Industry Bulletin
May 2026

The Guidance offered below supersedes Section 3.3.8 Culverts in the 2011 Stormwater Management & Design Manual (SWMDM). In addition, as summarized following the culverts verbiage, to ensure consistency and alignment other sections in the 2011 SWMDM are being replaced or amended as well.

Sections with incomplete numbering (represented by an X in the text below) will be updated when this bulletin is incorporated into the future SWMDM update.

Questions regarding the technical guidelines in the bulletin can be directed to Alexa Baker alexa.baker@calgary.ca. Questions regarding the general implementation of the bulletin can be directed to Development Engineering Utility Specialists based on the location of the project on the Area Map.

For Agricultural Crossings please contact Development Engineering Utility Specialists based on your project location on the Area Map.

The requirements of this bulletin will be mandatory for all submissions received on or after August 1, 2026.

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Calgary

3.3.8 Culverts

Culverts are buried storm drains that connect one open channel to another, usually across a raised embankment. A typical culvert has no intermediate structures or tie-ins, such as manholes or service connections. The City of Calgary defines culverts as either **Minor Culverts** or **Major Culverts**. The minimum size for a culvert is a nominal diameter/dimension of 450 mm. Note that the term "dimension" means width or height.

Much of the guidance below holds for all culverts; however, the guidance is focused on typical installations as part of municipal drainage systems. Special consideration must be given to crossings located in riverine environments, project specific environmental/fisheries/wildlife requirements, larger 'Bridge Sized' structures and infilled/open bottom structures; further reference material is provided in ***Section 5.3 Special Structures***.

Culverts meeting the following criteria are considered to be **Bridge-Sized Culverts** and are subject to additional guidelines listed in **Section 5.3 Special Structures:**

- Have a span of greater than or equal to 3.0 m; or
- For adjacent multiple cell culverts, have a sum of individual spans greater than or equal to 3.0 m; or,
- For multiple cell culverts (each with spans of at least 2.0 m) separated by soil (with a width not more than the span of the smallest individual cell), have the sum of the individual spans of greater than or equal to 3.0 m.

Minor Culverts:

- typically convey local runoff from swales and ditches.
- typically cross a roadway or are located in MR/ER (e.g., agricultural or industrial crossings, pathway crossings).
- typically have a catchment area less than 2 hectares.
- require an R/W if located on private land.
- have a design flow less than 350 L/s.
- have a maximum nominal diameter/dimension of less than 900 mm.

Major Culverts:

- typically form key linkages in the major (overland) drainage system located in named watercourses, ravines, ephemeral streams and/or MR/ER lands.
- require a registered R/W or PUL designation where located on a titled parcel.
- have a minimum nominal diameter/dimension of 900 mm or greater and a maximum nominal diameter/dimension of less than 3000 mm
- usually cross a roadway or other embankment.
- service multiple parcels or have a catchment area greater than 2 hectares.

Additional information relevant to culvert design and construction is provided in the following City of Calgary publications:

- *Standard Specifications for Sewer Construction (SSSC)*
- *Standard Practice for the Design and Construction of Flexible Plastic Pipe*
- *Standard Practice for the Design and Installation of Rigid Gravity Sewer Pipe*
- *Standard Specifications for Roads Construction*
- *Development Guidelines and Standard Specification for Landscape Construction*

If conflicts are noted contact The City for clarification regarding a particular situation.

3.3.8.1 Analysis and Design Requirements

3.3.8.1.1 General Requirements

All culverts are to be reviewed and accepted by The City of Calgary. Submission of hydrologic, hydraulic and civil design information is required, see ***Chapter 11 – Technical Requirements***.

Culvert design submissions must meet all regulatory requirements, including but not limited to, Alberta Environment's Code of Practice for Watercourse Crossings (*Water Act*), as well as Transport Canada (*Navigable Waters Protection Act*), Fisheries and Oceans Canada (*Fisheries Act*) and Environment and Climate Change Canada, as applicable. Refer to ***Chapter 2 – Authorizations and Processes*** for further information.

Where culverts are required in fish-bearing streams, the design must achieve hydraulic conditions that meet or exceed Federal and Provincial fish passage requirements. In general, natural bed or baffled designs are preferred. Hydraulic requirements may not govern the design, bridges are often preferred to better accommodate debris, ice, fish passage, wildlife movement and pathway connectivity.

Energy dissipation and scour and erosion control measures must be addressed in the design. The design should address events up to the 1:100-year peak discharge rate. Depending on site conditions, the governing design scenario for scour and erosion protection may occur at a lower return period or before the peak of a design event. Guidance on the design of erosion and scour protection measures will be published in the future.

3.3.8.1.2 Hydrology

Culvert hydrology should be addressed as part of the subdivision planning and design process. Refer to ***Chapter 11 – Technical Requirements,*** in this bulletin, for documentation requirements.

Where full planning level information is not available, refer to ***3.2 Runoff Analysis*** for guidance on determining design discharge rates. The hydrological analysis must document the drainage area, time of concentration, design storm or rational method calculations, routing approach/assumptions, upstream SWMFs or other informal storage areas, and hydraulic restrictions (including the rationale for how they are addressed). For further guidance on modelling using SWMM 5, refer to ***3.2.X SWMM 5***.

The governing hydrological regime is not always the full build out condition, that is, interim conditions may yield greater peak discharges. All relevant scenarios must be assessed and reported.

Due to the inherent uncertainty in hydrological assessments, a risk-based approach that considers a likely range of flows may be required as a basis for assessing a proposed design.

3.3.8.1.3 Hydraulics

For culverts under inlet control, entrance losses must be accounted for. Outlet control scenarios are to consider entrance, friction, and exit losses, see ***5.2 -Energy Losses***. The governing headwater elevation must be determined. For inlet control culverts the performance criteria is expressed as the ratio of the depth above the culvert invert to the diameter or height of the culvert. For outlet control conditions the governing headwater elevation is the sum of all energy losses plus the tailwater elevation. The freeboard is measured from the governing headwater elevation to the upstream crest of the embankment or edge of the roadway.

Culverts are typically designed using single-event modelling. The appropriate duration for the single event varies depending on site specific details, for more information see Section 3.2.4.5 of the Stormwater Management and Design Manual (2011).

Minor Culverts shall convey the 1:100-year peak discharge rate with a maximum headwater depth ratio of 1.2 (inlet control) or a maximum head loss of 300 mm (outlet control), and a minimum of 300 mm freeboard. Where existing upstream or downstream conditions cannot be altered to meet the above **Minor Culverts** may be designed to overtop provided the 1:100-year peak discharge rate can be managed within public property.

Major Culverts shall convey the 1:100-year peak discharge rate with a maximum headwater depth ratio of 1.0 (inlet control) or a maximum head loss under outlet control of 300 mm (outlet control), and a minimum of 600 mm freeboard, usually measured to the edge of roadway or the upstream crest of the embankment.

Wherever possible, culverts should operate under inlet control conditions; however, the potential of outlet control conditions governing should always be checked. Where outlet control conditions exist, culverts must be properly sized to not impose excessive head losses on the system. The design must also ensure upstream or downstream flood risks are not increased, or where upstream and downstream constraints exist, flood risks are managed appropriately.

Where **Major Culverts** also convey emergency overland escape(s) from one or more SWMF(s) the headwater depth ratio may be increased to 1.2 (inlet control) or the maximum head loss increased to 450 mm (outlet control), and the freeboard reduced to 300 mm for the combined 1:100-year peak discharge rate and the design flow rate corresponding to the emergency overland escape conditions.

Where **Major Culverts** are located downstream of Regulated Dams, the Consequences Classification of the Dam may require more stringent design criteria, for instance additional conveyance capacity or limits on the overtopping elevation.

3.3.8.1.3.1 Nomograph Method

The key measure of the hydraulic performance of a culvert is the governing headwater elevation. For a given set of design parameters a culvert can generally be characterized as operating under inlet control or outlet control conditions. During a storm event the control regime may shift between inlet and outlet control. The Nomograph Method yields the governing headwater elevation by checking inlet and outlet control conditions for peak flow rate conditions.

Culvert design using the Nomograph Method is outlined in detail in Chapter 3 and Figure 3-18 of the US Department of Transportation – Federal Highway Administration (FHWA) Hydraulic Design Series No. 5 (HDS-5). For standalone designs, the Nomograph Method provides a reliable and efficient hydraulic design procedure.

When properly configured, culvert designs performed using SWMM 5, HY-8 and HEC-RAS generally utilize the same parameters and should yield similar results.

3.3.8.1.3.2 Modelling

Culvert designs may be analyzed using HEC-RAS, HY-8, and SWMM 5; acceptance of the use of any other modelling platforms is at the discretion of The City of Calgary. Below is a brief overview of some of the key points regarding culvert modelling in these programs. For further details or instructions on the use of these models, refer to their respective user manuals.

3.3.8.1.3.2.1 SWMM 5

In SWMM 5, any conduit may be modelled as a culvert by assigning it a Culvert Code. The code is selected from a menu of options based on the culvert shape, material, and inlet configuration. In addition to the Culvert Code, the user must specify all conduit attributes, including shape, dimensions, roughness coefficient, inlet and outlet offsets, entrance and exit loss coefficients, and number of barrels.

For conduits designated as culverts, SWMM 5 first calculates the flow through the culvert using its standard dynamic wave procedure, which represents the outlet control scenario using user specified hydraulic loss parameters. Culvert performance under inlet control is then calculated using the Nomograph Method to determine the governing headwater elevation.

SWMM 5 only considers the velocity head at the culvert outlet when calculating exit losses.

3.3.8.1.3.2.2 HY-8

HY-8 was developed by the FHWA and is based on the HDS-5 Nomograph Method. The user must provide the culvert shape, material, dimensions, inlet configuration, design discharge, downstream channel, and roadway data. The Manning's roughness value and entrance loss coefficient will automatically populate based on the user selected culvert material and inlet configuration.

Two methods of calculating exit losses are available. The 'Standard Method' (default) only considers the velocity head in the culvert. Alternatively, the 'Utah State University (USU)' method calculates the exit loss using the difference between the velocity head in the culvert and downstream channel. Both methods assume an exit loss coefficient equal to 1.0.

3.3.8.1.3.2.3 HEC-RAS

In HEC-RAS, the user must provide the culvert shape, dimensions, material, Manning's 'n', inlet configuration, entrance and exit loss coefficients and design discharge (steady) or hydrograph (unsteady). A minimum of four cross sections is required: one at the upstream end of the culvert, one at the downstream end of the culvert, and one sufficiently upstream and one sufficiently downstream of the culvert, such that the culvert is no longer influencing the flow.

HEC-RAS allows the user to specify whether the culvert calculations are performed under inlet control, which uses the FHWA HDS-5 Nomograph Method, or under outlet control, which uses a detailed energy balance. To determine the appropriate nomograph and scale numbers for use in the inlet control calculations, the user must select the culvert material and the inlet configuration, respectively. The 'Computed Flow Control' (default) option computes both and yields the greater headwater; this option is recommended for most cases.

In HEC-RAS, exit losses are calculated using the difference between the velocity head in the culvert outlet and the downstream channel.

3.3.8.1.3.3 Entrance and Exit Velocity

The entrance and exit velocity are required to determine appropriate inlet and outlet erosion and scour protection measures.

The entrance velocity is determined based on continuity (velocity = flow rate/area) at the pipe inlet.

The exit velocity under inlet control conditions can in most cases be taken as the Manning's uniform flow velocity in the culvert barrel, even if the governing headwater elevation is based on outlet control.

The method for determining the exit velocity under outlet control conditions is based on the tailwater depth:

- If the critical depth exceeds the tailwater depth, the critical depth shall be used.
- If the tailwater depth exceeds the critical depth, it is determined based on continuity (v = Q/A).

Under some circumstance the governing headwater elevation may be based on outlet control conditions; however, the governing velocity may occur at either a lower return period event or prior to/following the peak of a storm when the full extent of backwater is not present. If the designer is unsure of the governing condition, they may assume the exit velocity reflecting inlet control conditions as the governing design velocity.

Detailed information on the design of erosion and scour protection for inlets and outlets, including culverts, will be published in the future.

3.3.8.2 Civil Design

3.3.8.2.1 Typical Materials

The selection of the culvert material and structural design must meet the requirements of the SSSC. The Design Engineer must provide a complete specification of the proposed material and burial condition on the Construction Drawings and the culvert must be designed and constructed in accordance with the manufacturer's recommendations. Discussion of specific materials is provided in ***3.3.2.5 Pipe Material, Strength, and Bedding***.

3.3.8.2.2 Layout and Geometry

The culvert location should be selected to minimize impacts to the waterbody and consider future natural morphologic changes to the channel, if relevant. The alignment of the culvert should typically be parallel to the channel, while skewed crossings should be avoided, if possible. Existing channels should not be relocated or straightened to accommodate culverts. This avoids net loss in channel length, habitat and riparian function, and increases in velocity, shear stress or erosion risk. Culverts should be located at least six (6) times the bankfull width away from bends in the channel alignment.

Culverts should be depressed 150 mm below the channel invert at the inlet and the outlet. Perched/elevated culvert outlets with a free drop onto splash pads are not permitted. The preferred minimum slope for Minor Culverts is 2%, for Major Culverts the minimum preferred slope is 0.5%. If the culvert slope is reduced below the preferred minimum slopes, then approval from The City is required.

The culvert slope may be reduced below the preferred minimum slope to 0.5% and 0.1% for Minor and Major Culverts, respectively, but the size of the culvert must be increased to account for sedimentation and blockages, see 3.3.8.2.8 Debris and Blockages. Slopes below these minimum slopes will only be acceptable where the culverts are designed to match existing channel slopes.

Multiple barrel culverts are generally not allowed but may be permitted, where necessary, provided that each barrel meets the requirements stated herein and that the barrels fit within the channel or ditch. Multiple barrel culverts should be avoided where there is a potential for debris. When multiple barrels are provided, the inlet of one of the barrels should be installed at a lower elevation than the other barrel to concentrate the flow during low flow conditions. Sufficient clearance between the barrels must be provided to allow for proper haunching of the pipe or a controlled density fill must be specified.

For additional requirements related to culvert ends located inside the Clear Zone (i.e., a road design requirement), refer to the Alberta Transportation Roadside Design Guide. The Clear Zone is defined as: the total roadside border area adjacent to the travelled way provided for use by errant vehicles. This area may consist of a shoulder, a recoverable slope, a non-recoverable slope, and/or a clear runout area.

3.3.8.2.3 Cover and Live Load

Culverts shall be designed to meet CL-800 live load requirements. The preferred minimum cover for culverts is 1.2 m. If the desired minimum cover is demonstrated, to the satisfaction of The City, to be infeasible, the required minimum cover may be reduced to (i) a depth that is equal to the diameter or height of the barrel, or (ii) in extreme cases to be as low as 450 mm, or (iii) to the depth of the road structure, whichever is greater. Reduced cover applications must meet all City of Calgary requirements and specifications and satisfy all of the manufacturer's recommendations. Additional submissions may be required where a cover less than 1.2 m is proposed, refer to ***Chapter 11 – Technical Requirements***.

3.3.8.2.4 End Treatments

Designs incorporating beveled or mitered ends projecting from an embankment are not permitted, with the exception of concrete flared ends. A headwall, collar, anchor block and/or other anchoring method must be included where identified below to prevent uplift associated with differential head and/or buoyant force.

Table 3-19A: Suitable Applications of Culvert End Treatments

End Treatment	Applicable Materials	Suitable Applications
Projecting end	CSP, Concrete	• Only acceptable for **Minor Culverts**. • In most cases should be avoided.
Mitered end section	N/A	• Not acceptable.
Bell end	Concrete	• Only acceptable for **Minor Culverts**. • In most cases should be avoided.
Flared end section	Concrete	• Acceptable for concrete up to 900 mm in nominal diameter. • May present foundation challenges at interface with inlet/outlet aprons and haunching, where installed flush with the slope • CSP flared ends are not permitted unless a compliant Trash/Safety Grate is included and all sharp edges are fully mitigated.
Headwall (Precast, Cast in Place, FRP or approved equal)	CSP, Concrete, PVC, HDPE	• Preferred in most cases for CSP, Plastic and Concrete Pipe. • FRP or other lightweight headwalls may be considered but usually require ballast and/or other anchoring provisions.
Headwall with wingwalls	CSP, Concrete, PVC, HDPE	• Usually limited to **Major Culverts** exceeding 1200 mm in nominal diameter or height. • Will require fall protection railings.

All culverts equal to or greater than 600 mm in nominal diameter or height require Trash/Safety Gratings on the inlet and the outlet as per ***3.3.7.X Gratings;*** breakaway features (e.g., shear pins) are only required for **Major Culvert** outlets. All culvert inlets and outlets must meet the requirements of ***3.3.7.4 Safety and Aesthetics***.

Detailed information on the design of erosion and scour protection for inlets and outlets, including culverts, will be published by The City in the future.

3.3.8.2.5 Backflow Prevention

In most cases, culverts located within the 1:100-year inundation area of a named river or creek or other sources of potential backflow require backflow prevention; refer to ***3.3.7.X – Backflow Prevention*** and ***X.X.X – Combined Probabilities***.

3.3.8.2.6 Geotechnical

3.3.8.2.6.1 Seepage Mitigation

Where seepage considerations warrant, clay plugs, seepage collars or other measures are required. The minimum length of the clay seal is twice the culvert rise, at both the inlet and outlet. Where compaction of clay around a circular pipe may be difficult, the use of a concrete collar or Control Density Fill (See City of Calgary Specifications for Roads Construction) is recommended to create an impermeable seal around the pipe.

3.3.8.2.6.2 Cambered Installations

The use of cambered installations may be considered where differential settlement is anticipated. Where a cambered installation is proposed the design submission shall include:

- monitoring plan(s),
- quality assurance and control plan(s),
- timeline(s), and
- the proposed acceptance criteria (FAC conditions).

3.3.8.2.7 Overtopping of Embankment

In cases where overtopping of the raised embankment cannot be avoided for the design event, or where the risk of embankment failure to public safety or the environment is high, provisions to protect the embankment are required. This includes mitigating erosion and scour of the embankment and seepage through the embankment to prevent a wash-out.

Designing for overtopping requires establishing a defined and protected spill location across the embankment and protecting the embankment crest and slopes from scour and erosion. Provision of a drainage layer to safely allow the drawdown of groundwater within the embankment and mitigate the potential for a piping failure may also be warranted, refer to ***3.3.8.2.6 Geotechnical***.

Analytical guidance on the hydraulics of overtopping flows is available in FHWA HDS-5.

3.3.8.2.8 Debris and Blockages

Culvert design must consider the potential for debris accumulation and sedimentation. This may include:

- an inlet grate (see **3.3.8.2.4 End Treatments**),
- oversizing the culvert to allow for debris passage and sediment deposition, and
- recommendations and projected schedules for maintenance activities.

Where a culvert slope is proposed to be reduced below the preferred minimum slope as per **3.3.8.2.4 Layout and Geometry,** or where sedimentation and/or debris is reasonably foreseeable, the design shall meet the hydraulic requirements assuming the culvert is infilled by 300 mm, or the bottom 25% of the diameter or height, whichever is greater. Alternatively, in the absence of such hydraulic analysis, the culvert diameter or height may be increased by 300 mm, or the bottom 25% of the diameter or height, whichever is greater. For **Minor Culverts**, where an overland spill route is provided within public land or via an ODR/W (accommodating inadvertent overtopping of the raised embankment), a 150 mm size increase of the culvert diameter or height and width may be accepted.

3.3.8.2.9 Cold Weather

Culvert design must consider winter ice conditions and the potential for ice accumulation. This may include reviewing winter flow conditions in the channel to determine the likelihood of ice developing or accumulating. A review of current and historical site conditions should be undertaken to identify:

- past ice marks,

- possible ice thickness, and
- potential groundwater exfiltration (e.g., daylighting from a hillslope).

When ice accumulation is likely, oversizing of the culvert as per the requirements in ***3.3.8.2.8 Debris and Blockages*** or other mitigations (e.g., steam diffuser or heat trace lines) to mitigate ice blockage should be considered.

3.3.8.2.10 Maintenance and Access

Designs must consider access for both personnel and vehicles for inspection and maintenance purposes. Where feasible, the upstream and downstream ends of culverts should be located within 4 m of a drivable surface so that maintenance vehicles, including the Combination Unit (see ***X.X Access Road Requirements***) can access the culvert.

In ER or MR where formalized vehicle access is unacceptable, walking access to culverts shall be provided and sufficient PUL or Access R/W dedicated to allow temporary equipment access.

The following Sections are an addition to the SWMDM:

3.3.7.X Backflow Prevention

Where required to prevent backflow from a floodplain, flood fringe or other potentially inundated areas (e.g., ponds) backflow prevention should be provided. Contact The City to discuss available options.

Passive

Passive backflow prevention options are most commonly check valves and flap gates. The design of such elements must consider the potential for debris and sedimentation, exposure to hydraulic forces and ease of maintenance and inspection. The advantage of a passive approach is that, if properly maintained, they should provide a reliable barrier against backflow.

Active

Sluice gates provide an active option but require operation in advance of and following a flood event.

Redundant

A redundant system combines passive and active systems and is advisable where the consequences of failure are high.

11.X Submission Requirements pertaining to Culverts

11.X.1 Minor Culverts

Typically, the recommended hydrological and hydraulic requirements for **Minor Culverts** must be documented in the Stormwater Management Report (SWMR), including for Development Permits or Development Site Servicing Plans. This should include:

- Tributary area
- Design flow
- Governing flow regime (inlet or outlet control)
- Governing headwater elevation
- Diameter or height and width
- Upstream and downstream invert
- End treatment

The Construction Drawings and Block Plan Profiles shall, at a minimum, identify all **Minor Culverts** in plan view with associated annotation or table(s) to construct the culvert. Profiles are usually not required for **Minor Culverts**. General notes and standard details may be used or referenced. Where standard (off-the-shelf) products are proposed a representative shop drawing from the proposed manufacturer may be required. The minimum civil design information provided shall include, but is not limited to:

- Design flow rate
- Governing headwater elevation
- Diameter or height and width
- Upstream and downstream invert
- Material (including pipe class, wall thickness and/or dimension ratio)
- End treatment details
- Trash/safety grating details

- Inlet and outlet erosion/scour protection measures
- Seepage control requirements
- Location and direction of the overland escape
- Authenticated technical memorandum, shop drawings and/or loading calculations for low cover installations

11.X.2 Major Culverts

All minimum requirements for **Minor Culverts** also apply for **Major Culverts**.

The recommended hydrological and hydraulic requirements for **Major Culverts** must typically already be documented in the Staged Master Drainage Plan, especially when the performance of the culvert impacts the extent of the floodplain along a drainage course, and referenced in the SWMR. If added at the SWMR stage, full information must be provided in that report. In addition to the basic requirements, full hydraulic design calculations and/or modelling must be submitted, including culvert performance curves that show the inlet head, outlet head, and water surface profiles for all relevant design scenarios including an overtopping scenario. The overtopping elevation and location requirements shall be clearly documented and shall conform to the requirements of ***3.1.3 Major System*** and ***3.4.2.3 MGs/TOSs, and Restrictive Covenants***.

The civil and geotechnical design shall be documented in the report or in a standalone Technical Memorandum.

The Construction Drawings for **Major Culverts** shall include all civil design information. At a minimum, drawing sheet(s) showing the General Arrangement and Profile shall be provided. Additional information required includes:

- Full existing and proposed topographic contours (0.5 m resolution)
- Identification of the governing headwater elevation in plan and profile view
- Identification of the overtopping elevation and location in plan and profile view
- Proposed land designation(s) (PUL, MR, R/Ws, etc.)
- Seepage mitigation design
- Minimum clearance between barrels (for multiple barrel installations)

Contact The City pertaining to the submission requirements pertaining to **Bridge Size Culverts**.

The following referenced Sections will be added at a later date to the SWMDM:

- ***X.X.X Net Zero Design Criteria***
- ***X.X.X Combined Probabilities***
- ***3.2.X SWMM5***
- ***3.3.7.X Gratings***
- **3.3.*X Erosion and Scour Protection***

The following Sections of the SWMDM are superseded by the text below.

3.3.2.2 Capacity & Size

i) Manning's equation shall be used to determine the gravity flow capacity, and required size of pipe, assuming that the pipe is flowing full, refer to ***5.2.1.1 – Manning Equation***.

ii) **Minimum** storm sewer diameters are as follows:

- residential areas: 300 mm
- commercial/industrial: 375 mm
- roof drains: 100 mm
- weeping tile drains (main): 150 mm
- service connections and weeping tile drains: 75 mm

Refer to ***3.3.6.3 Size & Slope*** for more information on weeping tile drains.

3.3.2.4 Cover

The depth of cover is measured from pipe obvert to finished road grade. The **minimum** depth of cover for public stormwater piping is:

- Storm sewers and storm service connections: 1.2 m
- Catchbasin leads: 0.9 m

In special circumstances culverts may have lower cover. A greater cover depth is preferable.

3.3.2.5 Pipe Material, Strength, and Bedding

All storm sewer pipes must be approved products and must be designed and constructed in accordance with the latest edition of the City of Calgary's *Standard Specifications for Sewer Construction* and any additional manufacturer recommendations. The structural design must conform to the City of Calgary's *Standard Practice for the Design and Construction of Flexible Plastic Pipe* or *Standard Practice for the Design and Installation of Rigid Gravity Sewer Pipe*.

3.3.2.5.1 Concrete Pipe (CP)

In cases where long term and/or differential settlement is not expected and soil conditions have low corrosivity Concrete Pipe (CP) is generally a good choice. In areas where high surface or groundwater elevations are expected the higher weight of CP can be beneficial in overcoming buoyancy. CP is considered a rigid pipe and as such is less sensitive to installation conditions than flexible alternatives but is more susceptible to joint separation due to settlement. CP is also less susceptible to potential vacuum failure.

Example of a complete specification: 900 mm DIA RCP, CLASS 4, TYPE 2 Install

3.3.2.5.2 Plastic Pipe

Poly Vinyl Chloride (PVC)

Poly Vinyl Chloride (PVC) provides a lighter and readily available alternative to CP but is more susceptible to degradation from UV light and buoyant conditions. PVC pipe can be deflected at the joints but should not be bent. Fused PVC is not permitted in the City of Calgary. Detailed guidance is available in the SSSC.

Example of a complete specification: 900 mm DIA PVC, DR35, TYPE 2 Install

The maximum size of PVC culverts is 1050 mm. As per the Standard Specifications for Sewer Construction 1200 mm and 1500 mm diameter PVC pipes are only allowed with specific approval.

High Density Polyethylene (HDPE)

Solid wall, butt fused High Density Polyethylene (HDPE) is more typically used for watermains and forcemains. In certain cases where settlement is unavoidable and/or highly corrosive soils are present this may be appropriate for culvert installations. HDPE can tolerate tighter bend radii and generally has much higher wall thicknesses than solid wall PVC. HDPE is prone to thermal expansion/contraction, especially during installation but also during the service life. Thermal effects and buoyancy must be addressed in the design; most commonly this requires anchor blocks at the pipe extents. Solid wall HDPE may be appropriate for cambered installations. Requirements for fusion are shown in the SSSC; joining by extrusion weld is not acceptable. Solid wall HDPE is usually specified in IPS (Iron Pipe Size); this size specification does not indicate the pipe's inner diameter. For diameters larger than 12" the size specification corresponds to the outside diameter.

Example of a complete specification: 900 mm DIA IPS HDPE, DR11, TYPE 1 Install

Profile Pipe

PVC, HDPE and Polypropylene Profile Pipe are allowed in certain situations by the SSSC. Only dual or triple wall products will be considered; the pipe stiffness must not be lower than 320 kPa.

Example of a complete specification: 900 mm DIA PVC PROF, TYPE 2 Install

3.3.2.5.3 Corrugated Steel Pipe (CSP)

Corrugated Steet Pipe (CSP) is susceptible to corrosion and generally has a shorter design life than concrete and many types of plastic pipe. CSP is not permitted:

- beneath permanent paved public roads,
- where it is connected to a manhole or a bend,
- where a service connection is or may be required, or
- at a cover depth of greater than 2 m.

The SSSC provides additional design and construction requirements for CSP. The Design Engineer must specify the wall thickness and coating based on the proposed installation details including determination of the pH and Electrical Resistivity of the in-situ soils.

Example of a complete specification: 900 mm DIA CSP, 2 mm WT, Zinc Polymer, TYPE 2 Install

3.3.2.5.4 Other Materials

In special circumstances, steel, large diameter profile HDPE (typically smooth inner wall), plastic-steel hybrids (e.g., steel reinforced polyethylene), fibre reinforced plastic (FRP) or other materials may be proposed by the Design Engineer. If the proposed materials are not approved as per the SSSC a technical review of the proposed product will likely be required.

5.2.1 Friction Losses

The major loss in a channel or pipe system is the friction or boundary shear loss. The head loss is computed from the general definition:

Equation 5-2: Computation of Friction Loss

$$H_f = S_f L$$

H_f = head loss due to friction
S_f = average friction slope
L = length of channel or pipe

Depending on flow conditions, the friction slope (S_f) can be computed from one of three friction formulas:

- Manning's Equation - uniform and gradually varied flow in pipes and open channels.
- Hazen-Williams Formula - smooth pressure flow in a pipe
- Darcy-Weisbach Equation - primarily for pressure flow in pipes

5.2.1.1 Manning's Equation

In most cases the Manning Equation shall be used in storm sewer design, refer to ***3.3.2.2 Capacity & Size***.

Equation 5-2A: Manning's Formula

$$Q = \frac{\left(A\, R^{\frac{2}{3}} S_f^{\frac{1}{2}}\right)}{n}$$

Q =discharge (m3/s)
R = hydraulic radius (A/P) (m)
A = cross-sectional area of pipe (m2)
P = wetted perimeter (m)
Sf = friction gradient (or slope of pipe)
n = Manning's roughness coefficient

Table 5-0: Manning's Roughness Coefficients for Storm Sewers and Culverts

Type of Pipe	Recommended Manning's 'n'
Concrete	0.013
Solid Wall PVC and HDPE	0.011
Profile Pipe (Smooth Inner Wall PVC, HDPE and PP)	0.012
Corrugated Steel	0.014 to 0.033
Smooth Wall Steel	0.012 to 0.016
Corrugated Polyethylene (single wall)*	0.020

*Not permitted for new construction in public system, provided for reference.

If the pipe material is not known a default value of 0.012 may be assumed.

The following references provide additional information:

- Hydraulic Engineering Circular No. 22, Third Edition, Urban Drainage Design Manual (FHWA, 2013)
- Stormwater Management Model Reference Manual, Volume II - Hydraulics (EPA, 2017)
- Handbook of Steel Drainage & Highway Construction Products (CSPI, 2007)

5.2.2.2 Culvert Form Losses

Entrance and exit loss coefficients for culverts of various pipe materials and inlet configurations are presented in ***Figure 5-3*** and ***Table 5-4***. It is recommended that an exit loss coefficient of 1.0 be used to model typical culverts.

Figure 5-3: Values of k_e for Outlet Control Culverts with Full or Partly Full Entrance[1]

Type of Structure and Design of Entrance	Coefficient K_e
• Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end	0.2
Square-edge	0.5
Rounded (radius = D/12	0.2
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7^{0} or 45^{0} bevels	0.2
Side- or slope-tapered inlet	0.2
• Pipe. or Pipe-Arch. Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7^{0} or 45^{0} bevels	0.2
Side- or slope-tapered inlet	0.2
• Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of D/12 or B/12 or beveled edges on 3 sides	0.2
Wingwalls at 30^{0} to 75^{0} to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of D/12 or beveled top edge	0.2
Wingwall at 10^{0} to 25^{0} to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: "End Sections conforming to fill slope," made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections, incorporating a closed taper in their design have a superior hydraulic performance. These latter sections can be designed using the information given for the beveled inlet.

[1] Source: U.S. Department of Transportation 2005 (page 223).

Table 5-4: Exit Loss Coefficients

Culvert Outlet Transition	Exit Loss Coefficient
Abrupt transition – typical culvert	**1.0**
Semi-gradual transition	0.5
Gradual transition	0.3

5.3 Special Structures

Special structures such as inlets, culverts, outfalls, energy dissipators, drop structures, and outlet structures require careful hydraulic design consideration to ensure that they function properly. It is the responsibility of the designer or consultant to ensure the structures are properly designed. Reference material should be consulted for more information. All special structures are subject to approval by The City.

All culverts must be hydraulically designed. Please note that the guidelines in **3.3.8 Culverts** are minimum guidelines that should be adhered to at all times. The designer or consultant is responsible for consulting appropriate references and ensuring proper design. The following references are recommended reading for information about culvert design, but should not be used solely when other sources are available.

• Alberta Transportation's Design Guidelines for Bridge Size Culverts.
• Alberta Transportation's Hydrotechnical Design Guidelines for Stream Crossings.
• Alberta Transportation's Culvert Sizing Considerations.
• Alberta Transportation's Fish Habitat Manual.
• Alberta Transportation's Engineering Consultant Guidelines for Highway and Bridge Projects, Volume 1, Design and Tender.
• Transportation Association of Canada's Drainage Manual, Volume 2, Culverts and Storm Sewers.
• US Department of Transportation's Hydraulic Design of Energy Dissipators for Culverts and Channels: Hydraulic Engineering Circular No. 14, Third Edition.

Bridge Sized Culverts will require consultation with the Bridge and Transportation Structure Section, Public Spaces Delivery, and are subject to the requirements in:

- Canadian Highway Bridge Design Code CSA S6
- The City of Calgary's Design Guideline for Bridges and Transportation Structures
- Transportation Association of Canada's Guide to Bridge Hydraulics
- The City of Calgary's Design Guide for Subdivision Servicing – Section 6