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Unrealistic Roughness Coefficient Could Impair Pipe Capacity

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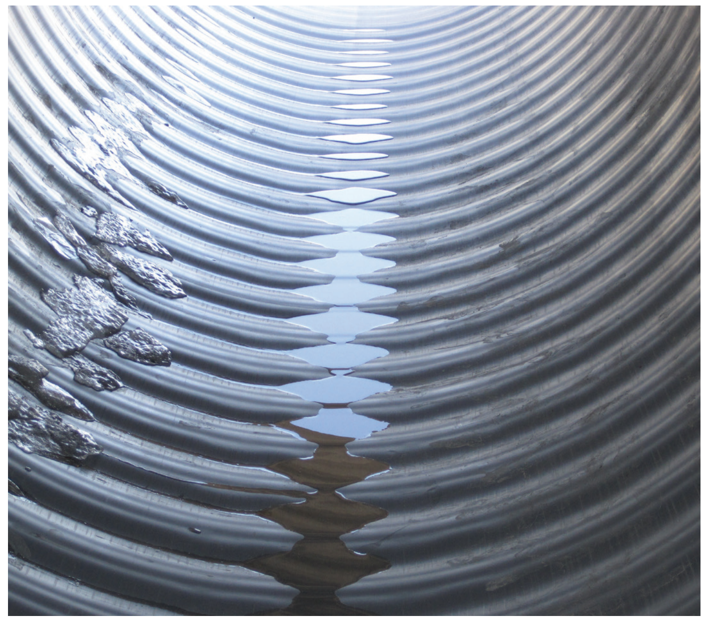
Due to factors like climate change and intensified urban development, insurance claims in Canada from water damage exceed claims from fire, theft, and other natural disasters combined. This is compounded by the fact that the average cost of each home insurance claim is rising significantly because more homeowners are furnishing their basements as a living space. This has prompted the Insurance Bureau of Canada to recognize the need to better understand their exposure from municipal-side factors and motivated them to develop the Municipal Risk Assessment Tool (MRAT), a pilot project which assesses the impact of severe weather events on urban drainage systems and identifies where potential municipal infrastructure vulnerabilities may exist.

One aspect of sewer and culvert design which may come under scrutiny is how the Manning formula is used to determine a pipe size that is sufficient to carry a design peak flow. More specifically, design engineers need to use an appropriate flow resistance coefficient, or Manning's *n* roughness coefficient. As indicated in Table 1, many jurisdictions across Canada seem to agree that a Manning's *n* Value of 0.012 or 0.013 is appropriate for all smooth wall pipe, which includes concrete, PVC, and HDPE pipe with a smooth interior surface. Surprisingly, a small number of Canadian municipalities are willing to ignore the best practices adopted by many of these jurisdictions and still allow the use of a Manning's *n* Value as low as 0.009 for plastic pipe.



Corrugation growth in plastic pipe impacts Manning's n Value

Design engineers must keep in mind that the Manning formula, developed in 1890, is an empirical relationship with a roughness coefficient *n* Value that actually varies with pipe size, slope of the pipe, and flow depth. Engineers must also recognize that the Manning's *n* Value of 0.009, recommended by the plastic pipe industry, is derived from laboratory studies that examined small pipe sizes, or is based on clean water flowing through short sections of new pipe, not in-service sewers. Similar laboratory studies with concrete pipe have also resulted in Manning's *n* Values of 0.009, however the concrete pipe industry has traditionally promoted the use of a more conservative *n* Value to account for the differences between laboratory testing and actual installed conditions.

Table 1 – Authorities Recommending the Same Manning's *n* Value for All Smooth Wall Pipe

Jurisdiction	*n* Value	Specification
British Columbia	0.013	Master Municipal Construction Document (MMCD) – Municipal Infrastructure Design Guidelines
Edmonton, AB	0.013	City of Edmonton – Design & Construction Standards Vol. 3
Saskatchewan	0.012	Ministry of Highways & Infrastructure – Hydraulic Manual
Regina, SK	0.013	City of Regina – Development Standards Manual
Winnipeg, MB	0.013	City of Winnipeg – Wastewater Design Guidelines
Ottawa, ON	0.013	City of Ottawa – Sewer Design Guidelines
Ontario	0.013	Ontario Ministry of the Environment – Design Guidelines for Sewage Works
Ontario	0.012	Ontario Ministry of Transportation – Gravity Pipe Design Guidelines, Circular Culverts & Storm Sewers
Québec	0.013	Ministère du Développement durable, Environnement et Lutte contre les changements climatiques – Directive 004
US Federal Hwy Administration	0.012	FHWA – Hydraulic Design of Highway Culverts
Great Lakes-Upper Mississippi River region	0.013	Ten State Standards – Recommended Standards for Wastewater Facilities

Engineers familiar with pipe design know that flow resistance in a pipe is significantly affected by more factors than just the pipe material. Based on lab experiments, field studies, and hydraulic theory, it is evident that all hydraulically smooth wall pipes should be designed with the same Manning's *n* Value, regardless of pipe material. For a simplified and conservative method of estimating pipe capacities and flow velocities in actual working conditions, a constant Manning's *n* Value of 0.013 for all smooth wall pipe materials will account for the head losses at manholes, pipe joints and fittings, and alignment changes. Sediment deposits and slime buildup inside an in-service pipe also results in the roughness coefficient to be essentially the same for all pipe materials.

Plastic pipe in service will experience ring deflection from external loads with a slight reduction in cross sectional area from a circular to elliptical shape and a flattened bottom. Plastic pipe with an open profile wall (smooth inside layer with corrugated outside layer) also has a thin inner or waterway wall thickness which gives it a wavy appearance and could experience corrugation growth over time. The actual inside diameter of a PVC or HDPE pipe is also generally smaller than a concrete pipe for most nominal pipe sizes. Using a Manning's *n* Value as low as 0.009 will result in a false notion that a smaller diameter plastic pipe could carry the required peak flow; however, this effort to achieve a more economical sewer design can actually result in a hydraulically inadequate pipe.

Any jurisdiction that still allows the use of an unrealistically low Manning's n roughness coefficient for a sewer or culvert design may be unintentionally putting its own infrastructure and residents at risk of future sewer backups and flooded basements.