Chapter 3

Design Basis

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The Regional Municipality of Durham

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3. Design Basis

3.1 Overview

Bill 23 Schedule 10, the *Supporting Growth and Housing in York and Durham Regions Act* of 2022*,* requires the Regional Municipality of York (York Region) and the Regional Municipality of Durham (Durham Region) to expand and improve the existing York Durham Sewer System (YDSS).

In support of the York Region Sewage Works Project, York Region and Durham Region developed updated population projections to 2051 for wastewater collection systems and sewershed areas to be serviced by Duffin Creek Water Pollution Control Plant (WPCP).

This chapter outlines the population forecasts and wastewater generation unit rates used to develop the design basis for the York Region Sewage Works Project in accordance with legislated requirements. The chapter also defines the design assumptions used to prepare the conceptual designs. These design assumptions are based on previous work experience with York Region and Durham Region, York Region's 2022 Water and Wastewater Master Plan (York Region, 2021), operational considerations and published guidelines and standards. Chapters 4 to 10 provide further details on the conceptual designs of each project.

The design basis summarized in this chapter was developed to a conceptual planning level. A comprehensive design basis and detailed operational strategy based on the results of site-specific field investigations will be developed during preliminary design and detailed design in consultation with York Region and Durham Region.

3.2 Population Forecasts

York Region and Durham Region population and employment forecasts for sewershed areas draining to the Primary Trunk Sewer and Duffin Creek WPCP are summarized in Table 3.1. Population growth forecasts within York Region and Durham Region consider an accelerated growth rate through 2031 triggered by the Bill 23 housing targets.

It is noted that York Region sends flow to both the Regional Municipality of Peel (Peel Region) and to the Duffin Creek WPCP in Durham Region. Population forecasts in Table 3.1 indicate the number of people who would contribute to flows that would be conveyed to the Duffin Creek WPCP and do not include population forecast flows being conveyed to Peel Region.

It is anticipated that future development within the federally owned lands (Pickering Lands) in Durham Region will also be serviced by the Duffin Creek WPCP. Flow projections for wastewater coming from the Pickering Lands were provided by Durham Region. It is anticipated that flows will begin to increase in 2032 and reach 54.5 megaliters per day (ML/d) by 2042, after which it will remain constant. Land use for employment (airport, commercial and light industrial) was assumed. An equivalent employment population for the Pickering Lands was back-calculated using Durham Region's per capita wastewater generation rate for employment population shown in Table 3.3.

Table 3.1 **Forecasted Service Population to Duffin Creek WPCP**

Population type	2021 Population (persons)	2031 Population (persons)	2041 Population (persons)	2051 Population (persons)
York Region residential	976,000	1,390,000	1,527,000	1,860,000
York Region employment	527,000	636,600	733,000	871,000
Total York Region population	**1,503,000**	**2,026,600**	**2,260,000**	**2,731,000**
Durham Region residential	228,870	372,870	481,190	559,520
Durham Region employment	76,350	99,450	123,480	155,700
Pickering Lands employment (equivalent)	0	35,851	125,642	179,583
Total Durham Region population	**305,320**	**508,171**	**730,312**	**894,803**
Total population	**1,808,320**	**2,534,771**	**2,990,312**	**3,625,803**

3.3 Wastewater Generation Rates

3.3.1 York Region Wastewater Generation Rates - Linear Infrastructure

The dry weather flow (DWF) and wet weather flow (WWF) wastewater generation rates applied in the conveyance infrastructure for future growth areas in York Region were obtained from York Region's 2022 Water and Wastewater Master Plan, Appendix A (York Region, 2021).

The York Region wastewater system is sized and designed to convey wet weather flows from a 25-year storm event with a four-hour duration. The modelling approach utilized is consistent with York Region's 2022 Water and Wastewater Master Plan (York Region, 2021). How peak flows are modelled varies depending on whether infrastructure is existing or proposed.

For existing infrastructure, dry and wet weather flows are calculated using a calibrated model. For wet weather flows in existing service areas, this is based on measured flow data and normalized to a 25-year design storm.

Future service area dry weather flows are based on combining groundwater base infiltration allowance (90 litres per capita per day [L/cap/d]) with the wastewater rates shown in Table 3.2. Wet weather flows for future service areas are derived by adding domestic flows based on wastewater rates in Table 3.2 to the York Region inflow and infiltration flow hydrograph with a peak flow of 0.26 litres per hectare per second (L/ha/s).

Table 3.2 **Wastewater Generation Rates - York Region Linear Infrastructure**

Generation type	Rate
Model residential average DWF (L/capita/d)	211
Model employment average DWF (L/capita/d)	160
Base infiltration allowance average DWF (L/capita/d)	90
Infiltration and inflow allowance peak WWF (L/ha/s)	0.26

3.3.2 Durham Region Wastewater Generation Rates - Linear Infrastructure

The DWF and WWF wastewater generation rates applied in the conveyance infrastructure for future growth areas in Durham Region were obtained from Durham Region Design Specifications for Sanitary Sewers (Durham Region, 2023). These design specifications provide a single wastewater generation rate for residential areas of 364 L/capita/d for all future flow projections. Because no wastewater generation rates are indicated for employment areas, a ratio of 84 percent (%) (the ratio of the average employment rates to the residential rates) for York Region (from Table 3.2) was used to calculate an employment generation rate for Durham Region. This unit rate was used to estimate future employment flows and back-calculate equivalent employment populations. This value was used for all design years up to 2051. The DWF and WWF unit rate allowances for future areas are added to existing flows in the calibrated wastewater collection system hydraulic model to project total future peak flows used for design of new infrastructure. Durham Region wastewater generation rates for linear infrastructure are shown in Table 3.3.

Table 3.3 Wastewater Generation Rates – Durham Region Linear Infrastructure

Generation type	Rate
Model residential average DWF (L/capita/d)	364
Model employment average DWF (L/capita/d)	304
Infiltration and inflow allowance peak WWF (L/ha/s)	0.26

3.3.3 Duffin Creek WPCP Wastewater Generation Rates

The wastewater unit rates used to design conveyance works (e.g., sewage pumping stations [SPSs] and linear infrastructure) typically differ from values used to design treatment works (e.g., the Duffin Creek WPCP) because flows are dissipated in the collection system.

The wastewater generation rates used to project future wastewater flow rates at the Duffin Creek WPCP were based on a review of historical per capita flows. As shown in Table 3.4, a per capita flow rate of 350 L/capita/day was used to forecast the future average daily flow (ADF) at Duffin Creek WPCP. This value is a reduction as compared with the per capita flow of 406 L/capita/day used for the Stage 3 liquids expansion for Duffin Creek. The per capita flow rate used in the Project Report accounts for uncertainties surrounding the historical reported sewershed populations and uncertainties in planning projections. This methodology is also described in the 2022 York Region Water and Wastewater Master Plan (York Region, 2021). York Region and Durham Region's water efficiency and inflow and infiltration programs were considered in estimating future wastewater generation rates at the Duffin Creek WPCP.

Table 3.4 Design Wastewater Generation Rates – Duffin Creek WPCP

Generation type	2031	2041	2051	2061
Residential average daily flow (ADF) (L/capita/d)	350	350	350	350

3.4 Flow Projection

The future peak DWF and WWF used to prepare the conceptual design of conveyance infrastructure were derived from wastewater collection system hydraulic model simulations. The DWF and WWF for existing service areas were obtained from calibrated hydraulic model using actual flow monitoring data. A 25-year design storm is applied in the model simulation, and allowances for future areas, using wastewater generation rates, are added to existing flows in the hydraulic model to project total future peak flows.

Flow rates that were used in preparing conceptual designs of the proposed infrastructure are as follows:

– For pumped systems (e.g., SPSs and forcemains), the conceptual design flow is the flow rate at which the system is intended to be designed and controlled.
– For gravity systems, the conceptual design flow is the peak flow taken as an average across the entire length of the infrastructure segment.
– For the Duffin Creek WPCP Expansion, the conceptual design flow is based on the design ADF, which is defined by the peak hydraulic capacity of the existing Stages 1 and 2 and Stages 3 and 4 influent pumping stations (IPSs) (3,290 ML/d) and a design peak instantaneous flow (PIF) peak factor of 3.5. The annual flow for each year was estimated as follows:

$$\mathrm{Flow}_{\mathrm{year}} = \mathrm{Total\ Population\ Projected}_{\mathrm{year}} * 350\,\frac{\mathrm{L}}{\mathrm{cap} * \mathrm{day}}$$

– For the Duffin Creek WPCP New Outfall, the conceptual design flow is defined by the peak hydraulic capacity of the existing Stages 1 and 2 and Stages 3 and 4 IPSs (3,290 ML/d), which is the maximum flow that can be pumped through the plant.

Conceptual design flows are the model output and were used as a basis for sizing infrastructure for the purpose of the conceptual design. Flows will be refined during subsequent design phases. Conceptual design flows are provided in Chapters 4 to 10.

3.5 General Design Assumptions

The following subsections outline design assumptions and operational basis for the conveyance system, including SPSs and linear infrastructure, and the treatment system, including the Duffin Creek WPCP expansion and the new outfall.

3.5.1 Conveyance Works

3.5.1.1 Sewage Pumping Stations

York Region and Durham Region’s design guidelines will generally be used in sizing the footprint for each SPS.

The required property for the 2051 conditions will be assessed, and the wet well structure will be sized in accordance with the 2051 conditions. The footprint for ancillary buildings and infrastructure (e.g., standby generators and transformers) will also be included for an estimate of the final build-out requirement.

General design attributes for each SPS include:

1. Firm capacity (that is, largest pump out of service) will be sized to pump peak wet weather flows as modelled.
2. Number and sizes of pumps will be selected to allow for staging and adjustment to suit the varying flows at different projected populations.
3. Space will be allocated for surge tanks at the sites; however, surge modelling will not be undertaken at this stage of design.
4. Space will be allocated at the sites for exterior valve chambers for large-diameter isolation valves for the twin forcemains.
5. Space will be allocated for air management systems, buildings and support infrastructure at the sites.
6. Site layout will include vehicle access and parking.
7. Stormwater and environmental or floodplain compensation areas have not been separately allocated at each site; because availability of site areas at SPSs is limited, an overall plan will likely be required that will include off-site compensation.
8. Ancillary buildings will include space for operator needs (office and control room, maintenance area).

9. The electrical systems footprint will include primary transformer and standby generator system(s) sized for full station redundancy (running N-1 pumps).
10. For SPSs that discharge directly to the multiple trunk sewers, provisions will be made to allow discharge to either or both trunk sewers as required.
11. Generally, the SPS operating levels will be set to maintain an operating level at or slightly below the invert of the incoming gravity sewer.

3.5.1.2 Gravity Sewers

The following design basis was used in the conceptual design of gravity sewers:

1. Gravity sewers should operate typically at a velocity of 0.8 metre per second (m/s) to 3.0 m/s within pipe flow depths of 30% of the sewer diameter under dry weather conditions in accordance with York Region and Durham Region's design guidelines and the Ministry of the Environment, Conservation and Parks (MECP) Design Guidelines for Sewage Works (MECP, 2008).
2. Target flow depth of 85% of the sewer diameter under a 25-year storm event, including infiltration allowance.
3. Freeboard greater than 1.8 metres (m) in sewer maintenance holes for wet-weather conditions with a 25-year storm event, including infiltration allowance, to minimize the risk of basement flooding. Freeboard is the difference between the ground elevation and the hydraulic gradeline.
4. Pipe capacity for gravity sewers (when calculated outside of models) is to be computed using Manning's Formula based on sewer pipe flowing full and using Manning's pipe roughness coefficient of n = 0.013, in accordance with York Region and Durham Region's design guidelines. In the model, pipe full-flow or capacity is calculated from Manning's formula and indicates the design flow carrying capacity, again using Manning roughness 0.013.
5. MECP guidelines recommend minimum slopes for gravity sanitary sewers of up to 1,050 millimetres (mm) to obtain the greatest practical velocities and minimize problems with solids settling. The MECP does not provide minimum slope requirements for larger-diameter sewers. The sewer slope will be selected such that the flow velocities accord with the York Region and Durham Region's design guidelines and MECP guidelines unless otherwise noted.
6. Method of construction may be either an open cut or trenchless approach, or a combination of both depending on factors such as results of field investigations, depth and social and environmental considerations.
7. Access and maintenance chambers are assumed to be situated at shaft locations.
8. Spacing of maintenance holes will be confirmed during detailed design, but at the conceptual design level, they have been assumed to be at all significant sewer bends; they commonly included approximately 1,000 m spacing to maintain flexibility for construction technology. Wider spacing may be selected considering environmental, social and field investigation results.
9. York Region's design guidelines note that maintenance holes are to have a minimum diameter of 1,800 mm for sewers at a depth of less than 10 m and a minimum diameter of 2,400 mm for sewers at a depth of greater than 10 m.
10. A single-pass system for the gravity sewer is acceptable, with corrosion protection. Therefore, segmental lining or jacking pipe would be suitable as the carrier pipe provided a liner is installed to protect the concrete from corrosion. The pipe should be able to withstand the external water pressure to minimize infiltration, and a two-pass system may be preferable at certain locations.
11. The gravity sewer will need to include design considerations to address low flow conditions before sufficient scouring flow comes online.
12. Drop structures will be used where required to reduce tunnelling depth.

3.5.1.3 Forcemains

The following design basis was used in the conceptual design of the forcemains:

1. York Region does not currently have a standard for spacing for isolation of large diameter forcemains. The forcemain alignments will be reviewed, and isolation valve locations will be identified to facilitate draining of the forcemain while minimizing property and staging impacts. Forcemains with a continuously rising profile that drains back to the SPS will be preferred. However, this may not be possible in all cases, given the existing topography, if constructed using open cut methods.
2. Shallow forcemain chambers will be designed to adhere to operational and maintenance requirements outlined in the York Region and Durham Region’s design guidelines. If deep chambers are required, vertical ladders and safety platforms should be used for all depths, with platforms at 5 m spacing in accordance with the Occupational Health and Safety Act.
3. Method of construction may be either open cut or trenchless, or a combination of both depending on factors such as results of field investigations, depth and social and environmental considerations. Materials of construction will be consistent with applicable York Region and Durham Region design guidelines.
4. York Region requires forcemains to be twinned for redundancy. They can be installed either by open cut or trenchless methods. If a trenchless method is employed, the forcemains can be installed in a combined tunnel or as separate tunnels.
5. Each forcemain will typically be sized for the 2051 target design flow, with both forcemains being available to manage flow forecasts beyond 2051. In some cases, the use of two forcemains for flows before 2051 will be permitted depending on extended forecast flows. The level of redundancy available at each of the projected future flow conditions will be outlined in further detail in the associated conceptual design sections of Chapters 4, 5 and 8.
6. Degree of pipe roughness (C values) to be between 100 and 140; final C values to be applied during detailed design upon confirmation of pipe material.

3.5.1.4 Air Management

The following assumptions will be made regarding air management; these assumptions will support confirmation that sufficient property is available to construct and maintain the infrastructure if modelling confirms that air management is required. Locations and requirements for air management will be analyzed and selected during design. At this stage, the area for air management facilities will be allocated:

1. At new or upgraded SPSs.
2. Where forcemains are connecting to the gravity system.
3. Where there is an approximate 90-degree horizontal bend in the gravity sewer.
4. Where there is a vertical drop within a maintenance hole.

3.5.2 Duffin Creek WPCP

3.5.2.1 Duffin Creek WPCP Expansion

The following assumptions were used in the conceptual design of the Duffin Creek WPCP expansion:

1. The expansion of the Duffin Creek WPCP capacity is limited by the total firm pumping capacity of the existing Stages 1 and 2 and Stages 3 and 4 IPSs (3,290 ML/d); therefore, the plant expansion is based on a hydraulic capacity of 3,290 ML/d and a design PIF peak factor of 3.5, providing an expanded ADF capacity of 940 ML/d.
2. Average daily wastewater flow projections are based on population projections for Durham Region and York Region and a conservative per capita flow rate of 350 L/capita/d.
3. Peak wastewater flow projections are based on peak factors used in the design basis for the Duffin Creek WPCP Stage 3 Expansion, that is a peak daily flow factor of 1.6, a peak hourly flow factor of 2.5 and a PIF factor of 3.5.

4. Future capacity expansions for liquid treatment processes (preliminary treatment, primary treatment, secondary treatment, phosphorus removal and disinfection) are based on conventional treatment technologies consistent with those used for the Duffin Creek WPCP Stage 3 Expansion.
5. Raw sludge (co-thickened primary sludge and waste-activated sludge) production projections are based on a sludge generation rate of 100 gallons per capita per day plus projected growth of imported sludge from other wastewater treatment plants in Durham Region and York Region.
6. Future capacity expansions for solids treatment processes are based on technologies consistent with those currently used at the plant (anaerobic digestion, dewatering and incineration).
7. Construction of a fifth sludge incinerator will be required to provide reliable incinerator capacity when the largest unit is offline for maintenance. The fifth incinerator will have a rated capacity of 105 dry tonnes per day (same capacity as that of each existing incinerator).
8. The design of capacity expansions for each unit process is based on the MECP Design Guidelines for Sewage Works (MECP, 2008) and the Duffin Creek WPCP Stage 3 Expansion design basis (Jacobs, 2006).
9. Treated effluent concentration limits established upon completion of the Biosolids Treatment Replacement Project, as outlined in ECA No. 5547-C43QV9, dated October 26, 2021, are used as the basis for the future plant expansion and treatment technologies.
10. A new renewable natural gas purification facility will be sized based on the maximum biogas generation with four digester tanks in operation.

3.5.3 Duffin WPCP New Outfall

The following assumptions were used in the conceptual design of the Duffin Creek WPCP new outfall:

1. The design hydraulic capacity of the outfall is equivalent to the total firm pumping capacity of Stages 1 and 2 and Stages 3 and 4 IPSs (3,290 ML/d).
2. The new outfall will be designed with a hydraulic gradient that allows for gravity flow from the Duffin Creek WPCP to Lake Ontario.
3. The existing Stage 1 and 2 and Stage 3 chlorine contact tank weirs are used as the lowest hydraulic control point upstream of the proposed outfall drop shaft, allowing for a maximum water level elevation at the drop shaft of 80.77 m plant datum (PD).
4. The outfall design will be based on a high Lake Ontario water level of 77.18 m PD, determined as the maximum daily high-water level of 76.18 m PD (recorded in June 2019), plus an additional 1 m for lake-level contingency.
5. The outfall design will allow for a maximum headloss of 3.6 m at the design PIF of 3,290 ML/d and high lake water level conditions.
6. The design minimum velocity in the new outfall tunnel is 0.3 m/s to prevent solids from settling.
7. The design diffuser port exit velocity is 0.75 m/s at the ADF-rated capacity of 940 ML/d to provide enough effluent dispersion to meet the MECP near-field dilution requirements as established in the 1994 Water Management Policies and Guidelines (MECP, 1994).
8. The new outfall length and alignment will be selected to minimize the impacts in the far field region, including the Ajax Water Supply Plant intake and other environmentally sensitive sites.

3.6 References

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