Appendix B

Design Specifications and Provisions

CITY OF YELLOWKNIFE

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1.1.1 Asphalt Mix Design and Job Mix Formula

A qualified testing laboratory engaged and paid for by the developer shall be employed to prepare a mix design and job mix formula for the aggregate on which the project is based. The mix design and job mix formula shall be submitted and approved in advance of a deadline agreed upon by developer and City Public Works team during the project kick-off meeting, where testing source will be taken into consideration when setting the deadline

The Developer shall conduct QC Field and laboratory tests on the material delivered to and laid for the work. The test must demonstrate that the material produced will consistently meet the mix design and specification requirements with respect to density, asphalt content, air voids content, quality of surface appearance etc.

The laboratory mix design shall be based on the Marshall Method. Absorption of asphalt into the aggregate shall be taken into account using the ASTM Bulk Specific Gravity of the aggregate in calculating optimum asphalt content.

1.1.1.1 Asphalt Mix Design

The mix design shall meet the following specifications:

Table 1: Asphaltic Concrete Specifications

Tolerance Criteria	14 mm	10 mm
Number of compaction blows each end of specimen	75	75
Stability (kN)	6.7	8
Flow (mm)	2-4	2-4
% voids total mix	3.5-4.0	3.5-4.0
Film Thickness µm	6.5	6.5
% Voids Filled	65-75	68-75
Manufactured Fines	60%	50%

The job mix formula shall list the following information:

- Batch Plants:
  - The sieve analysis of the combined aggregate in the mix;
  - The aggregate size range in each bin separation to be used;

- The weight of material to be used from each bin for 1 batch of mix;
- The weight of asphalt to be used in each batch; and
- The mixing temperature of the asphalt mix as determined from the temperature-viscosity relationship for the asphalt.

Continuous Plant:

- Proportions for a continuous feed mixing plant shall be determined on the basis of a field trial which shall be carried out at least forty-eight (48) hours prior to placing the mix on the job site.
- The volumetric settings of the aggregate and asphalt shall be determined by the Contractor and approved by the City's Engineer. These settings shall be interlocked, so that a change in the volume of aggregate automatically results in a corresponding change in the volume of asphalt.
- The following data shall be displayed at the plant:
  - The weight of asphalt per tonne of mix;
  - The mixing temperature of asphalt mix as determined from the temperature-viscosity relationship for the asphalt; and
  - The settings of the feed systems.

The job mix formula shall be posted in a conspicuous place within the sight of the plant operator.

1.1.1.2 Asphalt Binder

The asphalt binder shall be maintained at a temperature between 120°C to 150°C by approved means to obtain uniform heating of the entire contents of the storage tank. The temperature differential between aggregate and asphalt binder shall be no more than 15°C.

1.1.2 Asphalt Cement

The asphaltic Cement shall be PG58-34 to ASTM D6373 Table 2, uniform in character, free of water and shall not foam when heated to 175C. The percent of asphalt in the mix shall not vary by more than 0.3% from the percentage indicated in the approved mix design.

The tack coat shall be a liquid asphalt of the following type and grade:

- Emulsified Asphalt - SS-1 or SS-1h

The seal coat and fog coat shall be a liquid asphalt of the following type and grade:

- Emulsified Asphalt - SS-1 or SS-1h;

Asphalt prime coat shall be a liquid asphalt of the following type and grade:

- Emulsified Asphalt - SS-1 or SS-1h;

1.1.2.1 Asphalt Aggregate

All aggregate particles shall be composed of sound, hard, durable particles of sand, gravel and rock and shall be free from elongated particles, injurious quantities of flaky particles, soft shales, organic matter, clay lumps and other foreign matter. When tested by means of laboratory screens, the mixed aggregate shall meet the following gradation limitations:

Table 2: Asphalt Aggregate Gradation Limitations

Sieve Size	Percentage Passing by Weight	
	14 mm Asphalt Mix	10 mm Asphalt mix
20 mm	100	
14 mm	80-92	100
10 mm	70-84	83-92
5 mm	50-65	55-70
1.25 mm	23-42	23-42
630 um	14-35	14-35
315 um	10-25	10-25
160 um	3-18	3-18
80 um	2-6.5	2-6.5

The job mix gradation shall be maintained within the requirements listed above which are the master range of tolerances and shall govern over any other tolerances prescribed.

The weight of aggregate from any bin, as well as the total weight of aggregate for each bin shall not vary from the job mix formula by more than:

Table 3: Allowable Variation in Aggregate Grading

Aggregate Material by Weight Passing Sieve Size	% Variation
5 mm and larger	5
1.25 mm	3
630 um to 315 um	2
160 um and 80 um	1.5

The combined aggregate after going through the sieve shall have a sand equivalent value of not less than 45.

1.1.2.2 Preparation of Mineral Aggregate

For Pugmill Type Mixers:

- The aggregate may be blended either through a cold feed proportioning unit or by other means, but in any case, shall be screened into bins in accordance with the aggregate sizes called for the job mix formula.
- The mineral aggregate shall be dried to a maximum moisture content of 0.5%. The temperature of the aggregate, when delivered to the mixing unit, shall be at a temperature which is consistent with proper mixing and laying and in no case above the maximum allowable temperature based on the asphalt cement temperature-viscosity curve

For -Drum Type Mixers:

- Each aggregate size shall be fed through a separate feeder which has a positive feed and which can be easily and accurately calibrated. Each feeder shall be quick adjusting and shall maintain a uniform, constant flow throughout the range of its calibration. The plant shall be equipped with an aggregate cold feed control, such as a belt scale or other device, which automatically and instantly regulates the feed gates and which has an automatic, positive coupling with the bitumen flow to maintain the required asphalt content. The mineral aggregate shall be dried to a maximum moisture content of 0.5%. The temperature of the aggregate, when delivered to the mixing unit, shall be at a temperature which is consistent with proper mixing and laying and in no case be above the maximum allowable temperature based on the asphalt cement temperature-viscosity curve. Removal or addition of any size of aggregate, to attain gradation requirements, shall be done at the initial crushing and stockpiling stage. The cold feed control and bitumen flow shall be calibrated to the job mix formula.

1.1.2.3 Coarse Aggregate

Coarse aggregate is all material retained on the 5.00 mm sieve size. This aggregate shall consist of sound crushed stone, crushed gravel, or combinations of these materials. At least 70% of the coarse aggregate shall have at least 2 fractured faces. The percentage of wear of coarse aggregate used in surface course mixes shall not be greater than 40% when tested by ASTM C131.

Coarse aggregates shall be tested for soundness by ASTM C131 and ASTM C88 or will be satisfactorily proved sound through adequate record of service. When tested for soundness, the number of cycles shall be 5, the solution shall be sodium sulphate, and the maximum loss shall be 12%. Aggregates having known polishing characteristics shall not be used in mixes for the surface course.

When coarse aggregate grading is such that the material will tend to segregate in stockpiling or handling, such aggregate shall be supplied in 2 or more sizes. Each size of coarse aggregate required to produce the combined gradation specified above shall be placed in individual stockpiles satisfactory to the City's Engineer. When it is necessary to blend two or more coarse aggregates before placing them in the cold bins, the blending shall be done through separate bins at the cold elevator feeders and not in the stockpile.

1.1.2.4 Fine Aggregate

Fine aggregate is all mineral matter passing the 5 mm sieve size. It shall consist of natural sand and/or manufactured material derived by crushing of stone, slag or gravel. The aggregate particles shall be clean, tough, durable, and moderately sharp. Fine aggregations shall be tested for soundness. When tested for soundness, the number of cycles shall be 5, the solution shall be sodium sulphate, and the maximum loss shall be 15%.

When it is necessary to blend fine aggregates from one or more sources to produce the combined gradation specified, each source or size of fine aggregate shall be placed in individual stockpiles at the plant site and separated by bulkheads or other means satisfactory to the City's Engineer. The blending shall be done through separate bins at the cold elevator feeds and not in the stockpile.

If the Developer elects to use an approved dryer-drum asphalt mixing process, the designated aggregates shall be split on the 5 mm sieve size and each material shall be stockpiled separately such that intermixing of each size and type does not occur. The coarse aggregate stockpile shall contain no more than 20% passing the 5 mm sieve size and the fine aggregate stockpile shall contain no more than 20% retained on the 5 mm sieve size. At least 2000 tonnes of aggregate shall be placed in each stockpile prior to the start of mixing operations.

The Developer, during the crushing and splitting process, shall provide a convenient means for accurately and representatively:

- Sampling the individual coarse and fine aggregate streams, and the combined aggregate stream in its proper proportion, or
- Sampling the individual coarse and fine aggregate streams and weighing the total amounts of both coarse and fine materials being produced.

1.1.2.5 Mineral Filler

Mineral filler shall be added in the mixing plant if the aggregate gradation is such that its addition is necessary to meet the above specifications. Mineral filler shall consist of Portland cement, Pozzolan, commercially ground stone dust or other mineral dust approved by the City's Engineer. Mineral filler shall have a plasticity index of zero and shall meet the following gradation requirements:

Table 4: Mineral Filler Sieve Size

Sieve Size	% Passing by Weight
1.250 mm	100

1.1.2.6 Liquid Antistripping Additive

The amount required to meet the required Marshall Method or Superpave moisture sensitivity requirements:

- Minimum Tensile Strength Ratio to be 80%, to ASTM D4867, including freeze thaw cycles; or 0.5% by mass of asphalt cement.

Liquid anti-stripping additives shall be proportioned for use in the quantity required for the mix. Liquid anti-stripping additive shall be handled and mixed with the asphalt cement in accordance with the manufacturer's recommendations. The Developer shall provide the City with the following documentation prior to placement of mix containing liquid anti-stripping additive:

- The time period for which the liquid anti-stripping additive will remain stable in heated asphalt cement;
- Appropriate Health and Safety Data;
- The type and amount of liquid anti-stripping additive used; and
- The time and date when it was added to the asphalt cement.

If the liquid anti-stripping additive is added by the asphalt cement supplier at the refinery depot, for each tanker of asphalt cement, the Developer shall provide the City's Engineer with the above documentation in the form of a weigh bill or bill of lading which, accompanies the delivered asphalt cement.

If the liquid anti-stripping additive is added to the mix at a tank which is dedicated exclusively to producing hot mix, the liquid anti-stripping additive may be added to the asphalt tanks by an in-line metering device as described below or by other means, provided that the above documentation is given to the City's Engineer for each batch of asphalt cement with the liquid anti-stripping agent added.

If a liquid anti-stripping additive is added to the hot mix asphalt at a tank which is not dedicated exclusively to producing hot mix asphalt, the liquid anti-stripping additive shall be metered by an in-line metering device controlled from inside the hot mix asphalt plant's control cabin. The Developer must provide the City's Engineer with an approved statement of calibration for the metering device along with a continuous record of the process prior to placement of mix containing liquid anti-stripping additive in addition to the above documentation each time liquid anti-stripping additive is metered into the asphalt cement.

The Developer shall use the liquid anti-stripping additive in accordance with the obtained supplier information.

Regardless of hot mix asphalt type, the amount of liquid anti-stripping additive, either specified in the Contract documents or determined through mix design procedure, shall be a percentage of the total asphalt cement required in the hot mix asphalt if a liquid anti-stripping additive is used.

1.1.2.7 Mixing

For Pugmill Type Mixers

- The mineral aggregate and asphalt binder shall be mixed in such a manner as to produce a homogenous mixture in which all particles of the mineral aggregate are uniformly coated and in the proportions called for in the approved job mix formula. The volume of mineral aggregate and asphalt cement shall not be so great as to extend above the tips of the mixer blades when the blades are in a vertical position. After the hot aggregate and mineral filler have been charged into the mixer and thoroughly mixed for a period of not less than 15 seconds, the asphalt binder shall be added and the mixing continued for a period of at least 20 seconds and not more than 45 seconds.

For -Drum Type Mixers

- The -drum mixer mixing process shall produce a uniform mixture in which all aggregate particles are coated with asphalt. The plant shall be equipped with an automatic, positive coupling which instantly regulates the aggregate cold feed gates with the bitumen flow to maintain the required asphalt content.

In no case shall the mixing temperature exceed the maximum mix temperature indicated from the asphalt temperature-viscosity curve data.

1.1.3 Application on Site

1.1.3.1 Prime Coat

The use of prime coat is at the sole discretion of the Contractor. The placement of prime coat will not be measured or paid for separately. If utilized the application of material shall be in accordance with this specification.

The asphalt material shall be applied by means of a self-powered pressure distributor equipped with the following control devices:

- Tachometer
- Pressure gauge
- Adjustable length spray bar
- Positive displacement asphalt pump with separate power unit
- Heating coils and burner capable of applying even heat to the asphalt material
- Thermometer well and accurate thermometer

Before applying the asphalt material, the Contractor shall ensure that the distributor meets the following adjustments and requirements:

- The distributor vehicle will maintain a constant height of the spray bar as the tank is unloaded.
- All spray bar nozzles are of the same manufacture, type and size.
- Clogged nozzles have been removed and cleaned with solvent.
- All nozzles have been set in the spray bar so that the nozzle slots make the same angle (15 to 30 degrees) with the longitudinal axis of the spray bar.
- The spray bar has been adjusted to the correct height to ensure uniform application without streaking.
- The spray bar has been provided with a positive shut-off to prevent dribbling.
- The distributor cap is capable of maintaining a uniform speed.

Upon a uniformly damp base course, a prime coat of shall be uniformly applied, as follows:

- Dilution rate:
  - 2 parts SS-1 to 1 part water.
- Distribution rate:
  - 2.0 liters per square meter.
- Emulsion temperature:
  - 20°C to 50°C.
- Ambient air temperature:
  - Shall be greater than 4°C.

- Curing time:
  - Minimum of two hours. If weather or other conditions have been such that the prime has not fully cured at the end of two hours, the Consultant may extend the curing period as he deems necessary.
- Traffic shall be kept off primed areas until prime has cured.
- Apply additional prime to fill voids, to coat and bond particles, or as directed by the Consultant.
- If the prime surface is loose, roll with a pneumatic-tired roller.

The asphalt shall be uniformly applied without streaking.
Joints and seams shall not be excessively overlapped. Structures, wheel guards, guardrail or other roadway appurtenances shall not be spattered by the asphalt material. The Contractor shall remove, at his own expense, any spattering caused by his operation.
Areas missed by the distributor or inaccessible to the distributor shall be treated using a hand spray or pouring pot.

The prime coat shall be maintained by the Contractor at his own expense, including the required liquid asphalt. Any area of Prime Coat that has become fouled shall be repaired before Hot Mix Asphalt Concrete is placed.

1.1.3.2 Tack Coat

Tack coat shall be applied to the edge of curbs, existing asphalt concrete, manholes, etc. where the surface of these structures will be in contact with new asphalt concrete pavement.

Where the surface course of asphalt concrete pavement is not placed immediately after the lower course and when directed by the Consultant, tack coat shall be applied to the lower course of asphalt concrete pavement as specified for existing asphalt concrete pavement surfaces.

Tack coat shall be applied only when ambient conditions are in accordance with paragraph 1.10A.1. Care shall be exercised in the application of tack coat to avoid application to areas which will not be paved. Existing asphalt concrete surfaces shall be thoroughly cleaned by a power-driven sweeper immediately prior to applying the tack coat.

Tack coat shall be uniformly applied with an approved pressure distributor at a rate of 0.25 to 0.17 litres per square meter. The temperature of the material shall be maintained between 32˚C and 38˚C.
Traffic shall, where possible, be kept off tack coat areas.

1.1.3.3 Connections to Existing Pavement

Connections to existing pavement shall be made by saw cutting back the existing pavement to sound material, and providing a neat vertical face with a straight edge. The new pavement shall be placed tight to the existing pavement and the finished surface shall be flush with the existing pavement. Prior to paving, the exposed face of the existing pavement shall be painted with tack coat.

1.1.3.4 Level Course

Leveling of uneven or broken surfaces over which asphaltic concrete is to be placed shall be accomplished by the use of asphaltic concrete placed with a paving machine, by hand raking, or by a combination of these methods as directed by Consulting Engineer.

Before commencing the level course operation, the Consulting Engineer shall be contacted so that assistance can be given in maintaining the proper grades, lines and typical cross-sections.

After placement, the asphaltic concrete used for leveling shall be compacted thoroughly with pneumatic-tired rollers

In the event that the level course is to be used as a wearing surface, the level course shall be machine placed.

1.1.3.5 Base Preparation

The Hot mix shall be laid upon a dry firm base, true to grade and cross section and free from all screenings, loose, or foreign material. No hot mix shall be spread when the base is wet, frozen or when other conditions prevent proper spreading, finishing or compaction.

If undercutting and subsequent backfill with hot mix is done, the backfill operation shall be performed sufficiently far ahead of the paving operation to allow the asphalt concrete sufficient time to cool down to support equipment

1.1.3.6 Clean up and Traffic

The entire project, including construction areas as well as contractor's yards, shall be left in a neat and tidy condition. All construction refuse shall be removed from boulevards, ditches, roadways and yards to the satisfaction of the City.

Traffic shall not be permitted on the finished pavement until it has cooled to atmospheric temperature. The contractor shall be responsible for traffic control during construction and shall maintain traffic to the satisfaction of the City's Engineer.

1.1.3.7 Transitions

Transitions shall be constructed by saw cutting and removing the existing pavement to the limits shown on the drawings, or as directed by the Consultant. The exposed road base shall be regraded and base material added as required to attain the specified grade and cross section. Before placing the asphalt concrete, the exposed road base shall be thoroughly compacted to 100% of Standard Proctor Density (ATSM D698). The pavement thickness shall be as shown on the drawings, or as specified by the Consulting Engineer.

1.1.3.8 Diesel Fuel

Diesel fuel is prohibited from use as a lubricant or asphalt release agent on all City projects. This includes its use on the beds of asphalt delivery vehicles, pneumatic tire roller, tools and for clean-up operations.

1.1.3.9 Joints

Joints must be completed in the following manner:

- Longitudinal and transverse joints shall be made in such a manner as to provide proper bonding between the two mats for the full depth of the joint.
- Transverse joints shall be made by cutting back on the previous course in order to expose its full depth. When spreading the course is resumed, the exposed edge of the joint shall be painted with an approved bituminous material and the freshly laid mixture shall be raked against the joint, tamped with hot tampers and rolled.
- The mixture shall be spread and laid so that all longitudinal joints are made while the asphalt mat which was laid first is still no less than 65°C. If less than 65°C, an asphalt infrared joint heater can be used to reheat the longitudinal joint.
- Longitudinal joints shall be vertical butt type, well bonded and sealed and finished to provide a continuous, smooth profile across the joint. Longitudinal joints shall not be permitted in the lane.
- A narrow strip along the edge of a mat which is to be jointed with another asphalt mat shall be left without rolling until the adjoining mat has been placed against it. The joint which is formed shall be rolled immediately after the adjacent mat has been placed to ensure a bonding of the material while the asphalt is still hot. Any cooled longitudinal joint shall be cut and tack coated prior to the commencement of an adjoining mat.
- Care must be taken during the forming of the joints so that there will be a continuum of surface planes devoid of ridges or depressions at the joints. Any joint which is not straight or is hollow, segregated, raised or in any way deemed by the Consultant as being unsatisfactory will be rejected.
- Transverse joints in succeeding lifts shall be offset at least 0.6 m and in adjacent lanes they shall be offset a minimum of 0.3 m. Longitudinal joints shall be offset at least 0.2 m.
- Where mechanical placing methods do not produce proper joints at gutters, curbs, or other structures, hand methods will be required.

- When paving is discontinued on the roadway, the asphalt concrete shall be temporarily feathered to a slope of 10 horizontal to 1 vertical. When paving is resumed, the transverse joint shall be straight and have a vertical face when the taper is removed.
- The exposed edges of all cold asphalt joints and the face of concrete gutter shall be cleaned and painted with a thin coat of hot asphalt cement. Joints shall be heated using an infrared heater prior to painting with hot asphalt cement.
- Where a transverse joint is made with a cold asphalt mat, the joint shall be made on a vertically true line. Cold jointing shall be done in such a manner as to ensure a thorough and continuous bond between the cold and the hot mats.
- A cold asphalt shall be one where the surface temperature, taken within 600 mm of the edge of the mat is less than 65°C.
- In order to eliminate longitudinal cold joints in the surface course, the use of two asphalt spreaders in tandem shall be required wherever road widths permit.

1.1.3.10 Transportation

- The hot mix shall be transported from the mixing plant to the work, in vehicles with tight metal boxes previously cleaned of all foreign materials. The inside surface may be lightly lubricated with soap solution just before loading but excess of lubricant shall not be permitted. Any puddling of the lubricant constitutes excess usage. Thin oil or diesel is not permitted.
- To allow the recording of asphalt mix temperatures, trucks shall have an accessible 15 mm diameter hole drilled into the driver's side of the box, at a distance of 300 mm from the box bottom and 150 mm clear of the reinforcing ribs.
- To protect the load from adverse weather conditions during transit, trucks shall carry at all times tarpaulins of sufficient weights and size to cover the entire open area of the truck box. Tarpaulins shall be used at all times, regardless of weather conditions when ordered by the City's Engineer.
- No loads shall be sent out so late in the day as to prevent spreading and compacting the mixture during daylight hours.
- The Developer shall provide a sufficient number of trucks to ensure a continuous supply of asphalt to the paver during placement.

1.1.3.11 Spreading

- The asphalt mix shall be laid at a temperature not lower than 120°C or more than the maximum allowable temperature based on the asphalt cement temperature-viscosity curve.
- Place mixture when the roadway surface temperature is 7°C or higher unless otherwise approved.
- The asphalt mix shall be spread on dry, clean and unfrozen surfaces.

- The asphalt mix shall be spread by means of a mechanical self-propelled paver or approved mechanical spreader capable of spreading the mixture true to the line, grade and crown set by the City's Engineer. Unless operating on fixed side forms, the paver shall employ mechanical devices such as equalizing runners, straight-edge runners, evener arms or other compensating devices to adjust the depth and confine the edges of the mixture to true lines without the use of stationary side forms.
- The paver shall be operated in such a manner as to distribute the asphalt mix to the proper cross-section, width and thickness without causing segregation of the mix. Small segregated areas which may occur shall be corrected immediately. The forward motion of the spreader shall be controlled so that no irregularities in the pavement surface are caused by excessive speed or stops.
- The rate of placement of the asphalt mix shall be uniform and coordinated with the production rate of the asphalt plant to minimize intermittent operation of the spreader.
- The paver shall be equipped with an adjustable strike off screed of such design that drag marks will be eliminated. The paver shall carry an approved 3 meter straight-edge for checking finished surface.
- Immediately after any course is screened and before compaction is started, the surface shall be checked and any irregularities adjusted. Irregularities in alignment and grade along the outside edge shall also be corrected by the addition or removal of mixture before the edge is rolled.
- The Developer shall provide a competent worker who is capable of performing the work incidental to the correction of all pavement irregularities. Special attention shall be given by the worker to the straight-edge checking of each course immediately following the initial rolling.
- Compacted depth of 75 mm or less of asphalt mix may be placed in (1) lift. Depths greater than 75 mm shall be placed in 2 equal lifts.
- Where the asphalt mix is to be placed in 2 lifts, the first lift shall be placed, finished and compacted for the full width as shown on the drawings, prior to commencing on the second lift.
- In placing the second lift, the individual mixture spreads shall be aligned in a manner such that the longitudinal joints in each layer are offset by at least 200mm.
- In narrow areas, deep or irregular sections, intersections, turnouts, or driveways where it is impractical to spread with a paver, the Developer may use hand methods as directed by the Consulting Engineer.
- Hauling over new pavement will not be permitted until the mixture has been thoroughly compacted in the manner specified and has cooled to atmospheric temperature.
- Contact faces of curbs, gutters, Maintenance Holes and sidewalks shall be coated with asphalt using a hand applicator before placing the asphalt mix.

1.1.3.12 Compaction

- After the asphalt mix has been spread to the uniform thickness required, it shall be compacted to a minimum of 93% of the Maximum Theoretical Density. The Developer shall be responsible for the selection of the type and number of units of compaction equipment. Compaction to the specified density shall be completed before the asphalt mixture has dropped in temperature to 80°C.
- The rollers shall be kept in continuous motion while on the hot mat in such a manner that all parts of the pavement receive equal compression.
- The Consulting Engineer reserves the right to reject the use of any equipment or construction procedure which does not or will not, in his opinion produce proper results.
- The Developer shall provide a sidewalk roller, hand tampers and other compaction equipment as required for compaction in restricted areas.
- The speed of compaction equipment shall not exceed 5 km/hr and shall at all times be slow enough to avoid displacement of the asphalt mix. Any displacements which occur as a result of reversing the direction of the roller, or from any other cause, shall at once be corrected by the use of rakes and the addition of fresh mixture where required. Rolling shall proceed continuously until all roller marks are eliminated and no further compression is possible. To prevent adhesion of the mixture to the roller, the wheels shall be kept moist with water, but excess water will not be permitted. Fuel oil, lubricating oil or kerosene will not be permitted.
- Along curbs, Maintenance Holes and other structures not accessible to the rollers, the mixture shall be compacted thoroughly by means of hot tampers. The joints between these structures and the mixture shall be effectively sealed.
- Longitudinal joints shall be rolled directly behind the paver.

1.1.3.13 Smoothness and Grade

- After final compaction, the asphalt surface shall be smooth and true to the established crown and grade and have a smooth riding quality. The finished surface of the mat shall be free from segregation, waves, hairline cracks and other obvious defects.
- The surface of the mixture after compaction shall be smooth and true to established section and grade. Areas in which any mixture shows an excess or deficiency of asphalt, or uneven distribution of asphalt due to insufficient mixing, or which becomes loose, broken, raveled, mixed with dirt, or is in any way defective, shall be removed and replaced with fresh hot mixture at the Developer's expense and be immediately compacted to conform with the surrounding area.
- The surface of the finished pavement shall be free from depressions exceeding 3mm as measured with a 3 m straight-edge parallel to the direction of travel; and 6mm as measured with a 3 m straight-edge perpendicular to the direction of travel.

- The surface of the finished pavement shall not be more than 15 mm above the gutter lip, but in no case lower than the gutter lip. In general, the elevation of the finished asphalt surface shall not be more than 15 mm below or more than 25 mm above the elevation staked. The finished surface shall not contain any variations which will impede drainage.

1.1.4 Asphalt Segregation

Areas of segregation will be identified visually by the City Engineer per the Alberta Transportation Segregation Rating Manual and the areas for repair will be marked out. Areas of segregation and surface defects will be considered unacceptable work until the areas are repaired, at no additional cost to the City. City and City Staff and Consulting Engineer shall have final decision on repair method to be employed for each area of segregation.

Table 5: Segregation Repairs

Segregation Repairs	
Segregation Type	Top Lift Repair
Slight Segregation	Slurry Patch
Moderate Segregation	Slurry Patch, or Remove and Replace
Severe Segregation	Remove and Replace, or Overlay
Center of Paver Streak (moderate or severe only)	Slurry Patch, or Remove and Replace
Obvious Defect	Slurry Patch, or Remove and Replace

Repairs using a slurry patch shall meet the following requirements:

- The seal shall be a mixture of a dry, non-plastic sand, an emulsified asphalt SS-1 (slurry), potable water and if needed, acceptable additives such as Portland Cement and Carbon Black for color.
- The mix proportions for a 1,000 liter batch of seal shall be as follows:
  - 360 liters of SS-1 (slurry);
  - 270 liters of potable water; and
  - 850 kg of dry, non-plastic sand. The Developer shall add the water to the emulsified asphalt followed by the addition of the sand.
- Thoroughly mix the seal.
- If a mineral filler is used, it shall be blended into the mixture.
- A minimum amount of additional water may be added to obtain a fluid, homogeneous mixture.
- If a tack coat is required, the same asphalt chosen for the seal binder shall be used.
- The seal shall be neat and square; and uniform and homogeneous with no uncovered areas, ridges or loose aggregate.
- Hand or mechanical squeegees may be used to spread the seal.
- The completed seal shall be kept free of all traffic until it has cured sufficiently to prevent pickup of aggregate particles.

Repairs for segregation using removal and replacement shall be for the full lane width. The full depth of the asphalt lift shall be removed and replaced in accordance with the specification.

Repairs for segregation using an overlay shall be for the entire pavement width.

All asphalt material used for overlay and removal and replacement repairs shall have a tack coat applied prior to placement.

1.1.5 Testing Requirements and Tolerances

One complete Marshall Test including asphalt content, aggregate gradation stability, flow and air voids per 1000 tonnes of mix.

Each site shall be tested on the basis of one (1) thickness and density test per 1,000 square meters of asphalt, with a minimum of three (3) thickness and density tests per site. Test locations shall be determined by a random number system as specified in the Asphalt Institute Manual Series Number 1 (MS-1).

Areas found to be less than the specified density or thickness shall be subject to further investigation. This investigation shall be carried out on either side of the test locations indicating below specified pavements and shall cover the entire area between adjacent test locations which indicate adequate pavement.

1.1.5.1 Thickness

Thicknesses as follows:

- The minimum compacted thickness of hot mix shall be placed on all areas unless specified otherwise.
- Pavement deficient in thickness by 13 mm or more shall be removed and replaced at the Developer's expense.

1.1.5.2 Density

The mixture shall be compacted immediately after spreading to a Maximum Theoretical Density required by the asphalt mix design. Asphalt which fails to meet the density specified shall be removed and replaced at the Developer's expense.

1.1.5.3 Asphalt Content

For deviations of 0.5% or more in the asphalt content from the design value, the Developer shall either overlay or remove and replace the previously placed asphalt.

1.2 Concrete

1.2.1 Concrete Mix Design

Concrete mixes shall be designed by a qualified testing laboratory engaged and paid for by the Developer. The mix design shall be submitted to the Consulting Engineer for approval a minimum of 7 days prior to delivery of any concrete to the site. As a minimum, and unless specified elsewhere, the properties of the concrete shall be:

- The specified compression strength at 28 days is 25 MPa. The strength level of 25 MPa shall be considered to be achieved if the averages of all sets of three consecutive strength tests equal or exceed the specified strength and no individual strength tests is more than 5 MPa below the specified strength;
- The concrete shall contain not less than 315 kg of Portland Cement per cubic meter of concrete produced;
- The maximum water to cementing materials ratio is 0.45;
- The total air content of the concrete shall be maintained between the limits of 5 - 8%;
- For hand placed concrete the slump shall be 60mm ± 20mm;
- For slip-formed concrete the slump shall be 30 ± 10mm;
- Concrete placed after September 30 shall attain the specified compressive strength in 7 days;
- The nominal maximum size of coarse aggregate is from 14 to 20 mm;
- Chemical admixtures to be used only when approved by the Consultant; and
- Use of calcium chloride shall not be permitted.

In the event flowable fill (slurry) is required, it shall meet the following criteria:

- Hydraulic Cement Type;
- 28 day compressive strength of minimum 0.5 MPa;
- Minimum cement content of 30 kg per cubic meter of flowable fill;
- Maximum aggregate size of 5 mm; and
- Maximum of 30% passing 80 µm sieve.

Use accelerating admixtures in cold weather only when approved by Consultant. Use of admixtures will not relax cold weather placement requirements. Use calcium chloride only when approved by Consultant. Use set retarding admixtures during hot weather only when approved by Consultant. Add air entraining agent to normal weight concrete mix for work exposed to exterior.

1.2.2 Concrete Mix Materials

1.2.2.1 Portland Cement:

Non-shrink grout to follow:

- Dry pack grout containing non-metallic aggregate, plasticizing agents and Portland cement. 28 day compressive strength 45 MPa minimum.

Portland cement shall meet the requirements of CAN A23.1 Portland Cement and shall be either GU (Type 10) Normal, or HE (Type 30), High Early Strength as required by these specifications.

Water used in mixing concrete shall be clean and free from injurious amounts of oils, acids, alkalies, organic material or other deleterious substances.

1.2.2.2 Aggregate

Fine Aggregate shall be normal density aggregate graded to CSA-A23.1/A23.2. Coarse Aggregate is to be normal density aggregate graded to CSA-A23.1/A23.2. Size in accordance with Group 1, table 5.

1.2.2.3 Admixtures

Admixtures as follows:

- Air entraining admixtures shall conform to ASTM C260.
- Chemical admixtures shall conform to ASTM C494.

1.2.3 Placement

Verify existing conditions before starting work. Verify all dimensions and locations required on drawings. Verify requirements for concrete cover over reinforcement. Verify that anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not impede concrete placement. Verify locations of all openings and embedments required for other work.

Prepare previously placed concrete by methods approved by the Consultant. In locations where new concrete is dowelled to existing work, drill holes in existing concrete.
Insert steel dowels and pack solid with non-shrink grout. Coordinate the placement of joint devices with erection of concrete formwork and placement of
form accessories.

Place concrete in accordance with CSA-A23.1/A23.2., and:

- Notify Consultant minimum twenty-four (24) hours prior to commencement of operations.
- Ensure reinforcement is not disturbed during concrete placement.

- Maintain records of concrete placement. Record date, location, quantity, air temperature, and test samples taken. Place concrete continuously between predetermined expansion, control, and construction joints. Do not interrupt successive placement; do not permit cold joints to occur. Saw cut joints within twenty-four (24) hours after placing. Use 5 mm thick blade, cut minimum 1/4 depth of slab thickness.

A. Fine broom finish surfaces which are scheduled to be exposed. Immediately after placement, protect concrete from premature drying, excessively hot or cold temperatures, and mechanical damage. Maintain concrete with minimal moisture loss at relatively constant temperature for period necessary for hydration of cement and hardening of concrete.

1.2.4 Reinforcement

1.2.4.1 Materials

Reinforcement materials shall comply as follows:

- Reinforcing is to be standard grade rebar and wire mesh, sized according to drawings stamped by a registered Professional Engineer in the Northwest Territories.
- Reinforced crossings shall be reinforced with 152 x 152 – MW 18.7 / MW 18.7 welded wire mesh, conforming to CSA 630.5. Where reinforcing bars are required, they shall conform to CSA G30.12-M. Reinforcing steel shall be free from rust, scale, or other coatings which may adversely affect the bond.
- Reinforcing steel:
  - billet steel, grade 400, deformed bars to CSA G30.18, unless indicated otherwise.
- Cold-drawn annealed steel wire ties:
  - to CSA G30.3.
- Welded steel wire fabric:
  - to CSA G30.5. Provide in flat sheets only.
- Chairs, bolsters, bar supports, spacers:
  - to CSA A23.1.
- Mechanical splices: subject to approval of Consulting Engineer.
- Fabricate reinforcing steel in accordance with CSA A23.1.

1.2.4.2 Installation

Installation work shall comply as follows:

- Prior to placing concrete, obtain Consulting Engineer's approval of reinforcing material and placement.
- Place reinforcing steel as indicated on drawings and in accordance with CSA A23.1.
- Overlapping of wire mesh reinforcing shall be a minimum of 300 mm and be wired together.
- Overlapping of bar reinforcing shall be 30 bar diameters and be wired together.

- The mesh and/or bar reinforcing shall be supported above the compacted gravel base to ensure a 50 mm cover of concrete. The manner of supporting the reinforcing shall be approved by the Consulting Engineer.

1.2.5 Formwork

1.2.5.1 Materials

Materials used for formwork shall comply with the following:

- Plywood and wood formwork materials to CSA A23.1.
- Removable or snap-off metal ties, fixed or adjustable length, free of devices leaving holes larger than 25 mm dia. in concrete surface.
- Plywood is to be Douglas fir to CSA O121 standard grade, square edge, 15 mm thick.
- Form release agent is to be a chemically active release agents containing compounds that react with free lime in concrete resulting in water insoluble soaps.
- Falsework materials to CSA S269.1.

1.2.6 Testing

The Developer will employ a qualified testing laboratory to perform all quality tests to ensure that the product meets the requirements of the contract documents. Samples of concrete shall be obtained in accordance with CSA Test Method A23.2-1C for Sampling Plastic Concrete.

1.2.6.1 Frequency of Testing

Not less than (1) set of concrete cylinders to be cast and tested for each 50 cubic meters of concrete placed. There shall be less than 1 test from each day's pour

Conduct slump and air content tests shall be conducted for each set of cylinders cast and every 75 lineal meters of sidewalk and/or curb & gutter.

1.2.6.2 Air Content

Air Content shall comply with the following:

- Air content determinations shall be made in accordance with CSA Test Method A23.2-4C Air Content of Plastic Concrete by the Pressure Method.
- During construction start-up, every load or batch of concrete shall be tested until such time as satisfactory control of the air content has been established. Air content test taken with the test cylinders will be sufficient once satisfactory control has been established. Whenever a test falls outside the specified limits the testing frequency shall revert to 1 test per load or batch until such time as satisfactory control is re-established.

- Failure - If the measured air content falls outside the limits specified, a check test shall be made immediately on another portion of the same sample. In the event of a second failure, the load of concrete shall not be used for construction.
- Where deemed necessary, the Consulting Engineer will test hardened concrete for air content and spacing factor by the linear transverse method, ASTM Designation C457, Modified Point-Count Method, Air-Paste Ratio Method of Calculation. Concrete tested by this method using a magnification of 100X and found to have a spacing factor greater than 0.23 mm will be rejected, and complete replacement of the work will be required. Linear transverse testing cost will be borne by the Developer, if the concrete is proven defective. Linear transverse testing costs will be borne by the City when the concrete is proven to meet the above requirements.

1.2.6.3 Slump

Slump tests made in accordance with CSA Test Method A23.2-5C Slump of Concrete, shall be made in conjunction with each strength test. If the measured slump falls outside the limits specified, a check test shall be made immediately on another portion of the same batch. In the event of a second failure, the City's Engineer may refuse to permit the use of the batch.

1.2.6.4 Test Cylinders

Test cylinders shall be made and stored in accordance with CSA Test Method A23.2-3C.
Each strength test shall consist of 3 test cylinders, 1 tested at 7 days and 2 at 28 days. All test cylinders representing concrete placed after September 30 shall be tested at 7 days. Compressive strength of test cylinders shall be in accordance with CSA Test Method A23.2-9C Compressive Strength of Cylindrical Concrete Specimens and shall be the average of the strengths of the test cylinders tested at the same age.

Failure

In the event that the concrete tested in accordance with these specifications fails to meet the strength requirements, the City's Engineer shall have the right to require any one or all of the following at no additional expense to the City:

- Core the portion of the work in question and test in accordance with CSA Test method A23.214C, obtaining and testing drilled cores for compressive strength testing. The average of the core strengths shall be at least 90% of the specified strength. No single core shall be less than 85% of the specified strength; or
- Replace the concrete, represented by the tests, with concrete which meets these specifications.

1.2.7 Retempering

1.2.7.1 Slump

Do not add water after initial production unless slump at point of initial discharge is less than specified. Introduce water into drum mixer at an amount not exceeding twelve (12) litres/cubic meter, to bring slump to within specified limits. Rotate drum a minimum of thirty (30) revolutions at mixing speed until uniform. Do not subsequently add additional water to the load. If after retempering, the slump exceeds specified maximum slump, load is rejected. If the need to retemper with water is persistent or continuous, Consultant may reject all loads that have been retempered with water.

1.2.7.2 Air Content

Retempering with air-entraining admixtures is only permitted under the following conditions:

- Retempering is completed under direction of concrete supplier.
- Retempering admixture is comparable to original admixture used in the mix design.

The use of reverse air-entraining admixtures is not permitted. Following addition of air-entraining admixture, rotate drum for three to five minutes or until uniform. Perform air content test on each load retempered with air-entraining admixtures and immediately provide results to Consultant. For loads that test at or between 4.0 - 4.9% air, Air-entraining admixture or air-entraining admixture and water must be added as deemed necessary by supplier to meet specifications. For loads that test at or below 3.9% air, Retempering is not permitted. Load is rejected. Each load has only one opportunity to be retempered to meet specified air content. If following retempering the load does not meet the specified air content, it is rejected. If the need to retemper with air-entraining admixtures is persistent or continuous, Consultant may reject all loads that have been retempered with air-entraining admixtures.

1.2.8 Weather Requirements

1.2.8.1 Cold Weather Requirements

When the atmospheric temperature is lower than 5°C, all aggregates and water shall be pre-heated. All reinforcing materials, forms, and ground with which the concrete is to come in contact shall be defrosted by means of live steam or as approved by the Consulting Engineer.

When depositing concrete at freezing or near freezing temperatures the concrete shall have a temperature of between 10°C and 30°C and shall be maintained at a temperature of at least 10°C for 3 days. If hot water is used in the mixing, the water and aggregates shall be mixed for half a minute prior to adding the cement. If a temperature of 10°C cannot be maintained for 3 days after placing concrete work will be suspended.

Calcium chloride not exceeding 2% by weight of Portland Cement may be used in concrete, if approved by the Consulting Engineer. Calcium chloride shall not be used with HS (Type 50) Sulfate Resistant Portland Cement.

Canvas and other protective coverings used to conserve heat shall be kept clear of the concrete to permit free circulation of air.

Concrete showing evidence of freezing shall be removed from the job and replaced at the Developer's expense.

1.2.8.2 Hot Weather Requirements

When the atmospheric temperature is higher than 23°C, the concrete temperature at the time of placing shall not exceed 30°C. In the event this limit is exceeded, the concrete operations shall be suspended until the constituent materials of the concrete are cooled.

Concrete shall be protected from excessive loss of moisture during periods of hot or windy weather. Placing operations shall be discontinued if shallow cracking due to excessive drying is evident.

1.2.9 Curb and Gutter

1.2.9.1 Finishing

The top of the gutter and the top of the curb shall be trowelled to a smooth finish and the edges neatly rounded. Excessive trowelling shall be avoided. The final finish shall be a lengthwise brushing with a nylon bristle brush as approved. A mortar coat or excessive water in the finishing process shall not be used.

The gutter lip on the curb and gutter shall be lowered where a swale gutter joints the curb and gutter structure to allow for free flow of drainage water.

1.2.9.2 Joints

Transverse contraction joints shall be constructed every 3.0 m by means of a marking tool, steel plate or as approved. Joints shall be not less than 50 mm in depth and shall be 6 mm in width. When steel plates are used, an area of not less than 50% of the concrete shall be continuous through the joint. The joint shall be edged with a tool having a radius of 6 mm.

Contraction joints in medians, traffic islands and gores shall extend the full width of the median, traffic island, curb & gutter and gore. If because of irregular shapes the matching of joints is not possible, the City Engineer may approve an alternate jointing pattern.

1.2.10 Sidewalk

1.2.10.1 Longitudinal Grades

Grades shall be provided by the Consulting Engineer.

Sidewalk cross-slope down to the curb shall be consistent within 2 to 4% minimum-maximum limits except at lanes and crossings.

1.2.10.2 Joints

Transverse contraction joints shall be constructed every 3.0 m by means of a marking tool or as approved. Joints shall be not less than 50 mm in depth and shall be 6 mm in width. The joint shall be edged with a tool having a radius of 6 mm.

Transverse surface joints shall be constructed midway between contraction joints and shall be 15 mm deep and 6 mm wide. The joint shall be edged with a tool having a radius of 6 mm.

1.2.10.3 Finishing

The top of the sidewalk or median shall be trowelled to a smooth finish and the edges neatly rounded. Excessive trowelling shall be avoided. The final finish shall be a transverse brushing with a nylon bristle brush approved by the Consulting Engineer. The edges shall be neatly rounded. A mortar coat or excessive water shall not be used in the finishing process. Sidewalks shall be edged and broom finished.

1.2.10.4 Erection

Leave formwork in place for a minimum of 1 day after placing concrete.

1.2.11 Swale Gutters

Locations where surface runoff is unable to reach the curb and gutter system require a swale constructed in the roadway. Swale gutter cross-section shall be a minimum of 1 meter wide and 200 millimeters thick with steel reinforcing.

Tolerances for Concrete Structures:

- All exposed concrete surfaces shall be checked by the Developer with a 3 m straightedge, and any water pockets or deviations in line or grade exceeding 6 mm shall be corrected immediately.
- Differences in elevation at any given point from the design grade shall not exceed ± 20 mm.
- Deviations in alignment at any given point from that specified shall not exceed ±15 mm and the variation over 100 meters intervals shall not be greater than 25 mm.

1.2.11.1 Sidewalk, Curb and Gutter Failures

Replacement of affected sections required when one or more of the following exist:

- Any crack greater than 3 mm in width, with no vertical displacement, or chipping or spalling edges;
- Any crack with vertical displacement, chipping or spalling edges;
- Any longitudinal crack greater than or equal to 1.5 mm in width;
- A displacement, at a joint of greater than or equal to 12 mm;
- A dished surface of sidewalk or gutter;
- A reverse cross fall, or cross fall greater than 8% or less than 0.7%;
- A corner cut exists.
- A random cracking of any size;
- Any feature considered detrimental to pedestrian safety or appearance of the sidewalk and/or curb and gutter; and
- Honeycomb or embedded debris in the concrete.

All breakout shall end at a contraction, expansion or surface joint. The edge of a surface mark shall be sawn to a depth of 50 mm minimum, while contraction joints may be neatly hand chiseled to produce a true straight joint. The contact edge shall be exposed to produce a good bond.

Joints which have expanded up to a maximum of 13 mm without vertical displacement shall be sealed by use of an approved flexible sealant.

Defective Concrete:

- Concrete not conforming to required lines, details, dimensions, tolerances or specified requirements. Repair or replacement of defective concrete will be determined by the Consultant. Do not patch, fill, touch-up, repair, or replace exposed concrete except upon express direction of Consultant for each individual area.

2.0 Water Distribution

It is required that Developers and Consulting Engineers ensure they have a full understanding of The City's water systems before commencing design and development. The City of Yellowknife's water distribution system is unique from Southern systems and it is the duty of a developer to familiarize themselves with the standards for Northern Municipal development and incorporate these changes at the conceptual design stage.

2.1 Watermains

Water Service is not to be interrupted for more than 3 hours and confine this period between 10:00 and 16:00 h local time.

2.1.1 Materials

Materials shat be as follows:

Steel Water Pipe and Fittings

- Transition steel -Schedule 40 steel with factory applied two part epoxy coating on both interior and exterior surfaces to AWWA C210.
- Threadolets, are to be welded to the steel pipe and the full diameter hole drilled through the threadolet before epoxy coating is applied.

Ductile Iron Pipe

- Ductile Iron - AWWA C151, Class 52.
- Lining - standard thickness cement mortar to AWWA C104 complete with sealcoat.
- Coating – asphaltic coating to AWWA C151.
- Pipe ends are to be capped or covered during shipment to Yellowknife.

Ductile Iron Pipe Fittings

- Fittings – to AWWA C110 1.03 MPa working pressure.
- Lining – cement mortar lined to AWWA C104 complete with seal coat or two part epoxy coated to AWWA C210.
- Coating - asphaltic coated to AWWA C151 or two part epoxy coated to AWWA C210.
- Joints – push-on joint with continuous rubber molded ring gasket to AWWA C111.
- Restraint - the bell ends of the fittings shall have ears attached so that the pipe restraint clamps can be connected to the fitting.
- Couplers – Robar or equal interior and exterior two part epoxy coated (factory applied) to AWWA C210.
- Bolts, nuts, ready rods and washers – shall be stainless steel for all buried use.

2.1.2 Pipe Installation

Pipe Installation shall be as follows:

1. Lay pipes to applicable AWWA Specification for type of pipe selected and manufacturer's standard instructions and specifications. Do not use blocks.
2. Join pipes in accordance with to applicable AWWA Specification for type of pipe selected and manufacturer's recommendations.
3. Handle pipe by approved methods. Do not use chains or cables passed through pipe bore so that weight of pipe bears on pipe ends causing damage to insulation or cement mortar lining and asphaltic coating.
4. Lay pipes on prepared bed, true to line and grade. Ensure barrel of each pipe is in contact with shaped bed throughout its full length. Take up and replace defective pipe. Correct pipe which is not in true alignment or grade or pipe which shows undue settlement after installation.
5. Face socket ends of pipe in direction of laying. For mains on a grade of 2% or greater, face socket ends up-grade.
6. Do not exceed permissible deflection at joints as recommended by pipe manufacturer.
7. Keep jointing materials and installed pipe free of dirt and water and other foreign materials. Whenever work is stopped, install a watertight screw plug at the open end of last the pipe laid to prevent entry of foreign materials.
8. Position and join pipes with approved equipment. Do not place bars, rods or any other objects inside ends of pipe to position or handle pipe. Do not use excavating equipment to force pipe sections together.
9. Cut pipes as required for specials, fittings or closure pieces, in a neat manner as recommended by pipe manufacturer, without damaging pipe or its coating and to leave a smooth end at right angles to axis of pipe.
10. Align pipes carefully before jointing.
11. Install gaskets to manufacturer's recommendations. Support pipes with hand slings or crane as required to minimize lateral pressure on gasket and maintain concentricity until gasket is properly positioned.
12. Avoid displacing gasket or contaminating with dirt or other foreign material. Gaskets so disturbed or contaminated shall be removed, cleaned, lubricated and replaced before jointing is attempted again.
13. Complete each joint before laying next length of pipe.
14. Minimize deflection after joint has been made.
15. Apply sufficient pressure in making joints to ensure that joint is completed to manufacturer's recommendations.
16. Ensure completed joints are restrained by compacting bedding material alongside and over installed pipes.
17. When stoppage of work occurs, block pipes in an approved manner to prevent creep during down time.

18. Recheck any joints assembled above ground after placing in trench to ensure that no movement of joint has taken place.
19. Do not lay pipe on frozen bedding.
20. Protect hydrants, valves and appurtenances from freezing.
21. Upon completion of pipe laying and after Consulting Engineer has inspected work in place, surround and cover pipes between joints with approved granular material placed to dimensions indicated or directed.
22. Leave joints and fittings exposed for hydrostatic and leakage testing where directed by City Engineer.
23. Hand place pipe zone backfill material (20 mm minus granular bedding) in uniform layers not exceeding 150 mm thick to minimum 300 mm over top of pipe. Dumping of material directly on top of pipe is not permitted.
24. Place layers uniformly and simultaneously on each side of pipe to prevent lateral displacement of pipe.
25. Compact each layer to at least 95% maximum density ASTM D698, Method D.

2.1.3 Pipe Insulation and Protective Jacketing

Climatic conditions in the City of Yellowknife create the need for proper insulation of the waterworks system. The intent is to have a fully insulated water system that includes the watermains, water services and related appurtenances. The Consultant must submit to the City its proposal regarding the insulation procedure they plan to use prior to acceptance of the final design. It is suggested the Consultant meet with the City's Engineers well in advance of final design to save unnecessary changes in final design.

The thermal insulation for the watermains and services shall be factory applied. The minimum requirements for the insulation are as follows:

- 50 mm thickness, rigid, closed cell polyurethane;
- Core density to ASTM D 1622, 35 to 48 kg/m^3;
- Compressive strength at 25 °C, 10 % deflection, ASTM D 1621, 2.81 kg/cm^2;
- Thermal conductivity at 25 °C, ASTM D 2326, 0.00225 W/cm°C;
- Upper thermal limit, 121°C;
- Closed cell content, ASTM D 2856, 90% minimum;
- Water absorption, ASTM D 2842, max. 12 gm/1000cc;
- Dimensional stability, ASTM D2126, procedure B & E, 3; and
- Cut-back insulation at each end to permit pipe jointing.

Thermal insulation for joint closures, fittings, couplers, valves and related appurtenances shall be snug fit half shells or field applied polyurethane. Infill gaps, where factory applied or half shell insulation cannot be utilized, with field applied polyurethane. Field applied polyurethane shall be placed with the use of forms (where required) and shall be trimmed to the contour of the pipe or fittings.

Thermal insulation is not required on the piping in hydrant vaults or water Maintenance Holes. The outside of the vault and Maintenance Hole structure is insulated.

The factory applied thermal insulation on the watermains and service pipes shall have a protective jacketing to be either of the following:

- A 1.14 mm thickness of continuously extruded high density polyethylene over a rubber mastic under-adhesive as manufactured by Shaw Pipe Protection, “Insul-8” system; or
- A 1.27 mm thickness in two layers spirally wrapped high density polyethylene tape, hot applied, counter-wound, overlapped 15% of tape width on each seam, URECON Ltd. “U.I.P.” system or Thermal Pipe Systems.

The thermal insulation on the following items shall have a protective jacketing as described below:

- Heat shrink sleeves shall be used for joint closures on copper water services and for areas of damaged jacketing on watermain and water service pipes. Canusa Heat Shrink Pipe Sleeve with adhesive coated cross-linked polyethylene sleeve is acceptable.
- Heat shrink tape shall be used for areas of damaged jacketing on watermains and water service pipes and for insulation half shells. Raychem thermoclad adhesive coated heat shrinkable tape in 100 mm widths is acceptable.
- Mastic shall be used as a protective jacketing for field applied polyurethane on fittings, couplers, valves, pipe clamps, gap infills, and other related appurtenances. Flintguard No. 110-14 asphalt mastic vapour barrier is acceptable.

Geotechnical recommendations may require an increase in the minimum insulation specification stated in **Section 5.16**.

Unless approved by the City, the minimum insulation thickness stated in **Section 5.16** shall not be increased to compensate for inadequate circulation flows (See **Section 5.5**). The Consultant shall attempt to design circulation flows that are adequate for the minimum insulation thickness. The City prefers, for operations and maintenance purposes, to have greater circulation flows and the minimum insulation thickness. At the discretion of the City, exceptions to this minimum insulation thickness that may be allowed include, but are not limited to, the following:

- Unacceptable heat loss in small diameter mains;
- Inadequate circulation flows (or water temperatures) in the City system that feeds the development (this situation may require a recirculation station), and
- The reduction of watermain bleeder flow during the developments construction phases.

The City will consider the use of alternate thermal insulation systems, protective jacketing systems and products mentioned in **Section 2.1.3**.

2.2 Valves

Valves shall be resilient seated gate valves in accordance with AWWA C509 and the following:

- Standard iron body, bronze mounted, flanged body, non-rising stem, stuffing box O-ring stem seal, suitable for 1 MPa;
- Double disc or solid wedge gate with full 360° rubber to iron resilient seat. Resilient seat to be bonded or mechanically attached to gate and valve body;
- Valves to open by turning in a counter clock-wise direction;
- Handwheel and flanged joints for inside hydrant vaults and water Maintenance Holes, flanged valves to be accompanied by flexible couplings;
- Interior and exterior surfaces of valve to have factory applied, two part epoxy coating to AWWA C210;
- Direct bury valves require joints equivalent to pipe and a 50 mm square operating nut; and
- Exterior nuts and bolts to be stainless steel.

Direct bury valves shall have a cast iron valve box as follows:

- Type “A” valve box for valves less than 400 mm dia., Type “B” for valves 400 mm dia. and larger;
- Bituminous coated sliding type;
- Adjustable over a minimum of 450 mm, complete with valve operating extension rod, 25 x 25 mm cross section of such length that when set on valve operating nut, top of rod will not be more than 150 mm below cover;
- Base to be large round type; and
- Top of box to be marked “WATER”.

The City shall operate all existing valves as required by the development. The Developer shall not operate existing valves. Valves constructed by the Developer and accepted by the City for operational purposes shall be considered existing valves.

All temporary valves installed for construction purposes shall be removed prior to the start of the warranty period.

2.3 Hydrostatic and Leakage Testing

The water system will not be accepted by the City until all requirements of this section are satisfactorily completed.

2.3.1 Water Pipe Testing

Water pipe testing shall be as follows:

- Provide labour, equipment and materials required to perform hydrostatic and leakage tests hereinafter described, including any temporary valves or caps.
- Notify City Engineer at least 24 h in advance of all proposed tests. Perform tests in presence of City Engineer.
- Where any section of system is provided with concrete thrust blocks, do not conduct tests until at least 5 days after placing concrete or 2 days if high early strength concrete is used.
- Test pipeline in sections not exceeding 365 m in length, unless otherwise authorized by City Engineer.
- Before testing, bed and cover pipe between joints to prevent movement or snaking of pipe line when test pressure is applied.
- Leave joints and fittings exposed where directed by City Engineer.
- Strut and brace temporary caps, bends, tees, and valves, to prevent movement when test pressure is applied.
- Open valves.
- Expel air from main by slowly filling main with potable water. Install corporation stops at high points in main where no air-vacuum release valves are installed, Remove stops after satisfactory completion of test and seal holes with brass plugs.
- Fill concrete-lined pipe at least 24 h before testing to allow water absorption by pipe material.
- Thoroughly examine exposed parts and correct for leakage as necessary.
- Apply hydrostatic test pressure of a minimum of 125% of the working pressure at the highest point of the test section. The maximum test pressure shall be 150% of the working pressure measured at the lowest elevation or 1035 kPa whichever is greater. Hydrostatic test may be combined with the leakage test.
- Examine exposed pipe, joints, fittings and appurtenances while system is under pressure.
- Remove pipe, joints, fittings and appurtenances found defective and replace with new sound material and make watertight.
- Repeat hydrostatic test until all defects have been corrected.
- Apply a leakage test pressure of 1000 kPa after complete backfilling of trench, based on elevation of lowest point in main and corrected to elevation of gauge, for a period of 2 hours.
- All service lines to vacant lots are to be kept dry. Pressure test these lines using air to 35 kPa. Apply a soap solution to each joint and visually check for leaks. Repair all defective joints.

- Apply a leakage test pressure of 1035 kPa after complete backfilling of trench, based on elevation of lowest point in main and corrected to elevation of gauge, for a period of 2 hours.
- Define leakage as amount of water supplied from water storage tank in order to maintain test pressure for 2 hours.
- The allowable leakage is to be calculated as:

$$\text{Allowable Leakage} = \left(HSD\sqrt{P} \right) / 794797$$

Where: *H = number of hours*
S = length of pipe tested (meters)
D = nominal diameter (mm)
P = average test pressure (kPa)

This formula is based on a testing allowance of 0.971 L/d/km/mm of nominal diameter at a pressure of 1034 kPa.

- Locate and repair defects if leakage is greater than amount specified.
- Repeat test until leakage is within specified allowance for each section of watermain.
- Document Pressure and Leakage Test on form at the end of this section.

Results of all pressure tests are to be recorded in the approved City format provided by City Engineer**.**

2.3.2 Water Maintenance Hole or Hydrant Vault Leakage Testing

At the discretion of the City, conduct Maintenance Hole leakage tests. Install watertight plugs or seals on inlets and outlets and fill the Maintenance Hole with water for 2 hours. Leakage shall not exceed 0.3% per hour. If permissible leakage is exceeded, correct defects and repeat test.

2.4 Hydrants

The hydrants shall be as follows:

- Compression type to AWWA C502, McAvity M67 on-line type;
- Two 63.5 mm hose connections at 180°, one 114 mm pumper connection and a pentagonal shaped operating nut, all as presently in use by the City;
- Hydrant main spindles shall turn counter-clockwise to open;
- Hydrant barrel lengths to suit depth of watermain, required clearance in hydrant vault, and required height above final grade as per **Section 2.5**.
- Break-away flanges at the base of the body;
- “Dry-Top” design with totally enclosed chamber for the operating mechanism, sealed by use of O-ring seals;

- Outlet nozzles fastened into the barrel by a threaded connection;
- Drain ports to close as compression valve starts to open;
- Hydrant base to be suitable for attachment to a 150 mm flange; and
- The paint of the hydrant upper body shall be two coats of exterior enamel CGSB 1-GP-59M, colour fire engine red.

The hydrant and hydrant vault piping shall utilize the City's circulating water system for freeze protection as per **Development Standards**. In-line hydrants are not permitted. Circulation pumps in Maintenance Holes, water bleeders, aqua-flows or heat trace shall not be used to provide for freeze protection.

2.4.1 Hydrant Location & Installations

Hydrant Location and installations shall be as follows:

- In accordance with the AWWA Manual of Practice;
- Hydrants shall not be installed in alleyways, but adjacent to roadways;
- Hydrants are not to be installed through private property;
- Hydrant rods shall be coupled at the top and bottom of extension;
- Set hydrants plumb, with hose outlets parallel with edge of pavement or curb line and with pumper connection facing roadway; and
- Drain plugs shall not be installed.

Existing hydrants adjacent to the development shall not be operated by the Developer. Subject to approval and conditions as set out by the City, the Developer may be granted use of the hydrant for construction purposes. New hydrants that have been constructed by the Developer and accepted by the City for operating purposes shall be considered existing hydrants.

All hydrant components to be epoxy coated by manufacturer. Field applications of epoxy coatings will not be accepted. Burn marks from welding will result in immediate refusal for acceptance.

During construction, signs stating "Out of Service" shall be placed on hydrants when they are not in service and shall be removed when the hydrant is back in service. Also during construction, the City Fire Department shall be notified, on a continual basis, of the operational status of new and existing hydrants. City Fire Department approval is required to put operating hydrants out of service.

2.5 Hydrant Vaults

Ensure the Maintenance Hole entrance of the hydrant vault is located behind the back of the walk or back of curb. Do not allow surface drainage to enter the hydrant vault through the Maintenance Hole entrance. Do not locate the Maintenance Hole entrance in a gutter, swale, low-point, or drainage course.

A hydrant vault structure shall be watertight (except for the roof joint), and constructed of structural concrete.

The concrete roof slab shall be removable for piping maintenance purposes. The roof slab shall have lifting hooks at each corner of the slab. The hooks shall be of sufficient strength so that the roof can be lifted at any two corners without damaging the hooks or concrete.

Hydrant vaults shall be bedded as per bedding specifications with Class B bedding. Bedding compaction densities shall comply with specifications in this document, with the exception of 100% under the base of the vault. Bedding shall surround the vault for a distance of 1.0 m and shall cover the vault to the under surface of roadway structures or shall cover the vault to a depth of 150 mm below final grade in areas to be landscaped.

Vault insulation shall be as shown in **Appendix C - Drawings and Details.** The insulation shall be 50 mm thickness rigid, expanded polystyrene, closed cell foam, Styrofoam HI-40 or equal. Insulation shall be fitted to provide a maximum gap of 12 mm between insulation pieces. Geo-technical recommendations may require additional insulation.

Concrete type and concrete work shall be as per **Section 2.2**.
Hydrant vault frame and cover and ladder rungs shall be as shown in **Appendix C – Drawings and Details**. Do not place vault entrance over sump pit in base slab.

Piping in the vault shall be configured to allow the hydrant to be shut-off and by-passed without stopping the circulation flow in the watermain. A piping schematic specification drawing is required as per **Appendix C – Drawings and Details**.

Services shall not connect in the hydrant vault without prior approval from the City.

Provide adequate spacing, between the hydrant vault and adjacent buried utilities, to facilitate future maintenance excavations without undermining the vault.

Circular Maintenance Hole barrels, flat slab tops, or eccentric cone top sections shall not be used to bring the vault to final grade. The walls and roof slab of the vault shall be cast to near final grade with an allowance for grade rings and the frame and cover.

Wrap each vault, on outside of insulation where present, from the top of the lowest pipe to the top of the roof slab with two layers of tar paper and, on the outside of the tar paper, place two layers of 6 mil polyethylene sheet secured with fibreglass tape.

The City may require the installation of Lamocoid plates in the hydrant vault to label watermains and/or to show operational schematics.

2.6 Maintenance Holes

A Water Maintenance Hole is a hydrant vault without the hydrant. For City record purposes, the term "Water Maintenance Hole" shall be used to describe this insulated, underground chamber that contains watermain valves.

All the requirements for hydrant vaults as specified in **Section 2.5** shall apply to water Maintenance Holes with the exception of:

- References to fire hydrant locations; and
- Location of Maintenance Hole entrances behind back of walk or back of curb.

Where possible and practical, locate water Maintenance Holes such that the watermain alignments intersect with the water Maintenance Hole without the use of bends. (i.e. Do not use bends to redirect the watermain from the main alignment towards a water Maintenance Hole location, and then redirect it back out to the alignment.) This reduces the number of bends and clamped joint restraints on the watermain.

If a hydrant is required at a location, such as an intersection, then place all valves as required by into that vault. Do not construct a water Maintenance Hole in the same intersection in order to house the valves. This may require additional bends and watermain length, however, the City prefers to have as few underground structures (Maintenance Holes, vaults, etc.) as possible.

The high Maintenance Hole (or dead end Maintenance Hole) at the start of a sewer main run shall be insulated. The insulation shall be of 50 mm thickness, rigid, expanded polystyrene, closed cell foam, Styrofoam HI-40 or equal. Insulation shall be fitted to provide a maximum gap of 12 mm between insulation pieces. Geo-technical recommendations may require additional insulation.

The high Maintenance Hole shall be fitted with a prefabricated frost cover as detailed in **Appendix C – Drawings and Details**.

Drop Maintenance Holes shall not be allowed. However, if necessary and at the City's discretion, an interior drop Maintenance Hole may be allowed.

2.6.1 Maintenance Hole Materials

Maintenance Hole materials shall conform to the following:

- Circular Maintenance Hole sections shall be precast reinforced concrete conforming to ASTM C478 for pipe diameters up to and including 600 mm;

- Maintenance Holes for pipes greater than 600 mm shall be cast-in-place. Maintenance Hole details shall be submitted to the City for approval;
- Top sections shall be eccentric cone with opening offset for vertical ladder installation. At the discretion of the City, flat top type top sections may be allowed in situations where eccentric cones cannot be utilized;
- Joints shall be made watertight using rubber rings or bituminous compound. Bituminous joint sealing compound shall be to CGSB 56 – CP – 4a;
- Adjusting rings shall be a minimum of one 150mm ring and set onto Maintenance Hole with cement mortar;
- Precast Maintenance Holes shall be 1200 mm inside diameter;
- Ladder rungs shall be as per CAN/CSA 30.18, No. 25M billet steel deformed bars, hot dipped galvanized to CSA G164. Rungs to be safety pattern (drop step type). Alternate rungs shall be aluminum step, type 350-16, c/w anchor sleeves;
- Frames and covers shall be as per the following:
  - Maintenance Hole frames and covers to be Norwood Foundry Model F-39 or approved alternate.
  - Covers shall bear evenly on frames. Gray iron castings as per ASTM A48 strength class 30B.
  - Frame and cover castings shall be sand blasted or cleaned and ground to eliminate surface imperfections and coated with two applications of asphalt varnish.
- Concrete type and concrete work shall be as per **Section 2.2**.

2.6.2 Bolts, Nuts, Tie-Rods, Washers and Pipe Clamps

- All bolts, nuts and washers used for fittings in water Maintenance Holes shall be cadmium plated or stainless steel.
- Buried bolts, tie-rod, nuts and washers shall be stainless steel. The nuts and washers shall have a teflon washer, or equivalent, placed between them and the restraining clamps.
- All pipe restraining clamps shall be two part epoxy coated, factory applied, to AWWA C210.
- Clamps shall be installed and secured prior to tie rod installation.

2.6.3 Frost Cover

Maintenance Hole Frost Protector for 1200 mm Diameter Maintenance Hole

- Frost Protector as manufactured by Far North Fiberglass (Whitehorse, Yukon) or approved alternates.
- The Maintenance Hole frost protector to be constructed of an ortho resin and fiberglass chopped strand mixture.
- The exterior surfaces to be an isothalic white gel coat finish that is corrosion and chemical resistant.
- Insulation between the sandwich layers of fiberglass to be a minimum thickness of 50 mm (2”) of rigid polyurethane foam.

- Handles and joining tabs to be aluminum.
- All bolts, nuts and washers to be 9.5 mm (3/8”) stainless steel.

2.6.4 Maintenance Hole Location and Installation

Maintenance Hole ladder rungs shall be installed securely in the Maintenance Hole barrel and spaced at 400 mm maximum. First step 500 mm maximum below frame and last step 300 mm maximum above base. No rungs shall be installed in the joints of the Maintenance Hole barrels or the adjustment rings. Ensure horizontal rung alignment is plumb from top to bottom.

Maintenance Hole bases shall be poured in-place. Set bottom section of precast unit in wet concrete or pour wet concrete around set in place bottom precast unit.

Where applicable and practical, locate Maintenance Holes in areas of bedrock. The geotechnical investigation and test probe holes shall be used to locate bedrock for a design Maintenance Hole location in regions of overburden. If bedrock is not found prior to final design, the Consultant shall monitor trench excavations during construction in an attempt to place the Maintenance Hole on exposed bedrock or to avoid placement in poor ground conditions. If necessary, the City will consider allowing slight deviations from the requirements of **Development Standards** to facilitate Maintenance Hole placement on bedrock.

Do not allow surface drainage to enter the Maintenance Hole through the Maintenance Hole cover. Do not locate the Maintenance Hole entrance in a gutter, swale, low-point, or drainage course.

The Maintenance Hole structure shall be watertight. Plug lifting holes with mortar or mastic compound.

Maintenance Holes shall be bedded with Class B bedding. Bedding compaction densities shall be as per specifications of this document with the exception of 100% under the base of the Maintenance Hole. Bedding shall surround the Maintenance Hole for a distance of 1.0 m and up to the under surface of roadway structures or to a depth of 150 mm below final grade in areas to be landscaped.

Individual sanitary services shall not connect to a sewer Maintenance Hole. An exception shall be large diameter services (150 mm dia. and larger) with multiple units using the same service line.

Where possible, provide adequate spacing between the Maintenance Hole and adjacent buried utilities to reduce undermining if future Maintenance Hole maintenance excavations occur.

Maintenance Hole Insulation to match insulation outlined in **Section 2.4**.

2.6.4.1 Concrete Testing

One set of concrete cylinders to be cast and tested for every three Maintenance Holes or catch basin bases in each section of the work. If there is only one Maintenance Hole or catch basin in one section of the work, a set of cylinders shall be cast and tested.

2.7 Thrust Blocking and Joint Restraint

Concrete thrust blocking shall be provided at valves, bends, tees, wyes, reducers, plugs, changes in pipe diameter and caps. Ensure concrete bears on the steel portion of the pipe or fitting, not on the insulation. **Appendix C** shows what is typically required in Yellowknife.

Thrust blocks shall not bear against abandoned pipes. Abandoned pipes shall be cut and removed to minimum 1.0 m away from sides or bearing face of block.

Thrust blocks shall be bedded as per **Section 2.9** with Class B bedding and compacted to 98% maximum density ASTM D698, Method D.

Concrete type and work shall be as per **Section 1.2**

Riser clamps (underground pipe clamps) shall be provided across pipe joints at the thrust blocking and at pipe joints leading away from the thrust blocking in accordance with **Appendix C – Drawings and Details**. All nuts, bolts, washers and ready rods shall be stainless steel. All clamps shall have factory applied two part epoxy coating to AWWA C210.

Thrust Blocks

1. Place concrete thrust blocks at valves, tees, plugs, caps, bends, changes in pipe diameter, reducers, hydrants and fittings, all bearing against undisturbed ground as indicated.
2. Concrete to bear on fitting, not on insulation.
3. Keep joints and couplings free of concrete, wrap with polyethylene prior to placing concrete.
4. Where the Consulting Engineer permits thrust blocking to bear against backfilled material, the block
   shall be formed with a vertical face.
5. Do not backfill over concrete within 24 hours after placing.
6. Do not allow concrete to freeze for a minimum of 72 hours.
7. Thrust blocks shall not bear against abandoned pipes. Abandoned pipes shall be cut and removed to minimum 1.0m away from sides or bearing face of thrust block.

2.8 Concrete Testing

A set of concrete cylinders are to be cast for compression testing for:

- Every three thrust blocks;
- Each water valve chamber; and
- Each hydrant vault.

2.9 Bedding

Class A Bedding – Concrete Bedding (Where required)

- Set lower part of pipe exterior on suitable thickness of concrete. Concrete shall extend upward on each side of pipe for a distance of one quarter of the pipe diameter.
- Concrete type and concrete work shall be as per Concrete Materials.
- Hand tamped granular material shall cover the pipe to depth of 300 mm.

Class B Bedding – Granular Bedding

- Class B Bedding is the most common type of bedding used for pipes in the City.
- Pipe shall be set on a minimum of 300 mm of bedding. The remainder of the pipe shall be surrounded and covered to a depth of 300 mm above its top. Bedding shall be placed by hand to fill completely all spaces under and adjacent to the pipe.
- The bedding encasing the pipe shall be compacted to at least 97% maximum density ASTM D698, Method D. The bedding shall be compacted in layers not exceeding 150 mm.
- Granular material for bedding of all pipes shall be evenly graded crushed gravel. Bedding sand requires specific approval of the City. Granular material for bedding shall conform to the following:

Table 6: Granular Bedding Sieve Passing Specifications

Sieve Size (mm)	Percent Passing by Weight	
	50mm Minus Road Gravel & Trench Backfill	20mm Minus Bedding
50	100	100
25		100
20	65-100	85-100
12.5	50-100	60-90
5	35-65	35-65
1.25	0-40	0-40
0.315	0-25	0-25
0.08	0-10	0-10

Shape bed true to grade and provide continuous uniform bearing surface for pipe exterior. Shape transverse depressions in bedding as required to receive bell if bell and spigot pipe is used. Do not use blocks when bedding pipe.

Where trench bottom is bedrock, lay pipe on minimum 150 mm of granular bedding.
Bedding shall not be placed in water laden trench bottom. Water must be removed from excavation for bedding compaction and pipe installation.

Work shall not be covered with bedding until checked by the Consultant or City.

The consultant shall ensure that the placement and compaction of bedding around or over structural concrete do not occur until the concrete has reached sufficient strength.

Bed all existing utilities exposed during construction as with Class B bedding or as per the requirements of the utility owner.

2.10 Cathodic Protection

The Geo-technical Report done to assist the Consultant in arriving at a final design shall evaluate the need for cathodic protection. Should there be active soils discovered, a proper cathodic protection design shall be completed and submitted to the City for approval.

2.10.1 Bleeders

Bleeders are to be 1/16”, Bleeders must have a Double Back Flow Preventive installed on the 1/16" tubing that bleeds into the sewer system to prevent contamination if there is a sewer back up. Orifice plates are normally used for the orifice system in down town area. Orifice plates can be provided by the City at Developer’s request once appropriate permitting has been received. It is the responsibility of the developer to inquire to the city whether the area of construction requires orifice plates.

2.11 Water Meters

Displacement type to ANSI/AWWA C700 and C710 complete with top mounted odometer, low flow leak detectors, threaded union fittings. Only City Approved Sensus Water Meters shall be installed, to ensure compatibility with current water meter reading technology and software. All meters and touchpads will be supplied by the City of Yellowknife. Sensus 510 MXU Radio Water Meter Reader inside the buildings allow the water meters to be remotely read. City supplied meters and touchpads can be picked up at City Stores Monday to Friday between 7:00 am and 4:00 pm.

Touchpad Wire

- Sheathed multi-conductor telephone type wire as indicated below:
  - CSA Type PCC, 24 AWG, two (2) pair, FT4 rated insulation

Installation

- Install in accordance with Canadian Plumbing Code and local authority having jurisdiction.
- Install in accordance with manufacturer's instructions and as specified.
- Install new water meters in a horizontal run of pipe. Obtain written permission from the City prior to any vertical installation.

Installation of Remote Readout

- Remove old remote reader.
- Install new remote readout receptacle as directed by the City Engineer and local authority. Remote readouts are generally to be installed on the front (street side of the building).
- Install wiring between meter location and touchpad location on building exterior. Seal all wall penetrations with electrician's mastic.
- Attach nylon fasteners every 600 mm.

Meter Documentation

- Accurately record the following information for each meter installation:
  - Street address.
  - Date of change.
  - Existing meter reading & existing meter serial number.
  - New meter reading & new meter serial number.
  - Turn over meter documentation to the City Engineer when requested.

2.12 Flushing and Disinfecting

Prior to proceeding with flushing and disinfection operation, the Consultant shall submit the proposed procedures to the City for approval. Include information such as direction of flushing, existing mains that will supply the water, injection point for the chlorination, and the existing valves that need to be operated.

At no time shall water be allowed to flow from the new mains into the existing mains. Flushing and disinfecting shall be done in full sections from water Maintenance Hole to hydrant or hydrant to hydrant, including any existing mains in this section.

Arrangements shall be made with the City for the supply of water from the existing system at a mutually agreed time. The supply of water will be restricted to off-peak hours. Chlorine solutions used to disinfect the water system shall be flushed into the City's sanitary sewer system.

Ensure the capacity of the sewer main is not exceeded while flushing. At the discretion of the City, dechlorinating of the flushed water may be required.

The City will not allow the watermain or water system to go into operation until all requirements and satisfactory test results are met.

Flushing and disinfecting of watermains and services greater than 50 mm diameter shall be completed in accordance with AWWA C651 and applicable health standards. The basic procedures include, but are not limited to, the following:

- Flush mains through available outlets for 10 min., or until foreign materials have been removed and flushed water is clear. The flushing flows shall be as follows:

Table 7: Minimum Flushing Velocities

Pipe Size (mm)	Flow (L/s) Minimum
150	38
200	75
250	115
300	150

- For larger diameter pipe calculate flow by using following formula:

$$Q\ (L/s) = 0.00124D^2$$

- Where D is pipe diameter in mm. Open and close valves, hydrants and service connections to ensure thorough flushing.
- When flushing is complete, introduce a strong solution of chlorine into the watermain and ensure that it is distributed throughout the entire system.
- The chlorine solution shall not be too strong that it damages gaskets, linings or other water system components. Manufacturer's recommendations shall be followed for maximum chlorine solution strengths.
- Chlorine application shall be near the point of the filling watermain and shall occur at the same time as filling.
- Provide connections and pump as required.
- Operate valves, hydrants and appurtenances while main contains chlorine solution.
- After adequate chlorine residual of not less than 50 ppm has been obtained, leave system charged with chlorine solution for 24 hours. Further samples shall be taken to ensure that there is still not less than 10 ppm of chlorine residual remaining throughout system.
- If at the end of a 24 hour period, chlorine residual is less than 10 ppm, flush watermain and repeat chlorination.
- Upon completion of successful chlorination, flush line to completely remove chlorine solution.

- Perform bacteriological tests on water samples taken from main after chlorine solution has been completely flushed out. Take samples daily for a minimum of two days. Complete flushing of the main shall not be allowed prior to each water sampling; however, partial watermain bleeding is necessary for accurate samples. The intent is to have water samples for bacteriological tests that are representative of the water within the main being chlorinated. Repeat chlorination procedure should contamination remain or recur during this period.
- Disinfection of main will be considered complete for the purposes of putting the service connections into operation, only when bacteriological tests show no contamination for the 24 hour period.

Temporary water lines used to maintain water services to existing buildings during construction shall be flushed and chlorinated as per this Section. With prior City approval, short sections of watermains may be swab chlorinated in accordance with AWWA C651.

For single water service installations of greater than 50 mm diameter, the following shall apply:

- A service of typical length must be flushed and swab chlorinated in accordance with AWWA C651;
- At the discretion of the City, longer services shall be flushed and chlorinated;
- Bacteriological tests are required;
- For a single water service installation of 50 mm or smaller, the following shall apply:
  - The service shall be adequately flushed; and
  - At the discretion of the City, bacteriological tests may be required.

Submit results of all chlorination and bacteriological tests to the City for its files. The Consultant shall witness the flushing and disinfecting.

2.13 Plumbing Pumps

Circulation Pumps

- All circulation pumps will be supplied by the City of Yellowknife.
- City supplied circulation pumps can be picked up at City Stores Monday to Friday between 7:00 am and 4:00 pm.
- Return any unused circulation pumps to City Stores prior to application for Substantial Completion.

Piping

- Copper tube, hard drawn, Type L, to ASTM B88M.

Fittings

- Bronze pipe flanges and flanged fittings, Class 150 and 300:
  - to ANSI B16.24.
- Cast bronze threaded fittings, Class 125 and 250:
  - to ANSI/ASME B16.15.
- Cast copper, solder type:
  - to ANSI B16.18
- Wrought copper and copper alloy, solder type:
  - to ANSI/ASME B16.22.

Joints

- Rubber gaskets, 1.6 mm thick:
  - to ANSI/AWWA C111/A21.11.
- Bolts, nuts, hex head and washers:
  - to ASTM A307, heavy series.
- Solder:
  - lead free.
- Teflon tape:
  - for threaded joints.
- Type K copper termination:
  - Meuller A-314 flare to M.I.P. adaptor.
- Unions:
  - 1030 kPa all bronze for copper piping.
- Thread sealant shall be approved for use with potable water.

Circulation Pumps

The City will supply Grunfos Alpha 2 15-55SF, 115 V, stainless steel body, flange mount, with terminal box, or alternate as City may define. Suitable for minimum liquid temperature of 2 °C.

EXECUTION

1. Install plumbing and piping in accordance with Canadian Plumbing Code and local authority having jurisdiction
2. Springing of the piping to correct piping misalignment will not be permitted.
3. Ensure that all piping is adequately and properly anchored, suspended, supported and/or blocked to prevent movements, sagging, displacement and undue stress on adjacent piping and equipment.
4. On completion of assembly, test all piping at system pressure for a period of one (1) hour. Piping shall be tested, where ordered, at 1033 kPa (150 psi) for one (1) hour.
5. Piping passes tests if no leakage is observed.

6. Tests will be repeated after any work has been replaced or repaired.
7. On completion of the Work, remove all debris, repair any damage done to existing equipment or surfaces, and leave the installation in a clean and new condition.
8. Set pumps to “Low Fixed Speed”

3.0 Sanitary Sewer System

3.1 Pipe, Fitting and Coupler Materials

3.1.1 Pipe

Pipe to be as follows:

- Ductile iron- to AWWA C151P Pressure Class 350.
- Joints - Bell Tite or Tyton.
- Exterior finish - asphaltic coating to AWWA C151.
- Interior finish - to AWWA C104 cement-mortar lined complete with seal coat.
- Fittings - to ANS1/AWWA C11/A21.10, cement mortar lined to ANS1/AWWA.
- C104/A21.4 or factory applied two part epoxy coated to AWWA C210. Joints the same as pipes.
- Insulated Sewer main - 50 mm thick factory applied insulation.

3.1.2 Pipe Couplers

Pipe Couplers to be as follows:

- Robar, Dresser, Hymax, Romac or equal. Use manufacturers recommended coupler type for pipes to be connected, couplers to be two part epoxy coated, factory applied, to AWWA C210 with stainless steel nuts and bolts. Use teflon washers between nuts and robar body.
- Connection of existing corrugated metal pipe to ductile iron pipe to be made with Robar Stainless Steel repair clamps, Series 300.

3.1.3 Ductile Iron Pipe Fittings

Ductile Iron Pipe Fittings to be as follows:

- Fittings – to AWWA C110 1.03 MPa working pressure.
- Lining – cement mortar lined to AWWA C104 complete with seal coat or two part epoxy coated to AWWA C210.
- Coating - asphaltic coated to AWWA C151 or two part epoxy coated to AWWA C210.
- Joints – push-on joint with continuous rubber molded ring gasket to AWWA C111, Bell Tite or Tyton.
- Restraint (forcemains only) -the bell ends of the fittings shall have ears attached so that the pipe restraint clamps can be connected to the fitting.
- Couplers – Robar or equal interior and exterior two part epoxy coated (factory applied) to AWWA C210.
- Bolts, nuts, ready rods and washers – shall be stainless steel for all buried use.

3.2 Pipe Insulation and Protective Jacketing

Insulation is required for all sewer mains.
The Consultant shall utilize depth of cover, sewage flows generated by the development and, if required, to increase freeze protection. Water bleeders and/or heat trace shall not be used in place of sewer main insulation to provide freeze protection.

During staged construction of the development, and subject to approval from the City, the Developer may use temporary water bleeders to provide sewer main freeze protection. If a water bleeder is required, the intent is to provide an adequate flow for freeze protection in the main until the development is sufficiently occupied at which time the bleeder shall be removed.

3.3 Maintenance Holes

Maintenance Hole materials and Installations to be done in accordance with Place stub outlets and bulkheads at elevations and in positions indicated.

- Where pipe enters precast Maintenance Hole section, break a clean and neat hole not greater than 100 mm plus the outside diameter of the pipe.
- Bench to provide a smooth U-shaped channel. Side height of channel to be 0.75 times full diameter of sewer. Slope adjacent floor at 1 on 10. Curve channels smoothly. Slope invert to establish sewer grade. Steel trowel finish all surfaces.
- Mortar parge coat is not allowed.
- Where sewer pipes pass straight through a Maintenance Hole, the top 25% of the pipe shall be removed and benching poured flush with the cut edge of the pipe.
- Slope benching adjacent to pipe at 1 to 10.
- Set frame and cover to required elevation on no more than one concrete ring.
- Make ring joints to frame with cement mortar, parge and make smooth and watertight.
- Place frame and cover on top section to elevation indicated. If adjustment required use concrete ring.
- Clean units of debris and foreign materials. Remove fins and sharp projections.
- Prevent debris from entering system.
- Place rigid insulation around base and walls of all water valve chambers and where specified, sanitary Maintenance Holes. Fit insulation sections and straps closely around circular structures, pipes etc. so that maximum gap is 12 mm between insulation pieces.
- Wrap each Maintenance Hole, on outside of insulation where present, from the top of the lowest pipe to the top of the cone with two layers of tar paper and two layers of 6 mil polyethylene sheet secured with fiberglass tape.

3.4 Pipe Installation

Pipe installation for sewer and forcemains shall be as:

- Commence laying of pipe at outlet and proceed in upstream direction with socket ends of pipe facing upgrade.
- If foreign materials have entered the sewer during construction, flush with water and remove from pipe. Do not allow flush water along with the foreign material to enter downstream sewers.
- Thrust blocking and joint restraint for forcemains shall be as per **Section 2.7**.
- Trench excavation, backfilling and compaction shall be as per **Section 9.0**.
- If the sewer main installation occurs in developed areas, minimize the contents of existing sewer or sewer connections flowing into the trench by diverting upstream flow around excavation by use of pumps.
- Rainwater leaders shall not be connected to the sanitary sewer system.

During construction, builders shall not allow ground water to enter the sanitary sewer system.

3.5 Inspection and Testing Requirements

For initial acceptance by the City, an inspection must be carried out by a City representative, including a video inspection with a report and digital file of the vide inspection provided. If requested, an exfiltration/infiltration test is to be carried out.

3.5.1 Maintenance Hole Leakage Testing

At the discretion of the City, conduct Maintenance Hole leakage tests. Install watertight plugs or seals on inlets and outlets and fill the Maintenance Hole with water for 2 hours. Leakage shall not exceed 0.3% per hour. If permissible leakage is exceeded, correct defects and repeat test.

3.5.2 Television and Photographic inspections

Conduct closed caption television inspections of the gravity sewer main system as soon as practicable after all mains, Maintenance Holes and service connections have been installed.
Power flush all mains prior to inspections. Ensure all foreign debris has been removed.
Repair all defects which will impair the structural integrity and the performance of the sewer system including but not limited to the following:

- Improper joints;
- Cracked, sheared or unduly deflected pipe;
- Sags or rises which pond water in excess of 35 mm;
- Protruding service connections;
- Visible leaks; and
- Debris in pipes.

Once the defects are corrected, re-inspect the sewer.

Supply to the Consultant one copy of the video tape inspection together with a typed copy of the report. Identity each section of sewer on the video tape and cross reference it to the report. Report shall detail significant findings of the television inspection. Once the Consultant has reviewed the report and deemed the results acceptable, forward the report to the City for its records.

At least one month prior to the end of the warranty, power flush the sewer main and carry out a closed caption television inspection as per the steps above. Provide a copy of the report to the City for its records.

3.5.3 Infiltration Testing

At the discretion of the City, infiltration tests shall be conducted on the gravity sewer system in new developments after all the mains, Maintenance Holes, and services laterals in a particular section have been completed. The tests shall be completed prior to the services being connected to the building. Carry out tests on each section of sewer between successive Maintenance Holes including service connections.

Conduct infiltration tests in areas where there is a static ground water level of at least 300 mm above the top of the pipe at any section.

Infiltration Test shall be as follows:

- Install a watertight plug at the upstream end of the main test section.
- Place a 90 degree V-notch weir, or other measuring device approved by the Consultant in the invert of the sewer at each Maintenance Hole.
- Measure rate of flow over a minimum of 1 hour, with recorded flows for each five minute interval.
- Infiltration shall not exceed 5 litres/day/mm pipe diameter/km pipe length.

Infiltration tests are not required for sewer system installations or replacements in areas where there is existing sewage flow.

At the discretion of the City, an ex-filtration test shall be carried out in place of an infiltration test if the construction of the sewer system was completed during seasonably cold weather.

Forcemains are to be pressure tested as per **Section 2.3 Hydrostatic and Leakage Testing**.

4.0 Storm Drainage

4.1 Pipe, Fittings and Coupler Materials

Pipe Fitting and Coupler Materials

- Refer to Schedule of Quantities for pipe type in various areas.
- Galvanized Corrugated Steel Pipe:
  - To Corrugated Steel Pipe Institute Specification No. 501, CSA G401, wall thickness 2.0 mm, corrugations 68 x 13 mm helical.
- Aluminized Type 2 Corrugated steel pipe:
  - to Corrugated Steel Pipe Institute Specification Can G401, gauge of CSP is to be 2.0 mm, corrugations 68 x 13 mm helical
- Armtec Hec-Cor or approved alternate.
- Aluminized Type 2 steel spiral rib pipe or approved alternate to corrugated steel pipe institute specification CSA CAN G401. Gauge of spiral rib pipe shall be 2.0 mm, external spiral ribs shall be 19 mm x 19 mm at 190 mm spacing as per ASTM A760.

Pipe Couplers and Transition Fittings

- Armco "Hugger-Band" complete with "O"" ring gaskets conforming to CSA CAN3-G401 and JS 701 polybutene tape sealant or approved equal.
- All fittings and couplers to be Aluminized Type 2 to CSA CAN3-G401 for aluminumized Type 2 pipe or Ultra-flow, galvanized for galvanized pipe.

Repair of Damaged Pipe Coatings

- Repair damaged metallic coating or galvanized surfaces.
- Clean damaged surfaces with wire brush removing loose and cracked splintered coatings. Apply two coats of approved zinc-rich coating conforming to CGSB Standard 1-GP-181M.

Culverts

Culverts to be of the same materials as typical storm sewer mains as described above. Culvert installation is outlined in **Appendix C – Drawings and Details**

4.2 Pipe Insulation and Protective Jacketing

Storm main insulation and protective jacketing shall be as per **Section 3.2 Pipe Installation**.

4.3 Catch Basins

Frames, gratings, covers to plan dimensions and following requirements:

- Metal gratings and covers to bear evenly on frames. A frame with grating or cover to constitute one unit. Assemble and mark unit components before shipment.
- Gray iron castings to ASTM A48 strength class 30B.
- Castings to be sand blasted or cleaned and ground to eliminate surface imperfections and coated with two applications of asphalt varnish.
- Maintenance Hole frames and covers:
  - Norwood Pattern F-39 or equal.
- Catch basin frames and covers:
  - Norwood Foundry Model F-51, loose lid.

4.4 Installation

1. Lay and join pipe in accordance with manufacturer's recommendations.
2. Lay storm sewer pipe to grade with use of a laser.
3. Catch basin leads shall be installed at a minimum grade of 10 mm/m, or as directed by the Consulting Engineer.
4. Handle pipe by approved methods. Do not use chains or cables passed through pipe bore so that weight of pipe bears upon pipe ends.
5. Lay pipes on prepared bed, true to line and grade with pipe inverts smooth and free of sags or high points. Ensure barrel of each pipe is in contact with shaped bed throughout its full length.
6. Do not exceed maximum joint deflection recommended by pipe manufacturer.
7. Do not allow water to flow through pipes during construction except as may be permitted by Consulting Engineer.
8. Whenever work is suspended, install removable watertight bulkhead at open end of last pipe laid to prevent entry of foreign materials.
9. Position and join pipes by approved methods. Do not use excavating equipment to force pipe sections together.
10. Cut pipes as required for special inserts, fittings or closure pieces in a neat manner without damaging pipe and to leave a smooth end at right angles to axis of pipe.
11. Make watertight connections to Maintenance Holes and catch basins. Use non-shrink grout when suitable gaskets are not available.
12. Use prefabricated saddles or approved field connections for connecting pipes to existing storm sewer pipes. Joint to be structurally sound and watertight.
13. Plug open upstream ends of pipes at end of work under this contract with removable watertight concrete, steel or wooden bulkheads.
14. Install joints as detailed.
15. Tap coupler firmly while tightening, to take up slack and ensure a snug fit.

16. Ensure bolts are inserted and tightened.
17. New pipe shall be connected at joints with factory ends.

4.5 Maintenance Hole Abandonment

Plugs

Grout Plugs:

- Packaged Dry, Hydraulic-Cement Grout conforming to ASTM C1107.

Flowable Concrete Requirement

- Unconfined compressive strength - minimum 0.5 MPa at 28 days and maximum 1.0 MPa at 56 days as determined based on an average of three tests for same placement. Present at least three acceptable strength tests for proposed mix design in mix design report.
- Placement characteristics -self-leveling.
- Shrinkage characteristics - non-shrink.
- Water bleeding for concrete to be placed by grouting method in storm sewers not to exceed 2 percent according to ASTM C940.
- Minimum wet density 550 Kg per cubic meter.

Cutting and Capping of Storm Sewer Mains

1. Storm sewer main to be abandoned shall be cut, plugged, clamped, valve off at location shown on drawings or as directed the Consulting Engineer.
2. Do not begin cut, plug, and abandonment operations until replacement storm sewer main has been constructed and tested, all service connections have been installed, and main has been approved for use.
3. After storm sewer main to be abandoned has been cut and capped, check for other
4. Sources feeding abandoned storm sewer main. When sources are found, notify City Engineer immediately.
5. Plug or cap ends or opening in abandoned main in manner approved by the City Engineer. Install concrete around cap and over pipe to ensure it is not penetrable by groundwater.
6. Backfill excavations
7. Repair road surfaces in accordance with Contract Specifications.
8. Mark location of abandoned storm sewer laterals on Drawings and provide to the Consulting Engineer.
9. Service lines shall be cut and capped at the storm sewer main and/or as directed by the Consulting Engineer.

Installation of Flowable Concrete

1. Abandon existing storm sewer mains underneath roadways and paved areas by completely filling storm sewer line with flowable concrete. Place flowable concrete to fill volume between Maintenance Holes. Continuously place flowable concrete from Maintenance Hole to Maintenance Hole with no intermediate pour points, but not exceeding 150 m in length.
2. When using grout plug, place masonry bulkhead or manufactured plug approximately 300 mm inside pipe. Fill pipe end completely with dry-pack grout mixture.
3. Mix flowable concrete in automated batch plant and deliver it to site in ready-mix trucks. Performance additives may be added at placement site if required by mix design.
4. Pump flowable concrete with sufficient pressure through bulkheads constructed to overcome friction and to fill storm sewer from downstream end, to discharge at upstream end.
5. When using manufactured plug or cap, install fitting as recommended by manufacturer's instructions, to form water tight seal.
6. Backfill to surface, above pipe or structures left in place, with flowable concrete in restricted areas and with granular materials in unrestricted areas to be paved or select fill in unrestricted areas outside of pavement. Place and compact backfill, other than flowable concrete.
7. Collect and dispose of excess flowable concrete material and other debris in accordance with local requirements or as directed by the Consulting Engineer.

4.6 Adjustments to Catch Basins and Maintenance Holes

Maintenance Hole Adjustments (Existing)

Any Maintenance Hole which is not at the correct elevation shall be raised or lowered to a level 6 mm below the design finished pavement surface elevation. Adjustments to Maintenance Holes shall be made using the types of materials and workmanship used in constructing the original structures.

Maintenance Hole frame shall be set in mortar to final grade shown on drawing or as directed by the Consulting Engineer.

Catch Basin Adjustments (Existing)

Any catch basin which is not at the correct elevation shall be raised or lowered to ensure drainage of the finished gutter elevation. Adjustments to catch basins shall be made using the types of materials and workmanship normally used in constructing these structures. Frames shall be set in concrete to final grade shown on drawing or as directed by the Consulting Engineer.

5.0 Services

5.1 Water Services

All water service lines shall meet National Building Code and National Plumbing Code and other Municipal bylaw requirements except as superseded by specifications contained in this By-law.

All services shall be located within 2 meters of the centre lot line unless otherwise authorized by the Senior Administrative Officer of the City or a designate.

No new single line services are to be installed.

5.1.1 Requirements and Sizing of Services

Water for Residential Services Shall Be:

- Dual, Type K (AWWA 800) copper lines 1.0 m past the property line of each lot to provide for a completed circulatory system once homes are connected.
- A gate valve on each line must be provided unless the service is extended to the residence at the time of construction.
- A main stop on each line must be provided.
- A horizontal gooseneck on each line must be provided. The gooseneck shall be integral with the first length of service pipe.
- Two 20 mm supply lines shall be provided to each residential lot.
- Copper connections shall be flared end only.
- Water service lines shall be insulated as per **Section 2.1.3**. All joints shall be completed with field applied foam or half shells of urethane and a heat shrink tape seal.
- Minimum depth of cover at the property line is 1.5 m.

Flared Ends for all Service Types

- All water service lines of diameters less than or equal to two inches or 50 millimeters must have flared fittings on both ends.

Valve and Union for Shut-Off

- A threaded valve must be installed before the meter inside the building. This is the building shut-off valve. The valve shall be at least 300 millimeters above the floor level.

Fittings

- Any joints outside the building shall be made with a flared copper to copper fitting.
- There shall be no soldered or brazed fittings between the main line and the shut-off valve.
- Downstream from the meter, only threaded copper, bronze or brass non-compression fittings, shall be used.

Grade/Angles

- Only gradual bends shall be incorporated into the service line to provide directional change if necessary. Owners shall not install service lines from buildings to lot lines prior to installation of the property service from main to lot line by the City.
- A minimum positive slope of 1 in 50 shall be maintained.

All water service lines to mobile homes shall:

- Not be less than 3/4 inch or 20 millimeters in diameter for the supply line and return line.
- Terminate above ground;
- Incorporate a tamper-proof connection that is capable of being repeatedly connected, disconnected and sealed;
- Incorporate a means of draining, heating or circulating water within that part of the pipe from the City main to the property when not in use

5.1.2 Materials

5.1.2.1 Products

Copper Service Pipe

- Copper Tubing to ASTM B88M, Type K, annealed.
- Joints - Flare-end type suitable for minimum 1 MPa working pressure, Mueller A-319, Cambridge Brass 118NI, A.Y. McDonald 74758 or approved equal.
- Water service pipe for new services to be complete with factory applied insulation to
- Water service pipe to be supplied in 10.0 m lengths, all factory insulated. No joint is allowed in the 10.0 m length. The factory insulated gooseneck shall be formed on one end of a continuous 10 m length.
- Pipe ends to be capped during shipment, do not remove caps until installation and energizing of service line.

Corporation Stops

- Corporation Stops - to ASTM B5874, AWWA C800, red brass, Mueller 300 ball (300
- PSIG working pressure, B-2500), Cambridge Brass Model No. 301NL (ball style, 300 psi working pressure), A. Y. McDonald 74701B (ball style, 300 psi working pressure) or approved equal
- Inlet threads - tapered to AWWA C800.
- Outlet - flared end type.

Thread Sealant for Corporation Stops

- Multi-purpose thread sealant, with Teflon, containing no toxic materials, suitable for use with potable water; Jet-Lube V2 or equal.

Water Service Saddles

- Service Saddle - waterworks bronze saddle body tapped for AWWA taper thread, T304 stainless steel strap, bolts and nuts, and neoprene gasket under saddle body, Robar 2706, or equal.

Sewer Service Pipe

- Sewer service pipe to be complete with 50 mm insulation where service has less than 1.5 m of cover, is installed within 1.5 m of a Maintenance Hole or vault, or
- Insulated Sewer Service Pipe - 50 mm thick factory applied insulation.

Pipe Couplers

- Robar, Dresser, Hymax, Romac or equal. Use manufacturer's recommended coupler type for pipes to be connected.
- Couplers to be two part epoxy coated, factory applied, to AWWA C210 with stainless steel nuts and bolts.
- Use Teflon washer, or equivalent, between nut and robar body.
- Connections to "No-Corrode", Asbestos Cement, Clay Tile, Corrugated metal or light wall plastic sewer services shall be made with Robar 5606 Stainless Steel pipe repair clamps.
- Series 302, length 300 mm.

Sewer Saddles

- Strap-on saddle c/w gasket. Romac style "CB" or equal.

5.1.3 Looped Line Service

Looped Line Service with Pumped Circulation

- All new installations, in areas where a single City main supply is used, shall be a loop connection with a circulating pump.
- The water service line to the meter and the return loop to the City water main shall be of Type "K" soft copper.

- All connection fittings for the circulation pump shall be threaded and of copper, bronze or brass material.
- The circulating pump shall be installed in the loop as indicated in Diagram 2.

Looped Line Service with an Orifice/Union

- All installations, in areas where a City main supply and return line is used, shall be a loop connection using an orifice/union.
- The water service line, from the City water main supply line to the meter and the return loop from the building to the City water main return line, shall be of Type "K" soft copper.
- All service lines shall be properly orificed as indicated in Diagram 2 of these Specifications.
- Valves, connection fittings, the water meter and the orifice shall be located as indicated in Diagram 2 of these specifications.
- No person shall install a circulation pump in place of an orifice without the prior written approval of the S.A.O. Failure to obtain the written approval shall be an offence under this by-law.

5.1.4 Freeze Protection

All water service lines, including supply and return lines, shall be insulated with a waterproof equivalent of 2 inches or 50 millimeters, or more, urethane lining which shall extend 12 inches or 300 millimeters past the point of entry into the structure which it services.

The owner or occupant shall be permitted bleeder use only during the months of November through July of one year. The "Application to Install Water Bleeder" (W/S – 4), must be completed and approved. The bleeder shall be installed on the house side of the meter so that all water is metered.

A 1/4 inch or 6.5 millimeter plastic discharge line shall be made to discharge to the sanitary sewer service and provide a one (1) inch or twenty five (25) millimeter air gap between the discharge line and a properly vented fixture or a properly sized and vented P- trap. Discharge flow rates shall not exceed 1 litre per minute. Discharge line sizing and inclusion of an orifice is to be submitted for review to The City and The City's Engineer.

5.1.4.1 Removal and Repairs

The owner or occupant shall remove the bleeder and repair or replace the freeze protection device on his water service line during the period August through October of the following year.

The owner or occupant shall notify the City of the disconnection of a bleeder. The owner or occupant shall be charged for all costs of bleeder operation.

5.1.5 Seasonal Surface Water Lines

Seasonal Surface Water Line Connections to be as follows:

- All connections to seasonal service water lines shall comply with the Canadian Plumbing Code.
- Upon connection to the surface water line in early June and prior to June 30 of each year, the owner or occupant shall flush his system and report any leaks at the connection valves to the City.
- Between August 15 and September 1 of each year, the owner or occupant shall clean and repair the water holding tank, check all the plumbing from the tank to the water outlets and ensure that the pressure pump is working.
- Between August 15 and September 15, while performing the aforementioned maintenance. The owner or occupant shall be allowed temporary direct connection to the seasonal surface water lines to supply domestic service (pressurized water supply).

5.1.6 Trucked Water Services

5.1.6.1 Access

Access to be as follows:

- The water fill must extend out the wall facing the roadway.
- The water fill point shall be greater than five feet or 1.5 meters in a horizontal distance from the sewage pump-out point straight line access path.
- The water fill point shall be of a sufficiently small diameter that the sewage pump-out hose could not be inserted.
- The water fill point shall be clearly labeled at all times.

5.1.6.2 Line and Tank Specifications

Line and tank to be as follows:

- The connection point of the water fill point shall be a minimum of 36 inches or 914 millimeters and a maximum of 48 inches or 1,219 mm from the ground surface in all seasons.
- The water service line shall have a backgrade such that the water does not freeflow from the tank or sit in the service line, or the water service line shall have a check valve to prevent freeflow and a heat tape to prevent freezing.
- An overflow discharge point shall be installed at the same height as the fill point, a minimum of 12 inches or 305 mm in horizontal distance from the fill point.
- A red bulb or globe "full" indicator light shall be connected to a device in the tank and installed near the fill point such that it is visible from the cab of the delivery truck.
- If the water holding tank is elevated, a valve shall be installed at the line-tank connection point to prevent backflow.

- Water fill lines shall have a galvanized or copper nipple a minimum s6 inches or 150 millimeters long securely anchored to the exterior of the wall structure at the fill connection point. Piping which is not approved for use with potable water is prohibited.
- All overflow and water fill lines shall be insulated with a foil back covered insulation a minimum 1.5 inches or 38 mm and 6 ft or 1.8 m in from the point of penetration of the exterior building envelope.

Water holding tanks installed within the footprint of the building (crawl space/basement/mechanical room/accessible tank vault) must be provided with reasonable access to the equipment to be serviced which may be determined by an inspector based on the circumstances of the proposed installations with reference to Section 9.18.4.1 of the National Building Code and Section 2.1.3.2 of the National Plumbing Code:

- 0.6 m (2 ft) minimum clearance around the tank;
- 0.6 m (2 ft) minimum headroom clearance to the floor above;
- 0.9 m (3 ft) minimum clearance on the side or sides of the equipment to be serviced;
- Concrete pad or a flat support base of compacted granular material with a minimum of 50 mm (2 inches) of sand directly beneath the tank; and
- Water holding tanks installed away from the building are not permitted to be buried.

5.2 Sewer Services

5.2.1 Requirements and Sizing of Services

All piped sewer services shall meet National Building code and National Plumbing Code requirements except as superseded by this By-law.

Sanitary for Residential Services Shall Be:

- The sewer service line shall be of ductile iron piping.
- Single family dwelling shall have a sewer service line of 4 inches or 102 mm in diameter.
- It shall be extended to 1 m past the property line.
- A watertight plug shall be provided on each service.
- A 50 mm x 100 mm wood marker shall be provided at the property line. It shall extend from the service invert to 0.6 m above the ground surface.
- Minimum depth of cover from invert to finish grade at property line to service basements is 2.6 m. If there are no basements then the minimum cover from invert to finish grade is 1.5 m at property line.
- All sewer services are to be insulated, as per insulation process from **Section 3.2 Pipe Insulation and Protective Jacket.**
- All services shall be located within 2 m of the centre lot line in the same trench as and below the water line.

5.2.2 Installation

The sewer service line shall extend to the inside of the building foundation wall and the wall shall be sealed with an approved grouting material to prevent the inflow of water or moisture.

The sewer service line shall be equipped with a combination back water valve and clean out immediately upon entry to the building. All sewer service lines shall be laid to a uniform grade sloping to the main line at a minimum grade of 1 in 50. Total cumulative bends shall not exceed 180 degrees with individual bends not exceeding 45 degrees.

5.2.3 Non-Domestic Discharges

All non-domestic discharges into the sanitary sewer main shall be indicated to the S.A.O. using the "Water and Sewer Application Form – To Connect or Disconnect Services" (W/S – 1). Where a fixture discharges sewage that, in the opinion of the S.A.O., may damage or impair the sanitary sewer system or the functioning of the City or private sewage disposal system, provision shall be made for the treatment of the sewage before it is discharged into the sanitary sewer system.

A sampling Maintenance Hole suitable for determining the sewage quality, temperature and rate of flow, shall be provided where required by the S.A.O.:

- Where a fixture discharges sewage that includes grease is located in a public kitchen, restaurant, or in an institution, an appropriate grease interceptor shall be installed when and where it is required by the S.A.O.
- Where a fixture discharges sand, grit or similar materials, an appropriate interceptor shall be installed.
- Where the discharge from a fixture may contain a petroleum product, an appropriate interceptor shall be installed.
- Every interceptor shall have sufficient capacity to perform the service for which it is provided.

Rainwater leaders shall not be connected to the sanitary sewer system.

During construction, builders shall not allow ground water to enter the sanitary sewer system.

5.2.4 Installation

Sewer Service Pipe Installation

1. Sewer service pipes shall cross under the watermain, not over, unless authorized by the Consulting Engineer.
2. Where ordered by the City Engineer, undertake video camera inspection of existing sewer services from the property line to the building. The City Engineer may, based on the results of the video inspection, order additional sewer service replacement on private property and/or re-alignment of the sanitary service.

3. Undertake video inspection of all boxed sanitary services to remain, to ensure excavation has not disrupted joints within the box. Report results to the City Engineer, undertake repair or replacement as ordered by the City Engineer.
4. Do not core main opening until video inspections are completed and decision on sewer service re-alignment is made.
5. Connect 100 mm service lines to main by coring opening in main without cracking main, minimum spacing of openings 1.0 m. Minimum distance from end of pipe to center of core opening 1.0 m. Remove cuttings from main. Install Tee saddle and 45 degree bend. Do not project spigot into main. Make joint between saddle and main watertight.
6. 150 mm and larger service lines are to be connected to mains by use of a "T" or "Wye" on the main. 150 mm diameter service lines may only be installed by use of a saddle for main sizes 300 mm diameter or larger. Smaller mains require use of a "T" or "Wye" on the main.
7. Install bends, if required, only at following locations:
    - 45 degree bend with "T" connection (90 ° bends are not allowed).
    - 11.25 to 45 degree bend at property line, if required.
    - If 2 or more bends are required to connect existing sanitary service to new main, the length between bends to be minimum 1.5 m apart.
8. Maintain grade for sewers at 1 vertical to 50 horizontal unless otherwise directed.
9. Place and compact granular backfill around connection to adequately support the main, saddle and service. Support risers as detailed.
10. Install service pipe to property line or building as directed by the Consulting Engineer.
11. Handle pipe by approved methods:
    - do not use chains or cables passed through pipe bore so that weight of pipe bears on pipe ends causing damage to insulation or cement mortar lining and asphaltic coating.
12. Undertake a video inspection of the completed sewer service after trench backfill is complete and provide a written report as well as a copy of the video on a USB memory stick. Repair any defects noted and redo the video inspection at no cost to the Owner.

5.2.5 Trucked Sanitary Services

5.2.5.1 Access

Access to be as follows:

- The sewage pump-out point must extend out the wall facing the roadway. The owner or occupant of a property with a pump-out point that does not extend out the wall facing the roadway must submit written approval for the pump-out point location from the City Developer to the S.A.O.
- There shall be a minimum of five horizontal feet or 152 cm between the connection point for sewage pump-out and the fill point for water such that a crossing of established pathways by connection hose shall not occur.

- The sewage pump-out connection fitting shall be of a greater diameter than that of the water fill point such that a cross-connection cannot be made.

5.2.5.2 Line and Tank Specifications

Line and tank to be as follows:

- The service pump-out point shall be kept a minimum of 18 inches or 457 mm and a maximum of 48 inches or 1,219 mm from the ground, including snow and ice accumulations.
- The service pump-out point shall be fitted with an approved tightly fitting cap and kept closed at all times except during pump-out.
- The sewage holding tank shall have a large water-tight Maintenance Hole with a removable cover such that the owner or occupant may clean and flush the tank. The S.A.O. is authorized to direct that a sewage holding tank shall be cleaned and flushed.
- The pump-out line from the service point to the tank shall have at least a 5 degree slope to the building such that no sewage is allowed to stand in the line or drain to the outside of the building and the line within the holding tank shall not exceed a grade of 30 degrees.
- The sewage holding tank shall incorporate a vent line of a minimum interior diameter of 3 inches or 75 mm such that the tank is vented to the outside of the building or backvented to the highest interior point in the building such that air escape or supply will occur as the tank is being filled or emptied.
- The pipe from the sewage pump-out service point to the sewage holding tank shall have an interior diameter of a minimum of 4 inches or 100 mm or reduce to 3 inches (75 mm) when the developed length of the sewer pumpout is greater than 25 feet (7.6 m).
- Sloped Ground Cover
- If the sewage holding tank is buried (installations outside of the building footprint) the following requirements related to location and clearances shall be adhered to, unless otherwise determined at the discretion of the building inspector
- Anchors to concrete pads or pinned to bedrock to prevent movement or floating to the surface;
- Concrete pad; or a flat support base or a base of compacted soil with a minimum of 50 mm (2 inches) of sand cover;
- 1.5 m (5 ft) clearance from a lot boundary and any building foundation;
- 5.0 m (16 ft) clearance from a road, or have approved protection from vehicle traffic;
- 15 m (50 ft) from any source of potable water or natural boundary or high water level of any water body.
- Ground cover sloped such that surface liquids, including run-off or sewage, drain away from the tank."

Sewage holding tanks installed within the footprint of the building (crawl space/basement/mechanical room/accessible tank vault) must be provided with reasonable access to the equipment to be serviced which may be determined by an inspector based on the circumstances of the proposed installations with reference to Section 9.18.4.1 of the National Building Code and Section 2.1.3.2 of the National Plumbing Code:

- 0.6 m (2 ft.) minimum headroom clearance around the tank (i.e. plumbing fittings, access to the tank).
- 0.6 m (2ft.) minimum headroom clearance to the floor above.
- 0.9 m (3 ft.) minimum clearance on the side or sides of the equipment to be serviced.
- Structural side support for preventing side movement for cylinder type tanks.
- Concrete pad or a flat support base of compacted granular material with a minimum of 50 mm (2 feet) of sand cover.
- When the storage tank elevation is 1 meter or greater above the road level a valve shall be installed at the point of connection to the sewage pump out line to prevent a continuous siphon condition.
- All sewage pump out lines shall be rigidly secured or anchored at the point of connection and further to this all lines in excess of 3 meters in developed length shall be anchored every 3 meters. Buried lines do not require anchors except at the point of connection.
- The use of chemical toilets shall be prohibited.

6.0 Water Boosting Pump Stations

6.1 General

This guideline covers the design and construction of mechanical plants to be built or re-built in the City of Yellowknife (City).

General construction requirements, construction materials, and procedures are not alluded to in this section and are left to each consultant to present to the City for approval.

All mechanical plants shall be in accordance with all other relevant Standards and codes (i.e. electrical, building, etc.). Where a roof structure cost exceeds $50,000, ARCA certification is required.

6.1.1 Prefabricated Pumping Stations

The use of prefabricated pumping stations is not acceptable.

6.2 Water Booster Pumping Stations

6.2.1 Dry Well/Pump Room Layout

The layout shall be such that all equipment and valves are easily accessible. There shall be a minimum horizontal clearance around pumps and motors of 1.0 m and a vertical clearance of not less than 3 m. Additional clearance may be required by the City for critical or large pieces of equipment. Special attention shall be given to the ease of removal of pumps, motors, and valves for maintenance and repair.

If the initial capacity of the proposed pumps is to be less than the 25-year design capacity, the station shall be designed so that the capacity can be easily increased when required without significant changes to the existing structural, architectural, mechanical, electrical, or instrumentation systems.

6.2.2 Valves and Fittings

Valves and fittings as follows:

- Magnetic type flow meters shall be installed on all discharge headers.
- Check valves shall be installed in each pump discharge line between the pump and the discharge isolating valve. They shall be the tilting disc type with dashpot controlled closing or globe style silent checks.
- Isolating valves shall be installed on each pump suction and pump discharge line. They shall be flanged gate valves, butterfly valves are not permitted on the suction lines to pumps. In booster stations, isolating valves must be provided 10 diameters upstream.

- Motorized or hydraulic pump control valves shall be installed on constant speed pumps to reduce water hammer during pump start and stop. The pump discharge isolating valve may be motorized to function as a pump control valve.
- Air release valves shall be installed on the discharge header. Air and vacuum valves shall be installed between the pump discharge and the check valve on wet well vertical turbine pumps which do not have a separate pump control valve discharging back to the wet well.
- Pipes and valves shall be adequately supported, tied down by commercially available supports or concrete pillow blocks, spaced in accordance with the manufacturer's design data and restrained against thrust where necessary.
- A flexible coupling shall be installed on each pump discharge line to enable easy removal of the pump and check valve. The isolating valve shall allow the facility to continue to operate during removals.
- Pipe material up to and including 150 mm diameter shall be Schedule 10 Stainless Steel. Pipes greater than 150 mm shall be standard steel wall epoxy lined to AWWA Standard C210-07 or Schedule 10 Stainless Steel.
- Pipework may be painted and colour coded to WHMIS Standards and the Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Facilities.

6.3 Pump Station Auxiliary Systems

6.3.1 Air

Where compressed air is used in a pumping station, the air system shall be complete with dual air compressors (one duty, one standby), receiver, controls and all necessary appurtenances to supply dry air for all air-operated equipment. Each compressor shall be capable of continuously supplying air at a rate of at least twice the maximum anticipated consumption.

6.3.2 Water

Potable water for station service may be drawn from the pump discharge line or other suitable supply point having adequate pressure. Where necessary, a pressure reducing valve capable of maintaining the station service water between 350 and 700 kPa shall be provided. The line supplying water for non-domestic uses such as cooling, gland sealing, hose bibbs, etc., shall be provided with an approved reduced pressure backflow preventer. Water for domestic use shall be drawn from a point upstream of the backflow preventer. At least one hose bibb shall be provided in the wet well area, in the dry well area and on the exterior of the station.

6.3.3 Dry Well Drainage

Dry wells shall be provided with a sump and two sump pumps (one duty, one standby). Pump capacity shall be at least 200 L/min. Liquid discharged by the sump pumps shall be considered contaminated and shall be discharged only to a sanitary sewer or other approved wastewater disposal system.

The floor of the dry well shall drain towards the sump with a minimum slope of 1.0%.

6.3.4 Chlorination Systems

The need for a chlorination system will depend on circumstances and shall be determined during discussions between the City and the Developer. Where a chlorination system is deemed necessary, the installation shall in all respects comply with recommendations given in the "Chlorine Institute Manual" and with the requirements of the City.

6.3.5 Chemical Feed Systems

The need for systems to feed other chemicals will arise on relatively rare occasions. In such cases, the installation(s) shall be as required by the City and as recommended by the equipment supplier(s).

Refer to applicable guidelines for chemical containment and for design of chemical storage facilities. Occupational Health and Safety requires safety showers supplied with tempered water when operators are exposed to hazardous chemicals.

6.3.6 Lifting Equipment

Lifting equipment (bridge cranes, monorails, etc.) with capacity of 1.5 times over the heaviest load anticipated, with allowance for impact, shall be provided. Where a monorail is used to convey heavy equipment, the rail shall extend a minimum distance of 2 meters outside the building wall through a double doorway. A neoprene seal shall be installed around the monorail where it extends through the doorway.

6.3.7 Electrical Equipment

The pump station's electrical system shall be designed by a qualified electrical engineer licensed to practice in the Northwest Territories.

The Developer shall ascertain from the electric utility the nature of the available power supply and make all necessary arrangements for connection.

Wherever practical, there shall be two independent power supply feeders to the station, with provision for automatic switch over to the second feeder in the event of a failure of the first. An automatic standby power generation system shall be installed in the station. This system shall have sufficient capacity to allow the station to operate at the maximum anticipated flowrate.

Location of electrical switchgear and similar equipment shall be such that it is not subject to immersion in the event of dry well flooding.

Adequate lighting shall be provided throughout the entire structure to ensure the safe operation and maintenance of the complete facility. Metal Halide lighting (250 W) shall be used inside the facility; high-pressure sodium and incandescent lighting are not acceptable. LED (Light Emitting Diode) lights shall be installed as all outdoor lighting.

Conduit shall be required for all low voltage wiring (security systems, telephones, etc.).

6.3.8 Instrumentation and Control

All pumping stations shall have instrumentation and control systems which will allow the station to run unattended, and are fully integrated and compatible with the City's existing central control system.

The nature of the instrumentation and control systems will vary depending on the size, type and function of the station. This shall be decided during discussions between the Developer and the City. The following shall be the minimum acceptable:

- Station discharge flow (meter to be magnetic type)
- Wet well level indicator/controller (sensor to be ultrasonic type) - in critical applications a float back-up switch may also be required
- Station discharge pressure indicator/alarm
- Dry well flooding alarm
- Intruder alarm for all entrance points
- Pump failure alarm
- Pump on/off indicator
- Main power failure alarm
- All alarms to be locally indicated separately

All the above shall be telemetered by means of digital signals to a remote location determined by the City. The telemetry system shall have a battery uninterruptible power supply to allow the system to operate for at least four hours after a power failure.

All instruments and sensors to be installed in a wet well or limited access area shall be, wherever possible, accessible and removable without entering the wet well or limited access area. All instruments which have local indication, or which require access for programming, should be installed at eye level. All instruments and electrical or control panels which require occasional access must be readily accessible.

6.3.9 Heating, Ventilation and Air Conditioning

Heating and ventilation systems shall be provided for all pumping stations. Air conditioning will be required only in unusual circumstances.

Ventilation systems shall conform to all existing local and/or Territorial codes. Forced ventilation shall be provided for all rooms, compartments, pits and other enclosures below ground floor and for all areas where an unsafe atmosphere may develop or where excessive heat build-up may occur.

In areas where excess moisture could cause safety hazards or damage to equipment, a suitable dehumidification system shall be provided.

Heating facilities shall have sufficient capacity to prevent freezing temperatures in any part of the station during the coldest anticipated weather conditions.

City will not accept installation that use chlorine gas.

6.3.10 Truck Fill Station

In some applications, the need for a truck fill station may be identified. In general, the Developer shall provide a fill station with the following:

- The truck fill supply shall have a minimum pumping capacity of 1,000 L/min to minimize the truck fill time. All water supplied from the fill points shall be metered independently from the distribution system supply.
- An exterior overhead truck fill arm shall be provided minimum 5.2 m from ground level to centre of arm and project a minimum distance of 2.5 m into the drive lane.
- The design shall be such that there will be no cross-contamination during or after filling a truck.
- A computerized system approved by The City shall be provided to activate the fill station.
- Suitable drainage will be provided to accommodate overfill, and proper access to the station will be provided.
- Complete signage indicating fill station, coinage rates (if applicable), and safety precautions shall be provided.

6.4 Commissioning and Operator Training

6.4.1 General

The Developer shall provide, commission, train operating personnel and turnover a complete operating facility. Generally, commissioning will follow these steps:

- Test all individual items, ensure they are ready for operation
- Commission the entire system
- Turnover the facility to the City

The procedures outlined in this section are general only and more detailed requirements may be needed depending on the type and complexity of the system.

6.4.2 Preparation

Preparation to be as follows:

- Establish a written detailed procedure and schedule and submit to the City for review.
- Arrange for any specialty testing and certification personnel.
- Provide all instruments required to test, adjust, and balance operation.
- Inspect all equipment to ensure the installations are complete, secure and that the Manufacturer's instructions have been complied for lubrication, cooling fluids, and other requirements.

6.4.3 Personnel

Personnel requirements:

- Provide competent, experienced, and if necessary, factory trained personnel to supervise the installation, inspection, testing, and commissioning of equipment.
- The City will provide a list of operating personnel requiring training and will coordinate their attendance.

6.4.4 Testing Systems

Testing systems to be as follows:

- Each individual item of equipment shall be tested by itself and in combination with related items to ensure that the item or subsystem is ready for operation.
- Test, adjust, check, and lubricate each individual item of equipment and ensure Supervisory Control and Data Acquisition (SCADA) Systems are fully operational and in communication with any remote location determined by the City.

6.4.5 Commissioning

Commissioning to be as follows:

- Commissioning shall generally include the Developer's personnel operating the complete system for a two (2) week period and the City's personnel operating for the following two (2) week period under the Developer's supervision. These operating times will fluctuate depending on the complexity of the facility.
- Operation of existing facilities shall be performed by the City.
- During the commissioning period, the Developer shall demonstrate that the operation of the entire facility, as well as individual components, is correct and in accordance with the Manufacturer's performance criteria.
- All equipment shall be demonstrated in all expected conditions of operation including variation in flow, pressure, speed, and control.
- All alarm conditions, including malfunctions, safety devices, interlocks and annunciations shall be demonstrated.

- During the Developer's period of operation, the City's operators shall observe the operation and receive instruction.
- During the following period, the Developer shall observe the City's personnel operating the equipment and provide any necessary guidance.

6.4.6 Turnover

Upon completion of training, satisfactory testing results, operations, and repair of any deficiencies, the City will assume complete responsibility for operation of the facility.

7.0 Reservoirs

7.1 Optimum Location

The optimum location for a reservoir is between the supply source and the distribution system to ensure that all stored water is in a fresh condition. In addition, locating reservoirs as close as possible to the centre of demand, to minimize the size of distribution mains, is recommended.

7.2 Connection to Distribution System

The outlet main from the reservoir should be sized to pass the peak hourly flow or maximum day flow plus fire flow - whichever is greater.

Where reservoirs are located within the distribution system a combined inlet/outlet main may be used. However, separate metering of flows is required and short circuiting is to be prevented.

7.3 Reservoir Operating Philosophy

7.3.1 Stagnation

The design of reservoirs shall be such that stagnation caused by the retention of water for long periods is minimal.

The reservoir inlet shall be located at the opposite end as the outlet to ensure adequate turnover. In addition, the use of baffles or barrier walls is to be utilized to ensure water circulation.

7.3.2 Fill Control

All reservoirs shall be equipped with an electric operated solenoid control valve located on the inlet main. The valve shall be designed to close when the reservoir level is 150 mm below overflow level.

Where it is required to maintain a minimum upstream pressure within the fill line, a mechanism will be added to the valve to achieve this. All fill control valves shall be sized in accordance with the manufacturer's recommendations.

7.3.3 Isolation

All inlet and outlet mains shall be fitted with valves to permit isolation of the reservoir. The reservoir shall be divided into two or more sections and the pump wet well into two sections to permit cleaning of one section while maintaining service to the distribution system, unless approved otherwise by the City.

7.4 Reservoir Types

The following are acceptable reservoir types:

- Buried reinforced concrete
- Circular pre-stressed concrete

The optimum form should be determined for each particular application, taking into account serviceability, maintenance, and economic considerations. Other types may be considered if they can be used to advantage in a particular situation.

7.5 Structural Considerations

7.5.1 Foundations, Geotechnical Evaluation

A detailed geotechnical evaluation shall be carried out at each proposed reservoir location by suitably qualified and experienced geotechnical consultants. The reservoir foundations and yard piping shall be designed and constructed in accordance with their recommendations.

7.5.2 Structural Design

Structural design shall be in accordance with CSA CAN3-A23.1, CSA CAN 3A23.2, and CSA CAN 3-A23.3 and The City's Building By-Law.

7.5.3 Underdrainage

A 150 mm weeping tile drain shall be provided around the entire perimeter of the reservoir at a minimum depth of 500 mm below reservoir floor level. The effluent from the drain shall be disposed by gravity or pumping to prevent surcharging of a weeping tile drain. A means of visually monitoring the effluent line is to be incorporated in the design.

All exposed above-grade surface shall be insulated according to Section 6.2 of the City Of Yellowknife Building By-Law.

7.5.4 Construction Joints

All construction joints located beneath overflow level shall be cast with integral extruded ribbed PVC water stops of approved size and manufacture. Water stops shall be continuous with pre-welded corner and intersecting pieces.

7.5.5 Environmental Impact

The environmental impact of the reservoir at the proposed location shall be carefully considered and a consultation with all relevant authorities and affected parties will be conducted to achieve an acceptable appearance to all structures. The site shall be landscaped as required by the City.

7.6 Testing - Reservoirs

7.6.1 Water Tightness

Prior to testing, all visible cracks shall be sealed in an approved manner.

All water tightness tests shall be conducted before the placing of backfill material, insulation or siding. Tests shall be conducted as follows:

- Fill reservoir to overflow level;
- Allow to stand for 72 hours;
- Refill to overflow level;
- Measure water elevation;
- At the end of a further 72 hour period, again measure water elevation; and
- Inspect exterior for visible dampness and for leakage as measured by drop in water level.

Total leakage as measured by drop in water level during the second 72 hour test period shall not exceed one tenth of one percent of the reservoir volume. In addition, there shall be no visible exterior dampness or leakage.

If any test shows leakage, the structure shall be emptied, defects repaired and the test repeated until a satisfactory test has been achieved.

The water used for testing shall be clean to an approved standard and supplied at the Developer's cost.

7.6.2 Disinfection – Water Reservoirs

Disinfection is to be done in accordance with AWWA C52.

Prior to disinfection, the structure shall be thoroughly cleaned and all dirt and loose material removed.

The structure shall be disinfected, only after a water tightness test has been performed and accepted, using either of the two methods listed below:

- Spray and swab all interior surfaces, including the roof, with concentrated chlorine water solution. The minimum strength solution shall be 200 mg/l of chlorine in water.
- Disinfect structure by filling with water containing a minimum of 10 mg/l of chlorine. Fill structure such that water is in contact with underside of roof structure. Residual chlorine concentration after 24 hours to be 10 mg/l. Retain water in structure for 72 hours. Dechlorinate prior to discharging.

Disinfect again those areas within the structure which have been repaired or otherwise contaminated subsequent to initial disinfection.

No disinfection shall be carried out until all measures to protect the reservoir against intrusion by insects, animals or unauthorized personnel have been satisfactorily completed.

7.7 Other Considerations

7.7.1 Drawdown/Drainage of Reservoir

Provision shall be made to permit the drawdown or drainage of the reservoir with discharge to a suitable surface drain or stream. The reservoir floor shall have a minimum slope of 1:400 to the drain pipework or sump. Vacuum breakers shall be provided.

7.7.2 Overflow

The reservoir shall be provided with an emergency gravity overflow system designed to pass the maximum possible reservoir inflow rate. The overflow system shall be protected against ingress by insects, birds, or small animals.

The overflow system shall discharge into a suitable surface drain, stream, or soakaway capable of accepting the discharge flow at all times.

7.7.3 Venting

Each reservoir cell shall be provided with air vents sized at a rate equivalent to one 100 mm diameter vent per 1000 m3 of reservoir capacity.

Where possible the vents should be designed to discharge within any associated pumphouse.
All vents shall be fitted with insect screens.

7.7.4 Instrumentation

All reservoirs shall be provided with an ultrasonic type level indicator/controller. In critical applications, a float backup may also be required.

The discharge pipe and the fill line shall be provided with a magnetic type flow meter to balance consumption flows.

The requirement for further instrumentation, alarms, and control systems shall be discussed with the City at the design stage, and required equipment will be installed and shall be fully integrated and compatible with the City's remote control system.

Where pumps are provided to draw directly from the reservoir, low level shutdown controls shall be provided.

Where a reservoir is required to provide fire storage in addition to normal balancing storage, controls shall be provided to alert operators when the fire storage levels are reached.

All instruments and sensors to be installed in a wet well or limited access area shall be, wherever possible, accessible and removable without entering the wet well or limited access area. All instruments which have local indication or which require access for programming should be installed at eye level. All instruments and electrical or control panels which require occasional access must be readily accessible.

8.0 Sanitary Sewage Lift Stations

8.1 Influent Structures

Sumps and wet wells shall be designed in accordance with the current edition of the Hydraulic Institute and the recommendations of the pump manufacturer.

Sizing shall be determined after due consideration of all relevant factors, including flow, number of pumps, pump capacity, and collection system storage capacity.

In general, the usable pit volume should be at least equal to twice the maximum volume (in litres per minute) to be pumped. In addition, the pit should be sized so as to limit the number of starts per hour per pump to that recommended by the motor manufacturer. Sumps and wet wells shall be designed so as to minimize dead areas where debris may accumulate.

The floor shall have a minimum slope of 1:1 in the direction of the suction inlets. Suction inlets shall be of the bell-mouth (flared) type to minimize vortexing and accumulation of solid material.
Ancillary mechanical equipment such as screens, comminutors, and grit removal devices should be avoided, unless special circumstances make the use of such equipment unavoidable. When screens are required they must be a self-cleaning type and include compaction/dewatering equipment.

Provision shall be made for over-pumping or bypassing the pumping station.

8.2 Dry Well/Pump Room Layout

The layout shall be such that all equipment and valves are easily accessible. There shall be a minimum horizontal clearance of 1 m and a vertical clearance of not less than 3 m around pumps and drives. Additional clearance may be required by the City for critical or large pieces of equipment. Special attention shall be given to the case of removal of pumps, motors, and valves for maintenance and repair. Catwalks/ladders shall be provided for maintenance or repair of pump shafts.

Provision shall be made to allow the capacity of the station to be increased in the future to its ultimate design capacity by the installation of additional pumping units or substitution of larger units, without the need for substantial changes to the structural, architectural, mechanical, electrical, or instrumentation systems.

The elevation of the pump room shall be such that the pumps are under a positive suction head at the lowest wet well level anticipated, unless self-priming pumps are used.

8.3 Piping, Valves, and Fittings

Check valves used for sewage discharge pumps in dry well locations shall allow for an external arm to be mounted in conjunction with a proximity switch to monitor the check valve's position (open or closed). When arms and proximity switches are not used on check valves in a wet well application, a flow meter that is approved for submerged applications shall be provided.

Each pump shall have its own suction line from the wet well. Where suction lines pass through concrete walls, a wall casting with flanges on both sides of the wall and a waterstop cast into the wall shall be provided. Suction lines shall be kept as short as possible and shall incorporate an isolating valve, a non-metallic flexible coupling, and an eccentric reducer. Valve design shall be such that the interior is free of obstructions which could accumulate debris and prevent tight shutoff. Gate, knife, diaphragm, and eccentric plug valves are acceptable.

Pipe material shall be steel, AWWA C-200-05, standard wall thickness. The exterior surface of the pipes and fittings shall be coated in the wet well with coal tar epoxy, and in the dry well with polyethylene or epoxy type coating.

Discharge lines shall be designed to withstand the maximum pump discharge pressure, plus anticipated surge pressure. Each pump discharge line shall incorporate a concentric reducer, a restrained-type non-metallic flexible coupling, a check valve, and an isolating plug valve.

The isolating valve shall be located downstream of the check valve. The check valve shall be of the tilting disc type. Adequate supports and hangers shall be provided for all piping. Air relief valves shall be installed at all high points in the piping and drain valves at all low points. All pump discharge check valves must have an external arm to allow for position monitoring with proximity style limit switches that are located above flood level of the wet well or in the dry well.

8.4 Auxiliary Systems

8.4.1 Air

The air system shall be complete with dual air compressors (one duty, one standby), receiver, controls, and all necessary appurtenances to supply dry air for all air-operated equipment. Each compressor shall be capable of continuously supplying air at a rate of at least twice the maximum anticipated consumption.

8.4.2 Water

A potable water supply line from the City's distribution system shall be provided. Line size shall be determined by anticipated maximum demand and length of run, but shall in no case be less than 50 mm. The water service shall be installed inside the building, as per Northwest Territories standards. At least one hose bibb shall be provided in the wet well area, the dry well area, and on the building exterior. The wet well hose bib shall be 50 mm in diameter or greater. The dry well and external hose bibs shall be 25 mm in diameter or greater.

Where provision of a piped water supply is impractical because of distance or other considerations, a potable water holding tank of at least 4,500 litres (1,000 gallons) capacity and corresponding distribution system shall be provided.

8.4.3 Dry Well Drainage

Dry wells shall be provided with a sump and two sump pumps (one duty, one standby). Discharge shall be to the wet well at an elevation above the high liquid level. Pump capacity shall be at least 200 L/min. The floor of the dry well shall drain towards the sump with a minimum slope of 1.0%. Pumps must be controlled by use of a mechanical float switch.

8.4.4 Lifting Equipment

Lifting equipment (bridge cranes, monorails, etc.) with a capacity of 1.5 times the heaviest anticipated load, with allowance for impact, shall be provided. Where a monorail is used to convey heavy equipment, the rail shall extend a minimum distance of 2 m outside the building wall through a double doorway. A neoprene seal shall be installed around the monorail where it extends through the doorway.

When a monorail is not used, an engineered lift point must be installed so heavy equipment including pumps, motors, valves and auxiliary equipment can be safely removed/installed from its location using a lifting device.

8.5 Electrical Equipment

The pumping station's electrical system shall be designed by a qualified electrical engineer licenced to practice in the Northwest Territories.

Three-phase power shall be used and each phase shall be monitored using a 3-phase monitor back through the main control centre.

The Developer shall ascertain from the electric utility the nature of the available power supply and make all necessary arrangements for connection.

Wherever practical, there shall be two independent power supply feeders to the station, with provision for automatic switch-over to the second feeder in the event of a failure of the first. An automatic diesel standby power generation system shall be installed in the station. This system shall have sufficient capacity to allow the station to operate at the maximum anticipated flow rate. Standby generator shall be equipped with a fuel tank sized for 48 hours constant operation under maximum load.

All electrical equipment shall match the class and division of the area in which it is installed.

Location of electrical switchgear and similar equipment shall be such that it is not subject to immersion in the event of dry well flooding.

A minimum of two receptacles shall be provided on the wet and dry sides of the station.

Adequate lighting shall be provided throughout the entire structure to ensure the safe operation and maintenance of the complete facility. Metal Halide lighting (250 W) shall be installed for both wet and dry wells. High-pressure sodium and incandescent lighting are not acceptable in the wells. LED (Light Emitting Diode) lights shall be installed as all outdoor lighting.

Conduit shall be required for all low voltage wiring (security systems, telephone, etc.).

8.6 Instrumentation and Control

All pumping stations shall have instrumentation and control systems which will allow the station to run unattended and are fully integrated and compatible with the City's existing central control system.

The nature of the instrumentation and control systems will vary depending on the size, type, and function of the station. This shall be decided during discussions between the Developer and the City. The following shall be the minimum acceptable:

- Station discharge flow to be measured using a magnetic flow meter. Meter must be installed with a bypass to allow easy repair/replacement.
- Wet well level indicator/controller to be ultrasonic type 3.
- Station discharge pressure indicator.
- Dry well flooding alarm.
- Intruder alarm for all entrance points.
- Pump failure alarm.
- Pump auto/hand/off indicator.
- Main power failure alarm.
- Wet well high and low level alarm switches using mechanical float
- Switches to provide backup to the wet well level indicator/controller.
- Standby generator alarms status and alarms.

- Building HVAC alarms and controls.
- A visible alarm light must be mounted outside of the building located close to the main door entrance. Light will turn on if HVAC has failed to alert operators to potential low 0_2 conditions inside lift station.
- Odour control failure.

All alarms are to be locally indicated. All the above shall be telemetered by means of digital signals to a remote location determined by the City. The telemetry system shall have a battery-powered backup supply to allow the system to operate for at least four hours after a power failure.

All instruments, sensors and mechanical float switches to be installed in a wet well or limited access areas shall be, accessible and removable without entering the wet well or limited access area. All instruments which have local indication or which require access for programming should be installed at eye level. All instruments and electrical or control panels which require occasional access must be readily accessible.

8.7 Heating, Ventilation, and Air Conditioning

Heating and ventilation using heating oil (diesel) shall be provided for all pumping stations. Air conditioning will be required only in unusual circumstances. Ventilation systems shall conform to Northwest Territories requirements.

Wet well ventilation shall be continuous, and capable of providing at least 6 complete air changes per hour. Air shall be forced into the wet well rather than exhausted from it.

Dry well ventilation shall be continuous and capable of providing at least 6 complete air changes per hour.

Ventilation shall have sufficient capacity to provide 21°C discharge air. A low discharge temperature shut down and no airflow alarm shall be provided in the system.

8.8 Submersible Pumps

The use of submersible pumps, in either the submerged or dry well mode, may be acceptable. Pumps must be engineered to be removable without entering in the wet well. If submerged pumps are used, proximity switches shall be provided above over-flow levels. Wet wells shall have a galvanized grating located 1.5 m below the effluent outlet to allow access to valves and checks for repairs. Grating shall have removable sections to allow for the removal and servicing of pumps. Engineered tie off points must be installed to allow workers to be tied off when grating is removed. Full details of the proposed pumps and station layout shall be submitted to the City for approval.

8.9 Other Requirements

8.9.1 Aesthetics

All building Design shall comply with The City of Yellowknife's Building Bylaw's requirements for sustainability and efficiency.

The City shall be consulted regarding aesthetic requirements for the site. If the site is visible to the public, special architectural treatments, signage, landscaping, etc. are required.

Stations shall be equipped with double metal door structures complete with panic hardware for maintenance and removal of large equipment. Double doors will be fitted with a removable center mullion to facilitate weather stripping.

8.9.2 Personnel Considerations

The work shall be designed and constructed in full accordance with all relevant Municipal, Territorial, and Federal safety standards.

Separate access shall be provided to dry wells and wet wells, utilizing stairs wherever possible. Temporary ladders for access are not acceptable and fixed ladders shall be the minimum supplied.

The City may require office(s), telephone, storage areas/rooms and workshop facilities. Washrooms must be installed in all lift stations.

8.9.3 Security

Station design shall be such that the potential for vandalism is minimized. A chain link security fence, complete with locking double gate shall perimeter the site. Adequate outside lighting shall be installed with light sensitive switches.

All external doors and access hatches shall be provided with security locks to a standard approved by the City. Wherever possible, locate access hatches within the associated building structure. Intruder alarms for all entrance points shall relay to the City's Central Control System.

8.9.4 Access

An access road of minimum width 6m shall be provided at all stations. The minimum Standards shall be 60 mm asphalt surface, 250 mm granular base course, on a 300 mm deep scarified and recompacted subgrade. A more substantial road and parking structure may be required where the facility is subject to heavy wheel loads.

Adequate provision shall be made at the site to enable vehicles to park, turn and leave the site in a forward direction. A full perimeter road is not required but vehicle access must be available to all points.

8.9.5 Operations and Maintenance Manuals

Three (3) complete bound sets of the manufacturer's operation and maintenance manuals shall be provided to the City. In addition, a manual completely describing the design and operational philosophy of the station shall be provided (Process Functional Specification) including:

- PLC ladder logic printouts.
- Copies of PLC controller programs on disk.

8.9.6 Equipment

The City utilizes specific manufacturers of equipment and accessories common throughout their systems. Therefore, specific standard equipment (make and model) may be requested by the City and shall be supplied by the Developer. Coordinate with the City for specific requirements.

8.9.7 Lubrication and Spare Parts

Sufficient lubricants for all equipment shall be provided for all testing and trial runs and in sufficient additional quantity for 12 months operation by the City. All lubricants must be supplied with WHMIS documentation. Identify lubricants furnished by brand, grade, and item of equipment for which it is intended. Operate, drain, and flush out bearings and refill with a new change of oil before completion. Type of lubricants shall be as recommended by the Manufacturer and in consultation with the City's Operation Personnel.

Provide all spare parts as deemed necessary by the Manufacturer and the City for 12 months operation. Identify spare parts furnished by brand, grade and item of equipment for which it is intended. In addition, provide all special tools required for servicing and maintaining the equipment.

8.10 Instrument Installation Standards

Instrument installations shall be as follows:

- All instruments to be installed in such a way as to be easily accessible for maintenance and programming.
- All instruments with local indicators to be installed at a standard eye level and with sufficient light to be easily visible.
- All instruments which may be occasionally removed for maintenance must be easily removable.
- All instruments and control systems to be electrically protected by a surge control system, preferably a UPS.
- All communication equipment to have data line surge protection.
- ISA Standards may be specified by the City for purchase and installation of instruments.

9.0 Trench Excavation, Backfilling, and Compaction

Excavation, Backfilling and Compaction for Reservoir and station foundations require approval from a registered geotechnical engineer, are to comply with The City's building bylaw and NBCC. The following section pertains to trenching for municipal developments excluding the aforementioned buildings and reservoirs.

9.1 Site Preparation

Remove trees, shrubs, vegetation, fences and other obstructions, ice and snow from surface to be excavated within the limits indicated.

Cut pavement or sidewalk neatly along limits of proposed work in order that surface will break evenly and cleanly.

Strip topsoil from full width of right-of-way where roadway or underground utilities are to be built. Stripping shall be completed before any excavation is begun.

9.2 Dewatering

Dewatering shall be as follows:

- Keep excavations dry while work is in progress.
- Protect open excavations against flooding and damage due to surface run-off.
- Dispose of water in a manner not detrimental to public health, environment, public and private property, or any portion of work completed or under construction.
- Do not discharge drainage water lines into City sewers without City approval. Ensure water discharge does not contain silt held in suspension.
- Control grading in and adjacent to excavations to prevent water running into excavated areas or onto adjacent properties or public thoroughfares.
- Water flow over fresh concrete is not permitted. Concrete must not be exposed to water for a period of 24 hours.

9.3 Excavations

Excavations to be as follows:

- Excavate to lines, grades, elevations and dimensions indicated or as directed.
- Remove and dispose of all excavated pipe, concrete, masonry, pavement, demolished foundations and rubble, and other obstructions encountered during excavation. Ensure these materials are not used as backfill.

- Notify Consultant when soil at proposed elevation of trench bottom appears unsuitable for installation. Remove unsuitable material from trench bottom to extent and depth directed by Consultant. (See **Section 8.4**)
- Unless otherwise authorized by City, do not excavate more than 30 m of trench in advance of installation operations and do not leave more than 15 m at the end of day's operation. Provide secure barricades around all open excavations at the end of each day's operation.
- Where work is stopped for more than 24 hours, backfill all excavations. Upon request, the City may, at its discretion, grant an extension of the 24 hour period.
- Stockpile materials required for trench backfill in approved location.
- Do not obstruct flow of surface drainage or natural watercourses.

9.4 Over-Excavation

Over-excavation to be as follows:

- In soft or unstable soils (frozen or un-frozen), the sub-grade under the bedding of a pipe or utility structure shall be excavated as directed by Consultant. Typically the additional excavation (over-excavation) is 0.6 m below the bottom bedding elevation. In very poor soil conditions the over-excavation depth may need to be increased.
- Where directed by Consultant, filter cloth may be used to reduce the depth of over-excavation (See **Section 8.5** for requirements). Filter cloth for trenches shall be 8-oz non-woven fabric, Nilex 4553, Layfield Plastics LP801, or approved alternate.
- Over-excavation shall be replaced with 50 mm diameter granular material.
- The granular material for over-excavation replacement shall be well graded gravel consisting of hard durable particles free from clay lumps, cementation, organic material, frozen material and other deleterious materials. The material shall meet the following gradations:

Table 8: Granular Gradations

Sieve Size (mm)	Percent Passing by Weight		
	50 mm Minus Road Gravel & Trench Backfill	20 mm Minus Pipe Bedding	20 mm Minus Road Base
50	100		
25		100	100
20	65-100	85-100	85-100
12.5	50-100	60-90	60-100
5	35-65	35-65	35-70
1.25	0-40	0-40	15-40
0.315	0-25	0-25	5-25
0.08	0-10	0-10	0-10

The geotechnical investigation may recommend over-excavation depths; however, depths are typically determined by the Consultant during construction.

9.4.1 Trenching

Trenching to be as follows:

- Peat or high organic soil, silt-clay or highly compressible materials or other materials which would compromise the stability or drainage of an area shall not be used for foundations, bedding, hunching or backfilling.
- Where service lines are installed underground, the backfill shall be carefully placed and tamped to a height of 300 millimeters over the top of the pipe and shall be free of stones, boulders, lumps, cinders, frozen earth, water saturated fill, and foreign materials. This material shall be thoroughly tamped with a heavy iron hand tamper or other approved device under and on each side of the pipe or pipe boxes, in layers not exceeding 150 millimeters in thickness, to assure that all spaces under and adjacent to the same are completely filled and well tamped. Above this zone, backfilling may be done by machines, however material shall be rolled, not dropped, into trenches and must be compacted in lifts not exceeding 450 millimeters.
- Only 3/4 " (20 mm) crush shall be placed in the trench, below and above the pipe or pipe boxes, within a space of at least 600 millimeters of width.
- Compaction shall be for the full depth of the trench, particularly under parking lots and driveways.
- Backfill and compaction shall be such that natural drainage is not compromised and the adjacent surface area does not deteriorate. This is affected by the mounding of backfill and the placement of excessive fines in the upper layer of the backfill to prevent excessive drainage into the trench. If the stability of adjoining structures, walks, walls or services may be endangered by the work of excavating, adequate underpinning, shoring and bracing shall be provided to prevent damage to, or movement of, any part of the adjoining structure, or the creation of a hazard to the public.
- Rock or boulders shall be removed to provide a clearance of at least 150 millimeters below all pipes or pipe boxes.
- All water accumulated in the trench shall be disposed in compliance with all government regulations including but not limited to all environmental protection legislation.
- All waste excavation material shall be disposed of in a manner such that the surface drainage is not compromised.
- Where City sidewalks or roadways are dug up, the premise owner or occupant shall use suitable sub-base material compacted to a minimum 97% Proctor Density and reinstate the sidewalk curb or roadway to prevailing City specifications.

9.5 Trench Bottom Preparation

Trench bottom preparation to be as follows:

- Hand trim, make firm and remove loose material and debris from excavations.
- Where required, due to unauthorized over-excavation, bring bottom of excavation to bedding grade with 50 mm diameter granular material.
- Granular material shall not be placed in water laden trench bottom. Water must be removed from excavation for granular placement and compaction.
- Where directed by the Consultant, and prior to backfill material placement, filter cloth shall be installed to assist in stabilizing the excavation base. Provide a minimum of 600 mm overlap at fabric ends. Extend the fabric up the sides of the excavation to at least the top of the pipe bedding or as directed. Support the filter cloth to prevent dislodging during backfill.
- Trench bottom shall be uniformly excavated between mains. Do not leave a ridge of native material between mains if the ridge of material is not granular and acceptable as backfill or if filter cloth is being placed.
- Implement the applicable recommendations from the geotechnical investigation.
- The Consultant shall inspect and approve excavations prior to the commencement of installation operations.

9.5.1 Rock Excavation

Rock excavation shall be defined as the excavation of material from solid masses of igneous, sedimentary or metamorphic rock which, prior to its removal, was integral with its parent mass, and boulders or rock fragments having volume in excess of 1.0 m^3.

Rock excavation from site with use of explosives requires the following:

- A licensed explosives expert to supervise and program work, and to determine precautions, preparation and blasting techniques.
- Conformity with the blasting requirements of the Canadian Construction Safety Code 1977, the City, and local and Territorial codes.
- Prevention of damage to surroundings and injury to persons. Post guards, sound warnings and display signs when blasting is to take place.
- Covering of the blast. Typical methods of blast cover in the City are blasting mats or a sufficient depth of cover material. The intent of the cover is to prevent fly rock from escaping and causing public damage or injury.

9.6 Execution

Execution to be as follows:

- If rock is encountered during excavation, remove overburden and notify Consultant in sufficient time to take measurements to record the rock profile and, if applicable, to determine the volume of rock.
- Pre-blast inspections of all nearby buildings shall be done by a registered professional prior to any blasting.
- Correct unauthorized rock removal in accordance with the requirements specified in **Section 9.4** utilizing 50 mm diameter crushed granular material.
- Excavated rock bed to be level, sound, free of large loose rocks or fragments, earth or debris.
- With the approval of the Consultant, finer blast rock less than 150 mm in diameter may be left at the bottom of rock bed if some minor over blast has occurred. The intent is to ensure the larger rock fragments are removed to prevent the possibility of frost action moving them up through finer granular material.
- Scale down all rock slopes immediately after rock removal operations. Scaling shall consist of the removal of all loose rock and debris by scaling bar or other means, including any required minor blasting.
- Rock excavation for road structures and surface improvements shall be to alignments, profiles and cross sections indicated.
- Excavate trenches to lines and grades shown. Trim and shape trench bottom and leave free of irregularities.
- For buried utilities, rock shall be excavated to the same limits as is required for bedding, (refer to the appropriate sections). Typical rock excavation measurement for utility trenches is shown in **Appendix C.**

9.7 Warning Tape

Warning tape shall be placed as follows:

- Above all water, sanitary, and storm mains;
- Above each water and sanitary service. One tape will suffice for each pair of water service pipes in cases of double water services; and
- Above all catch basin leads.

Warning tape shall be Brady Identoline Tape (W.H. Brady Inc. Rexdale, Ontario) or Allen Markline (Allen systems, Houston Texas), polyethylene with a 4-mm minimum thickness, or equal. The tape shall be 150 mm in width.

Warning tape shall be placed at 300 mm above pipes and utilities, or as per utility owner requirements. Warning tape material shall be as per utility owner requirements as well.

Colour Code:

- Water - Safety Precaution Blue
- Sanitary and Storm - Safety Green

Imprint:

- Black letters, one side only, repeated continuously:
  - Water - "Caution Buried Water Line Below"
  - Sanitary and Storm - "Caution Buried Sewer Line Below"

9.8 Backfilling

9.8.1 Execution

- Do not proceed with trench backfilling operations until Consultant has inspected and approved installations;
- Ensure bedding requirements of all buried utilities are satisfactorily completed prior to backfill.
- Ensure trenches are free from debris, snow, ice and water and that ground surfaces are not in a frozen condition;
- Do not use backfill material that is frozen or contains ice, snow or debris.
- Use approved granular backfill material as indicated or directed.
- Do not backfill around or over cast-in-place concrete within 24 hours after placing. After this period of time, Developer shall ensure that concrete has reached sufficient strength before placement and compaction of backfill;
- Place layer simultaneously on both sides of installed work to equalize loading;
- Do not place backfill in freezing weather without written permission of Consultant;
- Place backfill material in uniform layers not exceeding 300 mm in thickness up to subgrade elevation. Compact each layer before placing succeeding layer;
- The consultant shall ensure that the placement and compaction of backfill around or over structural concrete does not occur until the concrete has reached sufficient strength; and
- Correct unauthorized excavation in accordance with **Section 9.4**. Unapproved material may not be used as backfill for areas excavated beyond indicated limits in error.

9.9 Compaction and Type of Backfill

Compaction and backfilling as follows:

- Under pavement, sidewalks, curbs, structures, graveled areas, and within structural embankments, the backfill material shall be compacted to 97% of maximum density ASTM D698, Method D and shall be:
  - 50 mm dia. crushed granular material; or
  - Select native granular material approved by the City and/or Consultant.
- Under or within areas, determined by the City, not to have future surface improvements such as pavement, sidewalk, curb, structures, graveled areas and structural embankments, the backfill shall be:
  - Select native material free of roots, organics, construction debris, frozen material, and rock (blasted or otherwise). The material shall be approved by the City and/or Consultant; and
  - The select native material shall be compacted to 95% of maximum density ASTM D698, Method D.
- Compact using approved mechanical tamping devices, or by hand tamping to achieve specified compaction.

9.9.1 Geotechnical Requirements

Where ice rich permafrost has been exposed during excavation, the Consultant shall ensure there is a short time frame between excavation and completed backfill. A Geotechnical Consultant shall recommend a time frame the excavation can be open during above freezing temperatures. The intent is to reduce the thaw degradation of ice rich permafrost by employing responsible construction techniques.

9.10 Existing Utilities

When existing utilities are exposed, notify the Consultant and allow time for record data to be gathered.

Adequately support all existing utilities crossing trenches. Inform Consultant and repair any damage to the existing utilities.

Re-bed exposed utilities with 20 mm diameter crushed granular as per **Section 9.8**. Class B bedding or as per the requirements of the utility owner.

Install appropriately labeled warning tape over all existing utilities exposed during construction.

Where excavation has occurred underneath existing cast iron watermains, which are to remain in temporary or permanent service, remove and replace the mains with Ductile Iron to a minimum of 1.5 m past the trench wall on each side of the trench or to the satisfaction of the Consultant.

9.11 Abandoned Utilities

Plug all abandoned pipes by the same process outlined for pipe abandonment in **Section 4.5**.

The City may require the complete removal of the abandoned pipes. Removal will be subject to type, depth, and diameter of utility and the risk it poses to material wash-in or surface settlements.

10.0 Landscaping

10.1 Trees

Trees shall be provided at the rate of one tree for every 25 square meters (269 square feet) of the required landscape area. A minimum of one coniferous tree shall be planted for every three deciduous trees. Shrubs shall be provided at the rate of two shrubs for every 25 square meters (269 square feet) of the required landscape area. A minimum of one coniferous shrub shall be planted for every three deciduous shrubs. Minimum tree and shrub size specifications at the time of tree planting shall be:

- Coniferous trees – 1.0 m (3.3 ft.) high
- Deciduous trees – 2.0 m (6.6 ft.) high
- Coniferous shrubs – 0.4 m (1.31 ft.) height or spread
- Deciduous shrubs – 0.6 m (2.0 ft.) height or spread

10.2 Projections into Yards

Unless otherwise regulated, architectural features may project into a required yard:

- 0.6 meters into a required side yard setback of 1.5 m; or
- 1.2 meters into a required yard setback where the yard setback exceeds 3 m.

10.3 Local Granite Boulders

Local granite boulders to be as follows:

- For Boulders set in concrete:
  - +/- 900 mm diameter, flat bottom, min. 250 mm height. Submit samples for approval by Geotechnical Engineer.
- For Boulders set in planting beds:
  - 500 - 900 mm diameter, flat bottom, min. 250 mm height. Submit samples for approval by Geotechnical Engineer.

10.3.1 Granite Boulders Set in Concrete

Boulders set in concrete to be as follows:

- Boulder placement to take place in conjunction with cast-in-place concrete works.
- Prepare subgrade and granular base as shown on the Drawings. Place reinforcing and concrete blocks as shown, adjusting to allow for best orientation of boulder.
- Lower boulders into position using a sling, adjusting orientation prior to final placement.
- Place concrete in accordance with Section 033000 Cast-in-Place Concrete.

10.4 Maintenance

Landscape maintenance to be carried out for a length of time agreed upon by Development Officer following Construction Completion Certificate.

10.4.1 Water

Water to be as follows:

- Free of impurities that would inhibit plant growth.
- The Developer shall supply and apply water using his own source, equipment and labour at no additional cost.
- The Developer shall supply his own labour, tools and equipment to water plant materials and sod.

10.4.2 Fertilizer

Fertilizer to be as follows:

- Fertilizers shall be organic type, slow release, water soluble fertilizer.
- Sodded areas:
  - 11-51-0 high phosphorous starter fertilizer.
- Trees, shrubs and perennials:
  - 11-50-0 high phosphorous starter fertilizer.
  - 20-20-20 all-purpose fertilizer.
  - 30-10-7 tree fertilizer.

10.4.3 Rodent Protection: Chemical repellent, liquid soap, and/or rodent wire

Rodent protection to be as follows:

- Burlap wrap:
  - Natural untreated products.
- Snow fencing for protection from snow traction and de-icing products:
  - 1.2m snow fence c/w posts lined with 6mm clear poly liner where heavily sanded and/or salted roads and walks interface with planted beds.

10.4.3.1 Sod Maintenance

Maintain all sodded areas immediately following acceptance for a length of time agreed upon by Development Officer following City approval of Substantial Completion.

Maintenance shall include all measures necessary to establish and maintain all sodded areas in a healthy vigorous growing condition, including but not limited to the following:

- Mow grass regularly to maintain height between 60 and 70 mm. Remove debris and other foreign material prior to cutting.
- Trim edges of sodded areas neatly, by hand clipping if necessary. Mulch clippings in sodded areas unless volume is such as to be harmful to turf areas or unsightly.
- Roll sod to remove depressions and irregularities.
- Water when necessary with sufficient amount to saturate sod and upper 100 mm of topsoil.
- Apply high phosphorous 11-51-0 fertilizer in spring and summer, in accordance with manufacturer's recommended application rates.
- Weed, insect and fungus control shall be carried out in accordance with the approved Integrated Pest Management (IMP) plan. Pesticides to be applied in accordance with manufacturer's recommendations and all territorial and municipal regulations.
- Re-sod areas which show deterioration or which are thin, bare or burned out. Repair all damages resulting from erosion and washouts or any other cause.

10.4.4 Plant Material Maintenance

Maintain all planted materials immediately following acceptance for a length of time agreed upon by Development Officer following City approval of Substantial Completion.

10.4.4.1 Planting beds and tree pits

Planting beds and tree pits to be as follows:

- Cultivate tree pits, shrub and planting beds whenever required to keep top layer of soil loose and friable, and free from weeds. Remove weed tops and roots from site.
- Remove and dispose of all litter, debris, animal waste, and weeds within planting beds and tree pits.
- Edge all plant beds and tree wells evenly to depth of 100 mm to maintain original line and shape. Do not damage roots of plants when re-edging.
- Place soil mix in plant beds to correct any low and-uneven areas.
- Maintain correct soil conditions in plant beds to promote optimum growth and health for each plant. Add soil amendments and organic matter according to soil analysis.
- Rake, level, spread and add mulch within planting beds and tree wells as necessary to achieve a fresh appearance and to correct any disturbances as necessary
- Remove dead and unhealthy plants, including roots, and replace when necessary.
- Straighten all plants that lean or sag. Raise plants that settle or are planted too low. Replant as necessary

10.4.4.2 Staking and tree protection

Staking and tree protection to be as follows:

- Keep required stakes and guy wires taut and plants plumb during maintenance period. Repair or replace guy wires, ties, flagging and stakes as required. .
- Install and keep plant protection materials in proper repair and adjustment when required or as directed by Consulting Engineer.
- Remove support stakes and staking accessories at the completion of the warranty period or as directed by the Consulting Engineer. Remove staking and accessories from the site.

10.4.4.3 Fertilizing

Fertilizing to be as follows:

- During the first and second growing season, fertilize trees with high phosphorous 11-51-0 fertilizer. Fertilize only before June 15 and after October 1.
- During the second growing season, fertilize trees with 30-10-7 tree fertilizer.
- During the first and second growing season, fertilize shrubs, ground covers and perennials with 20-20-20 all-purpose fertilizer.
- Apply all fertilizers in accordance with manufacturer's recommended application rates.
- Water immediately after fertilizing to obtain moisture penetration to minimum 50 mm depth, or as recommended by the manufacturer.

10.4.4.4 Watering

Watering to be as follows:

- Test moisture levels of individual plant species and apply sufficient water to each plant to ensure continuous healthy growth. Apply sufficient water per application to obtain moisture saturation of the root ball of the plant.
- Watering as required, but at least to the following minimum schedule:
  - Every week for first month, once per month during summer and three times in the fall to freeze trees and underlying soil in to prevent from drying out.
- In late summer and again immediately prior to freeze-up water all trees well, especially coniferous material, to saturate root zone. Pruning

10.4.4.5 Plant Replacements

Plant replacement to be as follows:

- Plant materials identified for replacement to be marked with flagging tape or orange florescent paint sprayed directly on tree trunk.
- Replace plant materials in a timely manner. Identify replacements in maintenance log and proposed schedule for replacement, to be approved by the Consulting Engineer.

- City Engineer reserves the right to extend warranty on any plant material not replaced within the approved replacement timelines.

10.4.5 Weed, Insect and Disease Control

Weed, insect, and disease control to follow:

- Integrated Pest Management:
  - Prepare and submit to the City Engineer an Integrated Pest Management (IPM) plan, including regular monitoring to identify pests, and consideration of various control measures (including biological, physical, cultural, mechanical and chemical controls).
  - Implement control measures only once IPM plan approved by City Engineer.
- Weed control:
  - Apply pre-emergent herbicide in the spring or fall to planting beds and tree pits.
  - Shallow cultivate and weed planting beds and tree pits when required.
- Plant material protection.
- Rodent wire protection to be used when necessary.
- Chemical control.
- Prior to the use of chemical control measures, provide to the City Engineer in written form:
  - Positive identification of infestations.
  - Proposed control measures.
  - Identification of plant species susceptible to damage from proposed control measures.
- Chemical control shall be undertaken in accordance with all territorial and municipal regulations regarding use, transportation and storage.
- Post signs within the construction area 48 hours before and after the application of chemical controls.
- Control measures shall give due regard to environmental conditions and potential adverse impacts on surroundings and occupants of buildings.
- Plant materials, including those not within the construction area, damaged as a result of chemical control shall be subject to compensation or replacement by the Developer at no cost to the Owner.

10.4.6 Winter Preparation

Winter protection to be as follows:

- Rake leaves and remove from site.
- Cut back foliage of perennials within one week after killing frost.
- Deep water trees and shrubs between October 1 and 15.
- Protect plants from rodent damage by use of rodent wire.
- Flag utility services for winter identification.
- Erect stakes and snow fences as directed by the Consulting Engineer.

10.5 Tree Protection

10.5.1 Hoarding and Accessories

Hoarding and accessories to be as follows:

- Safety Fencing – 1200 mm height UV protected high density polyethylene fencing.
- Plywood hoarding – 12 mm exterior grade plywood sheets 1200 mm x 2400 mm.
- Wood posts – 100 mm x 100 mm untreated posts - length as determined by Consulting Engineer.
- T-bar stakes - 50 x 50 x 2500 mm metal stakes.
- Wire – galvanized.

10.5.2 Tree Protection Zone

Tree protection zone to be as follows:

- The minimum barrier is a 1.2 m height orange safety fence, secured with T-bar stakes placed at 2.0 m o.c., along the perimeter of the Tree Protection Zone (TPZ).
- All hoarding shall be reviewed by the Consulting Engineer prior to the commencement of construction.
- Maintain all trees within the TPZ in accordance with these Specifications, and as directed by the Consulting Engineer.
- There shall be no addition of fill, excavation, or scraping within the TPZ. All equipment, soil, building materials and other debris shall be kept outside the TPZ.
- Allow only foot access to the TPZ. Limit foot access to that required for site reviews, re-assessment, and re-vegetation, in accordance with these specifications.
- The hoarding of the TPZ shall be maintained in a clean, safe and satisfactory condition. In the event the hoarding is punctured or damaged, contact the Consulting Engineer immediately to assess any damage and identify any corrective action to be taken.
- Any excavation that occurs within 5000 mm of a tree, including lowering of adjacent grades, is to be evaluated by the Consulting Engineer.
- No excavation will be allowed within the tree‘s structural root plate. The tree's root plate size is related to diameter at breast height (DBH) and is to be determined by the Consulting Engineer. See **Table 9** on the following page.

Table 9: Minimum Root Plate Size (Protective Distance for Excavation)

Diameter at Breast Height (DBH)	Minimum Protection Distance
< 100 mm	2000 mm
101 – 400 mm	2400 mm
401 – 500 mm	3000 mm
501 – 600 mm	3600 mm
601 – 700 mm	4200 mm
701 – 800 mm	4800 mm
801 – 900 mm	5400 mm
901 – 1000 mm +	6000 mm

- Construction activities which are likely to injure or destroy a tree are not permitted within a TPZ. Excavating, change of grade, storage of materials or equipment is not permitted within a TPZ.

10.6 Tree Shrub and Groundcover Planning

10.6.1 Plant Material

Plant material to be as follows:

- All plant material will meet the horticultural standards of the Canadian Nursery Trades Association with respect to size and development of plant material and root ball. Use trees and shrubs of No. 1 grade. All such plants will have been transplanted and/or root pruned regularly but not transplanted and/or root pruned less than nine (9) months prior to arrival on site.
- Use trees and shrubs with strong fibrous root systems free of disease, insects, defects or injuries and structurally sound. Use trees with straight stems.
- Use of plant material which has been held in cold storage will not be acceptable unless prior approval has been received, in writing, from the City Engineer.
- Plants which have been top worked, unnaturally sheared or colour-treated are not acceptable.
- Clump or multi-stem plants will have a minimum of three (3) stems originating from common base at ground level.
- Coniferous trees will have one straight central leader. Trees with dead, damaged or multiple leaders, shall be selected and trained up to replace the damaged or missing leader.
- Plants in containers will have well established root systems; root systems must be able to "hold" soil when removed from container. Plants that have become root bound are not acceptable.
- Herbaceous plants will have healthy crowns, size proportionate to root requirements typical of the species or variety.
- The sizes of the root ball for plant materials will be as outlined by the C.N.T.A. "Metric Guide Specification for Nursery Stock", latest edition.
- Machine moved plant materials shall be moved according to C.N.T.A. specifications.

- Supply trees with root ball sizes as specified, or larger. Ball size shall be adjusted according to growth habits of plants. Ball size shall be sufficiently large to contain at least seventy-five (75%) percent of fibrous root system with depth of root ball not less than fifty (50%) percent of ball diameter.

Table 10: Deciduous Tree Root Ball Requirements

Calipers (mm)	Root Ball Diameter (mm)
25	500
35	600
50	700
60	800
80	900
100	1000
110	1100
120	1200

Table 11: Coniferous Root ball Requirements

Height (m)	Root Ball Diameter (mm)
1.75	600
2.0	700
2.25	800
2.50	900
2.75	1000
3.0	1200
3.50	1400
4.0	1600

- Trees shall not be moved under the following conditions:
  - Temperature in excess of 25°C;
  - Extreme wind;
  - Unsuitable soil conditions; and
  - When buds have broken in spring until new growth has hardened off.
- Trees will be transported at 40 – 50 kph speed maximum.
- Trees will be planted, watered and guyed immediately upon arrival at site.

10.6.2 Soil and Accessories

Soil and accessories to be as follows:

- Soil for tree pits, shrub beds and other plantings will be natural, fertile, agricultural soil, capable of sustaining plant growth, reasonably free of subsoil, slag, clay, stones, lumps, foreign plants and their roots, sticks and other extraneous matter. Acidity range, pH of 6.0 - 7.5 and friable loam, containing 6 - 20% organic matter, sulphur content of 3 - 12 ppm and a Na content of not less than 200 ppm, and electrical conductivity of 1.5 mhos/cm2 or less.
- All inorganic fertilizers will be complete commercial fertilizers containing sixty (60%) percent or more urea formaldehyde by weight. All fertilizer will be in bags, clearly marked with the name of the manufacturer, contents, weight and analysis.
- Bone meal, finely ground and with a minimum analysis of four (4%) percent nitrogen and twenty (20%) percent phosphoric acid.

10.6.3 Recommended Assorted Products

Stakes

- 1 T-bar, heavyweight steel, primed, 40 x 40 x 5m thick x 2100 mm length.

Guying Wire

- #12, factory galvanized wire.

Guying Collar

- 12 mm diameter black rubber hose, reinforced two-ply, or approved equal.

Fertilizer

- Synthetic commercial type as recommended by soil test report.

Anti-Dessicant

- Wax-like emulsion.

Flagging Tape

- Fluorescent, orange colour.

Mulch

Wood chip, chipped deciduous trees. Mulch containing bark, wood and leaves (in summer) chipped to sizes ranging from 50 mm to 100 mm. Mulch may contain stringy twigs and seed, free of non-organic material, wood preservatives or diseased wood. Contains no more than 5% of the following in total: soil, sawdust, peat moss, coniferous wood and needles.

10.6.4 Pre-Planting Preparation

Pre-planting preparation to be as follows:

- Ensure plant material acceptable to City Engineer.
- Remove damaged roots and branches from plant material.
- Apply anti-desiccant to conifers and deciduous trees in leaf in accordance with manufacturer's instructions.

10.6.5 Excavation and Preparation

Excavation and preparation to be as follows:

- Preparation of planting beds is specified in Section 329121-Topsoil Placement and Finish Grading. Excavate planting beds to 450 mm depth (including 150 mm depth rototilling of native soil).
- For individual planting holes:
  - Stake out location and obtain approval from City Engineer prior to excavating.
  - Excavate to depth and width as indicated on the Drawings.
  - Adjust planting depth so the located root flare, at the first order lateral root, will be at finished grade. If root flare is not visible, expose by twine, burlap and / or excess soil.
  - Remove subsoil, rocks, roots, debris and toxic material from excavated material that will be used as planting soil for trees and individual shrubs. Dispose of excess material.
  - Scarify sides of planting hole.
  - Remove water which enters excavations prior to planting. Notify Consulting Engineer if water source is ground water.

10.6.6 Planting

Planting to be as follows:

- For jute burlapped root balls, top 1/3 of wire basket to be folded back or removed and the top 1/3 of the burlap to be cut back and removed from root ball hole.
- For container stock or root balls in non-degradable wrapping, remove entire container or wrapping without damaging root ball.
- With clean, sharp pruning tools, prune off any secondary / adventitious, girdling or potentially girdling roots.

- Planting shall be done during periods suitable with respect to weather conditions and local horticultural practice. Excessive moisture, high winds, frozen soil, frost or other similar factors by which satisfactory results are not likely to be obtained, work shall be stopped.
- Install plant materials immediately upon delivery to site. If this is not possible, protect adequately and water to prevent deterioration.
- Set plant in centre of tree pit and at same depth at which previously grown. Layout all plants in beds prior to installation. Adjust spacing to give best appearance.
- Face plant materials to give best appearance or relationship to adjacent structures.
- Tamp soil mixed with bone meal (6009 m/m^3) around root system in 150 mm layers to eliminate air pockets. Frozen or saturated soil is unacceptable. Backfill to a height above finished grade sufficient to allow for normal natural settlement. Create topsoil rim at perimeter of root ball area.
- When planting is completed give surface of tree pits and beds dressing of fertilizer, mix thoroughly with top layer of soil and water thoroughly immediately after planting. Fertilize according to soil test recommendations.

10.6.7 Tree Supports

Tree supports to be as follows:

- After planting, install tree supports as indicated consistent with contract drawings.
- For deciduous trees with 30 – 100 mm caliper, and coniferous trees 1.5 - 3.0 m height, support with two skates and two ties.
- Guy wires shall be looped around tree and anchored in such a manner that looped wire will not interfere with normal growth. Guys shall be placed around the trunk at a point to ensure adequate support of the tree and in such a manner that the tree stem or branches will not be subjected to undue strain or injury.
- Cover wires with rubber hose at points of contact with bark.
- Place stakes equally around plant and perpendicular to prevailing wind and so not to damage root ball.
- Fasten wires in upper half of tree and at strong crotch.
- Fasten flags to guy wire to make them clearly visible.
- The Developer shall be responsible for keeping guy wires taut at all times and replacing broken guys in accordance with the specified maintenance period and to ensure the guys do not damage the tree trunk during growth.

10.6.8 Mulching

Mulching to be as follows:

- Ensure soil settlement has been corrected prior to mulching.
- Spread wood chip mulch on shrub beds and tree beds to depths as indicated on the Drawings, level with adjacent surfaces, crowned in center of beds.

10.6.9 Exterior Site Furnishings

Exterior site furnishings to be as follows:

Benches

- Acceptable Product:
  - CityView bench c/w middle armrest, Part # CV1-1011-PF, Black colour, powercoat finish.
- Surface mount to concrete as per manufacturer's instructions.

Waste Receptacle

- Acceptable Product:
  - Paris Waste Receptacle Model # RC-2, Black Powdercoat Colour.
- Surface mount to concrete as shown on the Drawings.

Bicycle Rack

- Acceptable Product:
  - Echo serpentine bicycle rack, Part # EC2—07-SM, Black colour, powdercoat finish.
- Surface mount to concrete as per manufacturer's instructions

Tree Grates & Frames

- Rectangular grate:
  - 'Avenue' tree grate, Part # R-8810, cast iron grey colour.
- Rectangular tree grate frame:
  - Part #8500—3600.
- Place embed frames in concrete in accordance with manufacturer's written instructions.

10.7 Irrigation System

Irrigation system to be as follows:

Scope of Work:

- Supply and installation of DCVA, sleeves, mainlines, lateral lines, drip zone valves, micro-irrigation, controller, and all related items necessary to provide a properly operating automatic irrigation system to cover the project landscape.
- Maintenance of irrigation system.

Reference and Standards:

- ASTM 02241 - Poly (Vinyl Chloride) (PVC) Plastic Pipe (SDR-PR).
- ASTM D2564 - Solvent Cement for Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
- ASTM D1248 - High Density Polyethylene (HDPE) pipe.
- CSA B137.0-12:
    - Thermoplastic Pressure Piping.

Operations and Maintenance Manuals

- Prepare and deliver to the Consultant within ten (10) calendar days prior to completion of construction two (2) copies of the following information bound in 3-ring cover binders:
    - Index sheet stating Developer's address and telephone number, list of equipment with name and addresses of local manufacturer‘s representatives.
    - Catalog and part sheets on all materials and equipment installed under this contract.
    - Guarantee statement.
    - Complete operating and maintenance instructions on all major equipment.
    - Construction details from project.
    - Complete trouble-shooting guide to common irrigation problems.
    - Winterization and spring start up procedures.
    - Chart of approximate watering times for spring, summer, and fall showing the proposed run times for each zone relative to differing precipitation rates and plant water requirements, and a schedule of run times suggested for various weather conditions.

Substitutions

- Where materials are specified by brand name and model number, such specifications shall be deemed to facilitate a description of the materials and material quality and shall establish a standard for performance and quality against which proposed substitutes shall be evaluated.
- Substitution requests shall not be considered unless submitted in writing 5 business days prior to close of Tender with sufficient descriptive literature and product samples to permit product comparisons.
- Alternate materials shall match the specified materials in, performance, flow, and pressure loss so as not to compromise the intent of the design.
- Alternate materials proposed shall be applied according to their manufacturer's specifications.
- The written approval of the Consultant is required prior to the use of materials that are different from those shown in the design.

Micro-Irrigation

- Micro-irrigation components such as dripline, pressure compensating modules and drip zone kits shall installed as per owner's direction on contract drawings.
- Pressure compensating dripline shall be installed at a maximum depth of 50 mm – 75 mm below finished grade of top soil. Mulch or decorative rock is not considered finished grade.
- Miscellaneous components such as air relief valves and lateral end flush valves shall be indicated by type, size and location on the drawings or details. Install according to the manufacturer's specifications.

10.8 Topsoil Placement and Finish Grading

10.8.1 Products

Imported Field Topsoil

- Natural, fertile, friable, agricultural loam, or amended to contain not less than six (6%) percent or more than twenty (20%) percent organic material, a pH value ranging from 5.8 to 7.3, a nutrient content approaching 55 kg/ha actual N, 80 kg/ha actual P, 230 kg/ha actual K, sulphur content of not less than 3 nor greater than 12 ppm and a Na content not less than 200 ppm and electro conductivity of 1.5 mmhos/cm^2 or less. Soil reasonably free from subsoil, slag, clay, stone, lumps, live plants, roots, sticks, quack-grass, noxious weeds, and foreign matter. Soil free of all toxic substances.

Peat Moss

- Decomposed plant material, fairly elastic and homogenous, free from decomposed colloidal residue, wood, clay lumps, sulphur and iron. Minimum of sixty (60%) percent organic matter by mass, pH value between 5.0 and 7.0 with a conductivity of less than 0.5 mmhos.

Manure

- Completely decomposed, friable animal litter free from clay, stone, lumps, live plants, roots, sticks, straw, quack-grass, noxious weeds, field crop seed and foreign matter having a pH of 5.8 - 7.3 and conductivity less than 0.5 mmhos

10.8.2 Preparation of Existing Grade

Preparation of existing grade shall be as follows:

- Locate runs of utility lines before commencement of work. Protect active lines from damage.
- Verify that grades are correct. If discrepancies occur, notify Consulting Engineer and do not commence work until instructed by Consulting Engineer.
- Remove debris, roots, branches, stones in excess of 50 mm diameter and other deleterious materials. Remove soil contaminated with calcium chloride, toxic materials and petroleum products. Remove debris which protrudes more than 75 mm above surface. Dispose of removed material off site.

10.8.3 Placing and Spreading of Topsoil

Placing of topsoil shall be as follows:

- Place topsoil after Geotechnical Engineer has accepted subgrade.
- Spread topsoil in uniform layers not exceeding 150 mm.
- Spread topsoil as indicated to following minimum depths after settlement.
  - 100 mm for sodded areas.
  - 450 mm for planting beds.
- Topsoil should not be worked with heavy equipment while wet.
- Feather topsoil over areas requiring regrowth of native plants.
- Manually spread topsoil/planting soil around trees, shrubs and obstacles.
- Add peat moss and/or manure as required to bring native soil into organic and chemical ranges specified for imported field topsoil.
- Cultivate topsoil to depth of 100 mm by rototilling or by hand methods.
- Float until surface is smooth. Cut smooth falls to catch basin rim, finish flush.
- Native "organic soils" shall be rolled to establish a firm seed bed.
- Do not cover catch basins, valve covers or inspection pits.
- Fine grade to ensure positive drainage away from building and sidewalks.
- Leave surface smooth, uniform and sufficiently firm to prevent sinkage pockets when irrigated.

10.9 Sodding

10.9.1 Quality Assurance

Sodding quality assurance shall be as follows:

- Supply sod, healthy, vigorous and certified No.1 cultivated turf grass sod, as specified hereinafter.
- Supply sod with a strong fibrous root system, free from stones, burned or bare spots, disease, insect infestation and containing not more than one (1%) percent weeds.

10.9.2 Sod

Sod shall be as follows:

- Sod shall be No.1 cultivated turf grass, grown and sold in accordance with the Classification of the Alberta Turf Grass Association.
- Sod Type - 65% Kentucky Blue Grass blend and 35% Creeping Red Fescue or approved alternate.
- Sod shall be cut by approved methods in accordance with recommendations of the Nursery Sod Growers Association of Alberta. It shall be cut in pieces, approximately 500 mm^2 in area. Thickness of the sod soil portion shall be a minimum 25 mm and maximum 40 mm.
- Sod shall be rolled or folded prior to lifting in such a manner as to prevent tearing or breaking.

10.9.3 Fertilizing

Fertilizing shall be as follows:

- Obtain approval of finished grade prior to fertilizing.
- Apply 11-51-0 fertilizer at 2.5 kg per 100 m^2 or as indicated in soil fertility report.
- Spread evenly with mechanically calibrated distributor. Mix thoroughly into upper 50 mm of topsoil.

10.9.4 Sod Placement

Sod placement shall be as follows:

- Apply sod during normal growing season. Sodding at freezing temperatures or over frozen soil is not acceptable.
- Lay sod in rows, smooth, even and flush with adjoining areas and with joints staggered. Butt sections closely without overlapping or leaving gaps between sections.
- Lay sod flush with adjoining grass areas, paving and top of curbs.
- Water immediately in sufficient quantities to obtain moisture penetration through sod into upper 100 mm of topsoil.
- Roll sod to ensure sod contact with topsoil and to remove minor depressions and irregularities.
- All sodded areas which show open joints, cuts or are not butted flush with adjoining grass areas, paving, curbs and walks shall be top dressed. Topsoil shall be spread and raked to fill in open points, gaps and spaces between sod pieces and adjoining grass and paving materials. Top dressing shall be at the Developer's expense.

10.9.5 Acceptance

Sod acceptance will follow:

- Sod will be accepted provided that:
  - Sod is properly established.
  - Sod is free of dead or bare spots.
  - No surface soil is visible when grass has been cut to a height of 50 mm.
- Ali sodded areas shall be freshly mowed with clippings removed to facilitate inspection.

10.10 Tree Pruning

10.10.1 Qualifications

True pruning qualifications to follow:

- Staff undertaking pruning work to possess Canadian Nursery Landscape Association certification.
- Staff undertaking pruning work to possess safety certificate or equivalent as approved by local hydro utility.

10.10.2 Disinfectant

20% solution of sodium hypochlorite or 70% solution of ethyl alcohol.

10.10.3 Execution

Execution to be as follows:

- Prune in accordance with CNLA guidelines for pruning ornamentals, and as directed by City Engineer. Where discrepancies occur between standard and specifications, specifications govern.
- Notify Consulting Engineer immediately of conditions detrimental to health of plant material or operations.
- Prune during plant dormant period or after leaves have matured. Avoid pruning during leaf formation and at time of leaf fall (commonly done in winter).
- Prune heavy bleeder species, such as birch (Betula) and maple (Acer), when in full leaf or dormancy. Do not prune in early spring.
- Do not:
  - Flush cut branches.
  - Crush or tear bark.
  - Cut behind branch bark ridge.
  - Damage branch collars.
  - Damage branches to remain.

10.10.4 Pruning

Pruning to be as follows:

- Remove dead, dying, diseased and weak growth from plant material designated by Construction Manager in order to promote healthy growth.
- Remove live branches that:
  - Interfere with healthy development and structural strength including branches crossed or rubbing more important branches.
  - Are of weak structure including narrow crotches.
  - Obstruct development of more important branches.
  - Are broken.
  - Maintain tree shape, form or clearance from buildings and structures only as directed by the Consulting Engineer.
- Remove loose branches, twigs and other debris lodged in tree.
- Remove vines.
- For branches under 50 mm in diameter:
  - Locate branch bark ridge and make cuts smooth and flush with outer edge of branch collar to ensure retention of branch collar. Cut target area to bottom of branch collar at angle equal to that formed by line opposite to branch bark ridge.

  - Make cuts on dead branches smooth and flush with swollen callus collar. Do not injure or remove callus collar.
  - Do not cut lead branches unless directed by Consulting Engineer.
- For branches greater than 50 mm in diameter:
  - Make first cut on lower side of branch 300 mm from trunk, one third diameter of branch.
  - Make second cut on upper side of branch 500 mm from trunk until branch falls off.
- Ensure that trunk bark and branch collar are not damaged or torn during limb removal. Repair areas which are damaged, or remove damaged area back to next branch collar.
- Remove additional growth designated by Consulting Engineer.

10.11 Approved Plants Species List

Table 12: Approved Species for Landscape Development in Yellowknife

Plant Type	Common Name	Minimum Requirements
Coniferous Trees	White Spruce	1000 mm height (minimum exposure)
Deciduous Tree	Paper Birch	2000 mm
Deciduous Tree	Common Chokecherry	2000 mm
Deciduous Shrubs	Pygmy Caragana	400 mm Height/Spread
Deciduous Shrubs	Red Osler Dogwood	400 mm Height/Spread
Deciduous Shrubs	False Splrea	400 mm Height/Spread
Deciduous Shrubs	Black Currant	400 mm Height/Spread
Deciduous Shrubs	Prickly Rose	400 mm Height/Spread
Deciduous Shrubs	Double Flowering Plum	400 mm Height/Spread
Deciduous Shrubs	Haskap Berries	400 mm Height/Spread
Deciduous Shrubs	Bleeding Hearts	400 mm Height/Spread
Coniferous Shrubs	Common Juniper	400 mm Height/Spread
Perennials	Arnica	300 mm Height/Spread
Perennials	Fireweed	300 mm Height/Spread
Perennials	Sweet Vetch	300 mm Height/Spread
Perennials	Common Sweetgrass	300 mm Height/Spread
Perennials	Mock Orange	300 mm Height/Spread
Perennials	Artemesia	300 mm Height/Spread
Perennials	Karl Forrester Grass	300 mm Height/Spread
Perennials	Lilies	300 mm Height/Spread
Perennials	Begonia	300 mm Height/Spread
Perennials	Some Hostas	300 mm Height/Spread
Perennials	Arctic Dwarf Iris	300 mm Height/Spread
Perennials	Globe Flower	300 mm Height/Spread
Perennials	Delphinium	300 mm Height/Spread
Perennials	Yakkow	300 mm Height/Spread
Perennials	Peonioes	300 mm Height/Spread
Perennials	Some Hydrangea	300 mm Height/Spread
Perennials	Nuuk Potentilla	300 mm Height/Spread
Groundcover	Bunchberry	300 mm Height/Spread

Table 13: Alternate Species

Plant Type	Common Name	Plant Type	Common Name
Deciduous Trees	Green Alder	Deciduous Trees (Continued)	Schubert Chokecherry
	Saskatoon		Spur Schubert Chockecherry
	Amur Maple (single stem)		Bur Oak
	Manitoba Maple		Laurel Leaf Willow
	Silver Maple		American Mtn. Ash
	Silver Cloud Maple	Coniferous Trees	Siberian Larch
	Autumn Spire Red Maple		Tamarack
	Paper/ White Birch		White Spruce
	River Birch	Trees	Green Ash
	Sutherland Caragana		Western Mountain
	Hackberry	Shrubs	Canada Buffalo-Berry
	Dolgo Crabapple		Common Blueberry
	Siberian Crabapple		Cranberry, High Bush
	Thunderchild Crabapple		Cranberry, Low Bush
	Gladiator Crabapple		Currant, Wild Red
	Royalty Crabapple		Currant, Northern Black
	Big River Crabapple		Dwarf Birch
	Assinboine Poplar		Evans Cherry
	Trembling Aspen		Juniper, Upright
	Balsam Poplar		Red Raspberry
	Amur Cherry		Rose, Prairie
	Goldrush Amur Cherry		Rose, Prickly Wild
	Gold Spur Amur Cherry		Wild Gooseberyy
	Mayday Tree		Wolf Willow
	Pin Cherry	-	-

The Species Listed in **Table 13** have attributes conducive to Yellowknife Climate. Use of these species require review and approval by the City of Yellowknife.