SECTION
“C”

STORM WATER DRAINAGE SYSTEMS

Approved May 7, 2009

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C1. GENERAL

C1.1 Stormwater Management

The specific requirements of the storm sewage system will depend on whether the development is defined as a rural or urban development. In either case, the intent of the stormwater management system is to prevent any negative downstream effects as a result of the development.

Detailed design of the stormwater system will be consistent with a stormwater management plan to be submitted by the Developer and approved by the County. Deviation from the intent of the stormwater management plan must be approved by the County and supported by engineering analysis.

For both rural and urban development, the stormwater system will either be designed based upon a "net-zero" impact (runoff rates for a 24 hour duration, 1:100 year post development design storm will not exceed rates for the same design storm under pre-development conditions) or on the available capacity of the receiving stream and appropriate area contributions.

If these standards and specifications do not cover an area of drainage concern, the onus will be upon the Developer to present alternative corrective measures and recommend proposed drainage standards to be used, based on sound economic, engineering, environmental, maintenance and operational criteria for approval by the County. The system will meet the recommended standards of Alberta Environmental Protection and the Plumbing and Drainage Act of Alberta.

The Developer will provide rights-of-way or easements for drainage and have them registered in the name of the County so that future maintenance may be provided.

The Developer will be responsible not only for the drainage within the development, but also for drainage in the adjoining properties that would be affected by this development.

Any type of drainage diversion will be approved and licensed by Alberta Environment. Drainages works will include the constructions of ditches, berms, ditch checks, the installations of culverts, rip-raps and other means of erosion control.

C1.2 Urban Systems:

The storm sewerage system will be designed as a separate system. Pipes and their appurtenances (manholes, catchbasins, outfall structures, etc.) will comprise the minor system. This system will convey runoff from snow melt and rainfall events without sustaining any surface ponding or excessive surface flows from a 1-in-5 year event. The road system, detention/retention facilities, parkland and other land will comprise the major system. The major system will convey runoff from up to a 1-in-100 year event and will be sufficient to prevent any significant property damage (e.g.: flooding of buildings).

C1.3 Rural Systems:

For developments with a rural type street cross section, both the minor and major systems consist of roadside ditches/swales, culverts and storage facilities.

It is expected that a rural system will be comprised primarily of swales, ditches, culverts and similar open flow components. The system will convey runoff from snowmelt and rainfall events consistent with the stormwater management plan. The system will be considered the major system, and will convey runoff for the design storm sufficient to prevent property damage.

C2. DESIGN CRITERIA

C2.1 System Design:

1. The Rational Method may be used for analysis of minor drainage systems up to a maximum catchment area of 50 hectares. Computer simulation methods must be used for analysis of major drainage systems (catchment areas greater than 50 ha) and is recommended for all final analysis and detailed designs.

   The Rational formula is expressed as Q=CIA/360 where:

   Q = runoff discharge in cubic meters per second;
   C = dimensionless runoff coefficient;
   I = rainfall intensity in millimeters per hour; and
   A = catchment area in hectares.

2. The runoff coefficient, C, must be consistent with the following guidelines and based on sound engineering and best management practice:

Description	**Storm Frequency**	
	1:5	**1:100**
Undeveloped Farm Land	0.10	0.20
Lawns, Parks, Playgrounds	0.20	0.30
Residential (Urban)	0.35	0.60
Commercial (Urban)	0.60	0.80
Apartments (Urban)	0.70	0.80
Paved Surfaces	0.90	0.95
Gravel Surfaces	0.30	0.70

   These values may be further modified based upon the specific development proposed. In rural developments or where a mixture of land uses or surface characteristics are proposed, the weighted average of pervious and impervious area runoff coefficients will be used.

3. Rainfall intensity, I, will be determined using appropriate Intensity Duration Frequency (IDF) or rainfall data within the County. The maximum inlet time will be 15 minutes unless approved otherwise by the County.

4. Effluent from sanitary sewers and any drainage from industrial, agricultural or commercial operations that may potentially be contaminated will not be discharged into the storm sewer system.

5. Roof drainage from one-family and two-family dwellings will discharge to grassed or pervious areas. The point of discharge will be a sufficient distance to ensure the water flows away from the building. Roof drainage from apartment buildings, commercial areas and industrial areas will also be discharged to the surface drainage system.

6. Best management practices will be provided to minimize sediment discharge to the storm sewers. This will be in the form of properly graded and surfaced

streets and lanes, landscaping, catchbasin sumps, sediment control structures at pond and lake inlets, or other means where appropriate.

C2.2 Pipe:

1. Storm sewer pipe will be designed to convey the design flow when flowing full with the hydraulic gradeline at the pipe crown. All pipe crown elevations will match at manhole junctions.

2. Storm sewer pipe hydraulics will be calculated using Manning's equation. The minimum Manning's "n" value will be 0.013 for smooth-walled pipes. For corrugated steel and open channels the values suggested in "Modern Sewer Design", latest edition, will be used but will not be less than 0.013.

3. Storm sewer velocities will not be less than 0.60 m/s when flowing full. When the flow velocity exceeds 3.0 m/s, special consideration will be given to minor losses in the system and bedding requirements.

4. Storm sewers 900 mm diameter and smaller will be PVC SDR 35 or Ultra Rib PVC storm sewer pipe, provided that manufacturer recommended pipe loadings are not exceeded. Storm sewers greater than 900 mm diameter will be of concrete pipe unless approved otherwise by the County. Concrete pipe will be of sulfate resistant concrete with a gasketed jointing system. On steep slopes, welded steel pipe or another rigid piping system will be constructed as approved by the County.

5. The minimum inside diameter for storm sewers will be 300 mm. The minimum inside diameter for catchbasin leads will be 250 mm.

6. The Developer is responsible for providing the engineering expertise relating to the structural design of storm sewers, providing all test results and the quality control of all materials proposed to be used. All storm sewers will be designed to prevent damage from superimposed loads. Notwithstanding information contained herein, all materials and loading calculation will be consistent with current ASTM and CSA standards.

    i) For rigid pipes a 0.025 cm crack will be determined as exceeding the working strength and the pipe rejected. For flexible pipe, when deflection greater than seven and one-half percent (7 ½%) of the original diameter is reached, then the pipe will be considered to have exceeded the limit of serviceability and will be rejected.

    ii) Proper allowances will be made with regard to the class of bedding and the trench dimensions (width, depth) when determining the loadings on pipes. The recommended unit weight of soil is 2100 kg/m^3 metre.

    iii) The minimum depth of cover to pipe crown will be 1.20 m, or 2.6 m to invert, whichever is greater.

    iv) The "Marston Theory" is to be used in analyzing loadings in the single trench applications for rigid pipe. For flexible pipe, the modified IOWA formula will be used.

v) Concrete pipe specified under ASTM C655 may have combinations of circular and elliptical reinforcement with minimum steel requirements at all outer and inner points as specified under ASTM C76. The Developer will specify the horizontal and structural strength of all pipe.

7. Changes in flow direction at a manhole will not exceed 90 degrees in pipes greater than 600 mm diameter.

8. Curved sewers - It is recommended that sewers 600 mm inside diameter or less be installed with straight alignment between manholes, but curved sewers will be permitted providing that the following requirements are met:

   i) Permissible joint deflections will be in accordance with the manufacture's guidelines;

   ii) Manholes are to be located at the beginning and end of curve;

   iii) The curve will run parallel to the street centerline; and

   iv) The minimum grade for curved sewers will be fifty percent (50%) greater than the minimum grade required for straight runs.

C2.3 Manholes:

1. The maximum spacing of manholes will be 150 m. Manholes will be located at the upstream end of each line, at changes in size or alignment and at all junctions. The downstream invert in a manhole at a change in direction will be a minimum of 30 mm lower than the lowest upstream invert.

2. Manholes will be a minimum of 1200 mm in diameter. Precast (Type 50) reinforced concrete manhole barrels conforming to ASTM C478 will be used. The base will be constructed of 25 Mpa sulphate resistant (Type 50) concrete. Galvanized iron safety steps are required.

3. Manhole frames and covers will be of cast iron. Grated or standard manhole covers will be used as required. A Norwood NF - 49 or approved equal frame and cover must be used on manholes located in carriageways and an appropriate locking manhole frame and cover must be used on manholes located in parkland areas.

C2.4 Catchbasins:

1. For urban design, surface water will not be permitted to run a distance greater than 300 m along roadways without provision for interception by a catchbasin, except in lanes or walkways where 200 m in either direction may be permitted.

2. Surface water will be intercepted with a number of catchbasins such that the combined inlet capacity is sufficient to receive the design stormwater flow.

3. Minimum gutter grade will be 0.40% except in cul-de-sacs and around curb returns where minimum gutter grade will be 0.70%.

4. All catchbasin bodies will be 900 mm pre-cast sulfate resistant concrete sections. The body will be constructed to provide a minimum 600 mm sump unless otherwise approved.

5. All catchbasin leads will discharge directly into storm sewer manholes. The minimum catchbasin lead size will be 250 mm with a minimum slope of 1% and a maximum length of 30 meters. For leads of greater length or for those from a CBMH to a manhole the minimum lead size will be 300 mm.

   Catchbasin frames and covers will be combination precast iron inlet type. Norwood F41 & F51, Trojan K2 or approved equal will be used with 900 mm concrete sections.

C3. CONSTRUCTION

C3.1 Materials:

The requirements for this section will also apply to sanitary sewers as appropriate.

All materials used for storm sewer mains will be of the approved standards as listed herein or the latest revision thereof:

1. Non-Reinforced Concrete Pipe - The non-reinforced concrete pipe will conform to the Standard Specification "Non-Reinforced Concrete Sewer (ASTM C14)", designed for flexible rubber gasket joints to ASTM C443. Sulfate resistant cement will be used.

2. Reinforced Concrete Pipe - Reinforced concrete pipe will conform to the Standard Specification for "Reinforced Concrete Sewer-Storm Drain and Culvert Pipe (ASTM C76)", designed for flexible rubber gasket joints to ASTM C443. Sulfate resistant cement will be used.

3. Poly Vinyl Chloride (PVC) Pipe - PVC pipe will conform to the Standard Specification for "Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings (ASTM D3034)", CAN 3 – B182.1 and CAN 3 – B182.2 - minimum Class SDR 35, separate gasket and intergraded bell system. Joints will meet the Standard Specification "Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals (ASTM D3212)." Pipe may be any colour except blue.

4. Ultra-Rib PVC Pipe - Will conform to ASTM F794 and Uni-bell B-9, and fittings will conform to CSA B182.4 specifications. Pipe may be any colour except blue.

5. Manhole and Catchbasin Barrels, Cones & Rings - Manhole and catchbasin sections will conform to the Standard Specification for "Precast Reinforced Concrete Manhole Sections (ASTM C478)". All manhole barrels will be a minimum of 1200 mm inside diameter and all cones will be eccentric. Reducing rings or slabs may be used.

6. Manhole Frames & Covers - Manhole frames and covers will be of cast iron conforming to Class 20, ASTM C48 and have at least four (4) lift holes.

7. Manhole Steps - Manhole steps will be standard safety type of hot dipped 20 mm (3/4") galvanized iron spaced at 400 mm (maximum) distance.

8. Manhole Bases - Manhole bases will be reinforced precast slabs, vault or precast tees (reinforced). The concrete base is to be of a minimum of 150 mm in thickness constructed on compacted granular material or undisturbed native material. Perched manhole bases will be a minimum of 200 mm in thickness.

9. Catchbasin leads - corrugated steel pipe, 1.6 mm wall thickness conforming to CAN 3-6401 with watertight couplers with rubber gaskets conforming to ASTM C361M, or ultra-rib PVC pipe and fittings meeting CSA B182.4, ASTM F794 and uni-bell Uni B-9, with a minimum pipe stiffness of 320 kPa as measured in accordance with ASTM D2412.

C3.2 Aggregates:

Note: The requirements for this section will also apply to sanitary sewers, watermains and other utility pipe installation.

1. Bedding Sand - All bedding sand must be clean and meet the following requirements:

Sieve Size Passing	% Passing, By Mass
2,500	100
630	60 or more
315	30 or less
160	20 or less

2. Mortar Sand - All mortar sand will be clean, contain no deleterious material and conform to CAN 3-AS-M, Sulphate resistant (type 50).

3. Washed Rock - Washed rock must be washed and will contain no deleterious materials or other impurities and will meet the following grading requirements:

Sieve Size Passing	% Passing, By Mass
25,000	100
5,000	10
80	2

4. Backfill Sand & Gravel - Sand and gravel used for backfill will be well graded and approved by the County before use.

5. Concrete - Concrete will meet the specifications outlined in Section G - 8 Transportation and other applicable sections of these standards. Sulfate resistant cement will be used unless otherwise approved.

6. Developer's Responsibility for Material - Only approved materials are to be incorporated into the Work. The Developer will be responsible for all materials furnished by them and will produce certification by an independent testing authority that the materials used conform to the standards. The developer will be responsible for the safe transit, delivery and storage of all materials, and any found to be unsatisfactory will be promptly replaced. Unapproved materials will be removed and replaced with acceptable materials, all at the Developer's expense.

C3.3 Excavation:

Note: The requirements for this section will also apply to sanitary sewers, watermains and other utility pipe installation.

1. The trench will be excavated to the line and grade stipulated on the Contract drawings to a depth necessary to accommodate the bedding. The base under each bell must be hollowed sufficiently to allow bearing throughout its entire length. Where the trench has been excavated, it must be properly refilled to the

correct level with approved material, properly compacted. The Contractor will not use blocks or any other such items to raise the pipe to the required elevation, unless concrete bedding is being used and with the approval of the County. The trench will be braced and drained when necessary. Adjacent property will be protected at all times.

2. Trench walls will be vertical to 300 mm above the top of pipe.

3. The maximum trench width for single pipe will be:

Pipe Diameter	Max. Trench Width
Less than 750 mm diameter	O.D. + 450 mm
750 mm diameter or larger	O.D. + 600 mm

C3.4 Bedding:

Note: The requirements for this section will also apply to sanitary sewers, watermains and other utility pipe installation.

The pipe will be laid in the class of bedding shown on the plans as specified herein.

1. Class "A" - Method of bedding on which the lower part of the pipe exterior is set in concrete of suitable thickness to encase at least one quarter of the pipe diameter for the full trench width. Compacted sand will be placed to a minimum depth of 300 mm above the top of the pipe.

2. Class "B" - Method of bedding in which the pipe is set in compacted sand or gravel, as specified, on a trench bottom shaped to fit the pipe. The pipe is entirely encased with sand to a minimum of 300 mm above its top in layers not exceeding 150 mm in thickness. Depth of bedding below the pipe to be a minimum of 75 mm for 675 mm diameter pipe or smaller at 100 mm for pipe 750 mm diameter or greater.

3. Class "C" - Method of bedding in which the pipe is placed on an earth foundation shaped to fit the lower part of the pipe. The remainder of the pipe is encased in sand compacted to a height of at least 150 mm above the top of pipe.

4. Class "D" - Method of bedding in which the foundation is not shaped to fit the lower part of the pipe but the pipe must be evenly supported throughout its length (except for the pipe bells).

C3.5 Pipe Laying:

Note: The requirements for this section will also apply to sanitary sewers, watermains and other utility pipe installation.

1. Install pipe to the prescribed grade in accordance with manufacturer's standard instructions and specifications.

2. Pipe will not be deflected either vertically or horizontally in excess of that recommended by the manufacturer.

3. All jointing will be made between clean pipe ends

4. The trench must be kept dry during pipe laying operations and no water will be allowed to drain through the newly laid pipe for at least two hours where mortar joints have been used.

5. When pipe laying is not in progress, the open ends of installed pipe will be closed by an approved plug or cap to prevent entrance of trench water and/or any foreign or other material into the line.

6. Adequate backfill will be placed on the pipe to prevent floating. Any pipe which has floated will be removed from the trench and be re-laid as directed by the County.

7. No pipe will be laid in wet trench conditions that preclude proper bedding or on frozen trench bottom or when, in the opinion of the Engineer, the trench conditions or the weather are unsuitable for proper installation.

8. Each cast iron valve, hydrant, or fitting, will have a bell with an inside profile such that a seal can be made between the machined pipe end and the bell with a rubber ring. Fittings used with PVC pipe will be manufactured with a TYTON joint.

9. Before laying valves, hydrants or fittings, all lumps, blisters, and excess coating will be removed from the bell. The inside of the bell will then be wire-brushed and both the inside of the bell and the spigot end of the pipe wiped clean and dry. All surfaces to be joined will be kept clean until joints are made.

10. All bell and spigot joints will be sealed with rubber rings, unless otherwise approved in writing by the County. All defective joints will be cut out and entirely replaced with new material.

11. The cutting of pipe for closure to fittings, valves and other reasons will be done in a neat and workmanlike manner, without damage to the pipe and so as to leave a smooth end at right angles to the axis of the pipe. Pipe cutting for valves and fittings will be done accurately so as to bring all valves and fittings to their correct positions. Cut standard pipe used with rubber gasket joints will be field machined and chamfered as required by the manufacturer's instructions.

12. Upon completion, the storm sewer must be thoroughly cleaned.

C3.6 Backfilling & Compaction:

Note: The requirements for this section will also apply to sanitary sewers, watermains and other utility pipe installation.

1. General - Backfill material will be the soil excavated from the ditch or trench although sand or gravel may be substituted for poor existing soils. All backfill material will be subject to approval by the County. If possible, the excavated material will be placed back in the ditch in the vertical and horizontal order in which it was excavated. Backfill will be placed in uniform lifts not exceeding 300 mm loose depth. Where clay is used as backfill material, its moisture content will not exceed the Plastic Limit by more than fifteen percent (15%).

   Under no circumstances will backfill material within roadways contain ice, snow, straw, organic or frozen or other deleterious material be used.

2. Densities

   i) Prior to Street Construction - All excavations under proposed carriageways, sidewalks, street lights or other similar surface structures will be backfilled and compacted to minimum density of not less than 98% of the maximum standard Proctor Density or as otherwise approved by the County. Backfill will be placed in uniform lifts not exceeding 300 mm loose depth. A minimum of two density tests per 100 lineal meters of trench per 1.5 m of compacted backfill depth will be taken. Additional tests may be called for as deemed necessary. Any free water in a trench will be removed prior to placing additional lifts.

   ii) Under existing carriageways - All excavations under existing carriageways, sidewalks, lanes or other similar surface structures will be backfilled to meet the following specifications:

   - 300mm or more below final grade - compaction in this zone will be compacted to minimum density of not less than 98% of the maximum standard Proctor Density.
   - 0 - 300 mm below final grade - compaction in this zone will be to a minimum of 100% of the maximum standard Proctor Density and based on a minimum of two field tests per 100 lineal meters of trench of compacted backfill. Backfill will be placed in uniform lifts not exceeding 150 mm compacted depth.

3. Adjacent to existing carriageways - All material 300 mm below the finished grade will be compacted to a density not less than 95% of the maximum density of a five point Standard Proctor Compaction Test and based on a minimum of one field test per 150 lineal meters of trench for each 1.5 meters of compacted vertical backfill.

4. Sand or gravel backfill - Sand or gravel backfill will be compacted to meet the following density requirements:

   i) 300 mm or more below grade - the minimum acceptable density will be 98% of the maximum standard Proctor Density.

   ii) 0 - 300 mm below grade - all sand or gravel in this zone will compact to 100% of the maximum standard Proctor Density.

5. Water flushing - Water flushing will be permitted only under special circumstances, as approved in writing by the County.

6. Testing - For all density tests indicating insufficient compaction, two more density tests, proportionately representative of the ditch length tested, will be taken at that depth. If the average of the three tests is below the required density, the area of deficient density will be re-excavated and re-compacted to meet the specified density. Densities greater than 100% will be deemed to be at 100% for calculating the average of the three tests.

C4. INSPECTION

Note: The requirements for this section will also apply to sanitary sewers, watermains and other utility pipe installation.

C4.1 General:

All excavating, laying, joining of pipes, backfilling and completion of all works will be subject to inspection by the County of Lethbridge authorized representatives. Unsatisfactory conditions will be remedied at the Developer's expense. All equipment, tools and labor for testing will also be provided by the Developer at their expense.

C4.2 Video Sewer Inspection:

Prior to the Construction Completion Certificate Inspection, televising of all storm sewers will be completed. A video tape and written report will be submitted to the County's Operations Department. A written report indicating any deficiencies and recommending repair measures will be prepared within sixty (60) calendar days from the date of issuance of a Construction Completion Certificate.

C5. CULVERTS, STORM WATER POND FACILITIES & SPECIAL STRUCTURES

C5.1 Culverts:

1. Culverts will be placed so that the minimum distance from the finished grade of the roadway to the top of the pipe will be not less than one-half the diameter of the pipe or a minimum of 300 mm, whichever is greater, unless approved otherwise.

2. A trench will be excavated to the required depth and grade with the bottom shaped to conform to the bottom of the pipe to afford a firm and uniform bearing over the entire length of the culvert. If the material in the bottom of the excavation is unsuitable, the trench will be dug 100 mm below the grade as ordered, and backfilled with approved granular material and thoroughly tamped, or otherwise compacted, to ensure an unyielding foundation.

3. Where the trench is in solid rock or other hard material, it will be excavated to a depth of at least 100 mm below the grade established for the bottom of the pipe, and this additional excavation will be backfilled with suitable material in such manner as to ensure a uniform bearing for the length of the culvert.

4. Selected backfilling material, free from stones, frozen lumps, and other deleterious material, will be placed under and around the pipe and thoroughly tamped or otherwise compacted in place. The trench will be completely filled and the pipe covered to a depth of at least 300 mm with hand placed and properly compacted material before the construction of the embankment over the culvert proceeds.

5. If a trench is not required, the culvert pipe will be laid true to line and grade, on a bed that is uniformly firm throughout its entire length, and the backfilling, a minimum 100 mm granular over the pipe, will be completed as specified in the preceding paragraph.

6. When using corrugated pipe, the pipe will be laid in the trench with the separate sections firmly joined together and with outside laps of circumferential joints pointing upstream and with longitudinal laps on the side. Corrugated pipe will be so handled as to prevent bruising and scaling. In no case will pipe culverts be dragged on the ground.

7. Where it is necessary to remove any existing culvert or structures from the grade or right-of-way, the Developer will carefully remove and pile or place the materials as directed by the Engineer.

8. All drainage culverts will be rip-rapped at both inlet and outlet. The size and type of rip-rap will conform to good engineering practice and acceptable to the County.

9. Minimum size of roadway culvert will be 600 mm (wall thickness 1.6 mm or as required by the loading criteria).

10. Minimum size of entrance culvert will be 400 mm (wall thickness 1.6 mm or as required by the loading criteria).

C5.2 Storm Water Pond Facilities:

1. Detention facilities will be designed as part of both the minor and the major drainage systems. They must control the peak runoff conditions for events up to the 1-in-100 year return period.

2. Detention facilities become municipal property. The need for a specific detention facility will require the approval of the County. In assessing the need for specific detention facilities, the engineer must consider the impacts of uncontrolled drainage.

3. The ratio of land area for open space use around the pond will be twice the area of the water surface for the 1-in-100 year runoff event, unless approved otherwise.

4. Soils investigations specific to the detention facility will be undertaken to determine appropriate design factors. Where the facility is sited above a shallow aquifer or high water table, the potential for groundwater contamination must be minimized.

5. Wet pond detention facilities must be constructed in impervious soils to minimize water losses during dry weather periods. Intruding silt, sand or gravel seams must be sealed off.

6. Where a detention facility is to have multiple functions, its design must consider the aesthetic implications of shape, grading, landscape features and use.

7. An emergency overflow system will drain to a receiving watercourse, or outlet acceptable to the County, for storms greater than the 1:100 year event.

8. The effects of the maximum pond water levels will be considered in the design of the minor system and lot grading. The crown elevations of the pipes in the first manhole upstream of a facility will be at or above the maximum detention pond level during the 1-in-5 year storm event.

9. The maximum water level fluctuations for detention ponds in residential areas during the 1-in-100 year storm event will be 2.0 m. All inhabited building space, including basements, will be constructed above the 100 year flood level.

10. In design, wet ponds (retention) will:

    i) be located at local low points or adjacent to an existing water course;

    ii) have a minimum depth of 2.4m at normal water level;

    iii) have side slopes no steeper than 3:1 from the bottom of the pond to one and one-half meter below normal water level; from here to 5m (horizontal) beyond the 100 year flood level the side slopes will be no steeper than 7:1 (a slope of 4:1 will be considered if appropriate slope protection is constructed);

    iv) have inorganic shoreline treatment for 1.5m horizontal below and 3.0m horizontal above the normal water level (the edge treatment will be compatible with adjacent land use and consider safety, maintenance, access and erosion reduction);

    v) have inlets and outlets submerged below ice level and above the level of anticipated sediment accumulation (the invert will be at least 1.0m below normal water level);

    vi) have provision for sediment accumulation at the points of inflow, and for the later removal of the sediment;

    vii) address all safety issues;

    viii) have no dead bay areas;

    ix) have an annual volume exchange at least twice per year; and

    x) have an inspection manhole located no greater than 18m from shore on both the inlet and outlet lines;

    xi) have a 0.3m freeboard between the 1:100 year water level and area basements.

11. In design dry ponds (detention) will:

    i) be off-line storage areas designed to temporarily detain excess runoff and thereby reduce the peak outflow rates when a greater than 1-in-5 year rainfall event occurs;

    ii) have a low flow bypass for flows from minor events and be designed to meet current Alberta Environment guidelines. The maximum depth of storage in a dry pond for a 1-in-100 year rainfall event will be 1.5 m;

    iii) have a pond bottom graded to a minimum grade of 1.0% and will properly drain all areas after its operation;

    iv) be designed to have a maximum side slope of 5:1 (vertical) unless otherwise approved by the County;

    v) all inlet and outlet structures of the pond will have grates and accompanying hardware of corrosive resistant metal over their openings to preclude access by children and animals. These structures will be designed for a hydraulic capacity of twice the required capacity and address all safety and maintenance issues (particularly during operation);

vi) roadways can be considered as a temporary storage facility for major storm events as long as the ponding does not cause flooding of adjoining properties;

vii) the developer will provide equipment and documentation as required by the County for the maintenance of the storm water ponds;

viii) the pond's perimeter may require fencing in a manner approved by the County;

ix) have a 0.3m freeboard between the 1:100 year water level and area basements.

C5.3 Outfalls:

1. Obverts of outfall pipes will be at least 150 mm above the 1-in-5 year flood level in the receiving watercourse. Inverts of outfall pipes will be above the winter ice level. Otherwise, outfall pipes will be submerged below the bottom of ice level. In addition, outfalls will be located to avoid damage from moving ice during breakup.

2. Drop structures, slope protection material and energy dissipaters will be used where necessary to prevent erosion.

3. Facilities must be provided which will prevent entry by children and animals.

C5.4 Receiving Waters:

1. Measures must be incorporated in new developments to prevent any increase in the amount of downstream erosion.

2. If a development causes downstream erosion despite the use of on-site peak runoff rate controls, appropriate mitigating measures are to be taken in the downstream areas.

3. Preservation of watercourse aesthetics and wildlife habitat must be considered in erosion and bank stability work.

C6. RIP RAP

When required by the plans, or as ordered by the Engineer, embankments, the ends of culverts and ditch bottoms will be protected by rip-rap as directed. This item consists of supplying materials and constructing a protective covering of approved stone or sacked concrete on an earth bed, granular filter blanket or filter fabric in accordance with these specifications. Rip-rap will be constructed at the locations and in conformity with the lines and grades shown on the plans or as designated by the Engineer.

The developer will supply all rip-rap materials including filter fabrics. The materials supplied will be subject to the approval of the Director.

The County reserves the right to select an independent testing firm to conduct visual inspections and testing, and compile its own data during or after the construction period. Any costs associated with inspections and testing conducted by the County for areas that fail initial testing will be borne by the developer and taken from the security held by the County. These results will be made available to the developer and Engineer. This quality

assurance testing program does not relieve the developer of their responsibility to conduct their own quality control testing program.

C6.1 Type of Rip-Rap:

1. Stone Rip-Rap - materials will consist of sound, hard and dense stones, boulders or quarry rocks resistant to the action of air and water and free from seams, cracks or other structural defects. The particles will be generally of equal dimensions in all directions, with a minimum of flat and/or elongated particles.

   i) Stone rip-rap used for corrugated steel pipe culverts, ditch checks and ditch blocks will meet the requirements of "Normal Stone Rip-Rap". Normal stone rip-rap will consist of particles having dimensions of not less than one hundred and fifty (150) millimeters in any one direction.

   ii) Stone rip-rap materials used for corrugated structural plate pipe culverts, bridges, and major stream bank protection will meet the requirements for "Heavy Stone Rip-Rap" or "Armour Stone Rip-Rap".

   Heavy Stone Rip-Rap:

Weight of stones (Kg.)	Percentage
400 - 600	40 - 60
200 - 400	20 - 40
25 - 200	10 - 30
Under 25	0

   Armour Stone Rip Rap:

Weight of stones (Kg.)	Percentage
600 - 900	60 - 70
300 - 600	20 - 30
100 - 200	10 - 20
Under 100	0

2. Hand Laid Rip-Rap - Hand laid rip-rap will be sound, durable stones and in no case measure less than 150 mm. The stones will be placed with their beds at right angles to the slope, with larger stones used in the bottom courses, and the smaller stones at the top. They will be laid in close contact so as to break joints, and in such manner that the weight of the stone is carried by the earth and not by the adjacent stones. The spaces between the larger stones will be filled with spalls, securely rammed into place. The finished work will present an even, tight, and reasonably plain surface, varying not more than 75 mm from the required contour.

3. Random Rip-Rap - Random rip-rap, graded so that the smaller stone is uniformly distributed throughout the mass, will be dumped randomly over the areas until the required depth is attained. The occasional manual handling of rocks or stones will in no manner be construed to transform the classification of random rip-rap into that of hand laid rip-rap.

4. Sacked Concrete Rip-Rap - granular material will be used for the concrete and consist of a well graded gravel with a maximum particle size of seventy-five (75) millimeters. Sacks will be manufactured from burlap and will have a capacity of

approximately 0.03 cubic metres. The cement will be Portland Cement conforming to the latest C.S.A. Specifications A5, type 1.

C6.2 Construction:

1. Preparation of foundation: Aprons and slopes to be rip-rapped will be excavated as shown on the Plans or as designated by the Director. The foundation bed will be fine graded to form a uniform and even surface. Granular filter blankets or filter fabrics when required by the Director will be placed as specified by the Director. A thin lift of fine grained material will be placed over filter fabric to prevent damage to the fabric by the stones.

2. Hand placed rip-rap: The stones, boulders or quarry rocks will be placed by hand to conform to the lines and grades as shown on the Plans or designated by the Director. The stones will be firmly bedded into the bed and against adjoining stones and smaller stones used to fill in the voids. Hand placing will generally be designated for Normal Stone Rip-Rap.

3. Machine placed rip-rap: The stones, boulders or quarry rocks will be sorted and placed by machine to produce a uniform blanket or rip-rap conforming to the lines and grades shown on the Plans or designated by the Director. The equipment used will be capable of handling and positioning individual rip-rap particles. Machine placing will generally be designated for Heavy Stone Rip-Rap and Armour Stone Rip-Rap.

4. Random rip-rap: The stones, boulders or quarry rock will be dumped onto the surface to be rip-rapped and sufficient hand and/or machine work will be done to produce a uniform mat conforming with the lines and grades shown on the Plans or designated by the Director. Random placing may be designated for all types of stone rip-rap.

5. Sacked concrete rip-rap: The Director will establish the mix design for the concrete to be used and it will be based on a minimum compressive strength of fourteen (14) MPa after 28 days. Each burlap sack will be filled with at least forty (40) kilograms of concrete and securely stapled or tied with wire ties. Within one half hour after mixing of the concrete, the filled sacks will be placed in their final position on the prepared base and packed into conformance with the base and the adjacent sacks already in place. The pattern to which the sacks are laid will be as required by the Plans or as designated by the Director. Following placing, the sacked concrete rip-rap will be kept moist for 24 hours by sprinkling or by covering with at least one hundred (100) millimeter thickness of moistened earth.

C7. DITCHES

C7.1 Cross Section Elements for Ditches

i) Sideslope and backslope of channels or ditches will be 3:1 minimum.

ii) For a flat bottom ditch, the minimum width will be 1 metre for local and collector roads and a minimum of 3 meters for arterials, unless otherwise approved by the Engineer.

iii) Minimum depth of ditch will be 1.0 meter.

iv) All drainage channels will be topsoil and seeded. In channels, ditches and slopes that are highly susceptible to erosion, sodding will be provided, or other erosion treatments as recommended by the Engineer and approved by the County.

C7.2 Ditch Checks

1. Ditch checks are required for any ditch that has a 4% or greater grade. This ditch check will be considered as part of the design of the subdivision and addressed in the storm water management plan.

2. Ditch checks will be of a permanent nature and will be maintained by the Developer until final acceptance of the subdivision of the Municipality. The distance between ditch checks will be a minimum of 5 m from any culvert invert; and have a maximum spacing of 20 m.

3. Ditches with grades exceeding 3% must include erosion control design measures.

C8. GRADING

C8.1 General:

The intent is to achieve a proper relationship and balance between the street elevation, building grade elevation, surrounding development and existing topography. Basic to the grading design of lots is the selection of the proper building plan to meet and complement the land it is situated on.

Site grading will be done to ensure proper drainage of private property and to establish an adequate drainage system for the entire development.

The criteria recommended for the major system are:

1. provide a level of protection for the 1-in-100 year frequency;
2. no damage to structures due to flooding;
3. continuous road grades or overflow easements to open areas.

C8.2 Design:

1. Lot Grading (Urban Conditions)
    1. The finished grade elevation at buildings are to be based upon CMHC guidelines found under "Finished Grade Elevation at the Building for Residential Lots".

    2. Back-to-front drainage must be the standard practice in laneless subdivisions. They must be graded to achieve a minimum slope of 2% or greater away from buildings and along the lot lines. Provisions must be made to keep the runoff at least 3 meters away from buildings where practical.

    3. Split drainage or front-to-back drainage may be allowed when a road, lane or public right-of-way exists at both the front and back of the lot, or as approved otherwise by the County.

    4. Reserves and public lands will be graded to drain towards developed roadway, lanes and/or the storm drainage system according to a specific landscape or site plan submitted by the Developer and approved by the County.

5. The construction of all overland drainage control will be completed to the satisfaction of the County, in accordance with approved plans, prior to the issuance of the construction completion certificate for storm sewer mains.

C9. PLANS

C9.1 General:

All construction plans will conform to the standards outlined in Section B of this Manual.

C9.2 Plan Submission:

A description of existing and proposed storm sewer facilities and areas served must be submitted, including the following information as required:

1. Soils Reports
2. Stormwater Management Design Report
3. Storm Flow Computations (including catchment areas) using the Rational Method and/or computer modeling analysis
4. Approved drawings for all crossings

Prior to the issuance of the Final Acceptance Certificate, the following will be submitted:

1. Recent Plans
2. Maintenance & Operations Manuals
3. Video Inspection Reports
4. Registered easements and caveats

C9.3 Detail Plans:

At least four (4) copies of the Plans as amended pursuant to the requirement of the County will be supplied to the County after final approval, before any construction work will be authorized. Plans and profiles will show:

1. Location of streets and storm sewers within same.
2. Details of all storm sewer appurtenances (special manholes or junctions, inspection chambers, inverted siphons, sampling devices, weirs, etc.)
3. Details of special protection for pipe where high velocities are encountered.
4. Drawings for crossing permits for any oil, power, gas or other transmission lines or railways.