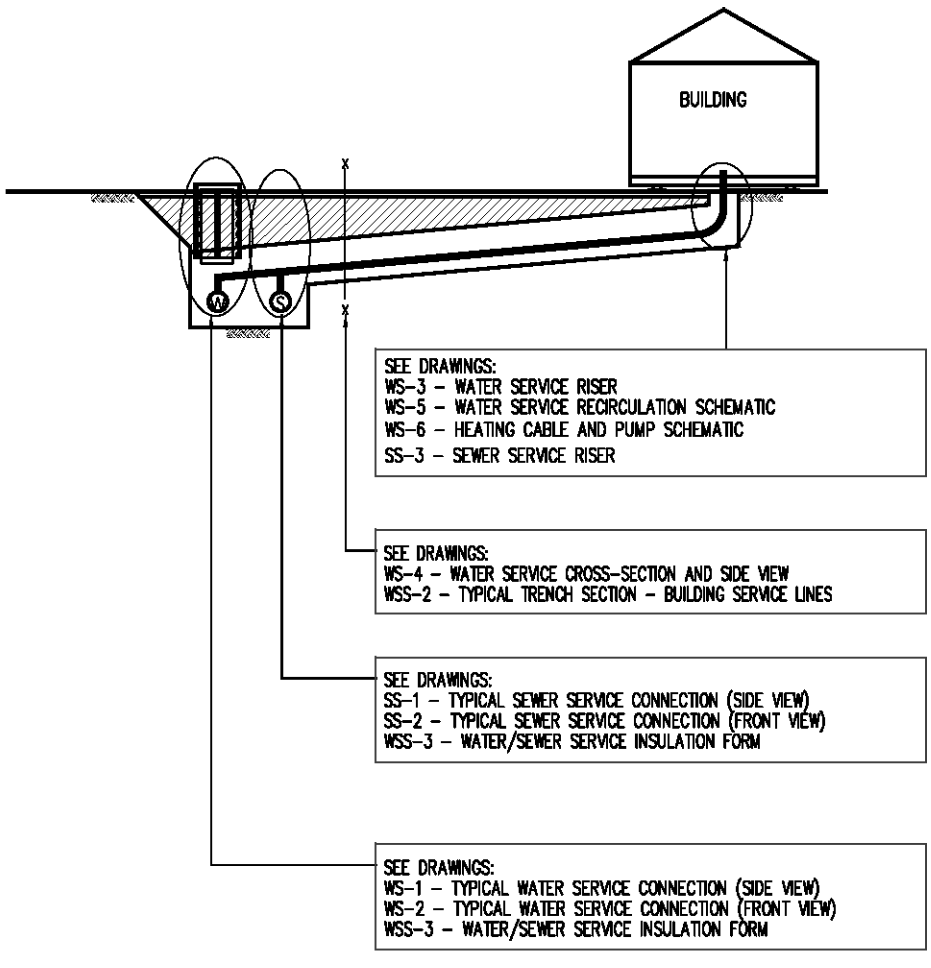
WSS-1 TYPICAL BUILDING WATER AND SEWER SERVICE HOOKUP

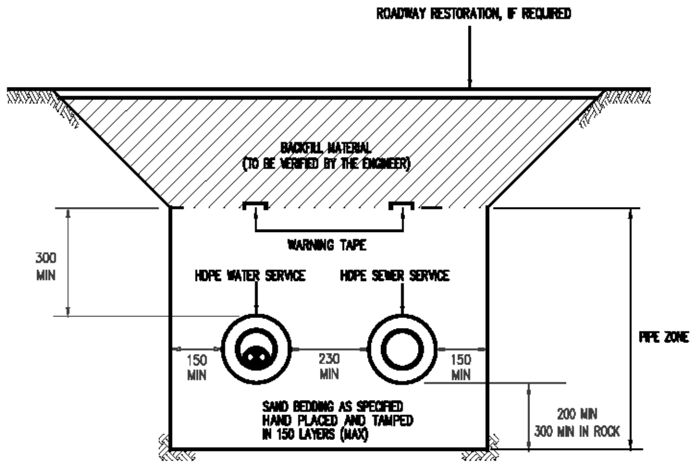


DRAWING WSS-1 TYPICAL BUILDING WATER AND SEWER SERVICE HOOKUP

ALL DIMENSIONS ARE IN mm

APPENDIX A

WSS-2 TYPICAL TRENCH SECTION – BUILDING SERVICE LINES



NOTES:

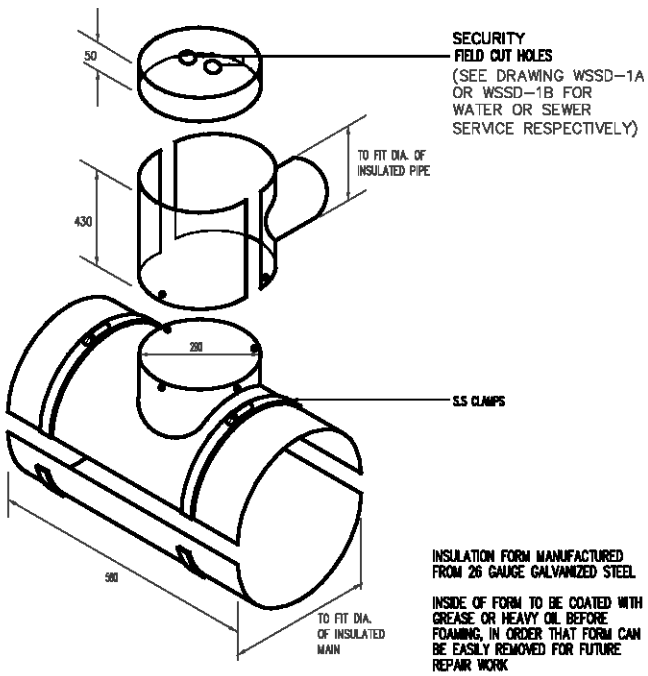
1. MATERIAL IN THE PIPE ZONE SHALL BE COMPACTED TO 95% STANDARD PROCTOR DENSITY.
2. MAINTAIN A MINIMUM COVER OF 600 UNDER ROADWAY AND 400 UNDER LOT.
3. MAINTAIN A MINIMUM GRADE OF 2% – SANITARY SEWER SERVICE CONNECTION.
4. WARNING TAPE FOR WATER SERVICE LINES SHALL BE BLUE IN COLOUR AND HAVE FACTORY APPLIED MARKINGS AT ONE METRE INTERVALS Ie. "CAUTION – BURIED WATER SERVICE LINE".
5. WARNING TAPE FOR SANITARY SEWER LINES SHALL BE GREEN IN COLOUR AND HAVE FACTORY APPLIED MARKINGS AT ONE METRE INTERVALS ie. "CAUTION – BURIED SANITARY SEWER LINE".
6. WATER SERVICE LINES SHALL BE CONTINUOUS AND WITHOUT JOINTS OR SPLICES BETWEEN THE STREET SERVICE VALVE AND BUILDING VALVE.
7. ALL FUSION JOINTS SHALL BE MADE BY A QUALIFIED AND LICENSED JOINTING TECHNICIAN.
8. JOINTS OR SPLICES WILL NOT BE ALLOWED ON HEATING CABLES.
9. TRENCH LIMITS SHOWN ARE MINIMUM. LIMITS SHALL CONFORM TO SAFETY REGULATIONS GOVERNING SUCH TRENCHES.
10. THE TRENCH SIDE SLOPES ARE SITE SPECIFIC AND SHALL CONFORM TO SAFETY REGULATIONS OR AS SPECIFIED BY THE ENGINEER.

DRAWING WSS–2 TYPICAL TRENCH SECTION – BUILDING SERVICE LINES

ALL DIMENSIONS ARE IN mm

APPENDIX A

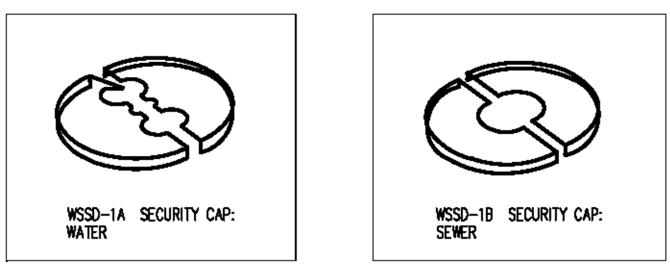
WSS-3 WATER/SEWER SERVICE INSULATION FORM



DRAWING WSS-3 WATER/SEWER SERVICE INSULATION FORM

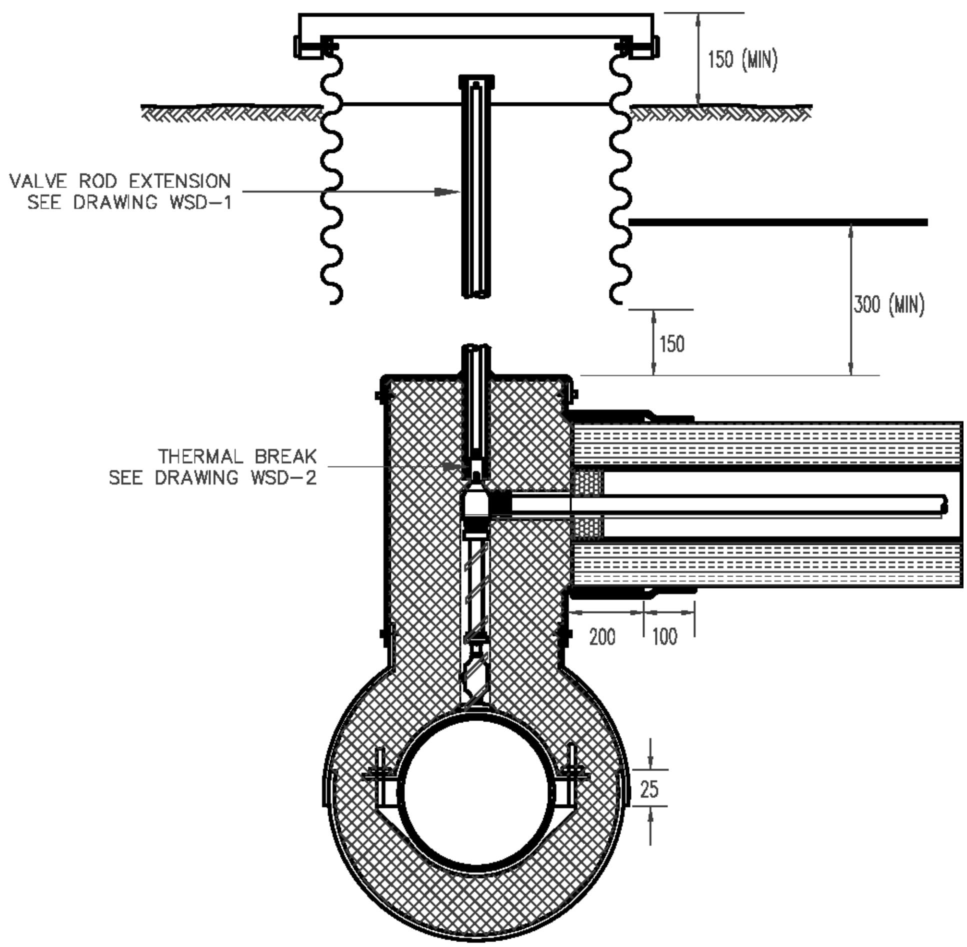
ALL DIMENSIONS ARE IN mm

DRAWING WSSD-1



APPENDIX A

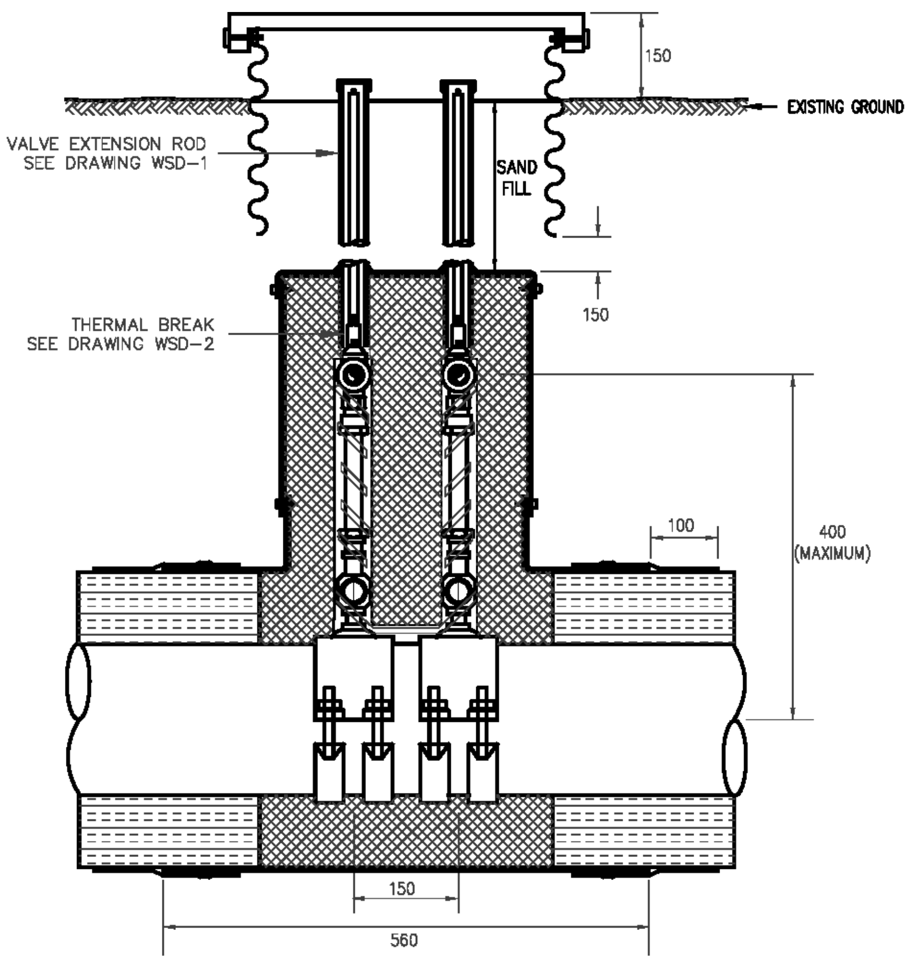
WS-1 TYPICAL WATER SERVICE CONNECTION (SIDE VIEW)



DRAWING WS–1 TYPICAL WATER SERVICE CONNECTION (SIDE VIEW)

ALL DIMENSIONS ARE IN mm

WS-2 TYPICAL WATER SERVICE CONNECTION (FRONT VIEW)

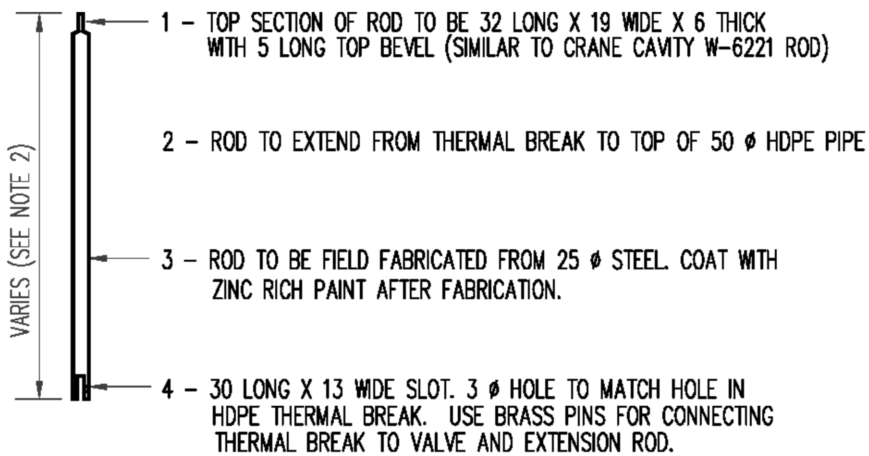


DRAWING WS-2 TYPICAL WATER SERVICE CONNECTION (FRONT VIEW)

ALL DIMENSIONS ARE IN mm

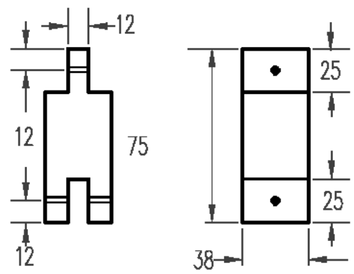
APPENDIX A

WSD-1 VALVE EXTENSION ROD and WSD-2 THERMAL BREAK



DRAWING WSD–1 VALVE EXTENSION ROD

ALL DIMENSIONS ARE IN mm



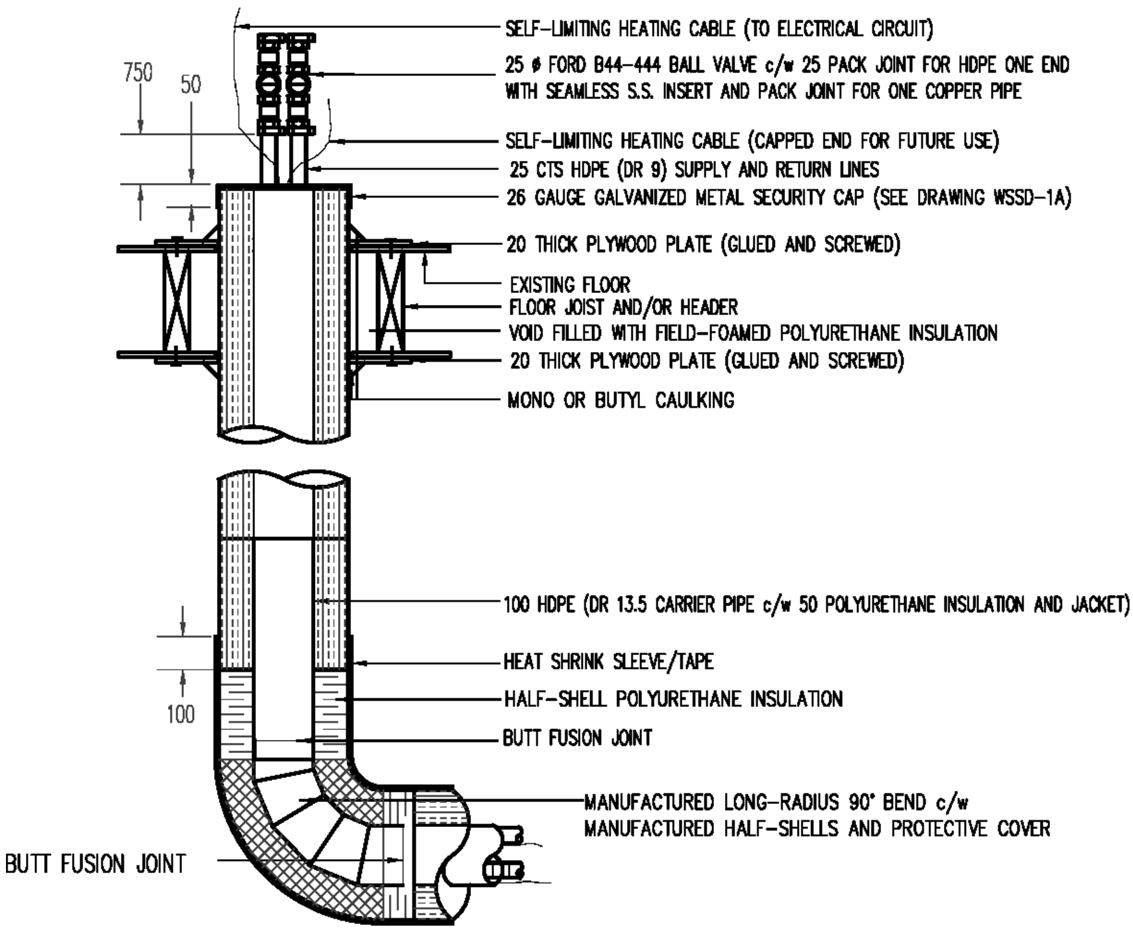
DRAWING WSD–2 THERMAL BREAK

(FABRICATED FROM 38 ø HDPE ROD STOCK)

ALL DIMENSIONS ARE IN mm

APPENDIX A

WS-3 WATER SERVICE RISER

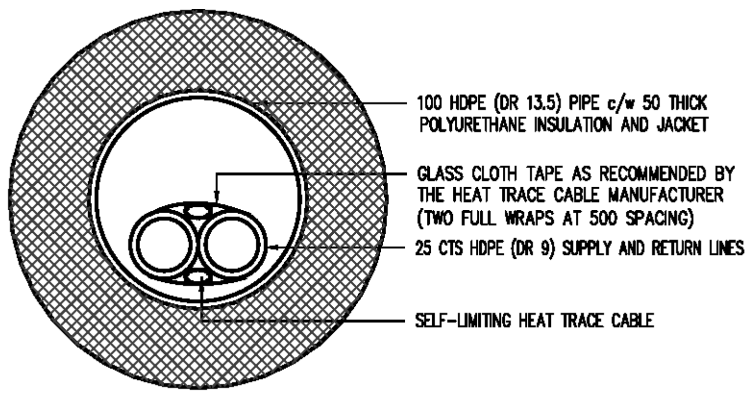


DRAWING WS-3 WATER SERVICE RISER

ALL DIMENSIONS ARE IN mm

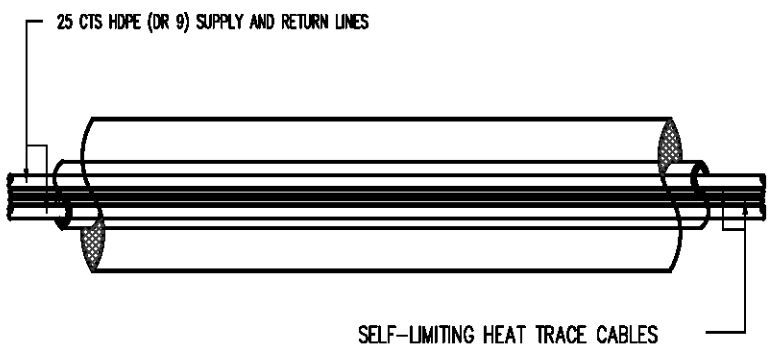
APPENDIX A

WS-4 CROSS-SECTION THROUGH WATER SERVICE and SIDE VIEW OF WATER SERVICE



DRAWING WS-4 CROSS-SECTION THROUGH WATER SERVICE

ALL DIMENSIONS ARE IN mm

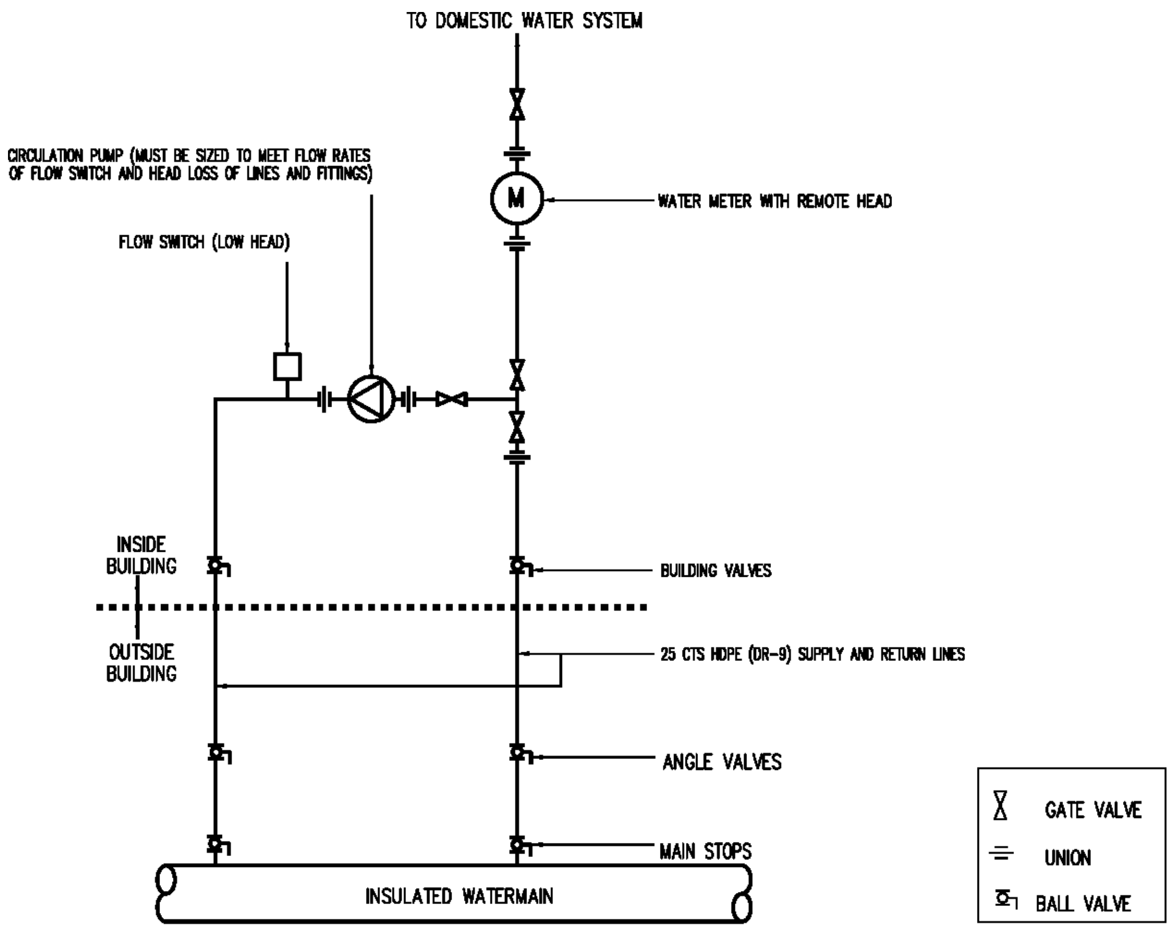


DRAWING WS-4 SIDE VIEW OF WATER SERVICE

ALL DIMENSIONS ARE IN mm

APPENDIX A

WS-5 WATER SERVICE RECIRCULATION SCHEMATIC

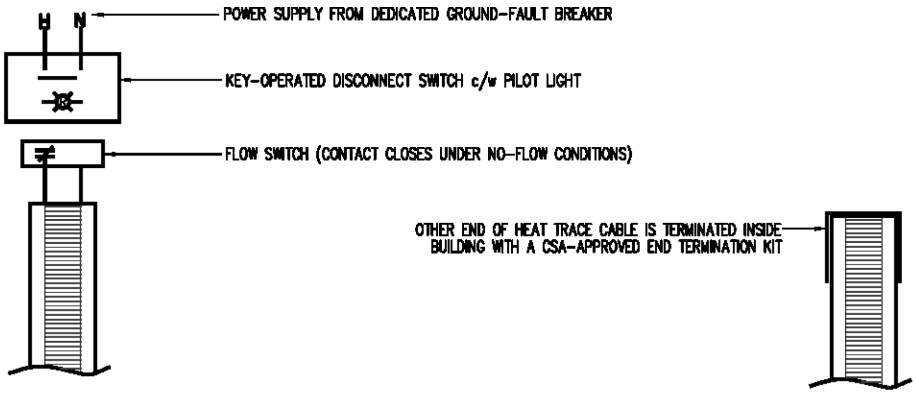


DRAWING WS-5 WATER SERVICE RECIRCULATION SCHEMATIC

ALL DIMENSIONS ARE IN mm

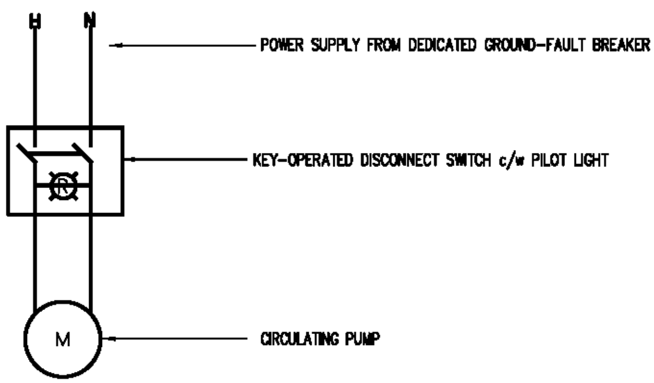
APPENDIX A

WS-6 TYPICAL WATER SERVICE HEATING CABLE SCHEMATIC and WS-6 CIRCULATING PUMP SCHEMATIC



DRAWING WS-6 TYPICAL WATER SERVICE HEATING CABLE SCHEMATIC

ALL DIMENSIONS ARE IN mm

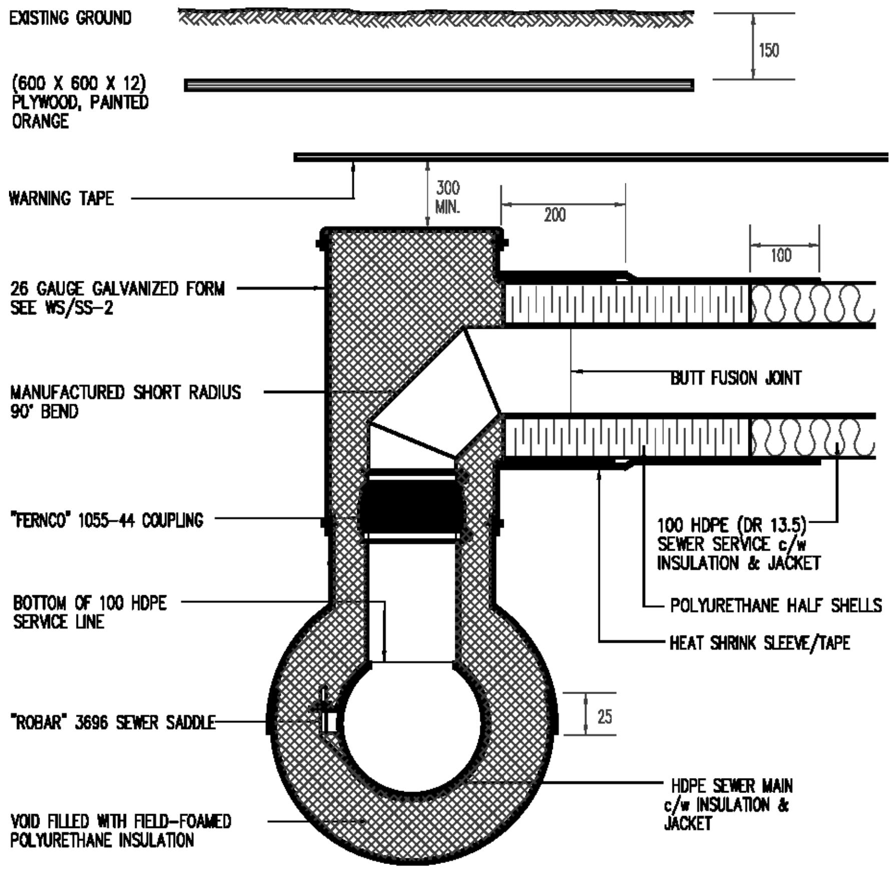


DRAWING WS-6 CIRCULATING PUMP SCHEMATIC

ALL DIMENSIONS ARE IN mm

APPENDIX A

SS-1 TYPICAL SEWER SERVICE CONNECTION (SIDE VIEW)



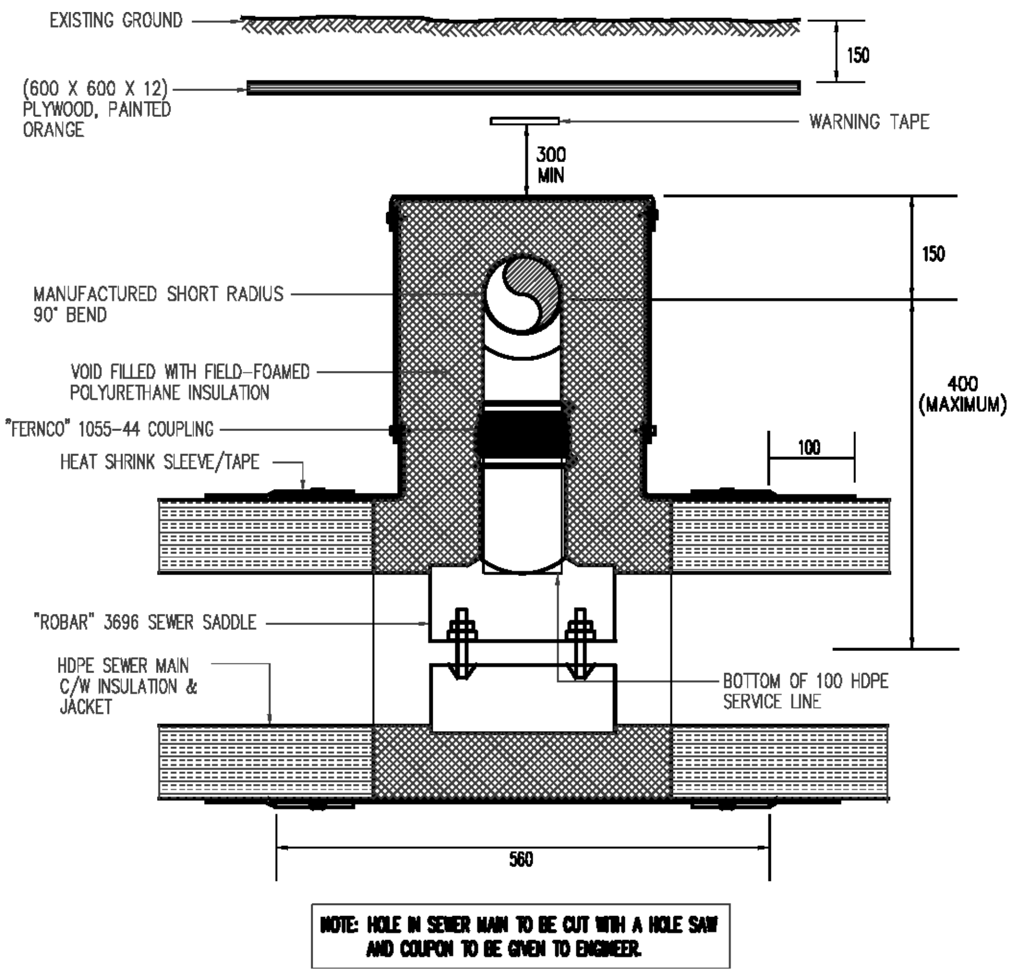
NOTE: HOLE IN SEWER MAIN TO BE CUT WITH A HOLE SAW AND COUPON TO BE GIVEN TO ENGINEER.

DRAWING SS-1 TYPICAL SEWER SERVICE CONNECTION (SIDE VIEW)

ALL DIMENSIONS ARE IN mm

APPENDIX A

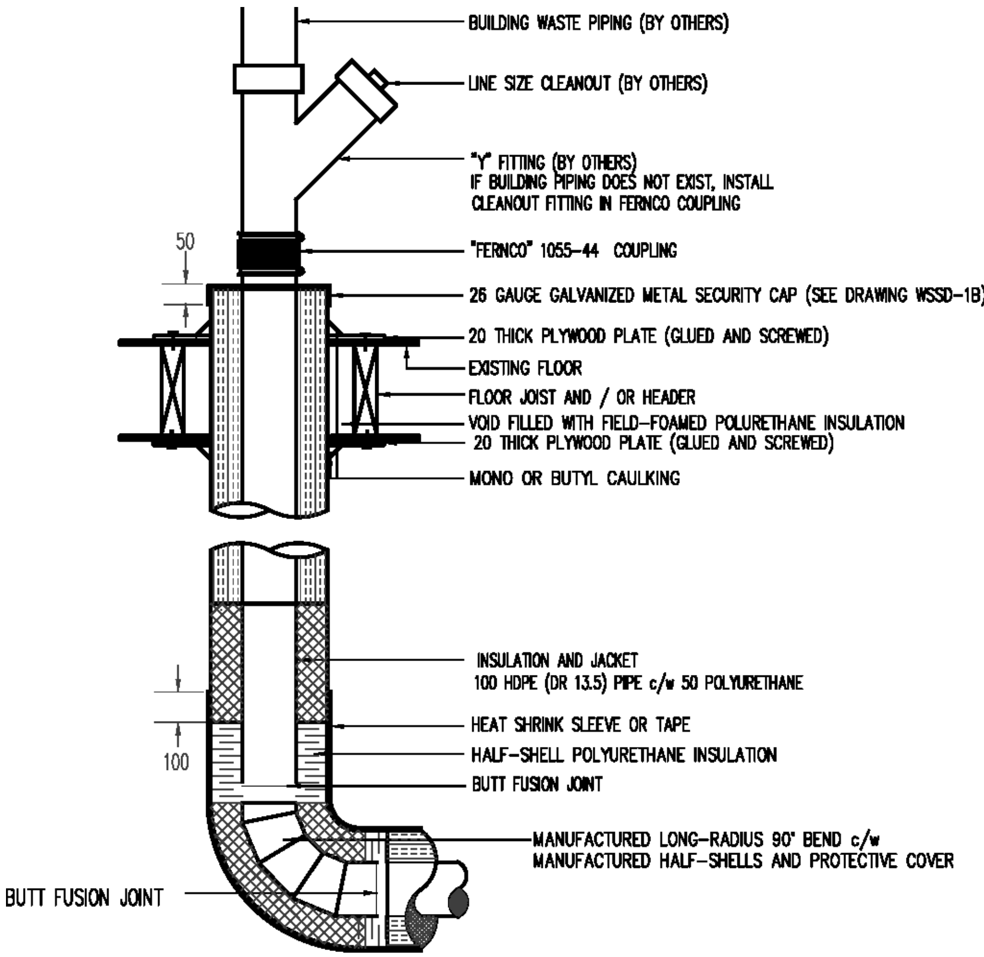
SS-2 TYPICAL SEWER SERVICE CONNECTION (FRONT VIEW)



DRAWING SS-2 TYPICAL SEWER SERVICE CONNECTION (FRONT VIEW)
ALL DIMENSIONS ARE IN mm

APPENDIX A

SS-3 SEWER SERVICE RISER



DRAWING SS-3 SEWER SERVICE RISER

ALL DIMENSIONS ARE IN mm

APPENDIX B

GNWT DEPARTMENT OF MUNICIPAL AND COMMUNITY AFFAIRS
WATER AND SEWAGE FACILITIES CAPITAL PROGRAM:
STANDARDS AND CRITERIA 1993

WATER AND SEWAGE FACILITIES CAPITAL PROGRAM: STANDARDS AND CRITERIA

1. PROGRAM STATEMENT

The Department of Municipal and Community Affairs will provide capital assistance under the Municipal Capital Assistance Policy to municipal governments for the purpose of providing water supply and sewage facilities (including works, buildings, furnishings, vehicles and equipment).

2. AUTHORITY

- Establishment Policy, Municipal Operations and Assessment Division
- Municipal Capital Assistance Policy
- Northwest Territories Waters Act (Canada), including Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories
- Environmental Protection Act
- Public Health Act, including Public Water Supply Regulations, General Sanitation Regulations and Public Sewerage Systems Regulations.

All construction of buildings and works in the Northwest Territories is governed by the current editions of:

- ASHRAE Standard 90A;
- Canadian Electrical Code;
- Canadian Measures for Energy Conservation in New Buildings, and Supplements;
- Illuminating Engineering Society's Lighting Handbook;
- National Building Code of Canada, and Supplements;
- National Fire Code of Canada.

3. LEVELS OF SERVICE

3.1 basic municipal infrastructure for water and sewage services are facilities (works, buildings, machinery, furnishings, vehicles and equipment) required by a municipal government in order to provide an essential level of water and sewage service. An essential level of water and sewage services is, in general terms:

3.1.1 a year round source of water;

3.1.2 safe, reliable and convenient supply of water for domestic, commercial, institutional, and fire protection purposes; and

3.1.3 safe, reliable and convenient collection and disposal of sewage.

3.2 Additional Municipal Infrastructure for water and sewage services are facilities required by a municipal government over and above a basic level of water and sewage service.

3.3 Water and sewage facilities and capacity for industrial purposes are not eligible for funding.

It is to be noted that before core area piping projects can proceed, there needs to be agreement from the majority of impacted property owners, in favour of charging the cost of piping against the cost of the land.

4. GENERAL CRITERIA

4.1 Replacement Criteria

Water and sewage facilities may be replaced before the end of their design expected (useful) life if the facilities are obsolete or can not supply the required capacity. The decision to undertake either major repairs or the replacement (with similar capacity or function) of an existing facility must be substantiated by an economic analysis considering the cost of repairs and the resulting extended useful life of the facility versus the cost of a new facility.

The maximum expenditure for major repairs to extend the useful life of an existing facility are as follows:

NUMBER OF YEARS THE USEFUL LIFE IS EXTENDED	MAXIMUM EXPENDITURE
1	0.06 x RC
2	0.11 x RC
4	0.21 x RC
6	0.30 x RC
8	0.37 x RC
10	0.43 x RC
15	0.55 x RC
20	0.63 x RC

Where:

RC = Replacement cost for a new facility.

Note 1: The maximum expenditure is based on the financial benefit of deferring the capital replacement expenditure. The financial benefit is the Present Value of:
(80% of the Replacement Cost of the Facility x Interest Rate) in each additional year of useful life of the existing facility.
Where 80% of the replacement cost is used to reflect the lower O&M cost and other benefits inherent with new facilities. The interest rate is 8%.

Note 2: Major repairs are those repairs which extend the useful life of the existing facility and which meet the definition of Capital Expenditure as defined in the GNWT Financial Administration Manual.

4.3 Expansion Criteria

Expansion of a water and sewage facility may only be undertaken when the capacity of the existing facility is projected to be exceeded in the next three years. Expansion of a facility must be designed with sufficient capacity to meet the projected needs of the community for the design horizon of the facility.

4.4 Standardization Objective

Communities with similar physical conditions and needs will require facilities with the same functional capabilities. A standardized design has been established for some facilities to be funded under this capital program. The standardized design should be utilized wherever practical.

The primary objectives of standardization under this capital program are:

4.4.1 to reduce capital costs;

4.4.2 to reduce O&M costs;

4.4.3 to simplify the capital planning process; and

4.4.4 to apply this capital program consistently to all communities with comparable municipal operation and maintenance responsibilities.

5. GENERAL PERFORMANCE CRITERIA

The following general performance criteria apply to all water and sewage facilities.

5.1 Cost-Effectiveness Analysis

The planning and design of water and sewage infrastructure must try to minimize the total present value of all associated capital and O&M costs net of any subsidies or grants. The present value shall be calculated over a 20 year planning horizon discounted at an annual rate of interest of 8% net of inflation.

The economic analysis methodology must comply with the methodology detailed in the "General Terms of Reference for a Community Water and Sanitation Services Study" in Appendix A, "Methodology for Economic Analysis of Alternatives", Community Works and Capital Planning Program Management Handbook, Department of Municipal and Community Affairs, April 1986.

5.2 Reliability of Service

Reliability of water and sewage service is a planning and design objective for systems and facilities provided by this capital program. Essential service should be available at all times. Essential service is as follows:

5.2.1 water supply to the water distribution system to provide:

(i) uninterrupted water supply to pipe serviced buildings; and

(ii) normal scheduled water delivery to truck serviced buildings;

5.2.2 availability of water requirements for fire protection;

5.2.3 public health is not endangered, for example through sewage overflows at sewage lift stations; and

5.2.4 the integrity of water and sewage facilities is not endangered.

Backup measures shall be incorporated where necessary to provide reliable essential service.

5.3 Backup Measures

The need for backup measures must be evaluated based on the following:

5.3.1 the consequence of interruption in service, considering the duration of the interruption in service, with respect to the provision of essential service (as outlined in Subsection 5.2. Reliability of Service);

5.3.2 the risk of interruption in service, for various durations (i.e., the likelihood of various events that could lead to interruption in service);

5.3.3 the cost of measures to prevent interruption in service, including backup measures.

Backup measures include a backup power supply, duplicate or alternate component, or an alternate system.

Backup measures for a facility must be compatible and coordinated with other backup measures within the water and sewage system and backup facilities (usually power) in the community, and complexed if practical in order to maximize the effectiveness of measures and to minimize duplication and costs.

If trucked serviced buildings have adequate water and sewage storage capacity in each building, short term (i.e., one to two day) interruptions in service may not compromise essential water delivery and sewage collection service.

All backup facilities will normally be considered as additional municipal infrastructure unless specifically identified as basic municipal infrastructure in these Standards and Criteria.

5.4 Freeze Protection Measures

All pipelines and other works and buildings shall be designed and operated to:

5.4.1 prevent freezing under design conditions;

5.4.2 provide adequate time to allow measures to be taken to minimize or mitigate damage before freeze-up in the event of cessation of flow, heat or other condition;

5.4.3 provide for safe failure by minimizing the potential damage if freezing occurs, including providing for the timely and convenient draining of pipes, both within buildings and outside; and

5.4.4 minimize the resources and time required to thaw and reinstate a frozen facility.

5.5 Monitoring and Control Measures

Instrumentation and monitoring shall be incorporated into systems and facilities to allow for safe and efficient operation.

All critical facilities shall have instrumentation, monitoring, alarm and notification systems to indicate critical conditions that would result in:

5.5.1 cessation of essential service (e.g., flow, temperature, pressure); and

5.5.2 damage to facilities (e.g., fire, freezing temperature).

Critical conditions (flow, pressure, pump operation, etc) should be monitored to prevent failure and to notify staff in the event of failure.

Communication from remote instrumentation may be via telephone line or radio transmission, whichever is cost-effective.

5.6 Siting

5.6.1 Siting of buildings and works must consider the following:

(i) community plan and zoning by-laws;

(ii) suitability from a community planning and development perspective;

(iii) land development costs; and

(iv) possibility of complexing with other buildings.

5.6.2 Buildings and works must be located on a site of sufficient area to:

(i) contain the facility and allow for future replacements and expansion;

and

(ii) provide adequate access and parking space for vehicles and equipment required for operation and maintenance.

5.6.3 Buildings and works must be designed and oriented to:

(i) minimize snow drifting effects on the facility, particularly around entrances;

(ii) minimize snow drifting effects on nearby buildings and roads; and

(iii) provide efficient access for service vehicles (water, sewage and garbage).

5.6.4 Buildings and works to be owned by a municipal corporation must be located within a public road allowance, within an easement, or on land registered in favour of the municipal corporation.

5.6.5 The design of access roads, circulation and service entries should accommodate potential future expansion as cost-effectively as possible.

5.7 Aesthetics

Facility design should be visually consistent with the functional requirements of the facility and with the community topography and adjacent buildings.

Facilities should be designed and located to minimize the impacts of offensive emissions including odours, smoke and noise.

5.8 Complexing

Where facilities are complexed, common service areas should not be duplicated within the complex. The design should allow for sharing of as many service areas as possible, such as washrooms, storage area and mechanical/electrical systems, including backup systems.

5.9 Energy Conservation

Energy conservation is a planning and design objective for facilities provided by this capital program. Energy conservation measures must be utilized where technically appropriate and cost-effective.

Insulation levels in all building components shall be established using life cycle costing procedures assuming the full unsubsidized cost of energy. Alternatives with the lowest present value shall be utilized.

5.10 Water Conservation

Water conservation is a planning and design objective for facilities provided by this capital program. Water conservation measures must be utilized where technically appropriate and cost-effective.

Building plumbing and fixtures shall be established using life cycle costing procedures assuming the full unsubsidized cost of water and sewage services. Alternatives with the lowest present value shall be utilized.

Water and sewage facilities shall be designed to operate without the need to bleed or waste water to prevent freezing.

6. DETAILED STANDARDS - GENERAL

The following detailed standards apply to all facilities or components in addition to the General Performance Criteria.

6.1 Design Capacity for Water Use

Facilities shall be designed using the following design values for water use. Total design value for water use is the sum of residential and non-residential water use. The sewage volume is generally assumed to be equal to the water use value.

6.1.1 Residential Water Use

The following design values for average daily residential water use per person are based on residences with full conventional plumbing and five occupants. These design values assume all customer water use is metered and there is no bleeding in piped systems.

Design values for various systems are as follows:

SERVICE	DESIGN WATER USE
Trucked water and sewage	90 lpcd
Piped water and sewage	225 lpcd
Piped water supply and trucked sewage pumpout	110 lpcd
Trucked water delivery and individual septic field	100 lpcd

6.1.2 Total Community Water Use

The total community water use varies with the extent of non-residential activities (i.e., commercial and institutional and industrial) in the community. The non-residential activities tend to increase in proportion to the population of the community. Unless specific data is available to estimate non-residential water use in a community, for design purposes, the total water use per capita for both trucked and piped systems is calculated using the following equations:

TOTAL COMMUNITY POPULATION	TOTAL WATER USE PER CAPITA
0 to 2,000	RWU x [1.0 + (0.00023 x Population)]
2,000 to 10,000	RWU x [-1.0 + (0.323 x Ln (Population))]
over 10,000	RWU x [2.0]

Where:

(i) RWU is the Residential Water Use

(ii) Ln is the natural logarithm

6.1.3 Partial Systems

For communities with both trucked and piped services, the design value for total water use shall be the sum of the appropriate design values for water use for each of the trucked and piped serviced buildings in the community.

6.1.4 Population

Community populations used in the design of facilities shall be those prepared by the Bureau of Statistics, GNWT.

6.1.5 Staging of Water Use

Where the current water use in a community is greater than the design values (e.g., due to bleeding or unmetered use) or less than the design values (e.g., due to buildings with honeybag toilets and limited plumbing), the design values for water use shall be assumed to be reached within five years.

6.2 Design Criteria

The design horizon, design economic life, and design expected life for facilities are as follows:

FACILITY	DESIGN HORIZON	DESIGN ECONOMIC LIFE	DESIGN EXPECTED LIFE
Wells	20	20	30
Intake	20	20	30
Truck Fill Station			
- Building	20	20	40
- Pumps	10	20	20
Water Supply Pipeline	20	20	30
Water Storage			
- Tank	10 to 20	20	30
- Reservoir	15 to 20	20	30
Water Treatment			
Plant	20	20	40
- Building	10	20	20
- Pumps	10 to 15	20	30
- Treatment Processes			
Sewage Lift Station			
- Building	20	20	40
- Pumps	10	20	20
Sewage Outfall/Forcemain	20	20	30
Sewage Treatment			
- Lagoon	15 to 20	20	40
- Mechanical Plant			
- Building	20	20	40
- Pumps	10	20	20
- Treatment Processes	10 to 15	20	30
Sewage Disposal Outfall	20	20	30

Where:

(a) Design Horizon is the period used to establish the capacity requirement for a facility.
(b) Design Economic Life is the period used in economic analysis to establish the present value (or equivalent annual capital cost) of a facility.
(c) Design Expected Life is the practical maximum expected life of a facility, assuming no premature failure, destruction or obsolescence.

7. DETAILED STANDARDS - COMPONENTS/FACILITIES

The following are detailed standards for water and sewage system components that are basic municipal infrastructure funded under this capital program. Facilities or standards that are additional municipal infrastructure funded under this capital program are identified for each component. For clarification, some water and sanitation facilities that are not funded under this capital program are identified.

These detailed standards for individual components apply in addition to the General Performance Criteria and the Detailed Standards - General.

7.1 Water Source

7.1.1 Basic Municipal Infrastructure

An all-season water source.

(i) Performance, Design Criteria and Capacity

The water source shall be selected to meet the total community water supply needs for 20 years but water supply planning should consider a 40-year planning period.

Different water sources may be used at different periods of the year where necessary or cost-effective, for example to avoid the need for additional water treatment.

Constructed water supply storage may be required in communities where no practical or cost effective water supply is available during the winter or other periods such as breakup or freeze-up.

The watershed of the water supply shall be protected against contamination and to ensure the best possible water quality.

Signs or fencing shall be installed to protect the water supply where the water source is close to the community or community activities and where the signs or fences are likely to be effective at protecting the water supply. Signs or fencing may only be necessary on part of the watershed perimeter.

(ii) Backup

Nil

7.1.2 Additional Municipal Infrastructure

Nil.

7.2 Water Supply

7.2.1 Basic Municipal Infrastructure

An all season water supply facility (well or intake) to procure water from the source.

(i) Performance, Design Criteria and Capacity

Groundwater is often a preferable water source to avoid the need for an expensive river intake or water treatment; however, groundwater and wells are not feasible in most of the NWT.

A permanent all season water intake is required where practical. A temporary (floating) intake is acceptable if provision is made for uninterrupted supply of water for essential service.

A single line intake is required for water intakes.

(ii) Backup

Nil.

7.2.2 Additional Municipal Infrastructure

Backup twin (dual) intake.

7.3 Water Treatment

7.3.1 Basic Municipal Infrastructure

Water treatment facilities necessary:

- for minimum water treatment of screening, chlorination and fluoridation; and
- to produce a finished water which meets the water quality objectives for microbiological, chemical, physical and radiological characteristics specified in the Guidelines for Canadian Drinking Water Quality.
- for preheating of water where required to facilitate water treatment or to prevent freezing during storage or transmission.

(i) Performance, Design Criteria and Capacity

Minimum water treatment facilities should be incorporated into an intake pumphouse or truckfill station where practical.

Where water treatment is required, consideration shall be given to simple treatment processes and systems.

Water treatment facilities shall be designed to meet the maximum day demand under the maximum combination of flow and worst raw water quality conditions.

Water testing equipment shall be provided to test for chlorine and fluoride levels and for appropriate water treatment plant operations.

Provision shall be made for the proper treatment and disposal of water treatment waste.

(ii) Backup

As a safeguard against malfunction and/or shut down, standby chlorination equipment having the capacity to replace the largest chlorine pump shall be provided. In addition, spare parts shall be available for all chlorination equipment.

7.3.2 Additional Municipal Infrastructure

Water treatment facilities designed to produce a finished water which exceeds the water quality objectives specified in the Guidelines for Canadian Drinking Water Quality or water quantity in excess of the community's forecast 20-year maximum daily demand.

7.4 Truck Fill Facility/Station

7.4.1 Basic Municipal Infrastructure

A truck fill facility where trucked water delivery services are provided by the municipal government.

(i) Performance, Design Criteria and Capacity
Truck fill facilities should be complexed with other water supply facilities where practical. A truck fill station is often remote from the community and includes the water intake (or well) and minimum water treatment facilities.

The truck fill supply shall have a minimum capacity of 1,000 litres per minute to minimize the truck fill time for fire-flow purposes.

An exterior overhead truck fill arm shall be installed.

All water supplied from a truck fill facility shall be metered.

An exterior key lock pump control shall be installed so that truck operators do not have to enter the building. The panel should include start and stop buttons, a pump selector switch, and an adjustable maximum run timer or volume control. Where more than one water hauler uses the facility, separate key locks shall be provided to activate separate recording of the volume of water supplied. Where minimum water treatment (i.e., screening, chlorination and fluoridation) is incorporated into a truck fill station, chemical mixing and dual injection equipment shall be provided and space shall be provided for mixing and storage of chemicals.

(ii) Backup

A standby emergency power generator is required unless:

(i) water storage for emergency and fire protection is provided elsewhere (independent of the truck-fill station); and

(ii) a readily available stand-by pump is available and a convenient access point for water delivery vehicles is maintained year round to the water/ice edge of the water source (i.e., reservoir, lake or river).

The electrical load should be arranged so that the pumping load and the heating load can be connected to the standby generator separately. The required capacity of the standby generator is the building load (i.e., lights, chargers, etc.) plus the greater of the pumping or heating load.

7.4.2 Additional Municipal Infrastructure

Nil.

7.4.3 Ineligible Municipal Infrastructure

Truck-fill station equipment or capacity for non-municipal purposes (e.g., for water supply outside the community or for commercial resale) are not eligible for funding.

7.5 Water Transmission

7.5.1 Basic Municipal Infrastructure

Trunk water supply pipelines where required to transport water between facilities including:

(i) trunk water supply pipelines between a water source and a treated water storage reservoir, reheat and circulation stations, a distribution pumphouse or a truck fill station;

(ii) trunk water supply pipelines from a distribution pumphouse to the first customer service connection to the piped water distribution network (laterals);

(iii) trunk water supply capacity incorporated into a water distribution pipe by oversizing the pipe to meet the flow required to planned treated water reservoir or distribution pumphouse in future expansion areas where the trunk water supply portion eligible for funding shall be based on the cost of the pipeline net of appurtenances (e.g., hydrants, valves, lateral and service connection tap-ins) and be proportional to the required increase in pipe diameter to provide the trunk capacity;

(iv) a pipeline required to fill a seasonal water storage reservoir.

(i) Performance, Design Criteria and Capacity

For raw water supply pipelines the addition of heat is usually required at the source (and potentially along very long pipelines if cost-effective) to prevent freezing. Recirculation may be required to prevent freezing if there are low demand or no demand conditions.

Pipelines must be capable of being drained in a timely and convenient manner. Drain valves shall be installed at all low points. Appurtenances such and drain valves should be housed in access points for easy access.

Provision must be made to thaw and start-up the pipeline if it becomes frozen. Injection thawing (steam or hot water injection) is generally used but heat tracing may be installed if it is cost effective. Where injection thawing is to be used, the equipment is required as part of the water transmission facility if it is not available within the water/sewage system.

Access points shall be provided along the pipeline and maximum spacing shall be based on the requirements for injection thawing equipment and is generally 150 to 200 meters.

Water supply pipelines should be buried wherever cost-effective and practical to provide protection from vandalism and accidents, to not impede community development and activities, to reduce heating and maintenance costs, and to reduce the risk of freezing (i.e., by increase the freezeup time). Pipelines shall only be buried where equipment to access buried pipelines is available.

(ii) Backup

Backup water supply pipeline if a risk assessment shows that a backup water supply pipeline is essential.

7.5.2 Additional Municipal Infrastructure

Backup water supply pipeline if a risk assessment shows that a backup water supply pipeline is not essential.

7.6 Water Pumphouse

7.6.1 Basic Municipal Infrastructure

Water supply pumphouse facilities for trunk water supply pipelines and water distribution pumphouse facilities for piped water distribution systems.

(i) Performance, Design Criteria and Capacity

Water supply pumphouse facilities are required at the source where raw water is piped from a distant water source to the community water facilities. A supply pumphouse contains pumping equipment and water tempering equipment if required. Supply pumphouse facilities should be complexed with other water supply facilities, such as water treatment, water intake and storage, where practical.

Distribution pumphouse facilities are required to supply water to piped water distribution systems. A distribution pumphouse includes pumps for demand, recirculation and fire flows and water heating systems. Distribution pumphouse facilities should be complexed with other water supply facilities, such as water storage and treatment, where practical.

(ii) Backup

Backup pumps and power are required for a water pumphouse.

7.6.2 Additional Municipal Infrastructure

Nil.

7.7 Water Storage

7.7.1 Basic Municipal Infrastructure

Water storage to meet the water system needs including:
(i) fire protection;
(ii) emergency (loss of supply);
(iii) equalization storage; and
(iv) seasonal water storage.

(i) Performance, Design Criteria and Capacity

Fire protection water storage requirements shall be determined in accordance with the NWT Fire Protection Study (1992) prepared for the Department of Municipal & Community Affairs.

Emergency water storage within the community may be required where the water source is remote (over 3.2 kilometres) from the community and interruption of supply is likely. Emergency storage required is as follows:
= (Projected average daily demand at the Design Horizon for the water storage facility) x (Longest probable supply interruption)

Equalization (operating or buffer) water storage is required where the water supply capacity is limited (e.g., by the source, treatment facilities or pipeline) and can not supply the peak demand.

For piped systems the equalization storage required is as follows:
= 25% x (Projected maximum daily demand at the Design Horizon for the water storage facility)

Where the maximum day factor is typically:

for population	500	to	1,000	=	2.75
for population	1,001	to	2,000	=	2.50
for population	2,001	to	3,000	=	2.25
for population	3,001	to	10,000	=	2.00
for population	10,001	to	25,000	=	1.90
for population	25,001	to	50,000	=	1.80

For trucked systems the equalization storage required is as follows:
= (Projected maximum daily demand at the Design Horizon for

the water storage facility) - (Average water supply or production during 8 hours)
Where the maximum day factor is 2.1 based on: (Maximum day demand factor of 1.5) x (Truck delivery factor of 7/5 based on water delivery 5 days per week).

Seasonal water storage is required where there is no practical source of water during the winter, spring breakup or fall freezeup. Seasonal storage required is as follows:

= (Projected average daily demand at the Design Horizon for the water storage facility) x (Longest probable supply interruption)
Where there are both piped and trucked services the required water storage volume shall be based on the sum of the requirements for piped and trucked services, at the design horizon for the water storage facility.

(ii) <u>Backup</u>

Nil.

7.7.2 Additional Municipal Infrastructure

Nil.

7.8 Sewage Lift Station

7.8.1 Basic Municipal Infrastructure

Sewage lift stations pumping into trunk sewage forcemains.

(i) <u>Performance, Design Criteria and Capacity</u>

Sewage lift stations may incorporate trucked sewage discharge facilities.

(ii) <u>Backup</u>

Standby pumping power, independent of the primary power supply, shall be provided at sewage lift stations. An emergency overflow bypass should also be provided in conjunction with the standby pumping capacity.

The standby pumping shall be capable of handling the peak sewage flows.

7.8.2 Additional Municipal Infrastructure

Nil.

7.9 Sewage Transmission

7.9.1 Basic Municipal Infrastructure

Trunk sewage transmission pipes (gravity outfall pipes and pressure forcemain pipes) where required to transport sewage between facilities as follows:

(i) gravity sewage pipes between the last service connection to the sewage collection network (laterals) and the sewage treatment/disposal facilities;

(ii) sewage forcemain between a sewage lift station and sewage treatment/disposal facilities;

(iii) sewage pipes between sewage treatment facilities and sewage disposal facilities;

(iv) trunk sewage capacity incorporated into sewage collection mains by oversizing the pipe to accommodate discharge from the lift station or forcemains of neighbouring developed subdivisions or future expansion areas where the trunk sewage portion eligible for funding shall be based on the cost for the pipeline net of appurtenances (e.g., service connection and lateral tap-ins, valves) and be proportional to the required increase in pipe diameter required to provide the trunk capacity;

(v) a sewage pipeline required to empty a seasonal discharge sewage lagoon.

(i) <u>Performance, Design Criteria and Capacity</u>

Heating or alternate meant of freeze protection must be provided if there is insufficient flow to prevent freezing.

Forcemains must be capable of being drained in a timely and convenient manner. Drain facilities shall be installed at all low points and vents and vacuum breaks shall be installed where appropriate. Appurtenances should be housed in access points for easy access.

Provision must be made to thaw and start-up the pipeline if it becomes frozen. Injection thawing (steam or hot water injection) is generally used but heat tracing may be installed if it is cost-effective. Where injection thawing is to be used, the equipment is required as part of the sewage transmission facility if it is not available within the water/sewage system.

Access points shall be provided along the pipeline and maximum spacing shall be based on the requirements for injection thawing equipment and is generally 150 to 200 meters.

Sewage transmission pipelines should be buried wherever cost-effective and practical to provide protection from vandalism and accidents, to not impede community development and activities, to reduce heating and maintenance costs, and to reduce the risk of freezing (i.e., by increase the freezeup time). Pipelines shall only be buried where equipment to access buried pipelines is available.

(ii) Backup

Nil.

7.9.2 Additional Municipal Infrastructure

Nil.

7.10 Sewage Treatment

7.10.1 Basic Municipal Infrastructure

Sewage treatment facilities where sewage treatment is required to produce an effluent which meets receiving water quality objectives and the wastewater effluent quality guidelines specified in Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories.

Sewage sludge treatment facilities where required for the continuing operation of the facility.

(i) Performance, Design Criteria and Capacity

Sewage lagoons are the preferred method of treatment due to their operational simplicity compared to mechanical sewage treatment plants.

Sewage lagoon should be planned and designed following the Guidelines for the Planning, Design Operation and Maintenance of Wastewater Lagoon Systems in the Northwest Territories (Department of Municipal and Community Affairs).

A sewage lagoon may be entirely artificial or it may be an engineered adaptation of a natural lake.

(ii) Backup

A standby power source shall be provided for mechanical equipment where the temporary discharge of raw or partially treated sewage may be reasonably expected to either endanger the public health, cause serious environmental damage, or create a significant public nuisance.

7.10.2 Additional Municipal Infrastructure

Sewage treatment facilities designed to produce an effluent which exceeds the receiving water quality objectives and the wastewater effluent quality guidelines specified in Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories or which exceeds requirements of the water license issued by the NWT Water Board.

7.11 Sewage Disposal

7.11.1 Basic Municipal Infrastructure

A sewage disposal facility to discharge effluent into the receiving environment which is required to meet the sewage outfall requirements specified in Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories.

(i) Performance, Design Criteria and Capacity

The sewage disposal location should be chosen to safeguard public health and minimize environmental impact.

Sewage disposal in coastal communities should be planned and designed following the Guidelines for the Disposal of Wastewater in Coastal Communities in the Northwest Territories (Department of Municipal and

Community Affairs).

(ii) Backup

Nil.

7.11.2 Additional Municipal Infrastructure

Nil.

7.12 Trucked Services

The Government of the Northwest Territories provides capital assistance to municipal governments for water delivery and sewage collection vehicles under the Mobile Equipment Capital Program.

7.13 Piped Water Distribution and Sewage Collection

Construction, upgrading or replacement of water distribution pipes or sewage collection pipes (i.e., lateral mains) are not eligible for funding. Therefore standards and criteria are not provided for these facilities.

7.14 Piped Service Connections

Construction, upgrading or replacement of piped service connections between buildings and the water distribution and sewage collection mains are not eligible for funding. Therefore standards and criteria are not provided for these facilities.

7.15. Storm Water Collection, Treatment and Disposal

The Government of the Northwest Territories provides capital assistance to municipal governments for storm water collection under the Roads and Sidewalks Capital Program. Therefore standards and criteria are not provided for these facilities.

Storm water treatment and disposal are not eligible for funding. Storm water must not be combined with the sewage collection and treatment system.

7.16 Access Roads to Water and Sewage Facilities

7.16.1 Basic Municipal Infrastructure

Access roads required and intended solely to provide access to funded water and sewage facilities (e.g., water source, sewage treatment/disposal site).

(i) Performance, Design Criteria and Capacity

The standard road-top width is 6 meters.

(ii) Backup

Nil.

(b) Additional Municipal Infrastructure

Nil.

Figures 1 and 2 are schematics showing what infrastructure is or is not grantable under this capital program.

APPENDIX C

LIST OF REFERENCE DOCUMENTS

The following documents are referenced within the text of *Good Engineering Practice for Northern Water and Sewer Systems*:

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