REVISION: February 2013

DESIGN STANDARDS AND PROCEDURES MANUAL
WASTEWATER PUMPING FACILITIES

CITY OF KITCHENER
Kitchener, Ontario

AUGUST 2003
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LIST OF ABBREVIATIONS

DFO	Department of Fisheries
EEAC	Environmental and Ecological Advisory Committee
GRCA	Grand River Conservation Authority
MCCR	Ministry of Consumer and Commercial Relations
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
MOL	Ministry of Labour
MTO	Ministry of Transportation
PEO	Professional Engineers Ontario
SPM	Standards and Procedures Manual

1.0 OVERVIEW

1.1 INTRODUCTION

This Design Standards and Procedures Manual (SPM) for Wastewater Pumping Facilities has been prepared for and in cooperation with the City of Kitchener by Conestoga-Rovers & Associates (CRA) to assist Consultants providing engineering services to the City of Kitchener (City) for the design of Wastewater Pumping Facilities.

Although this document is considered to be a standards manual, the Consultant is required to use their best judgement to find an innovative solution when challenging design conditions are encountered. The City's Project Manager must approve any deviations from this SPM. For aspects of design that are not covered in this document or where the standard is not clear, the Consultant will seek input from the City of Kitchener before any assumptions are made.

1.2 PURPOSE OF DOCUMENT

This document was prepared to:

1. assist Consultants with the execution of engineering services to the standards expected by the City of Kitchener;
2. provide the City and Consultant with general design preferences;
3. develop and apply a consistent design standard for all Wastewater Pumping Facility design and construction projects; and
4. increase the quality of the communications and involvement of the City and the Consultant to ensure expectations are understood, mutually accepted, and achieved.

1.3 OTHER APPLICABLE STANDARDS AND LEGISLATIVE REQUIREMENTS

Applicable standards that must be followed when completing designs in the City of Kitchener include but not limited to the following:

1. Ontario Provincial Standards (OPS);
2. Ontario Building Code (OBC);
3. Ministry of Labour Guidelines and Standards (MOL);
4. Ministry of Environment Guidelines (MOE);
5. Ontario Electrical Safety Code;

6. Canadian Standard Association (CSA);
7. National Fire Protection Agency (including NFPA 820); and
8. Technical Standards Safety Authority (TSSA).

1.4 DOCUMENT STRUCTURE

The document is structured in the following manner:

Section 1: Overview;
Section 2: Pumping Station Design Guidelines;
Section 3: Pumping Station Product Preferences;
Section 4: Responsibility of Consultant, Contractor and Owner; and
Section 5: Project Close-out Documentation.

1.5 AVAILABILITY AND UPDATES

This document will be updated on a regular basis by Development and Technical Services Department. Comments are encouraged and may be forwarded to:

Infrastructure Services Department
9th floor
200 King Street West
P.O. Box 1118
Kitchener, Ontario
N2G 4G7

Contact the above in order to ensure the copy of the SPM you are using is the most current version of the document.

2.0 DESIGN GUIDELINES

Information for wastewater pumping facilities must be submitted to the City as required by these guidelines.

The City may consider and allow deviations where adequate documentation is provided to justify the need for such deviation. The City may also elect to include/reference these design standards in the Terms of Reference for Consultant Selection for the design of future wastewater pumping facilities.

2.1 STATION CAPACITY

Wastewater Pumping Facilities should be able to pump the expected 10-year peak wastewater flows with the largest capacity pump out of operation. For a two-pump station, each pump should have sufficient capacity to handle the peak flows. For a three-pump station or larger, with the largest pump out of operation, the remaining pumps operating in parallel should be able to pump the peak wastewater flows.

Designers should consider the most economic solution for all components of a station over the entire expected life. A phased construction plan should be developed for all components including power supply, transformer size, wetwell, pumping capacity, discharge piping, standby power and general building components. Generally, it has been found to be most economical to build all structural components at the initial stage. This especially applies to deep structures.

Pumps should be of a capacity and in sufficient numbers to allow maximum operating flexibility and optimum performance of the station (including wetwell) over a range of flow conditions. The intent is to provide enough selectivity for efficient operation throughout the anticipated range of flows. This requirement is especially critical during the initial years of operation when actual flows are normally less than the ultimate design flows.

2.1.1 CITY OF KITCHENER DESIGN CRITERIA FOR MUNICIPAL SERVICES

The City of Kitchener Subdivision Manual should be referenced when completing the design of any wastewater pumping facility (new or upgrade) for the City.

The design data for a proposed project (new or upgrade) should include the following:

1. Design Period - Minimum design period for ultimate conditions is 50 years with initial installation provided for a minimum 10-year design period. Provisions for all isolation valves and piping are to be provided for the ultimate design;
2. Zoning Definition - Class, area of each type of zoning, population densities or equivalent densities per hectare, and total equivalent population served. All calculations to be as per current City standards;
3. Per Capita Wastewater Contribution - Expressed as an average daily and as a peak hourly value for each zoning class and totals as per City standards;
4. Calculation of Infiltration and Inflow - Based on the City of Kitchener Subdivision Manual; and
5. Calculation of Total Design Flow Rates - For both the maximum design period and for the minimum design period, if different, expressed as design minimum average and peak daily flow rate values.

2.1.2 CONTRIBUTING AREAS (ZONING AND DENSITY)

A description of the extent of the existing and proposed contributing area with reference to a general system map, as well as a description of probable future expansion of the contributing area, is required. Each area must have a defined land use zoning and density classification.

2.2 CRITERIA FOR SELECTION OF STATION TYPE

All types of pumping stations are acceptable to the City.

The typical efficiencies of the types of pumping systems (i.e. wetwell only, wetwell/drywell), along with capital, operating and maintenance costs should be considered when choosing between the two types of stations.

Pump weights and lifting height should be the determining factor in whether to use a wet-well design concept for a specific site. This criterion needs to be evaluated on a site by site basis and discussed with the City staff prior to selection.

Wastewater pumping stations that are of the drywell type are the most desirable; however, circumstances including size, economics, property and other factors will require consideration in the type of station to be provided.

Many smaller stations may justify the use of submersible-type pumps in a wetwell with or without a pumphouse.

2.2.1 DESIGN OF WETWELLS

Wetwells shall be designed with the following features:

1. hydraulic design is to be in accordance with the requirements of the National Institute of Hydraulics (NIH), or the requirements of the pump manufacturers;
2. the cross-sectional area of the wetwell above the benching should be constant for the full depth of the wetwell;
3. the wetwell should be benched to prevent solids deposition and to allow the solids to be transported into the zone of influence of the pump suctions. The benching should be at least at a 1:1 slope and extend to within D/2 of the edge of the intake flared elbow or suction opening (where "D" is the diameter of the mouth of the flared elbow);
4. the hatch opening to the wetwell should give access to level controls, floats, etc., without the necessity of entering the wetwell;
5. the requirements of the Ministry of Labour must be satisfied in the design of the wetwell. Provide access, ladder and platform in accordance with MOE Standard Specification 3 and 4;
6. wetwells are classified as Class 1, Group D, Zone I or II, Hazardous Location, and the requirements of the Ontario Electrical Safety Code, Section 18, must be satisfied for all electrical installations in wetwells. Equipment must be CSA-approved for use in wastewater wetwells. All electrical conduit shall be PVC;
7. a service platform is normally required to allow for equipment servicing and screen cleaning;
8. all wetwells are to be equipped with primary and secondary high water level alarm. Details on overflow and impact on receiving watercourse will be required by the MOE. Backwater and/or shut-off valving may be required on the overflow;
9. to minimize pumping costs and wetwell depth, normal high water level (including lag pump start elevation) may be permitted to be above the invert of the inlet sewer(s) provided basement flooding and/or solids deposition will not occur. Where these conditions cannot be avoided, the high water level (lag pump start elevation) should be approximately 300 millimetres (mm) below the invert of the inlet sewer;
10. where provided, low water level (pump shut-down) should be at least 300 mm or twice the pump suction diameter (D) above the centreline of the pump volute or more if required for suitable operation of the pump through-out its full range of flow requirements. The bottom of the wetwell should be no more than D/2, nor less

than D/3 below the mouth of the flared intake elbow. This aspect should be discussed with the City on a case-by-case basis;

11. divided wetwells should be considered for all pumping stations where applicable. Provisions should be made to permit the pumping station to continue operating while one portion of the wetwell is dewatered for maintenance or modification. Exception will include smaller stations where short term haulage is acceptable;
12. an ultrasonic or pressure transducer level sensor shall be installed in each well with both automatic and manual switching. Sensors should be sited to permit an unrestricted view of a large area of the wetwell. Narrow beam sensors shall be used whenever possible;
13. consideration should be given to the amount of storage capacity in the station should pumping failure occur. Often, there is storage available in the trunk sewer system and the amount of storage available in the sewers should be determined before finalizing wetwell capacity. Such volumes should not be included in calculating times to overflow;
14. wetwell sizing will be influenced by factors such as the volume required for pump cycling, dimensional requirements to avoid turbulence and air entrainment problems, the vertical separation between pump control points; the inlet sewer elevation(s), capacity required between alarm levels and basement flooding and/or overflow elevations, as well as number of, and horizontal spacing between pumps. The minimum plan area of a wetwell should be 4.9 m^2 (i.e., 2.4 metres-diameter or 2.15 metres-square); however, wetwells should not provide retention times in excess of 30 minutes;
15. do not exceed the motor manufacturers' recommendation for the maximum number of starts per hour. The City's preference is an operating range of 1.0m with no more than 5 pump starts per hour. Any design outside of this range should be in consultation with the City;
16. for pumping stations equipped with 50 kW or smaller pumps, the wetwell should be of sufficient size to allow for a minimum of 10 minute cycle time for each pump. To achieve this, the minimum detention time in a two-pump station using constant speed pumps, the volume in m^3, between pump start and pump stop should be 0.15 times the pumpage rate of one pump (expressed in L/s). For two-speed or variable speed pumps, pumps over 50 kW or for other numbers of pumps, the required volume depends upon the operating mode of the pumping units and/or the recommendation of the motor manufacturer;
17. float controls should be at least 300 mm vertically and 450 mm horizontally apart and positioned against a wall with splay rings and away from the turbulent flow areas. The floats should be capable of being removed without entering the wetwell and installed with extra float wire to accommodate future vertical adjustment;

18. the need for, and the type of screening facilities required for pumping stations varies with the characteristics of the wastewater. Specific requirements should be reviewed with the City Operations Departments on a site-by-site basis;
19. a potable water supply should not be connected to a wetwell. If a water source is required for the wetwell, it can be provided via a hose connection in the wall of the generator building or via a yard hydrant. All potable water service lines on a wastewater pumping station site must be equipped with a CSA-approved reduced pressure zone backflow preventer (double check valve type is not acceptable) and pressure regulator installed, field tested, and maintained in accordance with CSA B64.10M. A 40 mm fire hose connection is to be installed for cleaning and maintenance. Backflow discharge must be plumbed to a floor drain;
20. in wetwell/drywell installations, a building sump pump discharge should be installed above the high-level elevation, in either the wet or drywell, and should cross between the wells below the frost line;
21. give due consideration to the cleaning and flushing of station discharge forcemains. A pig or swab launcher may need to be provided in accordance with DWG. NO. K.E.S. -M01 (attached);
22. where possible, provide an overflow in accordance with the provincial guidelines;
23. provide an electronic recorder to record wetwell levels with data storage and download capabilities if a SCADA system is not utilized;
24. due consideration shall be given to the selection of materials because of the presence of hydrogen sulphide and other corrosive gases, greases, oils and other constituents frequently occurring in wastewater. Structural materials may require cathodic/anodic protection;
25. where a bar screen is provided, a mechanical hoist shall also be provided to remove the captured debris. The hoist and accessories shall be rated for not less than 1.5 times the heaviest anticipated load. All lifting equipment must be certified with the maximum load clearly identified on the equipment. Provide provisions for disposal container for captured debris; and
26. miscellaneous metals in wetwells should be corrosion resistant on materials such stainless steel or epoxy-coated steel. Hatches and other moving parts should be non-sparking material such as aluminium 300 spigots, stainless steel or brass, etc.

2.2.2 DESIGN OF DRYWELL

For detailed guidelines reference should be made to the MOE Standard Specification No. 4 for Dry Pit Vertical Wastewater Pumps. Some minimum design features are listed below:

1. Mechanical (forced) ventilation must be provided in accordance with the Ministry of Labour requirements. Positive pressure ventilation is preferred.
2. A sump pump must be provided to discharge any water accumulations from the drywell to the wetwell.
3. Discuss interlocks with a high water float alarm and influent control to the station with City staff.
4. Potable water service, if provided, shall be protected by a backflow preventer.
5. Dehumidification should be provided to protect electrical control equipment from excess moisture.
6. A lifting beam complete with permanently attached trolley or hook should be provided directly above each pump / motor assembly at a minimum height of 1.2 metres above the motors to facilitate removal of both the pump and motors. Equipment hatch floor openings shall be adequately sized for all intended uses. Provide electric hoist. All lifting devices are to be certified.
7. MCC and electrical panels are not permitted in the drywell and must be located above ground.
8. Each pump must have an individual intake. Wetwell design should be such as to avoid turbulence near the intake. Intake piping should be as straight and short as possible. Pump submersion benching and layout should be in accordance with NIH requirements as well as the requirements of the pump manufacturers.
9. Large radius turned-down bell mouth inlets are preferred. Where turned-down bell mouth inlets are used, the bell should be not more than D/2 and not less than D/3 above the floor of the wetwell.
10. It is recommended that wetwell and approach channel dimensions be designed in accordance with the requirements of the pump manufacturer.

2.2.3 EMERGENCY RESPONSE TIME

The emergency response time in the event of overflow is minimum 1 hour. Hence between the time the alarm is set off and the station starts to overflow, a 1 hour buffer needs to be built in. The time to overflow should be calculated under peak flow conditions. The 1 hour buffer should be in the form of storage, which could be a wet well, emergency storage tank, etc. The storage should not to include inlet pipe storage.

2.2.4 SIZE OF WETWELL

Consideration should be given to dividing the wetwell into two sections, properly interconnected and isolated, to facilitate repairs and cleaning.

The wetwell size and level settings shall be appropriate to avoid frequent pump starts and stops.

The effective capacity of the wetwell, except for large capacity stations, should be such that one pump will continuously run at least 5 minutes of every 30-minute period at the minimum flow. The volume of a wetwell between start and stop elevations for pump(s) and speed(s) can be determined by using the formula:

$V = T \times q/4$

where:

V	=	Required capacity in litres including storage of influent line.
T	=	Minimum time of one pumping cycle between successive starts, or speed increases of the control range in minutes.
q	=	Pump capacity in litres per minute, for one pump, or the incremental pumping capacity for an additional pump, or pump speed.

Where large pumping units are involved (i.e. 230 L/sec or larger), they should be operated continuously insofar as is practical, T should not be less than 20 minutes. For smaller pumps, T can be reduced to 10 minutes, with 15 minutes being the more desirable.

The wetwell benching shall have a minimum slope of one to one (1:1) to the bottom. The horizontal area of the bottom of wet well shall be no greater than necessary for proper installation and function of the pump inlet pipe.

2.2.5 RESISTANCE TO SURFACE FLOODING

Wastewater pumping stations shall not be subject to flooding. It is important that the stations be readily accessible and fully operational at all times. The structure, mechanical and electrical equipment and utility supply are to be designed to sustain a regional storm event. The station is to be readily accessible; preferably, located on property not located on right-of-ways or easements. Vehicular access should be provided from at least one street.

2.2.6 RESISTANCE TO UPLIFT FORCES

The pumping station compartments shall be designed to resist hydrostatic uplift pressures.

In design of the station a minimum safety factor of 1.5 is to be provided against flotation based on a regional storm event or highest groundwater elevation (which ever is worse). Any entrance into the pumping station or wetwell is to be a minimum of 0.45 metres above the Regional storm level at the pumping station location.

2.2.7 ACCESS AND SAFETY EQUIPMENT

Suitable and safe means of access shall be provided to drywells of pump stations and shall be provided to wetwells containing either bar screens, grinders or mechanical equipment requiring inspection or maintenance. The access to the wetwell should be no smaller than 900 x 900 mm and should be dependent on safety, emergency, and equipment requirements. City of Kitchener Operations Department staff should be consulted to confirm that the design is consistent with current maintenance requirements.

2.2.8 STAIRWAYS VS. LADDERS

Access to the wetwell should always be from the outside. A fixed end continuous access ladder should be provided from the wet well roof to the influent floor level where routine access to the wetwell is not required. A stairway should be provided from the wet well roof to the influent floor level where routine access to the wetwell is required for the purpose of screen cleaning or equipment maintenance.

Stairways should be provided for installations deeper than 4.5 metres and should be installed with rest landings not to exceed 3-metre vertical intervals. A man-lift or elevator may be used in lieu of landings, provided emergency access is included in the design.

2.2.9 HATCHES

Fall protection and grating below hatch cover shall be designed into all hatches. When hatch and grating are up, they should create fall protection around the opening.

2.3 SITE REQUIREMENTS

The proposed pumping station, forcemain and point of discharge into the existing sewer system shall be shown on a map suitable for display in Control Room. The map shall show the location of the by-pass valves and air release values. In addition, a report shall discuss the capacity available in the existing downstream sewer, its ability to convey the additional flow and the effect it will have on other pumping stations and on the treatment facility.

2.3.1 SITE SERVICES AND UTILITIES

Site Services

Where possible, the following services and utilities are to be provided to a Pumping Station site:

1. three-phase electrical power;
2. potable water where there is a pumphouse or stand-by generator building;
3. sanitary sewer connection where there is a building with floor drains and sanitary facilities, or a sump pump; with a connection to the wetwell may be permitted if the classification of the area with the sump pump is the same as the classification of the wetwell; and
4. storm sewer connection where required by the Building Code.

Water Supply

1. There shall be no physical connection between any potable water supply and a wastewater pumping station, which under any conditions might cause contamination of the potable water supply.
2. If a potable water supply is required for the station, it shall be provided with the proper air-gaps and backflow prevention devices. If a non-potable water supply is provided, all outlets shall be permanently posted to indicate water is not safe for drinking.

Telephone Service

1. Telephone service should be provided in all stations.
2. Telephone jacks are required at all levels in a drywell station.
3. Telephones should be equipped with a strobe in all situations.

2.3.2 SITE ACCESS

1. Suitable parking is to be provided for operation of the facility. A minimum of two parking places should be provided, unless approved otherwise. Larger stations should allow for more parking to meet the specific need for the station.
2. Access road having a minimum width of 6 metres and radius suitable for trucks and boom hoist shall be provided.
3. Turning area should be provided for delivery trucks.
4. All access roads and turning areas to be paved.
5. Consideration shall be given to snow ploughing, removal, or storage.
6. Bollard protection shall be used where appropriate to protect above grade structures.
7. Pavement depth must be equivalent to City Standard for Class 3 Street.

2.3.3 LANDSCAPING, GRADING AND DRAINAGE

1. Whenever possible, provide aesthetically pleasing, low maintenance landscaping design which blends in with local surroundings.
2. Site grading should allow for positive drainage away from the building.

2.3.4 SECURITY FENCE

The City should be consulted regarding their most current fencing policy and standard.

2.4 SUCTION AND DISCHARGE PIPING

Pump suction lines should be designed with the following features:

1. suction velocities for 20-year, or greater, pumpage requirements, preferably in the low end of the 0.8 to 2.0 m/s range;
2. flanged wall pipe with water stop collar;
3. knife gates or flanged gate valves for isolation;
4. flanged eccentric reducer; and
5. minimum pipe size of NPS-4.

Pump discharge piping should be designed with the following features:

1. velocities, for the 20-year, or greater, pumping requirements, preferably installed in the low end of the 0.8 to 4.0 m/s range;
2. flanged, concentric increaser;
3. spacer 300 mm-long (min) with one flanged end and one grooved end for flexible coupling;
4. elbows (flanged) (as necessary);
5. rubber flapper check valve, preferably horizontally placed;
6. wetwell - plug valve;
7. drywell - knife or plug valve;
8. flanged double branch elbows (for two-pump station);
9. riser pipe;
10. magnetic or other type of suitable flowmeter and recorder (or pump timers for small, constant speed stations where accuracy of flow measurement is not critical - three timers minimum, one for each pump and one for pumps operating in parallel). Designer should provide calculations ensuring meter is accurate within flow range of the station. Flow meter must be removable for maintenance. Valving and spool piece must be provided to assist in removal.
11. pressure gauges should be provided on each pump discharge flange to indicate pump pressure. A pressure gauge should be provided on the forcemain downstream of all pump connections. Provision should be made for a vacuum gauge on the suction piping. These gauges should be equipped with a shut-off valve and a diaphragm seal to isolate the gauge liquid components from the wastewater. Condensation of bourdon tube gauges will quickly accumulate sediment preventing their proper operation unless the seal prevents the entry of wastewater into the gauge. The wastewater side of the diaphragm can be easily cleaned periodically but a gauge cock should be fitted between the diaphragm and the pump so that the gauge can be left off except when being read. These gauges are useful as a means of indicating a change in pump discharge characteristics that might occur, possibly due to impeller wear;
12. unions shall be strategically located for easy removal of instruments;
13. for additional piping arrangements, refer to MOE Standard Specifications No. 3 and 4;
14. suitable shut-off valves shall be placed on suction and discharge lines of each pump with the exception of the suction line on submersible and vacuum-primed pumps. A check valve shall be mounted in a horizontal position on each discharge line and should be located between the shut-off valve and the pump. The size of the check valve should not be greater than 2 times the size of the pump discharge;

15. all control valves on the discharge line for each pump shall be placed in a convenient location outside the wetwell and be suitably protected from weather and vandalism;
16. valves should not be located in the wetwell. Valves shall be capable of withstanding normal operating pressure and transient pressure waves;
17. in dry pit stations, flushing and drain connections should be provided to flush and drain stations of pipe for maintenance; and
18. provide suitable flush line connections on suction and discharge piping of drywell pumps.
19. where "T" connections are required, the use of "TY" connections are preferred;

2.5 VALVES AND ACTUATORS

2.5.1 MANUAL OPERATORS

1. Manual Operators shall operate in the clockwise motion to close the valve.
2. For valves in wetwells, the operator shall have a square operating nut with shaft extension and floor box with access above high flood level.
3. Operators for valves in valve chambers shall have a direct manual handwheel. One "T" wrench must be supplied with each Contract and is to be stored in Control Room.

2.5.2 ELECTRIC ACTUATORS

1. Valve actuators to AWWA Standard C-505. Electric valve actuators and reduction gears should be sized for opening or closing speeds as dictated by potential surge conditions.
2. Actuators should have torque and position limit switch.
3. Provision required for remote control and status monitoring using SCADA system.
4. Actuated valves must be capable of manual operation.

2.5.3 VALVES

Whenever possible, no operating valves shall be located in the Wetwells.

Plug/Knife Gate Valves

1. Valves should be used for pump isolation on the suction side and after a check valve on the discharge side.

2. Valves should be flanged ASA, iron body, bronze mounted, rising stem type. For wetwell applications, valves shall be flanged, non-rising stem, cast iron, bronze fitted.
3. The City's preference is to use knife valves.

Check Valves

1. Check Valves to be rubber flapper or ball check. The City's preference is to use rubber flapper. Swing check valves are not acceptable.
2. A self-closing check valve must be incorporated in the discharge of each unit in the pumping station. Valves should all be designed in such a way that if station or pump flow is lost, the valve will close automatically.
3. Check valves should have flanged ends, bolted cover, rubber flap or ball-type spring assembly, positioned horizontally. Check valves shall have capability of being cleaned internally from the outside.
4. Rubber flapper valves to be equipped with manual opening feature and position indicator.

Plug Valves

1. Non-lubricated type, drip tight shut-off.
2. Cast iron body with flanged ends.
3. Body coated with BUNA-N or HYCAR.
4. Seats to be 316 stainless steel or nickel.
5. Valve size 75 mm to 100 mm manual operator with wrench.
6. Valve size 150 mm to 300 mm totally enclosed, geared with manual operator with handwheel.
7. Full Flow is preferred.

Knife Gate Valves

1. Valve to have jams to allow for a tight seal against seat to accommodate drip-tight shut-off.
2. Resilient seated bi-directional valve with zero leakage.
3. Valves shall meet TAPPI TIS 0405-8 and TIP 0402-25 standards.

2.5.4 FLANGES

Design shall incorporate sufficient number of flanges and couplings to easily allow removal of valves, pumps, etc. All valves and equipment should have flanged connections, pressure rated to suit the application.

2.5.5 CORROSION CONTROL

Designers should incorporate corrosion control in design through material selection or covering such as corrosion resistant paint.

2.5.6 PIPING MATERIALS

1. Stainless Steel is the City Preference for all in-station Piping (Wetwell, Drywell, Wall Penetrations), and is mandatory for use in wet wells.
2. Minimum Size - 100 mm.

2.6 DISCHARGE FORCEMAINS

Forcemains should have the following design features:

2.6.1 FLUID VELOCITY

Velocities should be in the range of 0.8 to 2.5 m/s, with the lower limit being preferred for the initial phase.

2.6.2 TRANSIENTS

The forcemain (including station piping and equipment) must be designed to account for transient pressures that may be experienced. A transient model shall be used in all forcemain designs and must be included in the design report.

If necessary, measures such as double-acting air valves at critical forcemain locations, damping valves on the discharge header, etc. may be required to avoid dangerous transient conditions in the forcemain and piping systems.

Combination air/vacuum release valves, suitable for use with wastewater, should be positioned at all significant forcemain highpoints. These should generally be of the low pressure double acting type.

2.6.3 VALVES

Automatic air release and vacuum valves shall be placed along a forcemain to prevent air locking and allow air entry as required to minimize adverse transient conditions. Additional valves may be needed for specific transient conditions. A blow-off shall be placed at the low points where grit material may accumulate and restrict flow through the forcemain. Locating air release and blow-off within travelled roadways should be avoided, if possible.

Leave future pump connections off headers and from wetwells complete with a plug or knife gate valve.

2.6.4 FORCEMAIN MATERIAL

Acceptable forcemain materials include cement lined ductile iron, HDPE, concrete pressure pipe (C301, C303) and PVC. Pipe material must not be blue in colour. White, green and black are acceptable colours. The pipe must not bear any markings that could be lead to the belief that the contents are potable water.

2.6.5 SIZE

Forcemains shall be no smaller than 100 mm-diameter.

2.6.6 BYPASS CAPABILITY

All forcemains should be equipped with a suitably-valved connection to permit connection of discharge piping from a portable pump(s). This will allow pumping stations to be bypassed, during emergencies or major modifications. This connection should be located near the pumping station, but on undisturbed ground, away from the excavation zone for the station itself.

2.6.7 CLEANING

Cleaning requirements should be reviewed with the City on a case-by-case basis. Provide Swabbing Port in accordance with Drawing No. K.E.S. - M01 (attached).

2.6.8 RESTRAINTS

Forcemains shall use restrained joints at bends to prevent movement occurring from maximum operating pressures or surges. Mechanical restraints, self-restraining joints, or concrete thrust-blocks are suitable.

Restraints must be designed in accordance with OPSS 412.

2.6.9 TERMINATION

Forcemains should enter the downstream gravity sewer system at a point not more than 300 mm above the flow line of the receiving manhole. This is to prevent turbulence and deterioration in the receiving manhole.

2.6.10 LINE VALVES AND DRAIN FACILITY

In certain instances, to be determined on a case-by-case basis, it may be required by the Ministry that a forcemain be equipped with intermediate line valve and drain facility(s) similar to that shown in Appendix K of MOE Guidelines for the Design of Sanitary Wastewater Works.

Factors to be considered in an individual assessment will include, but not be limited to, the diameter and length and volume of the forcemain, the location of the forcemain, (local soil conditions and availability of suitable receiving streams), and environmental implications of a forcemain failure and the subsequent impact of raw wastewater discharge.

If a forcemain drain is used it should be installed at the station to drain the forcemain back to the wetwell or storage tank.

2.6.11 LEAKAGE (EX-FILTRATION)

Forcemains shall be tested at a minimum pressure of at least 50 percent above the design operating pressure, for at least 120 minutes. Leakage shall not exceed the amount given by the following formula:

$L=NDP^{1/2}/1850$

Where:

L	=	The allowable leakage in gallons per hour
N	=	The number of pipe joints
D	=	The nominal pipe diameter in inches
P	=	The test pressure in psi

Allowable leakage = 2.22L/mm diameter/km of pipe/day.

At no time shall the test pressure exceed the pressure rating of the pipe.

2.6.12 MAINTENANCE

If the forcemain is taken out-of-service for repair or cleaning, the wastewater shall be discharged to a storage-detention tank or basin and returned to the sewer system with no discharge to the groundwater, surface of the ground or any watercourse. Alternatively, wastewater may be pumped into tank or trucks and hauled or a pumping bypass approach may be used. Procedures must be approved in writing by the City Operations Department.

2.6.13 TRACER WIRE AND TESTING

All forcemains are to be installed with tracer wire and test lead stations at intervals selected to provide a continuous signal for the purposes of locating the forcemain in the future. Test lead stations will be installed at all air release valves.

2.6.14 ODOUR CONTROL

Consideration must be given to the potential for odour generation within the forcemain. Sewage retention times particularly in long forcemains or during times of low flow between commissioning and substantial build-out of the drainage area need to be determined to evaluate the potential for odour problems. Appropriate chemical or biological measures used to eliminate odour should be considered in these circumstances.

2.7 PUMPS AND EQUIPMENT

2.7.1 ALL PUMPS

Refer to MOE Standard Specification No. 3 for requirements of submersible pumps.

Refer to MOE Standard Specification No. 4 for Dry Pit, Vertical Sewage Pumps.

Check the "net positive suction head" (NPSH) required by the pumps. Higher RPM pumps require a higher NPSH than lower RPM pumps. Ensure that there is sufficient NPSH available to prevent pump cavitation. The pump "best efficiency point" should be at the one-pump running condition on the system curve. Pumps will run at this condition a greater portion of their life than at the peak design pumping capacity of the station.

Specific City Pump Requirements are as follows:

1. non-corrosive inner parts;
2. sphere passing size to be "largest possible" in consideration of the riser diameter (75 mm diameter minimum);
3. suction and discharge piping sized as a function of flow;
4. pump speed not to exceed 1800 RPM;
5. certification of energy efficient motors;
6. confirmation of power factors;
7. non-clog impeller;
8. mechanical seals;
9. pump volutes to be equipped with air lock drain device; and
10. remote operation from Control Room.

2.7.2 WETWELL SUBMERSIBLES

1. Capable of unsubmerged operations in backup conditions.
2. Easily removed without effect on operation of other equipment.
3. Double rail lift system.
4. Fixed hoisting equipment (certified rating).
5. Provision shall be made to facilitate to easily remove pumps and motors.

2.7.3 DRYWELL PUMPS (SUBMERSIBLE VS. CENTRIFUGAL)

1. City's preference is dry pit submersibles, wherever possible.
2. Suitable for continuous submerged and non-submerged operation.
3. If centrifugal pumps are justified and approved by City, one unit is to remain as a submersible.
4. Provision shall be made to facilitate removal of pumps and motors.

2.7.4 SUMP PUMP

A separate sump pump equipped with dual check valves shall be provided in drywells to remove leakage or drainage. The pump discharge shall be above the overflow-level of the wetwell.

A connection to the pump suction is also recommended as an auxiliary feature.

Water ejectors connected to a potable water supply will not be approved.

All floor and walkway surfaces should have an adequate slope to a point of drainage.

High level signal from sump float connected to SCADA shall provide sufficient alarming. For large stations, consider providing a standby sump pump.

2.7.5 SYSTEM HEAD CURVES

Before selecting a pump, the designer shall review system head curves and pump selection criteria with the City for approval.

System head calculations and curves are required for each of three conditions as follows:

1. C = 120 and low water level in the wetwell;
2. C = 130 and median water level over the normal operating range in the wetwell; and
3. C = 140 and overflow water level in the wetwell.

Curve (2) should be used to select the pump and motor since this will reflect the normal operating condition. The extreme operating ranges will be given by the intersections of

curves (1) and (3) with the selected pump curve. The pump and motor should be able to operate satisfactorily over this full range, i.e., between (1) and (3).

Although it is normal practice to size pumps and motors for the 10-year peak flows, consideration should be given to how the 20-year and ultimate wastewater flow requirements can be handled. These operating points should also be shown on the system-head curves.

Consideration should be given to allow for staging growth of station to allow for new pumps, changing impellers, use of jockey pumps, or addition of variable frequency drives.

2.7.6 PUMP STATION STAGING

It is necessary to evaluate both short- and long-term operation of the pump station. The pump station staging must be closely examined and should include the following:

1. 1-year, 10-year, and 20-year planning horizon;
2. consideration must be given to size and number of pumps;
3. forcemain size;
4. potential for twinning; and
5. capital cost projections;
6. sewage retention time in forcemain

2.7.7 CONSTANT VS. VARIABLE SPEED PUMPS

Using constant speed pumps/motors is the City's preferred method.

In certain instances, such as pumping stations discharging directly to wastewater treatment plants or into other pumping stations, some means of flow pacing may be required. This can be provided by various means, depending upon the degree of flow pacing necessary. If even minor pump surges would have serious effects on downstream operations, variable speed pumps may be considered. If minor surges can be tolerated, two-speed pumps or multiple constant speed pumps can be considered.

It is preferable to control low flows with the use of a smaller jockey pump. This will allow for a low flow pump to be selected and be capable of operating at it Best Efficiency Point (BEP).

2.7.8 REMOVAL OF PUMPS

Submersible pumps shall be readily removable and replaceable without dewatering the wetwell and with continuity of operation of the other unit(s).

Wetwell submersible pumps must be extracted by a double rail system.

Hoisting equipment shall be considered in all facility designs, in order to easily remove equipment.

2.7.9 LIFE CYCLE ANALYSIS

1. Life-Cycle Analysis shall be completed for all pump selections.
2. *Pump Life-Cycle Costs: A Guide to LCC Analysis For Pumping System*, Euro Pump and Hydraulic Institute should be used when preparing life cycle costs for the project.

2.7.10 PUMP OPERATION

Submersible pumps shall be capable of unsubmerged operation without damage or reduction of service capability or positive provision shall be made to assure submergence (e.g., back-up controls).

Normal - Sequence consecutive starts between all units.

Emergency - Duty/Standby selection for use.

Hand/Off/Auto switch provided with each pump.

The following colour scheme is to be used for pump indicator lights on the MCC;

RED – Fault, float emergency

AMBER – Control power

GREEN – Power on, MCC power, system OK (floats etc.)

Bar Screens

Pumps handling raw wastewater should be preceded by readily accessible bar racks with clear openings not exceeding 38 mm, unless pneumatic ejectors are used or special devices,

such as grinders, are installed to protect the pumps from clogging or damage. Where the size of installation warrants, a mechanically cleaned bar screen with grinder or compaction device is recommended. Where screens are located below ground, convenient facilities must be provided for handling screenings. For the larger or deeper stations, duplicate protection units of proper capacity are preferred.

Pump Layout

At least two pumps shall be provided, with one pump acting as a standby. A minimum of three pumps should be provided for stations handling total station flows greater than 52 litres/sec.

If only two units are provided, they should have the same capacity. Each shall be capable of handling flows in excess of the expected peak hourly flow.

Where three or more units are provided, they should be designed to fit actual flow conditions and must be of such capacity that with any one unit out-of-service the remaining units will have capacity to handle peak wastewater flows. It is preferable that a standby pump be provided and available for service at all times.

Pneumatic Ejectors

Pneumatic ejectors will only be permitted with special permission from the City.

Pump Capacity

The pumps shall have sufficient capacity to pump at least four times the design average flow rates for laterals and sub-main sewers; either two and one-half times the design average flow rate or peak hourly flow rate, whichever is greater, for main, trunk and interceptor sewers. Each pump shall be capable of handling peak sustained flow rates.

Approval will be restricted to installations where the capacity does not exceed 12.6 L/second per pump and the total suction-lift does not exceed 4 metres.

Grit Removal

Where feasible, grit should be removed prior to entering the wetwell. In small stations consideration should be given to a manhole just upstream of the wetwell with a sump for grit removal. In larger stations consideration should be given to creating a stilling trough within the station to capture grit prior to entering the wetwell.

Where it may be necessary to pump wastewater prior to grit removal, the design of the wetwell should receive special attention and the discharge piping shall be designed to prevent grit settling in the discharge lines of pumps which are not operating in stations. Pumping more than 75 l/s grit removal should be considered prior to pumping.

2.8 GENERAL BUILDING REQUIREMENTS

The designer should become familiar with existing facilities in the City in order to gain an appreciation for the preferences outlined in this guideline.

2.8.1 STRUCTURE AND LAYOUT

1. When a building is required, it should be constructed of concrete block (with or without facebrick), pre-cast concrete panels, or other fire and graffiti resistant materials.
2. Building shall conform to local building and zoning bylaws and well as Ministry of Labour regulations.
3. The diesel generator set for auxiliary power should be located in a separate fire rated room, along with associated fuel supply equipment. The City will consider package generator sets in their own enclosures for exterior installations on a project-by-project basis.

2.8.2 ROOFING

1. Sloped, peaked roofs are preferred over flat roofs.
2. Roof design should prevent the build-up of ice and snow in front of man and equipment access doors.
3. Eavestroughing is to be avoided, whenever possible.
4. Steel roof or 35-year asphalt shingle as a minimum.

2.8.3 WINDOWS, DOORS AND LOCKS

1. Windows are to be avoided in pumping stations.
2. If windows are to be provided, they must be vandal proof.
3. All building locks shall be flush-mounted type, dead-bolt.
4. Keying arrangements shall be in accordance with the requirements of the City.
5. All exterior doors to be insulated hollow metal heavy duty doors.
6. All doors shall be fire rated.

2.8.4 FLOORS

1. Pumphouse floors must be cast-in-place reinforced concrete and shall be sloped toward a floor drain.
2. Finished floor elevation shall be set at a minimum of 450 mm above surrounding ground surface.
3. Finished floor must be a minimum of 450 mm above flood elevations for the area.
4. Floors should be clear, sealed, hardened and shall provide a slip-proof surface.

2.8.5 FIRE EXTINGUISHERS

1. Extinguishers must be supplied in accordance with applicable regulations.
2. Shall be ABC type and be provided in each Pumphouse; the Diesel Generator Room, and on all floors. The minimum size for extinguishers shall be 10 lbs.

2.8.6 PAINTING

The City has developed a painting schedule to be utilized in all new pumping stations. Table 2 indicates colour standard for stations.

1. All paint types should be selected by the consultant and be suitable for the surface and environment intended; and
2. Consult City Operations Department during preliminary design stage to finalize colour requirements for the project.

3. All interior levels to be painted including stairwells and floors

2.8.7 PERSONNEL FACILITIES

The requirements for personnel facilities such as lockers, office furniture, storage, water service, washrooms, showers, etc. will be determined on a case-by-case basis and should be discussed with the City Operations Department at the beginning of the project.

2.8.8 BUILDING ALARMS

The following building-related alarms are to be monitored by either an autodialer or by the SCADA system if a building or weather-proof cabinet exists at the site.

1. intrusion alarm on all doors;
2. building fire/smoke alarm;
3. low/high ambient temperature alarm;
4. flood alarm (drywell); and
5. power failure alarm.

2.8.9 SAFETY PRECAUTIONS

Stations should be designed in such a manner as to ensure the safety of the operators in accordance with the Occupational Health and Safety Act.

1. All equipment should be guarded in accordance with Z4324 Safeguarding of Machinery, Occupational Health and Safety, Canadian Standards Association.
2. Safety labels should be used throughout the facility.
3. Lockouts on all equipment should be supplied.
4. All lifting lugs must be certified and labelled for capacity.
5. Eye wash stations should be provided as appropriate

2.9 HEATING AND VENTILATION

Adequate ventilation shall be provided for all pump stations.

1. Where the pump pit is below the ground surface, mechanical ventilation is required. Ventilation shall be configured as to independently ventilate the drywell and the wetwell if screens or mechanical equipment requiring maintenance or inspection are located in the wetwell.
2. Ventilation must be sized adequately to cool dry pit pumps during high temperature conditions.
3. There shall be no interconnection between the wetwell and drywell ventilation systems.
4. In wells over 4.6 metres deep, multiple inlet and outlets are desirable.
5. Switches for operation of ventilation equipment should be marked and conveniently located.
6. All intermittently operated ventilating equipment shall be interconnected with the respective well lighting system. Consideration should be given also to automatic controls where intermittent operation is used.
7. If excessive moisture or low temperatures are a problem consideration should be given to installation of automatic heating and/or dehumidification equipment. Where drywell are located below the water table, special attention should be given to heating and purifying.

2.9.1 WETWELL VENTILATION

1. Wetwell ventilation should be intermittent and provide positive pressure. Such ventilation shall be accomplished by introduction of fresh air into the wetwell by mechanical means.
2. Intermittent wetwell ventilation should provide at least 30 complete air changes per hour, and provide a positive pressure environment.
3. The ventilating fan should be oriented to blow fresh air into the wet well at a point 99mm (36 inches) above the alarm level
4. The outside vent shall terminate in an inverted "U" construction with the opening at least 24 inches above the finished ground elevation.
5. Control switches for intermittent ventilation and wetwell lighting should be found in the building control room.

2.9.2 DRYWELL VENTILATION

1. Drywell ventilation must be capable of continuous and intermittent ventilation. When continuous, drywell ventilation should provide at least 6 complete air changes per hour.

When intermittent, wetwell ventilation should provide at least 30 complete air changes per hour. The heating system should not be incorporated with the ventilation system. Controls should be found above ground.

2.9.3 AIR DISTRIBUTION

1. Dampers should not be used on exhaust or fresh air ducts. Fine screens or other obstructions in air ducts should be avoided to prevent clogging.
2. Fan wheel and other components should be fabricated from non-sparking material.

2.9.4 OPERATION

1. Positive pressure in wetwells or other unrated areas during unmanned operation.
2. Positive pressure in wetwells or other unrated areas when occupied.
3. Equipment for intermittent operation shall be hardwired to start on door or hatch opening, or to light switches with a master control in the control building.

2.10 ODOUR CONTROL

Odour control at pumping stations are not typically required, however, the City would like to take a pro-active approach to odour control. The potential for odour should be considered for each pumping station project to determine the risk involved. Factors to be considered include but are not limited to public proximity and sewage retention time in gravity sewer and pumping station wetwell. Consideration should be given to chemical or biological treatment if standing time in the wetwell or forcemain is contributing to odour.

It will be the responsibility of the Consultant to investigate potential requirements for odour control and discussions should be completed with the City to determine requirements.

The following options are odour control measures that may be typically incorporated into the design of pumping station facilities. Consultation with City Operations is recommended:

1. granular-activated carbon (City preference);
2. misting (i.e. masking odour, does not remove or treat);
3. electrostatic precipitators;

4. oxidizing chemical added to liquid wastewater;
5. wet chemical scrubbers; and
6. bio-filters (bio-filters are becoming more popular and offer a low operating cost system).

2.11 ELECTRICAL SERVICE AND AREA RATINGS

Electrical systems and components (e.g., motors, lights, cables, conduits, switchboxes, control circuits, etc.) installed in enclosed or partially enclosed spaces where flammable or explosive mixtures may occasionally may be present (including raw wastewater wetwells) shall comply with the Canadian Electrical Code requirements for Class 1, Zone 1, Groups C and D locations. When such equipment is exposed to weather it shall meet the requirements of weatherproof equipment (EEMAC 3R).

2.12 STANDBY POWER

The requirement for standby power is to prevent the discharge of raw or partially treated wastewater to any waters and to protect public health by preventing backup of wastewater and subsequent discharge to basements, streets, and other public and private property in the event of interruption of electrical service. There shall be no bypassing of wastewater to the groundwater, private sewage services, surface of the ground, or into any watercourse.

Provision of a standby power supply for all pumping stations should be made. This supply may be accomplished by the following:

1. installation of a permanent standby power generator (preferred);
2. connection of the station to at least two independent public utility sources;
3. provision of portable or in-place internal combustion engine equipment; and
4. provision of portable pumping equipment.

All emergency power generation equipment should be provided with instructions indicating the essentiality of regularly starting and operating such units at full load.

If diesel engines are to be utilized for standby power, the requirements of the Environmental Protection Act (Section 9) must be satisfied. A separate Certificate of Approval for Air Emissions is necessary.

2.12.1 INTERNAL COMBUSTION EQUIPMENT

Where in-place internal combustion equipment is utilized, the following guidelines are suggested for use:

The unit shall be diesel driven, bolted in place. Facilities shall be provided for unit removal for purposes of major repair or routine maintenance. Fuel is to be provided in an approved dual wall tank or tanks with sufficient capacity to operate the station for a minimum of 24 hours.

Provisions shall be made for automatic and manual start-up and cut-off. These controls are to be located inside the building if the generator is outside the building..

Unit size shall be adequate to provide power for lighting, heating, ventilation systems, peak wastewater flows with a minimum of two pumps, and such further systems affecting capability and safety.

The unit internal combustion engine shall be located above grade with suitable and adequate ventilation of exhaust gases with provision for load banking hook-up. City staff should be consulted on capacity requirements of the stand-by generator.

2.12.2 PORTABLE EQUIPMENT

Where portable equipment is utilized, the following guidelines are suggested for use:

1. Portable pumping units shall have the capability to operate between the wetwell and the discharge side of the station. The station shall be provided with permanent fixtures which will facilitate rapid and easy connection of lines.
2. Portable generating units shall be surge-protected against loading when normal utility services are restored, and shall have sufficient capacity to provide power for lighting and ventilation firm capacity operations and all monitoring related to safety. When required by the City, a manual transfer switch and electrical inlet plug would be provided for quick connection of the portable generator system to building electrical distribution.

2.12.3 FUEL SUPPLY (USE AND STORAGE)

1. Diesel is preferred fuel supply for back-up power. If diesel is not available discussion with City as to the fuel source will be required.

2. Secondary containment must be provided for all fuel storage and distribution systems.
3. All fuel storage system must be indoors and not be located below-grade.
4. Low level alarm must be installed on all tank storage systems.
5. Fuel level indicator must be installed on all tank storage systems.
6. Secondary containment must have a visual warning device (i.e. float to alarm) to indicate breach in primary tank.

2.13 HOISTING EQUIPMENT

1. Proper marking capacity certifications on all units.
2. Separate lifting devices for equipment and man-rated if intended to lift personnel.

2.14 AUTOMATION DESIGN GUIDELINES

Level control float switches are to be non-mercury type and located so as not to be unduly affected by flows entering the wet well or by the suction of the pumps. In small stations with duplicate units, provision should be made to automatically alternate the pumps in use. Stations with a control building or having dry pit pump installations will use ultrasonic or pressure transducer level control as the preferred means of pump control. Float switches will be provided for low-level shut off- and high-level secondary alarm and pumps control backup. Floats in drywells shall be used to provide an alarm if flooding should occur.

2.15 EQUIPMENT

2.15.1 INSTRUMENTATION

The following instrumentation must be provided as a minimum:

1. ultrasonic level sensors or pressure transducers (each wet well);
2. floats (back-up operation for pumps);
3. flow meters (on station discharge);
4. pressure gauges;
5. thermostats; and
6. fuel levels sensors or switches.

2.15.2 LOCAL CONTROLLERS

For wetwell pump stations with no building, the control panel and alarm system shall be located outside the wetwell and suitably protected from weather, humidity and vandalism.

2.15.3 SECURITY AND ALARMING

Alarm systems should be provided for all pumping stations. The alarms shall be activated in cases of power failure, pump failure, or any cause of pump station malfunction. Pumping station alarms shall be telemetered to a pumping station operator 24 hours a day.

Pumping stations shall be designed with security and exterior lighting to discourage vandalism.

2.16 AUTOMATION DESIGN GUIDELINES

2.16.1 GENERAL

The City of Kitchener has field tested an automation system for their wastewater pumping facilities. These guidelines describe the automation system that will monitor and control all remote wastewater pumping facilities.

The automation system for the City's wastewater pumping stations is comprised of the local controller that automatically controls the station operation and communications with the central system, which controls, monitors and handles alarms for all remote stations. The City has standardized on Flygt, ITT Industries' FMC model basic controller [Remote Terminal Unit (RTU)]. These RTUs are pre-programmed with parameter-controlled functions for standard automatic control of wastewater pump stations. The RTUs are to be capable of storing historical data up to 7 days in the event of a communication failure with the central system.

The City is planning to install Flygt, ITT Industries' Aquaview SCADA system for central monitoring/control of their wastewater pumping stations. This software will provide the following features:

- process picture for each station;
- central control;
- central setting of parameters for the local RTUs;

- periodical reports;
- historical trends;
- alarm statistics and events;
- alarm distribution;
- capability to easily add new station without programming requirement;
- to set up operator level security access; and
- to customize Aquaview with the end user software application (AQVINI).

In order to properly integrate facilities into the existing Automation System, there are both suggested design guidelines and standards that must be closely followed. Detailed requirements for the Automation System must be reviewed with the City. In general, the following features are required:

- local RTU complete with a human-machine interface (HMI) capable of complete control and monitoring of the station. From the HMI, it is possible to manually control (start and stop equipment) and monitor (view status of equipment, i.e. on/off or the value of any analog device, i.e. flow, level, pressure, etc.);
- pumps are automatically controlled from the RTU, based on the analog signal from the sensor in the wet well;
- each station must have an unauthorized entry alarm system;
- each station must have building environmental alarms, i.e. temperature, flood, fire;
- there must be detailed alarm information provided for pumps, generators, and building. These alarms are transmitted to central control system where decisions regarding response can be made. This response may be a site visit, corrective action from central control, or from a portable workstation;
- each wet well must have a level transmitter connected to the RTU for continuous level monitoring;
- each wet well must have high and low level float switches for alarms;
- each station must have one low level and one high level float switch for pump protection and alarm; and
- each station must have a back-up control, based on the hardwired level float switches.

Recommended minimum alarms to central SCADA should include:

- Primary and Secondary High Wetwell Level;
- Level Transducer Fail;

- Pump Fault;
- Power Failure;
- Generator Fault;
- Unauthorized Entry;
- Drywell Flood;
- Fire/Smoke;
- Diesel Fuel Low;
- Low Wetwell Level; and
- Pump Pressure High.

2.16.2 RTU INPUT/OUTPUT SIGNALS

The instrumentation and control devices at each station provide the interface between the field equipment and the automation system. The standard and optional points to be monitored and controlled can be summarized as follows:

For reference:	AI	=	an analog input to the RTU, for control and monitoring
	AO	=	an analog output from the RTU, for control
	DI	=	a discrete input to the RTU, for monitoring and alarms
	DO	=	a discrete output from the RTU, for control

For each pump, or pump VFD, there should be:

- start/stop (DO) (standard);
- running status (DI) (standard);
- overload alarm (DI) (standard);
- overtemperature alarm (DI) (standard);
- leak detection (DI) (standard);
- amperage (AI) (standard);
- local/remote status (DI) (optional);
- VFD speed setpoint (AO) (standard for pumps with VFD);
- VFD speed feedback (AI) (optional for pumps with VFD); and
- VFD general fault (DI) (standard for pumps with VFD).

For each wet well, there should be:

- ultrasonic level control (AI) (standard);

- low level (float switch) alarm (DI) (standard);
- high level (float switch) alarm (DI) (standard); and
- overflow (float switch) alarm (DI) (standard).

For each diesel generator, there should be:

- running status (DI) (standard);
- generator general fault (DI) (standard);
- fuel tank low-level alarm (DI) (standard);
- auto/manual status (DI) (optional);
- transfer switch status (DI) (optional);
- fuel tank level (AI) (standard); and
- fuel tank leak detection (standard).

For the station and building, there should be:

- unauthorized entry (DI) (standard);
- control power failure (DI) (standard);
- power failure (DI) (standard);
- fire alarm (DI) (standard);
- station flood (DI) (standard);
- station flow monitoring (AI) (optional);
- station pressure monitoring (AI) (optional);
- station temperature or transformer room temperature fault (DI) (standard);
- ventilation fault (DI) (optional); and
- gas detection alarm (DI) (standard where required).

The standard points are to be included at all stations and are part of the basic RTU. For larger stations additional remote input/output module (RIO) can be added to the basic RTU to include optional points. The requirement for optional points at larger stations is to be reviewed with the City Operations Division.

2.16.3 CONTROL PHILOSOPHY

Pump Operation

The general control philosophy is to sequentially start the pumps as the wet well level rises monitored by a level transmitter. If one pump fails to start, the controller automatically starts the next pump. The start/stop band should be designated to minimize the pump starts/stops and provide a smooth operation. If VFDs are installed, the band can be increased.

In the event that the level transmitter or controller fails, the back-up high-level float should sequentially start all pumps (hardwired back-up control). A separate low-level float should stop all pumps. These should be adjusted such that they do not affect normal operation.

Pumps should be capable of running on hand past low-level. Low-level float should not stop pumps on hand. Operators will assume responsibility for the operation of pumps in hand-mode.

The finalized site specific control philosophy should be detailed in the Process Narrative submitted to the City.

Alarm Management

Station alarms shall be assigned priorities and sent to the central system. When critical station alarms occur, the staff should receive an alpha/numeric paging. City staff can acknowledge the alarm from any workstation.

If communication between the station and the central system is unavailable then the station controller shall directly page an alarm condition. The central system will also alarm a communication failure.

UPS/Standby Power

To smooth the transition from normal to emergency power, all critical equipment should be connected to an Uninterruptible Power Supply (UPS). This includes the PLC, radio, associated PLC devices, wet well level transmitters, back-up control, and other critical instruments.

In order to accurately monitor the power status, the RTU should monitor power failure and controller power failure.

On a power failure, the automatic initiation of the transfer switch and the starting of the diesel generator should be independent of the RTU.

Field Instruments

The City has preference on specific vendors for flow, level, and pressure instruments in order to minimize the spare parts and ongoing maintenance costs. As the model numbers change over time, the designer should request the current standards during design.

2.16.4 HARDWARE INSTALLATION

All control system equipment to be located above ground, preferably in an outdoor control panel cabinet for smaller stations and in the electrical or control room for larger stations. Do not install the RTU in classified areas or possible flood areas.

RTU hardware selected must match the existing system i.e. Flygt, ITT Industries FMC controllers. The controller and optional equipment is listed below:

Product	*Function*
FMC-200 STD	Standard controller for 2 pumps
FMC-400 STD	Standard controller for 4 pumps
FMC-600	Controller requiring custom programming
Modem	Optional
SIOX Input and Output System	
SIOX Driver	Optional communication driver for additional I/O
RIO	Optional additional I/O(module analog, DI)

CONTROL PANEL

For larger stations, RTUs are to be mounted on the face of a control panel and pre-wired to I/O terminal blocks, etc.

All field equipment and input/output signals must be labeled to the City's standard. Future pump control panels (MCC panels) should be installed (control cabinet without control devices). Control panels should be installed in sequence from left to right (ie. controls for pump #1 on far left, #2 next etc.)

2.16.5 CONTROL PANEL FABRICATION REQUIREMENTS

1. Shop fabricate control panels to CSA C22.2 No. 14, using cabinets and terminal blocks furnished in accordance with City requirements.
2. Control Panel Enclosure: Type 12 for indoor installation or Type 3R outdoor location.
3. Provide panel dimensions and complete Bill of Materials. Ensure items listed on the Bill of Materials can be mounted within given panel dimensions.
4. Install products in accordance with manufacturer's written instructions.
5. Install RTU hardware, controller optional equipment, power distribution equipment, and all control devices required to operate the pumping station.
6. Use 14 AWG 19-stranded copper wire within the panel, except for those wires which run to door-mounted items which shall be 14 AWG 41-stranded. Wire analog I/O inputs using 2/C 16 AWG stranded shielded cable. Wire other I/O signals using 16 AWG 26-strand single conductor.
7. Run wires for door mounted items in expando type flexible covering. Spiral type wrapping shall not be used.
8. Wire I/O points and other panel devices point-to-point.
9. Wire spare I/O points to spare terminal blocks and be identified as spare.
10. Run wires in wireway and exit the wireway at the point nearest to the device to which it is wired.
11. Do not splice wires within a wireway.
12. Identify each wire at each termination point using markers bearing the complete wire number in accordance with City Standard.
13. Neatly harness wires within wireways using tyrap fasteners.
14. Provide cabling required to connect the RTU equipment mounted in the panel as required by the controller manufacturer.
15. All field and panel wiring voltages to match the following standard:
    - discrete outputs 120 VAC with interposing relays;
    - discrete inputs 24 VDC;
    - analog outputs 4-20 mA, 24 VDC; and
    - analog inputs 4-20 mA, 24 VDC.
16. Wiring to be colour coding as follows:
    - 120 VAC control red;
    - 120 VAC power feeds black;
    - 120 VAC neutral white;

- 24 VDC power blue;
- instrument ground light green;
- power ground dark green;
- analog Signal White (positive), black (negative); and
- control wiring with separate power source external to RTU yellow.

17. Route AC wiring separately from DC wiring. Make allowance for this in the manufacture of the panel.
18. Verify that the number of terminal blocks is sufficient to make the identified connections. Furnish 20 percent spare terminal blocks.
19. Hot dip galvanized any steel fasteners. Under no circumstances shall interior fasteners penetrate the panel skin.
20. Provide surge suppressers across each relay coil and signals from all field mounted instruments.
21. All panel doors with door mounted electrical devices shall be grounded.

3.0 PUMPING STATION PRODUCT PREFERENCES

The City of Kitchener has reviewed the equipment requirements and has developed an equipment product preference table (Table 1, Product Preferences). This list is to be used as a guideline for product selection during the design stages of the project. The equipment and products listed in Table 1 should be considered when incorporating into contract specifications for all projects in the City of Kitchener.

It is the Consultant's responsibility to ensure the preferred products listed in Table 1 are suitable for use on each project. In addition, it is required that specifications be written in a manner to promote competitive bidding during tendering. The City of Kitchener Operations Division should be consulted during the selection of products. Some products or manufacturers are considered preferable while others are to be avoided due to past maintenance and performance issues.

4.0 RESPONSIBILITIES OF CONSULTANT, CONTRACTOR AND OWNER

4.1 RESPONSIBILITIES OF CONSULTANT - DESIGN STAGE

The Consultant will design the pumping station and ancillary equipment according to the City design guidelines, the terms of reference for the project and accepted engineering practice.

4.1.1 ACQUISITION OF BACKGROUND DOCUMENTATION

In the preliminary design phase, the Consultant is required to review the following:

1. previous pre-design reports;
2. specific engineering reports related to the project;
3. class environmental assessment;
4. other engineering reports and documents; and
5. geotechnical and topographical surveys (if not completed the requirements should be addressed at the initial stages of design).

4.1.2 PRE-DESIGN REPORT

The pre-design report is to form the basis and details for the final design report. As a minimum, the preliminary design report should include the following:

Project Description

1. Background;
2. Objectives; and
3. Process Units.

Scope of Work

Location Plan:

1. Show existing facility property;
2. Show land to be acquired (if necessary);
3. Prepare preliminary site plan;

4. Determine if project falls within Environmentally Sensitive Area or Grand River Conservation Authority regulated fill area or within Regional floodline;
5. Site Access; and
6. Stormwater Management.

Site Services and Utilities:

1. Municipal water supply (if required);
2. Municipal waste water connections;
3. Telephone;
4. Natural gas (discouraged); and
5. Electrical supply.

Design Data required for Certificate of Approval

Identify Design Flow/Capacity:

1. Average flow (daily);
2. Peak flow (daily);
3. Instantaneous peak flow; and
4. All calculations are to be completed in accordance with City of Kitchener Subdivision Manual.

Identify Sizing Criteria for Process Units:

1. Physical dimensions of equipment;
2. Head and capacity curves; and
3. Operating liquid levels.

Process Design Elements

1. Process Flow Diagrams (PFD) should be completed to the 90 percent level at the preliminary design stage of the project. The PFD shall depict equipment, piping, valves, in-line measurement devices;
2. Process and Instrumentation Diagrams (P&ID) should be completed to the 90 percent level at preliminary design stage of the project. The P&IDs shall depict instrumentation and control as well as indicate proposed monitoring and control I/Os;

3. Include a preliminary hydraulic profile and identify all major unit operating liquid levels. All assumptions used and calculations used to develop the hydraulic profile must be included; and
4. Detailed equipment lists shall be provided.

Conceptual Layout

1. Major equipment orientation and location need to be identified on floor plans;
2. Routing of all piping greater than 150 mm shall be shown on the drawings; and
3. Show all in line measuring devices included in the PFDs.

Building Design

1. Finished architectural elevation views shall be completed;
2. Area classification of each room and building need to be identified; and
3. Building height and dimensions.

Electrical Power Requirements

1. Identify source of electrical power supply and its usage in the project;
2. Provide preliminary single line diagram for the project;
3. Provide single line MCC drawings;
4. Lighting schedule for facility;
5. Description of alarms and alarm system;
6. Co-ordination study of main breaker system; and
7. Customer metering package

Emergency Standby Power (including Air Assessment)

1. Review of requirement for standby power;
2. If emergency power is required, complete MOE Standard Specification No. 2 - Diesel Engine Generator Sets, Issue No. 8 dated March 1986, Table 1, 2, and 3, Data Form; and
3. Model Air Emissions and complete Noise Assessment.

Heating and Ventilation

1. Prepare Heating and Ventilation Diagram indicating, exhaust fans, supply fans, temperature objectives, minimum ventilation requirements, pressurization requirement (positive), and building and room area classifications.

Instrumentation and Control

1. Generate a complete instrument list that corresponds to the P&IDs.

SCADA System

1. Identify necessary application and operating software requirements;
2. Review existing central control hardware and determine system capacity and capability;
3. Identify additional hardware requirements and modifications to the existing system;
4. Prepare a comprehensive preliminary process control narrative for each component and the system as a whole. The preliminary process control narrative will include a list of all proposed I/O points and analog signals proposed for the project; and
5. Ensure that SCADA system performance is not hampered as a result of the addition of the proposed facility.

Preliminary Drawings

A set of full-sized must be submitted with the preliminary design report. The following drawings should be provided in the preliminary design report as a minimum:

1. Title Page;
2. Legend Sheets;
3. Existing Condition Site Plan;
4. Preliminary Site Works and Grading Plan;
5. Architectural Elevations;
6. Preliminary building floor plans at each building level;
7. Process Flow Diagrams;

8. Instrumentation and Control Diagrams;
9. Electrical Single Line; and
10. Electrical MCC Single Line.

Drawing numbering should be numbered and labelled as follows:

G-01	Title Page
G-02	Drawing Index
G-03	Legend and Symbology
G-04	Mechanical Legend
G-05	Instrumentation and Control Legend
G-06	Electrical Legend

- All Civil Drawings shall be labelled with the prefix "C", followed by the drawing number in the series (i.e. C-01, C-02, … etc.);
- All Architectural Drawings shall be labelled with the prefix "A", followed by the drawing number in the series (i.e. A-01, A-02, … etc.);
- All Structural Drawings shall be labelled with the prefix "S", followed by the drawing number in the series (i.e. S-01, S-02, … etc.);
- All Mechanical Drawings shall be labelled with the prefix "M", followed by the drawing number in the series (i.e. M-01, M-02, … etc.);
- All Instrumentation and Control Drawings shall be labelled with the prefix "IC", followed by the drawing number in the series (i.e. IC-01, IC-02, … etc.); and
- All Electrical Drawings shall be labelled with the prefix "E", followed by the drawing number in the series (i.e. E-01, E-02, … etc.).

The City has developed specific drafting requirements and standards. The consultant should review the CAD requirements and standards prior to starting drawings for the project.

Other Deliverables

1. Preliminary Listing of Specifications.
2. Cost Estimates (+/-25%).
3. Project Schedule.

4.2 RESPONSIBILITY OF CONSULTANT - DETAILED DESIGN

The Consultant should have all the required information noted in the preliminary design stage prior to commencing the detailed design phase of the project.

The Consultant will meet and communicate on a regular basis with the designated representative of the City to coordinate and expedite the design of the project.

Detailed Design Preliminary Tasks

1. Initiate geotechnical investigations (may require to be completed during preliminary design).
2. Confirmation of existing utilities with utility companies.
3. Submit plans with conflict points identified for above- and below-ground utilities to utility companies.

Design Brief

Submit final design calculations carried out for the detailed calculations for the project. The calculations will include, but should not be limited, to the following:

1. System Curves;
2. Flow Requirement;
3. Pumping Capacity;
4. Transient Analysis;
5. Building/Structural Calculations;
6. Pipe and Valve Sizing Calculation;
7. Geotechnical Calculations;
8. Wetwell Capacity/Storage Volumes; and
9. Calculation of Time to Overflow.

Drawing and Specification Submission Requirements

Submit the following to the City for review at the 50%, 90%, and 100% Stage:

1. Drawings;
2. Specifications; and
3. Process Control Narrative.

4.3 APPROVALS AND PERMITS

The approvals required for each project will vary. The consultant should verify the approval requirements with the following, if required:

Provincial (or Higher) Level

1. Ministry of Labour;
2. Ministry of Natural Resources;
3. Ministry of Transportation;
4. Ministry of Environment;
5. Department of Fisheries;
6. Ministry of Consumer and Commercial Relations;
7. Bell Telephone;
8. Gas Pipeline;
9. Railways; and
10. Hydro-Electric Utility.

Municipal Level

1. Municipal Site Plan Approval;
2. Municipal Building Permit;
3. Grand River Conservation Authority;
4. Local Utilities; and
5. Regional Municipality of Waterloo - Transportation and Environmental Services.

4.4 DELIVERABLES

1. Design Brief;
2. Drawings and Specifications at 50%;
3. Drawings and Specifications at 90%;
4. Drawings and Specifications at 100%;
5. Pre-Selection Documents (Draft and Final), if applicable;
6. Process Control Narratives;
7. Equipment and Tag Number Listings;
8. All Permits and Approvals;
9. Pre-Tender Cost Opinion (+/- 10% accuracy); and
10. Complete Tender Documents.

4.5 RESPONSIBILITIES OF CONSULTANT - TENDERING STAGE

1. Provide City with a sample advertisement for publication.
2. Answer questions posed by Contractors concerning the project during the tender stage. Issue addenda as necessary.
3. Arrange and chair pre-tender closing meetings and site visits as required, including recording and issuing of meeting minutes.
4. Evaluate the tenders received on the following basis:
   - bonding;
   - performance and safety track record;
   - claims/litigation record;
   - payment record; and
   - references from last three construction projects of similar size/scope.
5. Give recommendation of Award to City based on evaluation.

4.6 RESPONSIBILITIES OF CONSULTANT - CONSTRUCTION SERVICES

The services provided during construction, as outlined below, are extracted from the PEO guideline publication: *"Guideline For Professional Engineers Providing Engineering Services to Municipalities"*. These services are provided by the consultant to determine that the

materials used and results achieved by the contractor are in general conformity with the design.

Contractors are responsible for discharging their obligations under the terms and conditions of the construction contract. The consultant, on behalf of the City, should carry out a review of the work during its execution. When, in the opinion of the consultant, a resident engineer and staff are required, the consultant should so advise the City.

4.6.1 SERVICES TO BE PROVIDED

1. Review for approval the construction schedule proposed by the contractor and comment on the procedures, methods and sequence of work.
2. Make periodic visits to the site during construction, to ascertain that the work is being executed in reasonable conformity with plans and specifications and communicate with the contractor, and the City regarding deficiencies in the work, and other matters of direct interest or concern.
3. Advise the contractor on the interpretation of the drawings and specifications and issue supplementary details and instructions during the construction period as required.
4. Investigate, report and advise on unusual circumstances which may arise during construction.
5. Review submitted shop drawings to the degree necessary to determine if the contractor's work is in general compliance with the design requirements.
6. Consider and advise on alternative methods, equipment and materials proposed by the contractor.
7. Report progress and deficiencies to the City.
8. Maintain adequate records related to the contracts.
9. Arrange for, or carry out, all necessary field testing and inspection of materials and equipment installed by authorized inspection and testing personnel, where construction calls for such testing.
10. Ensure adequate records are kept regarding field information of construction details for the modification of contract drawings to show the work "as- built".
11. Process contractor's progress and final requisitions and issue progress certificates for the City's acceptance.
12. Advise on the validity of charges for additions or deletions and advise on the issue of change orders.

13. Prepare recommendations to the City regarding payments to the contractor, taking into account progress of work, materials and equipment delivered to site, and contractual and statutory holdbacks.

4.7 RESPONSIBILITIES - COMMISSIONING

The commissioning phase of a project is a critical component of the system construction. All verification reports generated by the consultant and the contractor must submitted to the City for their records and included in the Operation and Maintenance Manuals for the facility.

4.7.1 CONSULTANT RESPONSIBILITY

1. The consultant must verify all equipment, system and subsystem and processes are fully tested, documented, and verified.
2. Provide a list to the City 60 days prior to commissioning listing all rotating equipment to be verified, all mechanical process systems to be verified, all instruments to be calibrated, and all digital and analog loops to be checked.
3. Provide the detailed requirements for RTU control software programming and SCADA system programming.
4. Direct contractor to perform and submit "Air Balance Report" and to correct all work that does not conform to specifications.
5. Provide the City 48 hours notice prior to testing equipment. A representative from the City Operations Department should be present at all times during start-up and commissioning.
6. All verification reports must be submitted to the City upon completion of verification report.
7. Assist the contractor if necessary during the commissioning process.

4.7.2 CONTRACTOR RESPONSIBILITY

The contractor will be responsible for the operation of the facility until the facility is accepted by the City. The following items are responsibilities of the Contractor:

1. RTU and/or SCADA Programming will be determined on a project by project basis.

2. Training of Operations Staff on O&M of Equipment (1 Day Training, 2 Training Sessions).
3. Rotating Equipment Check-out and Verification.
4. Mechanical/Process System Check-out and Verification.
5. Electrical System Check-out and Verification
6. Instrumentation Calibration.
7. Instrumentation and Control Loop System Check and Verification.
8. SCADA System Verification.
9. HVAC Check-out and Verification.
10. Co-ordination study of main breaker systems.

4.8 INFORMATION TO BE PROVIDED BY MUNICIPALITY

1. Copies of Existing Plans, Profiles or other topographical information (where available).
2. Registered Land Plans.
3. Front-end Section of City of Kitchener Contract Documents.
4. Other Reports, Studies and Information.
5. Entry to Property.

5.0 FINAL DOCUMENTATION (PRIOR TO CITY SIGN-OFF)

A. Acceptable Formats

B. Number of Copies

C. Locations for Documents

D. Drawings:

- As-Recorded Drawings:

  Laminated Drawings for Site

  Station Schematics with Pressures, Operating Points and Elevations

  Digital copy of as-constructed drawings

E. Documents (Bound Volumes):

- Certificate of Approval
- Pumping Station, Forcemain, Standby Power (as required)
- Contact Information for All Equipment Suppliers and Manufacturers:

  Company, Address, Phone, Fax, Website, Contact Person
- Copies of All Shop Drawings of Equipment Installed
- Copies of Pump Curves for all Pumps Incorporated into the Works:

  c/w All Design Operating Points
- Copies of Equipment Manufacturer's Documents:

  Installed Products Only
- Copies of Manufacturer's Installation Reports
- Equipment Start-up Reports, Calibration Certificates, Pressure and Leakage:

  Warranty Documentation
- Hydrostatic Testing on Structures
- Forcemain Pressure/Leakage Test

F. Infrastructure Testing Results:

- Copies of Material Testing Results:

  Concrete Strength, Mortar, Compaction Tests, Reinforcing Steel,

  Milling Certificates, Chemical Analysis, Pipe Material testing

G. Automation Operation and Maintenance Manual:

- Description of Station
- Description of Control Modes Available:

  Final Process Narrative

Normal Operation, Emergency Operation, Control, Setpoints

Numbering and Tagging Convention

All Testing and Commissioning Reports

H. Pumping Station Attributes Database:

- Fill in attributes into pumping station Microsoft ACCESS database