

Design of Gravity Sewers Checklist

Review Engineer: _____
 Application No.: _____
 Received Date: _____
 Project Name: _____
 Owner: _____
 Consultant: _____
 Scope of Project: _____

This checklist is a guideline to the requirements set forth in 10 CSR 20-8. Marking the YES box indicates the design meets minimum requirements. Marking the NO box requires further investigation by the review engineer and possibly additional information from the consultant. Deviations from minimum requirements may be approved with documentation supplied by the consultant that contains sufficient justification.

YES	NO	N/A	Submittal	Citation
			Approved Facility Plan or Engineering Report.	8.110(3)(C)
			Construction application for sewer extension. (Sewer Extension)	
			Construction Permit Fee of \$75 (≤ 1,000 linear feet).	6.011 Appendix A
			Construction Permit Fee of \$300 (> 1,000 linear feet or construction of a pump station).	6.011 Appendix A
			Continuing authority written approval letter.	6.010(3)(A)
			Summary of Design. (Summary of Design Guidance for Facilities with a Design Flow of 22,500 gpd or Greater)	8.110(5)
			Plans and Specifications signed, sealed and dated by a professional engineer.	8.110(6)(A)2.

10 CSR 20-8.110 ENGINEERING – REPORTS, PLANS, AND SPECIFICATIONS

Plans				
YES	NO	N/A	Requirement	Citation
			Plan shows – <ul style="list-style-type: none"> • Municipality, sewer district or institution name; • Scale in feet; • Graphical scale; and • North point. 	8.110(6)(A)2.
			Plant format is clear, legible and scaled appropriately.	8.110(6)(A)3.
			Detail plans consist of – <ul style="list-style-type: none"> • Plan views; • Elevations and relative elevations of structures, equipment, piping, water level and ground; • Sections; • Supplementary views; and • General layouts. 	8.110(6)(A)4.
			Operation during construction is specified in construction documents.	8.110(6)(A)5.
			Plans show – <ul style="list-style-type: none"> • Existing and proposed sewers; 	8.110(6)(B)1.
			<ul style="list-style-type: none"> • Topography and elevations; • Existing or proposed streets; • All streams or water surfaces; • Contour lines at suitable intervals; 	8.110(6)(B)1.A.(I)

YES	NO	N/A	Requirement	Citation
			<ul style="list-style-type: none"> Flow direction with high and low water elevations in all streams and overflows; 	8.110(6)(B)1.A.(II)
			<ul style="list-style-type: none"> Boundary lines of the municipality or the sewer district and the area to be seweraged; and 	8.110(6)(B)1.A.(III)
			<ul style="list-style-type: none"> Location, size, and direction of flow of all existing and proposed sanitary and combined sewers draining to the treatment facility concerned. 	8.110(6)(B)1.B.
			Plan views and profiles are on same sheet with – <ul style="list-style-type: none"> Vertical scale \leq 10 ft/in; and Corresponding horizontal scale \leq 100 ft/in. 	8.110(6)(B)2.
			Plans and profiles show – <ul style="list-style-type: none"> Location of streets and sewers; 	8.110(6)(B)2.A.
			<ul style="list-style-type: none"> Line of ground surface; Pipe size, material and type; Pipe length and grade between manholes; Invert and surface elevation at each manhole; Special construction features; Corresponding manhole numbers on plans and profiles; 	8.110(6)(B)2.B.
			<ul style="list-style-type: none"> Statement that sewers are deep enough to serve adjacent basements; or The elevations and locations of the basements on the profile; 	8.110(6)(B)2.C.
			<ul style="list-style-type: none"> Locations of all special features – inverted siphons, concrete encasements, elevated sewers, etc.; 	8.110(6)(B)2.D.
			<ul style="list-style-type: none"> Existing structures and utilities above and below ground; Water mains, water supply structures (i.e., wells, clear wells, basins, etc.); Gas mains; Storm drains; and Telephone, cable and power conduits. 	8.110(6)(B)2.E.
			Special detail drawings show – <ul style="list-style-type: none"> Stream crossings with elevations of the stream bed and high, normal and low water levels; 	8.110(6)(B)2.F.(I)
			<ul style="list-style-type: none"> Special sewer joints and cross-sections; and All sewer appurtenances – (i.e. manholes, lampholes, inspection chambers, inverted siphons, regulators, tide gates, elevated sewers, etc.). 	8.110(6)(B)2.F.(II)
Specifications				
			Date, PE signature and seal. Sent in with the plans.	8.110(7)(A)
			Construction information not shown on drawings.	8.110(7)(B)
			Specifications include – <ul style="list-style-type: none"> Type, size, strength, operating characteristics and rating of equipment; Allowable infiltration; Requirements for all mechanical and electrical equipment, including machinery, valves, piping and jointing of pipe; Electrical apparatus, wiring, instrumentation and meters; Laboratory fixtures and equipment; Operating tools; Construction materials; Special filter materials such as stone, sand, gravel or slag; Miscellaneous appurtenances; Chemicals when used; Instructions for testing materials and equipment; and Performance tests at design load for the completed facilities and component units. 	8.110(7)(C)

10 CSR 20-8.120 DESIGN OF GRAVITY SEWERS

Approval of Sewers																																				
YES	NO	N/A	Requirement	Citation																																
			Sewer design excludes rainwater from roofs, streets and other areas and groundwater from foundation drains.	8.120(3)																																
Design Capacity and Design Flow																																				
			Sewer capacities designed on estimated ultimate tributary population.	8.120(4)(A)																																
			Economic analysis of alternatives is required when design is for future relief sewers.	8.120(4)(A)																																
			Required sewer capacities consider –	8.120(4)(A)1.A.																																
			• Design peak hourly flow;	8.120(4)(A)1.B.																																
			• Industrial plants maximum wastewater or waste flow;	8.120(4)(A)1.C.																																
			• Inflow and infiltration (I/I);	8.120(4)(A)1.D.																																
			• Topography of area;	8.120(4)(A)1.E.																																
			• Location of wastewater treatment facilities;	8.120(4)(A)1.F.																																
			• Depth of excavation; and	8.120(4)(A)1.G.																																
			• Pumping requirements.	8.120(4)(A)1.G.																																
			Facility Plan/Engineering Report includes design basis.	8.120(4)(A)2.																																
			Flows based on design peak hourly flow and designed to prevent or eliminate SSOs.	8.120(4)(B)																																
Details of Design and Construction																																				
			8" in diameter minimum gravity sewer pipe.	8.120(5)(A)																																
			Sewer deep enough to receive wastewater from basements and covered with at least 36" of soil, other insulation or material.	8.120(5)(B)																																
			Buoyancy considered and appropriate construction, where high groundwater conditions are anticipated.	8.120(5)(C)																																
			Velocity \leq 2 fps when flowing full. Minimum slopes –	8.120(5)(D)1.																																
			<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Nominal Sewer Size</th> <th>Minimum Slope in Feet Per 100 Feet</th> </tr> </thead> <tbody> <tr><td>8"</td><td>0.40</td></tr> <tr><td>10"</td><td>0.28</td></tr> <tr><td>12"</td><td>0.22</td></tr> <tr><td>14"</td><td>0.17</td></tr> <tr><td>15"</td><td>0.15</td></tr> <tr><td>16"</td><td>0.14</td></tr> <tr><td>18"</td><td>0.12</td></tr> <tr><td>21"</td><td>0.10</td></tr> <tr><td>24"</td><td>0.08</td></tr> <tr><td>27"</td><td>0.067</td></tr> <tr><td>30"</td><td>0.058</td></tr> <tr><td>33"</td><td>0.052</td></tr> <tr><td>36"</td><td>0.046</td></tr> <tr><td>39"</td><td>0.041</td></tr> <tr><td>42"</td><td>0.037</td></tr> </tbody> </table>		Nominal Sewer Size	Minimum Slope in Feet Per 100 Feet	8"	0.40	10"	0.28	12"	0.22	14"	0.17	15"	0.15	16"	0.14	18"	0.12	21"	0.10	24"	0.08	27"	0.067	30"	0.058	33"	0.052	36"	0.046	39"	0.041	42"	0.037
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			Designed for velocity \geq 3 fps, based on Manning's formula using an "n" value of 0.013 when flowing full for sizes not included in table.																																	
			Slopes < table values –																																	
			• Depth of flow \geq 1/3 diameter for design average flow;																																	
			• Flow computations in engineering report/facility plan; and																																	
			• Written assurance from the operating authority that additional maintenance will be provided as required.																																	
			Pipe not oversized to justify using flatter slopes.																																	
				8.120(5)(D)1.																																
				8.120(5)(D)2.																																
				8.120(5)(D)3.																																

YES	NO	N/A	Requirement	Citation
			For slope < table values for smallest pipe – <ul style="list-style-type: none"> Section calculations for actual depths and velocities at minimum, average and design maximum day and peak hourly flow. 	8.120(5)(D)3.
			Sewers have uniform slope between manholes.	8.120(5)(D)4.
			Velocity >15 fps – special provision protect against displacement by erosion and impact.	8.120(5)(D)5.
			Sewers slope ≥ 20% anchored securely with concrete anchors or equal, spaced as follows: <ul style="list-style-type: none"> ≤ 36' center-to-center on grades 20% to 35%; ≤ 24' center-to-center on grades 35% to 50%; and ≤ 16' center-to-center on grades 50% and over. 	8.120(5)(D)6.
			Straight alignment between manholes with sewers ≤ 24" and checked using a laser beam or lamping.	8.120(5)(E)1.
			Curvilinear alignment of sewers > 24" – <ul style="list-style-type: none"> Specify compression joints; Within ASTM or manufacturers' maximum allowable joint deflection limit; Simple curves that start and end at manholes; and Calculated velocity ≥ 2 fps when flowing full, not table values; 	8.120(5)(E)2.
			Changes in pipe size requires – <ul style="list-style-type: none"> Manhole when a smaller sewer joins a larger one; Energy gradient maintained through manhole; and Invert of pipes 0.8 depth point at the same elevation. 	8.120(5)(F)
			Sewer extensions designed for projected flows.	8.120(5)(F)2.
			Manholes constructed to minimize turbulence where receiving sewer size < proposed extension.	8.120(5)(F)2.
			Future downstream relief sewer construction schedule.	8.120(5)(F)2.
			Sewer material appropriate for local conditions.	8.120(5)(G)
			Pipe and joint materials conform to ASTM specifications.	8.120(5)(G)1.
			Couplings joining dissimilar materials comply with ASTM specifications and meet leakage limitations in 8.120(5)(I).	8.120(5)(G)2.
			Sewer designed to prevent damage from superimposed live, dead, and frost induced loads (considering soil and potential groundwater conditions, width and depth of the trench).	8.120(5)(G)3.
			Special construction to withstand anticipated potential superimposed loading or loss of trench wall stability. See ASTM D2321 or ASTM C12.	8.120(5)(G)3.
			Basis of material and installation specs for pipes or joints without ASTM standards on criteria certified in writing by the manufacturer.	8.120(5)(G)4.
			Installation specifications based on industry established standards.	8.120(5)(H)
			Trench – <ul style="list-style-type: none"> Wide enough to properly lay/joint pipe, and place/compact bedding and haunching; Sides nearly vertical; and Appropriate bedding class and pipe strength used for wider trenches. 	8.120(5)(H)2.A.
			Minimum trench width calculations in unsupported and unstable soil consider – <ul style="list-style-type: none"> Size and stiffness of the pipe; Stiffness of the embedment; In situ soil; and Depth of cover. 	8.120(5)(H)2.B.
			Remove ledge rock, boulders and large stones to ≥ 4" below and on each side of all pipe(s).	8.120(5)(H)2.C.
			Dewater excavations or other parts of the work until complete. Trench water does not reach existing pumping stations or wastewater treatment facilities.	8.120(5)(H)2.D.
			Bedding, haunching and initial backfill – <ul style="list-style-type: none"> Rigid pipe – Bedding Classes A, B, C or crushed stone, as described in ASTM C12; 	8.120(5)(H)3.A.
			<ul style="list-style-type: none"> Ductile iron pipe – Bedding and initial backfill, as described in ASTM A746 for Type 1 through Type 5 laying conditions; 	8.120(5)(H)3.B.

YES	NO	N/A	Requirement	Citation
			<ul style="list-style-type: none"> Plastic and flexible pipe – Bedding, haunching and initial backfill, Classes I, II or III, as described in ASTM D2321; and 	8.120(5)(H)3.C.
			<ul style="list-style-type: none"> Composite pipe – Same as plastic pipe except as described in ASTM D2680. 	8.120(5)(H)3.D.
			Final backfill – <ul style="list-style-type: none"> Uses suitable material removed from excavation except where other material is specified; Within 2' of the top of the pipe backfill free from – <ul style="list-style-type: none"> Debris, frozen material, large clods, stones, organic matter or unstable materials; and 	8.120(5)(H)4.A.
			<ul style="list-style-type: none"> Placed in such a manner as not to disturb the pipe alignment. 	8.120(5)(H)4.B.
			Deflection tests – <ul style="list-style-type: none"> Performed on all flexible pipe; Conducted after the final backfill has been in place at least 30 days; 	8.120(5)(H)5.A.
			<ul style="list-style-type: none"> Pipe deflection \leq 5% or excavate and replace/correct per approved specs; 	8.120(5)(H)5.B.
			<ul style="list-style-type: none"> Performed without mechanical pulling devices; and Rigid ball or mandrel has a diameter \geq 95% of the base ID or average ID of the pipe per the ASTM specification. Mandrel has \geq 9 flutes or points. 	8.120(5)(H)5.C.
			Joints and infiltration – <ul style="list-style-type: none"> Specs include joint materials and installation; and Designed to minimize infiltration and prevent roots from entering. 	8.120(5)(I)1.
			Service connections – <ul style="list-style-type: none"> Watertight and not protrude into the sewer; Saddle-type connection designed for the type of pipe(s) which are to be connected; and Materials are compatible and corrosion proof. 	8.120(5)(I)2.
			Leakage tests – <ul style="list-style-type: none"> Include appropriate water or low pressure air testing; and Consider the range in groundwater elevations. 	8.120(5)(I)3.
			Water (hydrostatic) test – <ul style="list-style-type: none"> Leakage \leq 100 gal/inch diameter/mi/day between manholes; and Performed with a minimum positive head of 2'. 	8.120(5)(I)4.
			Air test procedures – <ul style="list-style-type: none"> ASTM C828 for clay pipe; ASTM C924 for concrete pipe 24" or less in diameter; ASTM C1103 for concrete pipe 27" or greater in diameter; ASTM F1417 for plastic, composite and ductile iron pipe; and Other pipe procedures approved by the department. 	8.120(5)(I)5.
			Alternative installation methods (Trenchless Technologies) evaluated on a case-by-case basis.	8.120(5)(J)
Manholes				
			Manholes – <ul style="list-style-type: none"> At the end of each line; 	8.120(6)(A)1.A.
			<ul style="list-style-type: none"> At all changes in grade, size or alignment; 	8.120(6)(A)1.B.
			<ul style="list-style-type: none"> At all sewer pipe intersections; 	8.120(6)(A)1.C.
			<ul style="list-style-type: none"> At distances \leq 400' for sewers 15" or less; 	8.120(6)(A)1.D.
			<ul style="list-style-type: none"> At distances \leq 500' for sewers 16" to 30"; and 	8.120(6)(A)1.E.
			<ul style="list-style-type: none"> Spacing $>$ 500' approved by the department in cases where adequate cleaning equipment can justify such spacing. 	8.120(6)(A)2.
			Cleanouts are not substituted for manholes nor installed at the end of laterals $>$ 150'.	8.120(6)(A)4.
			Drop type manhole – <ul style="list-style-type: none"> Sewer entering \geq 24" above the manhole invert. Filleted invert for sewer entering \leq 24"; 	8.120(6)(B)1.
			<ul style="list-style-type: none"> Outside drop; 	8.120(6)(B)2.
			<ul style="list-style-type: none"> Inside drop connections have manhole diameter large enough to attach 	8.120(6)(B)2.

YES	NO	N/A	Requirement	Citation
			drop to interior wall and provide access for cleaning;	
			<ul style="list-style-type: none"> Drop does not enter manhole at a joint; and 	8.120(6)(B)3.
			<ul style="list-style-type: none"> Outside drop connection encased in concrete. 	8.120(6)(B)4.
			Manhole diameter is – <ul style="list-style-type: none"> 42" on 8" diameter gravity sewers, 48" on sewer lines greater than 8"; and Larger diameters for larger sewers to maintain structural integrity. 	8.120(6)(C)
			Manhole access \geq 22".	8.120(6)(C)
			Straight flow channels – <ul style="list-style-type: none"> Conforms to shape and slope of sewers; and Doesn't obstruct maintenance, inspections or flow. 	8.120(6)(D)1.
			Curved flow channels – Slopes in 8.120(5)(D)1 increased to maintain acceptable velocities.	8.120(6)(D)2.
			Bench – <ul style="list-style-type: none"> On each side of manhole channel when the pipe diameter(s) < the manhole diameter; Sloped \geq 0.5 in/ft; and No discharge onto the surface of the bench. 	8.120(6)(E)
			Manholes – <ul style="list-style-type: none"> Are watertight; Are precast or poured-in-place concrete; <ul style="list-style-type: none"> Precast manholes conform to ASTM C478 and C497. 	8.120(6)(F)1.
			<ul style="list-style-type: none"> Lift holes, grade adjustment rings, precast joints and areas subject to infiltration are sealed watertight; and 	8.120(6)(F)2.
			<ul style="list-style-type: none"> Flexible watertight gasket connections join inlet and outlet pipes to the manhole. 	8.120(6)(F)3.
			Manhole covers – <ul style="list-style-type: none"> Watertight where the manholes may flood; and Surcharging manholes have bolt-down assemblies. 	8.120(6)(F)4.
			Inspection and Testing – <ul style="list-style-type: none"> Inspect for watertightness or damage prior service; 	8.120(6)(G)
			<ul style="list-style-type: none"> Vacuum testing, if specified for concrete sewer manholes, shall pass either ASTM C1244 or the manufacturer's recommendations. 	8.120(6)(G)1.
			<ul style="list-style-type: none"> Exfiltration testing, if specified for concrete sewer manholes, shall conform to ASTM C969. 	8.120(6)(G)2.
			Corrosion protection on manhole interior specified where corrosive conditions exist.	8.120(6)(H)
			Electrical equipment conforms to 10 CSR 20-8.130(4)(C)5.	8.120(6)(I)
Inverted Siphons				
			Inverted siphons – <ul style="list-style-type: none"> \geq 2 barrels, with a minimum 6" pipe; Appurtenances for maintenance, convenient flushing and cleaning; Inlet/discharge structures have adequate clearances for cleaning equipment, inspection and flushing; Sufficient head and appropriate pipe sizes to secure velocities of \geq 3 fps for design average flows; Inlet/outlet details divert design average flow to 1 barrel to allow each barrel out-of-service for cleaning; and Vertical alignment permits cleaning and maintenance. 	8.120(7)
Sewers in Relation to Streams				
			Cover – <ul style="list-style-type: none"> Top of sewers entering or crossing streams is below the natural bottom of the streambed; 1' of cover where the sewer is located in rock; \geq 3' of cover in material other than rock; and Top of the sewer line is below the bottom of paved stream channel. 	8.120(8)(A)1.

YES	NO	N/A	Requirement	Citation
			Horizontal sewers along streams are located sufficiently outside the stream bed.	8.120(8)(A)2.
			Sewer outfalls, headwalls, manholes, gateboxes or other structures don't interfere with stream flood flows.	8.120(8)(A)3.
			Sewer stream crossings are perpendicular to the flow with no change in grade.	8.120(8)(A)4.
			Minimized the number of stream crossings.	8.120(8)(A)5.
			Construction Materials – <ul style="list-style-type: none"> Ductile-iron pipe with mechanical joints used when entering or crossing streams; and Stone, coarse aggregate or washed gravel used to backfill trench. 	8.120(8)(B)1.
			Specifications include the construction method(s) used in or near streams. Specifications to include – <ul style="list-style-type: none"> Methods to minimize siltation and erosion; Immediate clean-up, grading, seeding, planting or restoration; and Exposed areas will not be unprotected for > 7 days. 	8.120(8)(B)2.
Aerial Crossings				
			Support all aerial crossing pipe joints. Supports prevent frost heave, overturning and settlement.	8.120(9)(A)
			Freeze protection provided for exposed pipe.	8.120(9)(B)
			Expansion jointing provided between above-ground and below-ground sewers.	8.120(9)(B)
			Special construction techniques used to minimize frost heaving where sewers change from buried to aerial.	8.120(9)(B)
			Considered the impact of flood water and debris. The bottom of the pipe placed \geq 50-year flood level.	8.120(9)(C)
			Ductile-iron pipe with mechanical joint for aerial crossings or constructed to be watertight and no changes in alignment or grade.	8.120(9)(D)
Protection of Water Supplies				
			Sewer system doesn't connect to a public or private potable water supply system.	8.120(10)(A)
			Water pipe doesn't pass through or come in contact with any part of a sewer manhole.	8.120(10)(A)
			Sewers meet the requirements of 10 CSR 23-3.010 with respect to minimum distances from water supplies. <ul style="list-style-type: none"> Existing waterworks units \leq 200' of sewer shown on plans. 	8.120(10)(B)1.
			Sewer in relation to water mains – <ul style="list-style-type: none"> No cross connections; Placed in separate trenches; \geq 10' horizontal separation; When above impossible – water on an undisturbed earth shelf and bottom of water main \geq 18" above the top of the sewer; and 	8.120(10)(C)1.
			<ul style="list-style-type: none"> When it is impossible to obtain above – sewer must be constructed of slip-on or mechanical joint pipe or continuously encased and pressure tested to 150 psi to assure watertightness. 	8.120(10)(C)1.B.
			Manholes located \geq 10' horizontally from existing/proposed water main.	8.120(10)(C)1.C.
			Sewers crossing water mains – <ul style="list-style-type: none"> Vertically \geq 18" apart; Joints are equidistant and as far as possible from water main joints; and Structural support provided for sewer crossing over water main. 	8.120(10)(C)2.A.
			Specify 1 of the following when it is impossible to obtain proper horizontal and vertical separation: <ul style="list-style-type: none"> Sewer designed and constructed equal to water pipe and pressure tested to assure watertightness prior to backfilling; or 	8.120(10)(C)2.B.(I)
			<ul style="list-style-type: none"> Water main or sewer line continuously encased or enclosed in a watertight carrier pipe of approved material which extends 10' in both directions, measured perpendicular to the water main. 	8.120(10)(C)2.B.(II)

Material Standard Recommendations:

Rigid and Ductile Iron Pipes	Material Specification	Joint Specification
Clay	ASTM C700	ASTM C425
Non-Reinforced Concrete	ASTM C14	ASTM C443
Reinforced Concrete	ASTM C76 ASTM C655	ASTM C443
Ductile Iron	ASTM A746 AWWA C151	ASTM A746 AWWA C111

Plastic Pipes	Material Specification	Joint Specification
Solid Wall PVC	ASTM D3034 (SDR < 35) ASTM F679	ASTM D3212
Open Profile PVC	ASTM F794	ASTM D3212
Closed Profile PVC	ASTM F1803	ASTM D3212
Corrugated PVC	ASTM F949	ASTM D3212 ASTM D2855
Polyethylene	ASTM D2239 ASTM D3035	ASTM D3261

Composite Pipes	Material Specification	Joint Specification
ABS and PVC Composite	ASTM D2680	ASTM D2680

Comments: _____

Legend:

- Fonts appearing in **green** are new requirements of 10 CSR 20-8.120.