City of Saskatoon

Design and Development Standards Manual

Section Five

Sanitary Sewer Collection System

Version 17

City of Saskatoon

Table of Contents

1 Objective

The sanitary sewer system shall collect all sanitary sewage generated in an infill development and convey it to a wastewater treatment facility for processing.

The sanitary sewer collection system shall be designed to be completely separate from the storm water drainage system. Interconnectivity with storm water pipes is not acceptable.

2 Submissions and Approvals

The Proponent is responsible for being aware of the regulatory requirements governing the development of the sanitary sewer collection system, and for compliance with these requirements.

Regulatory and supporting documents that shall be referenced for the design and installation of the sanitary sewage system include the following:

- *Sewer Use Bylaw (Bylaw No. 9466)*, City of Saskatoon;
- *Standard Construction Specifications and Drawings: Roadways, Water, and Sewer*, City of Saskatoon;
- *Sewage Works Design Standard EPB 503*, Saskatchewan Environment;
- *Saskatchewan Employment Act, S-15.1*, Province of Saskatchewan;
- *Occupational Health and Safety Regulations, 1996, O-1.1 Reg 1*, Province of Saskatchewan;
- *The Plumbing Regulations Chapter, P-37.1 Reg 13*, Province of Saskatchewan;
- Private Sewage Works Regulations, P-37.1 Reg 14, Province of Saskatchewan;
- *National Plumbing Code*, Canadian Commission on Building and Fire Codes, National Research Council of Canada;
- *Canadian Electrical Code, CSA C22.1*, Part 1, Sections 18 and 22, Canadian Standards Association (CSA);
- *Natural Gas and Propane Installation Code CSA B149.1*, Canadian Standards Association (CSA);
- *PVC Pipe: Design and Installation* (M23), AWWA; and
- *PE Pipe: Design and Installation*, (M55), AWWA.

2.1 City of Saskatoon

The City of Saskatoon (CoS) requires the submission of a *Sanitary Sewer Collection Plan*, based on modelling of the proposed sanitary sewer collection system, and a *Sewage Pump Station Design Report*.

2.1.1 Sanitary Sewer Collection Plan

At the development concept stage, an analysis of all pipes 200 mm or larger shall be carried out. The model shall be submitted to the CoS for verification. The conceptual Sanitary Sewer Collection Plan shall contain the following elements:

- A general description and site plan of the proposed development.
- Figures showing the proposed post-development topography of the site.
- A description of, and figures showing, the proposed staging of the development and the associated construction of the sanitary sewer collection system.
- A description of the contributions and flow rates that were used for modelling, together with an explanation of how these were calculated and assigned to the model.
- A description of boundary conditions and any other assumptions used for modelling (pipe materials, design coefficients, etc.), together with the rationale for their use.
- Figures showing nodes, elevations, pipes, major hydraulic elements, and anticipated flows.
- A description of the simulation results. Actual model-run data shall be appended to the *Sanitary Sewer Collection Plan*.

For detailed design, modelling of all pipes 200 mm or larger shall be carried out for each stage of development. The staged *Sanitary Sewer Collection Plans* shall include the same elements as the conceptual plan, but shall be specific to each stage of development. Models shall be submitted to the CoS for verification.

The CoS reserves the right to require resubmission of the *Sanitary Sewer Collection Plan*, if there are changes to the proposed development that significantly affect the sanitary sewer collection system and/or hydraulic analysis. Resubmissions shall be required at the discretion of the CoS and

shall typically relate to changes in the configuration of the system and/or changes to proposed land uses.

2.1.2 Sewage Pump Station Design Report

Proponents shall submit the following information, at the development concept stage, to the CoS for each proposed sewage pump station:

- A site plan showing the area served by the pump station.
- Justification of the need for a pump station.
- A design summary and present value life-cycle cost estimate for each station that includes:
  - Capital construction costs.
  - The present worth or operating costs (e.g. energy, equipment maintenance and replacement) over a 50-year design life.
- A comparison of technically viable options, if applicable. The technical or economic rationale for the preferred option shall be clearly outlined.
- Proposed routing of the force main.
- Any plans for staging of the proposed pump station considering continuity of service, responsibility, and financial arrangements for future stage implementation, and the most cost-effective method for implementing capacity changes.
- Estimated inflows at the initial stage of construction, by phase, and at full buildout.

The CoS shall be responsible for coordinating the design of the sewage pump station including:

- Design drawings.
- Pump and system curves.
- Calculations of sewage detention times in the force main and wet well (if applicable) under various operating conditions.
- Development of an operations and maintenance manual for each station.

2.2 Other Authorities

The Proponent shall be responsible for obtaining approvals from the appropriate authorities in a timely manner.

3 Design Flows

The sanitary sewer collection system shall be designed to be completely separate from the storm drainage system. Extensions to the existing system shall be designed and constructed with adequate capacity and in such a manner that the potential for extraneous rainwater and groundwater inflows are minimized.

Each sanitary sewer collection system extension or modification shall connect appropriately with the existing collection network, provide adequate capacity for the proposed development, and if applicable, shall include infrastructure and capacity provisions for adjacent future development areas as described in the sector plan for each development area.

Sanitary sewers shall have adequate capacity for peak flows and shall function satisfactorily with minimum maintenance at low flows.

3.1 Flow Calculation

The following calculations shall be used for the design of residential, commercial, industrial, and institutional design flows:

- The peak design flow (PDF) is the sum of the peak dry weather flow (PDWF), the inflow and infiltration (I&I) allowance, and the weeping tile flow (WTF) allowance, if applicable.
- The PDWF shall be obtained by multiplying the average dry weather flow (ADWF) by the peaking factor (PF).
- The PF shall be determined using the Harmon Formula.

  PDF = (ADWF x PF) + I&I + WTF

  $PF = 1 + 14/(4 + P^{½})$

  Where P = Population in thousands.

3.1.1 Population and Dry Weather Flow

Factors that shall be used to estimate population and dry weather flows are summarized in Table 3-1. The unit flow rate to convert equivalent population density to flow is 290 litres/capita/day

Table 3-1
Sanitary Sewer Design Factors

Land Use Category	Equivalent Population[1] (p/ha)	Comment
Low Density Residential	42	Typical single family residential
Low Density Multi Unit Residential	60-120[1]	Includes townhouses
Medium Density Multi Unit Residential	120-220[1]	Includes walk-up apartments, mixed use residential and commercial.
High Density Multi Unit Residential	220-460[1]	Includes medium to high rise apartments
Central Commercial	330[2]	Includes central business district, large hotels, and office towers.
Secondary Commercial and Local Commercial	160[2]	Includes wholesale and retail outlets, shopping centres, service stations, convenience stores, small and medium-sized hotels, motels, service establishments, institutions, clubs, and highway commercial.
Wet Industrial	530[2]	Includes food processors.
Dry Industrial	16[2]	Includes storage and light manufacturing.
Mixed Industrial	130[2]	Includes a combination of wet industrial, dry industrial, and commercial.

1) Maximum equivalent populations shall be used if population densities are not known.
2) Equivalent populations for non-residential land uses are used as guidelines. The actual or estimated ADWF is site specific and if known shall be provided to the CoS for review and potential approval.

3.1.2 Infiltration Allowance

The minimum infiltration allowance shall be 0.17 L/s/ha.

3.1.3 Weeping Tile Flow Allowance

Connection of foundation drains of any buildings to the sanitary sewer collection system is no longer permitted; therefore, there is no weeping tile allowance for new developments.

For portions of the sanitary sewer collection system that are intended to accommodate flow from existing upstream developments, the CoS will provide allowances for weeping tile flow.

3.2 Modelling

A hydraulic analysis shall be required for every development and for every change that significantly impacts a previous hydraulic analysis. The results of the modelling shall be summarized in the *Sanitary Sewer Collection Plan* and submitted to the CoS for approval.

The CoS has created an InfoSWMM model of the citywide sanitary sewer collection system. The software used by the Proponent shall be pre-approved by the CoS.

- The CoS shall provide information for existing nodes that will be connection points for the proposed network.
- The CoS shall provide the datum for node elevations.
- The Proponent shall model the total design flow at each major stage of development.
- Flow contributions shall be distributed throughout the network in accordance with the planned land use surrounding each node.
- All force mains and gravity sewer mains 200 mm in diameter or larger shall be modeled.
- Transient analysis is required for all force mains.
- Runs shall include, at a minimum, a simulation of peak flows including allowances for I&I and WTF (where applicable).

The model shall be submitted to the CoS for verification. The CoS shall map the neighbourhood model to the citywide model to determine the impact of the neighbourhood collection system on the citywide system.

3.3 Gravity Flow

Gravity sewer mains shall be sized for full flow during the total design peak flow. The Manning Equation shall be used for the design and modelling of gravity sewers.

$Q = (A*R^{2/3}*S^{1/2})/n$

Where: Q = Flow (m^3/s)

A = Cross-sectional area of pipe (m^2)

R = Hydraulic radius (area/wetted perimeter) (m)

S = Slope of hydraulic grade line (m/m)

n = Manning coefficient = 0.013 for all approved materials in straight alignment ($s/m^{1/3}$)

3.3.1 Velocity

A mean velocity of 0.61 m/s shall be maintained during peak dry weather flow conditions to provide self-cleansing flow. The maximum velocity shall be 3.0 m/s to reduce the risk of undue turbulence and scour.

3.3.2 Size

The minimum size of gravity sanitary sewer pipe shall be 200 mm diameter. Mains with diameters equal to or greater than 600 mm shall be deemed to be trunk sewers.

3.3.3 Slope

Minimum slopes, based on full flow, which shall be permitted for various sewer sizes are provided in the table below.

- For partial flows, the collection main shall have a minimum slope of 0.55% for the length of the first section.

- For partial flows, the collection main shall have a minimum slope of 0.5% until a cleaning velocity is achieved.
- Maximum slopes shall be based upon limiting the maximum flow velocity.

Table 3-2a
Minimum Permitted Sewer Slope at Full Flow
Straight Sewers

Sewer Size (mm)	Minimum Slope (%)
200	0.35
250	0.28
300	0.22
375	0.15
450	0.12
525 and greater	0.10

3.3.4 Curved Sewers

If sanitary sewers are curved, the coefficient of roughness and minimum acceptable slopes shall be subject to the approval of the CoS. The slope for curved sewers shall be as shown in the table below unless otherwise approved by the CoS. The minimum radius of curvature allowed shall be in accordance with the manufacturer's specifications for the material.

Table 3-2b
Minimum Permitted Sewer Slope at Full Flow
Curved Sewers

Sewer Size (mm)	Minimum Slope (%)
200	0.40
250	0.30
300	0.25
375	0.17
450	0.13
525	0.11
600 and greater	0.10

3.4 Pressure Flow

The Hazen-Williams Equation shall be used for the design and modelling of sanitary force mains.

$V = 0.85 \times C \times R^{0.63} \times S^{0.54}$

Where: V = Velocity (m/s)

R = Hydraulic radius (area/wetted perimeter) (m)

S = Slope of hydraulic grade line (m/m)

C = Coefficient of roughness ($m^{0.37}/s$)

A Hazen-Williams coefficient of 120 shall be used for modelling for all pipe material.

3.4.1 Velocity

In accordance with SE's *Guidelines for Sewage Works Design*, the flow in force mains shall provide peak flows with velocities in the range of 1.0 to 1.6 m/s.

3.4.2 Slope

All force mains shall be sloped sufficiently to prevent the trapping of gases at high points and to permit drainage by gravity. Force mains shall not be installed at zero slope.

3.4.3 Transient Analysis

Transient analysis of force mains may be required at the discretion of the CoS.

4 Design of System Components

Standards for the design of pipes, manholes, and sewage pump stations are presented in this section. Standard drawings that should be referenced for the design of the sanitary sewer collection system are listed in Appendix A.

4.1 Pipes

The sewer collection system shall consist of three types of sewage mains. Basic design criteria for each of these mains are summarized in the following table:

Table 4-1
Pipe Description

Type	Sewage Path	Diameter (mm)	Service Connections	Comments
Sanitary Collection Main	Within neighbourhoods to trunks	Minimum 200 (250 in industrial)	Allowed	--
Trunk Sanitary Main	From neighbourhoods to WWTP or SPS	Minimum 600 and the total flow rate more than 136 L/s	Not Allowed	Connections may be allowed at manholes with the approval of the CoS
Force Main	From sewage pump stations to gravity sewer	Minimum 100	Not Allowed	Smaller diameters may be used in conjunction with grinder pumps. A smooth flow transition to the gravity sewer is to be designed to minimize turbulence at the point of discharge

4.1.1 Sizing

Gravity mains shall be sized to accommodate the peak design flows for the proposed contributing area and if applicable, to reasonably accommodate extensions to adjacent future development areas as described in the sector plan for each development area.

Force mains shall be sized to accommodate flow from multiple pumps in parallel operation.

4.1.2 Depth

The depth of the gravity mains shall be sufficient to meet the following requirements:

- The depth of frontage sewers shall be adequate to receive piped connections (with a desired minimum depth of 3.45 m above crown).
- The depth of gravity sewers shall be adequate to allow gravity sewer connections to pass beneath the water main.
- Basement slab elevations and collection main elevations shall be designed to ensure that the slope requirements for sanitary sewer service connections are satisfied.
- Service connection risers shall be installed for depths to crown greater than 5 m but less than 6 m.
- Where depths to invert are 6 m or greater, a secondary (high level) sewer pipe shall be placed above the primary collector sewer to receive service connections.
    - The high level sewer shall be horizontally offset from the primary collector, unless otherwise authorized by the CoS. The amount of the offset shall be determined on a case-by-case basis and shall require the approval of the CoS.

Force mains shall be installed at adequate depth to prevent freezing.

- No less than 2.9 m of cover shall be provided without approval. If less than 2.9 m of cover is approved, the force main shall be insulated.

4.1.3 Clearance

- Sewer mains shall pass under adjacent water mains.
- The minimum vertical clearance from the bottom of one pipe to the top of the next lowest pipe shall be 150 mm.
- The minimum horizontal clearance between the outer walls of adjacent pipes shall be 300 mm.
- Any sanitary sewer main that was originally installed in common trench with another main shall be relocated at least 1.5 m away from it when replaced, regardless of the vertical separation between them.

4.1.4 Pipe Strength

The strength of pipe shall be calculated on the basis of transition width trench conditions.

- Pipe strength and wall thickness shall be determined in accordance with AWWA standard design manuals for various pipe materials.
- Pipe bedding shall be determined as per the City of Saskatoon *Standard Construction Specifications and Drawings*.
- Backfill weight shall be a minimum of 2,162 kg/m^3 unless a detailed geotechnical investigation indicates that a lesser value can be used.

4.2 Manholes

Manholes shall be provided at all changes in grade and alignment, at junctions of mains, and at the end of each line. Effort needs to be made to install the manholes at street ridges. Barrels shall be constructed with sulphate-resistant concrete.

4.2.1 Inflow

Manholes shall be designed to minimize storm water inflow.

- All manholes in low-lying areas shall be sealed.
- The CoS may, at their discretion, require sealed manholes or an increased size of sewer pipe where inflow is a potentially serious issue.

4.2.2 Locked Manholes

Manholes shall be locked when:

- Not located on a roadway.
- Located in crosswalks or along a public pathway.
- Located in proximity to an area that will be generally accessible to the public.

4.2.3 Spacing

The maximum spacing between manholes shall be 120 m for maintenance considerations.

- Greater spacing may be considered for pipes larger than 750 mm in diameter, subject to approval by the CoS. In no case shall the spacing exceed 250 m.
- Maximum spacing on curved sewers shall be 100 m unless otherwise approved by the CoS.

4.2.4 Diameter

The minimum manhole diameter shall be 1.2 m.

- For sewers at depths greater than 6.0 m, special manholes with safety platforms at intermediate levels may be used at the discretion of the City's engineer.
  - The lowest platform shall be above the incoming flow.
  - The maximum spacing of safety platforms is 6.0 m.

4.2.5 Drop Structure

A drop structure with an external riser shall be used when the crown of the inlet pipe is 750 mm or more above the outlet crown.

4.2.6 Flow-Through Channels

Flow-through channels shall be formed at the base of the manholes to minimize hydraulic losses and to avoid sedimentation.

- Where possible, sewer pipe shall be laid through the manhole and the top of the pipe shall be removed to the spring line.

4.2.7 Hydraulic Losses

- For pipes up to 375 mm in diameter, bends shall be 90° or less in deflection.
- For pipes greater than 375 mm in diameter, bends shall be 45° or less in deflection, unless otherwise approved by the CoS.
- Allowance shall be made for hydraulic losses through manholes by:
  - Maintaining grades of sewers and matching crowns for straight run manholes types.
  - Dropping the invert by 0.03 m at deflections of 45° to 90°.
  - Providing benching.

4.3 Sewage Pump Stations

Sewage pump stations may be used to eliminate excessive depth of sanitary sewers by pumping sewage to an elevation adequate to continue gravity sewage flow. The use of a sewage pump station shall require the submission of a *Sewage Pump Station Design Report* and the approval of the CoS. This report should include pump curves and system curves.

4.3.1 General

The design and construction of pump stations shall be standardized as much as possible to allow interchangeability of spare parts, to promote safe and reliable operation, to minimize space requirements, and to reduce life cycle costs.

- Safety, equipment reliability, and local availability of repair services shall be considered.
- Stations shall be designed for wet well only, or for wet well/dry well configurations, based on flow requirements and costs of construction.
  - Separate wet and dry wells shall be provided in stations with higher pumping requirements, with pumps located in the dry well.
  - To determine the preferred configuration of the pump station, where more than one technically feasible option exists, a comparison of present worth analyses shall be undertaken and the results recorded in the *Sewage Pump Station Design Report*.

4.3.2 Location

Stations shall be located to consider visual, odour, noise, and aesthetic impacts. The station site shall be readily accessible for maintenance.

Stations shall not be located in areas subject to surface ponding or flooding during major storm events.

Wherever possible, a sewage pump station shall be located on a separately titled parcel. If located on land dedicated to municipal reserve, the amount of land required for the current sewage pump station, plus any potential

upgrade, expansion, or replacement, shall be in addition to the designated amount of municipal reserve to be used for programming.

4.3.3 Building

Buildings shall be provided for all pump stations.

- All electrical equipment, controls/instrumentation, valves, and heating/ventilation equipment shall be housed in the building.
- Design and installation of the heating and ventilation system shall be in accordance with applicable occupational health and safety legislation, electrical codes, and environmental guidelines.
- Standby power shall be provided in all pumping stations.
  - Generators or auxiliary drives powered by diesel or natural gas engines may be used.
- Design and installation of all electrical equipment and all gas fired heating equipment shall be in accordance with applicable codes, legislation, and approval requirements.
- Adequate lighting for access and maintenance shall be provided.
- Suitable and safe means of access shall be provided to dry and wet wells.
  - Wet wells shall have separate access and be ventilated independently of the dry well.
  - All ladders, railings, platforms, etc., shall be in accordance with applicable occupational health and safety legislation and regulations.
- Care shall be taken to avoid cross connections with any potable water supplies.
- The controls and alarm system shall be compatible with that in use in other COS pump stations, or as specified by the CoS.

4.3.4 Dry Well

- Instrumentation shall include alarm systems, gas monitors, wet well level indicator gauges, hour meters, and ampere meters.
- The dry well shall be ventilated by mechanical means.
  - Pressure ventilation with heating of intake air is required.
- A dehumidifier shall be provided to control corrosion in dry wells.
- A sump pump is required to remove leakage and drainage.

- Metal dry wells shall have cathodic protection against corrosion using a rectifier-type system.

4.3.5 Wet Well

- A bubbler or ultrasonic system shall be used to detect liquid level in the wet well.
- Screens shall be provided to protect pumps.
  - Screens shall be accessible and easily cleaned.
- The wet well inlet pipe shall be valved.
- Ventilation of separate wet wells may be either by mechanical or natural means.
- Prevention of odours in wet wells shall be considered.
- Wet well storage capacity shall be adequate to prevent frequent starting and stopping of pumps.

4.3.6 Pumps

- Pumps shall be operated with a lead/lag system.
- A minimum of two pumping units are required, each of the same capacity and each capable of pumping the anticipated peak hourly inflow.
- Single and parallel operation of pumps shall be considered when selecting design flow and operating points.
- Pumps shall be identical and interchangeable.

4.3.7 Force Mains

Discharge points shall be designed to reduce the production of odours and hydrogen sulphide gas.

4.3.8 Overflow Connection

A bypass connection to an adjacent or downstream sanitary sewer main shall be provided wherever possible.

- The design of the bypass should not assume overflow of the wet well.
- Backflow prevention must be provided on any bypass connection.

5 Future Developments

In the event that the sanitary sewer main stubs are provided for future developments, they shall be installed at as great a depth as possible to maximize flexibility when the mains are extended.

- Stubs shall be capped with a watertight cover.
- Sanitary sewer stubs shall be staggered, by a minimum of 2.5 m, in relation to any other stubs to facilitate future access.

Appendix A Applicable Standard Drawings

Proponents shall be responsible for referencing standard drawings that are applicable to their development. Drawings are available from the City website.

Drawings are subject to revision, addition, or deletion. Revised drawings shall be renamed using the date of latest revision. Proponents are responsible for ensuring that they are referencing the latest version of any standard drawing.

Drawings that are applicable to the Sanitary Sewer Collection System include the following:

Drawing Number	Title
Manholes	
102-0011-001	Manhole Safety Platform
102-0011-004	Standard 1050 mm Manhole for 200 mm to 525 mm Sanitary Sewers For Rehabilitation Work Only
102-0011-005	Standard 1200 mm Manhole for 200 mm to 600 mm Sanitary Sewers with Drop Structure
102-0011-006	Standard 1200 mm Manhole for 675 mm to 900 mm Sewers
102-0011-008	Drop Structure Manhole for Connection to Trunk Storm Sewers
102-0011-009	Standard 1200mm Manhole for 200 mm to 600 mm Sewers
102-0011-010	Circular PVC Pipe Beddings
102-0011-011	Circular Concrete Pipe Beddings
102-0011-012	Concrete Manhole Collars
102-0011-013	Manhole Lifter Ring Details
102-0011-014	Rubber Manhole Adjustment Riser
102-0011-016	Manhole Rehabilitation Where Thickness of Concrete Below Invert Exceeds 125 mm
102-0011-017	Manhole Rehabilitation Where Thickness of Concrete Below Invert Does not Exceed 125 mm
102-0011-018	Sewer Force Main Inspection Manhole
102-0011-019	Standard Lockable CoS Manhole Frame & Cover for Public Properties
102-0011-020	Lock Wing & Spacers for Standard CoS Manhole Covers
102-0011-021	Standard Lockable CoS Manhole Frame & Cover for Private Properties
102-0011-022	TF-48 Beehive Grate
102-0011-023	TF-48 Beehive Frame

Drawing Number	Title
102-0011-024	Sanitary Sewer Manhole Drop Structure Between High Line and Low Line
102-0011-025	TF-101 Beehive Frame
102-0011-026	TF-102 Beehive Grate
102-0011-028	Standard Manhole Types for Large Sewers – Notes and Schedules
102-0011-029	Standard Manhole Types for Large Sewers – Sections and Details
102-0011-030	Standard Manhole Types for Large Sewers – Cast-In-Place Details
102-0011-031	Standard Storm Sewer Subdrain Detail – Crown Depth Deeper than 2.3m
102-0011-032	Standard Storm Sewer Subdrain Detail – Crown Depth Up to 2.3m

Source:
http://www.saskatoon.ca/business-development/development-regulation/specifications-standards