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INTRODUCTION

(A) INTRODUCTION

The City of Boulder Design and Construction Standards (DCS) were developed to regulate the design and construction of public infrastructure, improvements and landscaping in the city's public rights-of-way and public easements. The DCS was originally adopted on July 2, 1998 to replace the Design Criteria and Standard Specifications adopted in July 1982. The November 16, 2000 update replaced the July 2, 1998 manual and addressed changes in engineering practices, construction technology, and city review processes. The update also attempts to clarify sections that have been identified as unclear or in error by users of the manual. Updates to chapters 1, 4, 5, 6, 7, 9 and 11 and the Glossary and References were adopted on May 21, 2019. These updates were related to utilities infrastructure and to comply with requirements of the city's State of Colorado Municipal Separate Storm Sewer System (MS4) permit. Updates to chapters 2 and 4 and the Glossary and References were adopted on January 7, 2020. These updates were related to transportation standards and drawings and a correction to the minimum utility separations table in Chapter 4. Updates to chapters 2, 3, 10, and 11 and the Glossary were adopted on January 2, 2023. These updates were related to transportation standards and drawings and landscape standards. Updates to the traffic study format for hazard assessment were adopted on December 18, 2023. Updates to chapter 2 for street lighting design were adopted on May 2, 2024. Updates to chapters 8, 9, and 11 were adopted on December 5, 2024. These updates were related to narrow trenching and utility potholing requirements and associated transportation restoration requirements. Updates to chapter 2 were adopted on July 24, 2025 to modify standards for motor vehicle and bicycle parking.

The DCS prescribe minimum standards to be used in the design and construction of public infrastructure located in public rights-of-way and public easements in the City of Boulder, and the design of private transportation and utility improvements, such as driveway cuts, utility services and onsite drainage systems, which are connected to or impact public infrastructure. The standards in the DCS are intended to provide for the public health, safety and welfare by ensuring the comprehensive design and construction of adequate and functional public improvements associated with developing, redeveloping and subdividing lands and providing necessary right-of-way, transportation and utility services. The DCS requirements reflect accepted and well-founded civil engineering practices, construction industry specifications and conformance with national safety standards and are consistent with current city ordinances, standards, policies and practices.

(B) DCS ADOPTION

The updated DCS was adopted at second reading by City Council on October 17, 2000, with the passage of City of Boulder Ordinance No. 7088. The May 2019 updated DCS was adopted at second reading by City Council on May 21, 2019, with the passage of City of Boulder Ordinance No. 8324.

Information regarding the adoption of Ordinance No. 7088 can be reviewed at the City of Boulder Central Records Office as part of the Planning Board agenda materials for September 7, 2000 and the City Council agenda materials for October 3, 2000 and October 17, 2000.

Information regarding the adoption of Ordinance No. 8324 can be reviewed at the City of Boulder Central Records Office as part of the Planning Board agenda materials for April 18, 2019 and the City Council agenda materials for May 7, 2019 and May 21, 2019.

Information regarding the adoption of Ordinance No. 8370 can be reviewed at the City of Boulder Central Records

Office as part of the Planning Board agenda materials for November 7, 2019 and the City Council agenda materials for December 3, 2019, December 17, 2019 and January 7, 2020.

Information regarding the adoption of Ordinance No. 8608 can be reviewed at the City of Boulder Central Records Office as part of the City Council agenda materials for November 2, 2023and November 16, 2023.

Information regarding the adoption of Ordinance No. 8631 can be reviewed at the City of Boulder Central Records Office as part of City Council agenda materials for April 11, 2024, and May 2, 2024.

Information regarding the adoption of Ordinance 8672 can be reviewed at the City of Boulder Central Records Office as part of City Council agenda materials for December 5th, 2024, and December 12th, 2024.

Information regarding the adoption of Ordinance 8696 can be reviewed at the City of Boulder Central Records Office as part of City Council agenda materials for June 5th, 2025, June 26th, 2025, and July 24th, 2025.

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1.01 General

(A) Intent

The Design and Construction Standards ("Standards") are intended to protect the public health, safety, and welfare in the provision and maintenance of public improvements within the City of Boulder "City"). These Standards apply to the comprehensive design and construction of adequate and functional public improvements associated with developing, redeveloping and subdividing lands and providing necessary right-of-way, transportation, and utility services.

(B) Scope

The City will review, approve, and monitor the design and construction of all public improvements within the public right-of-way or public easements to ensure compliance with these Standards. The City has the sole authority for approving, accepting, or denying the design and construction of any public improvement.

(C) Minimum Standards

(1) These Standards prescribe minimum requirements that shall be met or exceeded when designing and constructing all public improvements. Whenever the requirements of these Standards are found to be inconsistent with any other adopted standards, regulations, or codes, the more restrictive standards, regulations, or codes shall control. Reference to any code, regulation, standard, criterion, or manual of any technical society, organization, or association, or to any law or regulation of any governmental authority, whether such reference be specific or by implication, shall mean the most recently adopted or current law, code, regulation, standard, criterion, or manual in effect at the time of City approval of any project.

(2) The design of all public improvements shall be prepared by or under the direct supervision of a professional Engineer duly registered and licensed in the State of Colorado. The construction of all public improvements shall be performed in a professional and workmanlike manner by a contractor licensed by the City as set forth in Chapters 4-6, "Contractor in the Public Right of Way License," and 8-5, "Work in the Public Right-of-Way and Public Easements," Boulder Revised Code, 1981. The City assumes no responsibility for supervising or directing construction activities performed by a licensed contractor.

(3) All materials and equipment used for public improvements shall be of new and good quality. Recycled materials and equipment may be used if they meet the quality standards and conditions equivalent to new materials and equipment. All materials and equipment shall be applied, installed, connected, erected, used, cleaned, and conditioned in accordance with the instructions of the applicable supplier or manufacturer, except as otherwise prescribed.

(D) Terminology

Terms, words, and abbreviations used in these Standards are defined in the Glossary (Appendix B).

1.02 Description and Use of These Standards

(A) Using these Standards

(1) These Standards are to be used when designing and constructing all public improvements and infrastructure within the City. For the purposes of this document, public improvements and infrastructure include without limitation: streets, sidewalks, trails, curb and gutter, curb cuts, streetscaping, water mains, fire hydrants, water services and meters, wastewater mains and services, manholes, stormwater mains, inlets, drainage swales and channels, and other improvements intended for public purposes or for the benefit of the community located within dedicated public rights-of-way and public easements.

(2) These Standards also provide design and construction requirements to be used when developing private lands that create an impact on public rights-of-way and public easements. The required private improvements associated with property development include without limitation: traffic mitigation, site access and driveway design, stormwater site drainage and detention ponding improvements, and stormwater quality and erosion control measures.

(B) Restrictions

The descriptions in this Chapter provide the reader with a general guide to using these Standards. Nothing in this Chapter is intended to be a substitute for the requirements, criteria, and procedures contained in these Standards.

(C) Public Improvements Design

(1) These Standards prescribe minimum requirements and specifications for designing adequate and functional public improvements. However, the design of public improvements also depends on the land use zoning and comprehensive planning requirements for the City, as well as the specific site geography of the land to be improved or developed.

(2) The City review for approval of submitted design plans for public improvements occurs as part of the development review process that distributes design applications to staff in multiple departments, divisions, and agencies. The Department of Public Works development review staff has the primary responsibility for the review and approval of construction plans for public improvements. An applicant for construction approval would be well advised to consult with the Department of Public Work's development review staff prior to submitting designs for public improvements.

(D) Construction Approvals

(1) An applicant seeking approval to construct public improvements in the City will need to develop engineering designs and construction plans that comply with the design and construction standards provided in this manual. In addition to complying with these Standards, an applicant will need to file the necessary applications and meet the requirements of the City's land use regulations, permit standards, and fee assessments as prescribed in the Boulder Revised Code (B.R.C.), 1981.

(2) An applicant seeking construction approval will need to consult local master plans and the

location of existing public infrastructure to develop specific project designs.

(3) In order to develop project designs that comply with these Standards, an applicant for construction approval will need to enlist the services of a professional civil Engineer and professional land surveyor to meet the requirements for certifying acceptable designs for public improvements. An applicant may consult local directories for listings of professional engineering and surveying service providers.

(E) Public Improvements Construction

(1) **Right-of-Way Permit:** The construction of public improvements in the City public rights-of-way and public easements requires a right-of-way permit, as set forth in Chapter 8-5, "Work in the Public Right-of-Way and Public Easements," B.R.C., 1981. An applicant for construction approval will need to enlist the services of a contractor licensed with the City, as set forth in Chapter 4-6, "Contractor in the Public Way License," B.R.C. 1981, in order to obtain a permit to construct public improvements.

(2) **Variances**

(a) When practical difficulties are involved in meeting the provisions of these Standards, the Director of Public Works ("Director") may alter, modify, or waive the strict application of these Standards to allow for the reasonable use of land or accommodate special circumstances peculiar to such land as set forth in Section 1.04, "Alternate Materials and Methods of Construction," and Section 1.05, "Alterations, Modifications, and Waivers," of these Standards.

(b) Alterations, modifications, or waivers are intended only for the special purposes described, and are not to be routinely considered or approved. Where it is necessary to vary from these Standards, an applicant for construction approval must clearly demonstrate that the provisions of these Standards cannot be met and the alteration, modification, or waiver will create the minimum variance necessary to accomplish the intended purpose.

(F) Standards

(1) **Transportation:** The transportation standards prescribed in Chapter 2, "Transportation Design," and Chapter 8, "Transportation Standards," provide for the study, design, and construction of site accesses, streets, sidewalks, bicycle facilities, and trails. A traffic impact study may be required as part of construction approvals to demonstrate adequate design and mitigation for traffic impacts associated with new streets and driveways.

(2) **Streetscapes:** The streetscape standards prescribed in Chapter 3, "Streetscape Design and Tree Protection," and Chapter 10, "Streetscaping Standards," provide for the selection, design, placement, and protection of trees and landscaping along public streets throughout the community. The City places high value on and strongly encourages the use of streetscapes as a means to calm automobile traffic, address environmental concerns for clean air and water quality, and enhance neighborhood qualities. General criteria are also included related to subsurface work impacting transportation infrastructure.

(3) **Water and Wastewater Utilities:** The utility standards prescribed in Chapter 4, "General Utilities Design," Chapter 5, "Water Design," Chapter 6, "Wastewater Design," and Chapter 9, "Utilities Standards," provide for the study, design, and construction of water

and wastewater service facilities. These Standards detail required forecasting for sizing water distribution and wastewater collection mains, specific construction requirements for ensuring public health standards, and requirements for installing domestic water and sewer service lines.

(4) **Stormwater:** The stormwater standards prescribed in Chapter 7, "Stormwater Design," and Chapter 9, "Utilities Standards," provide for the study, design, and construction of stormwater drainage, stormwater quality and flood control improvements. Detention ponding, storm sewer and drainageway systems, stormwater quality, and erosion control measures may be required as part of construction approval to mitigate the impacts of increased runoff resulting from land development and to comply with the city's Phase II Municipal Separate Stormwater System Permit.

(5) **Technical Drawings:** The standards for construction detail drawings prescribed in Chapter 11, "Technical Drawings," provide design requirements for specific construction features associated with the general construction of public improvements and infrastructure. These drawings are intended to supplement the design and approval of construction plans and ensure consistency in project construction to promote long-term dependability and maintenance of public improvements and infrastructure.

1.03 Submittal Requirements for Construction Approval

(A) Documentation

(1) An applicant for construction approval shall submit required engineering reports, rights-of-way and easement dedications, ancillary permits and agreements, and construction plans in compliance with these Standards. Construction approvals are subject to the Director's review, approval, and acceptance.

(2) Prior to approving construction plans, the Director may require an applicant to submit the following documentation:

(a) Engineering reports

(b) Rights-of-way and easement dedications

(c) Permits and agreements

(d) Financial guarantees

(3) Prior to issuing a right-of-way permit or building permit, the Director may require an applicant to submit the following documentation:

(a) Documents listed in Section 1.03, Paragraph (A)(1), above

(b) Construction plans

(c) City land use approvals

(d) Financial guarantees

(e) Documents required by Section 8-5-4, "Permit Application," B.R.C., 1981.

(4) Prior to the final acceptance of public improvements, the Director may require an applicant to submit the following documentation:

(a) Documents listed in Section 1.03, Paragraphs (A)(1) and (A)(2), above

(b) As-built drawings

(c) Testing results

(d) Inspection approvals

(e) Financial guarantees and warranties

(B) Engineering Reports

(1) Engineering reports required for construction approval shall be prepared as follows:

(a) In compliance with these Standards.

(b) Under the direct supervision of the Engineer certified as an expert in areas covered in the report, and it shall be signed, sealed, and dated by the Engineer.

(c) Containing adequate information to evaluate submitted findings and designs, including calculations, details, and references.

(2) Engineering reports required for construction approval may include the following:

(a) Geotechnical Soils Report, which provides geotechnical conditions and design requirements based on soils investigation and testing and geologic site conditions in compliance with standard engineering practices for soil mechanics and groundwater analysis.

(b) Pavement Design Report, which provides geotechnical soils conditions and adequate pavement design requirements and structural cross-sections for roadway, sidewalks, trails, and parking lot construction. Pavement design shall be in accordance with CDOT standards.

(c) Drainage Report and Stormwater Plan, which addresses stormwater conditions, impacts, and design requirements in compliance with Section 7.04, "Final Drainage Report and Stormwater Plan."

(d) Utility Report, which addresses water and wastewater utilities service impacts, demands, and design requirements in compliance with Sections 5.02, "Utility Report," and 6.02, "Utility Report."

(e) Traffic Study, which identifies traffic impacts from proposed developments or roadway modifications and proposes transportation design requirements and mitigation measures in compliance with Section 2.02, "Traffic Study."

(3) The Engineer shall be responsible for correcting any error or omission in the engineering report. City approval of the report in no way relieves the Engineer of any responsibility for errors or omissions in the report.

(4) An applicant for construction approval shall submit at least three copies of any required engineering report to the Director for review and approval. If acceptable, a City approval stamp signed and dated by the Director will be placed on each copy of the report. The City will retain one copy as a record set, one copy as a field copy for construction inspection, and one copy will be returned to the applicant.

(5) Engineering report approval expires 1 year following the date of approval, unless

construction of improvements under the report has been initiated.

(C) Rights-of-Way and Easement Dedications, Permits, and Agreements

(1) Rights-of-way and easements required for construction approval shall be described by a licensed professional land surveyor registered in the State of Colorado and dedicated as follows:

(a) In compliance with these Standards; and

(b) By subdivision platting or by a separate legal instrument that describes a specific legal description of the dedication.

(2) Agreements required for construction approval shall be executed and may include without limitation:

(a) Development agreement

(b) Public improvements agreement

(c) Public improvements extensions agreement

(d) Subdivision agreement

(e) Utility oversizing reimbursement agreement

(3) Permits required for construction approval shall be of approved and issued status and may include without limitation:

(a) City of Boulder floodplain development permit

(b) City of Boulder right-of-way construction permit

(c) City of Boulder revocable right-of-way permit

(d) City of Boulder wetland permit

(e) City of Boulder erosion control permit

(f) Colorado Department of Transportation access permit

(g) Colorado Department of Transportation utility permit

(h) Railroad right-of-way encroachment permit

(i) State of Colorado Public Health and Environment Department 401 permit

(j) State of Colorado general permit for stormwater discharges associated with construction activities

(k) United States Corps of Engineers 404 permit

(D) Construction Plans

(1) **Preparation Standards:** Construction plans required for construction approval shall be prepared as follows:

(a) In compliance with these Standards;

(b) Under the direct supervision of the Engineer certified as an expert in areas covered in the report, and it shall be signed, sealed, and dated by the Engineer;

and

(c) With adequate information and detail to evaluate submitted designs and ensure accurate and functional construction of public improvements.

(2) **Drafting Standards:** All construction plans shall meet the following minimum drafting standards to ensure legibility and consistency; to facilitate review, construction, and public inspection; and to provide a clear public record.

(a) Drawings shall be submitted in both hard copy and electronic, computer-aided design and drafting (CADD) formats to allow information to be transferred to the City's geographic information system and facilitate clear microfilming or digital scanning.

(b) Electronic drawing format, or electronic CADD files, shall be in ".DXF" or "AutoCad.DWG" format on computer media specified by the Director of Public Works. Construction plan drawings are to be layered in electronic CADD format by improvement type in a manner acceptable to the Director of Public Works. Separate layers shall be provided for individual improvement categories including without limitation base mapping, transportation, landscaping, water, wastewater, and stormwater.

(c) Hard-copy drawing format shall measure 24 inches by 36 inches and be clean, clear, and free from objectionable background.

(d) Symbols and line types shall comply with Technical Drawing 1.01 in Chapter 11, "Drafting Standards," and shall graphically distinguish between existing and proposed items.

(e) All drawings are to be numbered in consecutive order.

(f) Abbreviations reflected on the construction plans are to correspond to those presented in the Glossary.

(g) No hand-drawn or adhesively attached information, such as Kroy lettering, adhesive backed reproductive film, or tape, may be placed on construction plans.

(3) **Cover Sheet:** Construction plans required for obtaining construction approval shall include a cover sheet with the following elements:

(a) Project name, with legal description of the project parcel;

(b) Vicinity map, on a scale reflecting the location of the project and all streets within 1 mile of the project;

(c) Key map, on drawing sets of three sheets or more, of a scale reflecting the entire project, separate drawing numbers, and street names;

(d) Index of drawings presenting the title of each drawing and drawing number; and

(e) The following standard construction notes:

(i) "All work shall be performed in accordance with the "Design and Construction Standards" of the City of Boulder, and shall be completed to the satisfaction of the Director of Public Works. In the event that a design element does not reflect City standards, the matter must be immediately brought to the attention of the Engineer and the Director of Public Works.

The Engineer shall be responsible for recommending a solution or alternative solutions to the City for review and approval."

(ii) "The approval of a Construction Plan does not relieve the Contractor of the responsibility of constructing workable public improvements. All revisions and/or corrections required will be solely the Contractor's responsibility, and at their expense."

(iii) "These Plans have been checked by the City of Boulder only for conformance with the "Design and Construction Standards," compliance with development agreement conditions, and for general conceptual approval of public improvements as shown. The City's review does not verify or ensure the accuracy of existing or proposed dimensions, lines, coordinates, or grades shown, including all existing utilities shown or not shown."

(iv) "Utility locations shown reflect available record data. The Contractor shall take precautionary measures to protect all utility lines shown and other utility lines otherwise located. The Contractor shall contact the "Utility Notification Center of Colorado" at 1-800-922-1987 or 811 for utility locates 24 hours prior to beginning construction."

(v) "Before work begins, the Contractor shall obtain a permit to work in the right-of-way from the City and must notify the City Right-of-Way Inspection staff at least 24 hours in advance of commencing construction activities."

(vi) "The Contractor shall obtain and maintain a complete and approved set of Construction Plans. These drawings, and any required permits, shall be available at the project site at all times and shall be made available to City staff upon request. If construction plans are not readily available at the project site, the Director of Public Works may issue a stop work order and halt all construction activities pending compliance by the Contractor."

(vii) "The Contractor agrees to comply with the provisions of the Traffic Control Plan and the current edition of the "Manual on Uniform Traffic Control Devices," "Temporary Traffic Control" section, for construction signage and traffic control."

(viii) "All surplus materials, tools, and temporary structures, furnished by the Contractor, shall be removed from the project site by the Contractor. All debris and rubbish caused by the operations of the Contractor shall be removed, and the area occupied during construction activities shall be restored to its original condition, within 48 hours of project completion, unless otherwise directed by the Director of Public Works."

(ix) "The Contractor shall provide tree and landscape protection as set forth in Chapter 6-6, "Protection of Trees and Plants," Boulder Revised Code (B.R.C.) 1981 and the City of Boulder Design and Construction Standards (DCS). All landscaping shall be provided and maintained in compliance with the approved Landscaping Plan, B.R.C. and DCS."

(x) "The Contractor is required to provide and maintain erosion and sediment control measures in accordance with the Urban Drainage and Flood

Control District "Urban Storm Drainage Criteria Manual Volume 3", the M-Standard Plans of the Colorado Department of Transportation, and the approved stormwater management plan. The Director of Public Works may require the contractor to provide additional erosion control measures due to unforeseen erosion problems or if the plans do not function as intended."

(xi) "The City of Boulder requires that sidewalks constructed have a cross slope of less than 2%. Sidewalks shall be designed and constructed with cross slopes sufficiently less than 2% to ensure that they do not exceed the 2% maximum."

(4) **Plan Sheets:** Construction plans required for construction approval may include without limitation the following plan sheets:

(a) Stormwater Management Plan, prepared in compliance with Subsection 7.13, "Construction Stormwater Management."

(b) Utility Plan, prepared in compliance with Section 4.03, "Utility Plan."

(c) Final Stormwater Plan, prepared in compliance with Section 7.04, "Final Drainage Report and Stormwater Plan."

(d) Traffic Control Plan, when construction plans have an impact on existing transportation facilities, such as utility or access construction within existing public streets, sidewalks, or trails. The plan is to be prepared in compliance with Section 8.04, "Temporary Traffic Control Plan," of these Standards, the current edition of the "Manual on Uniform Traffic Control Devices," "Temporary Traffic Control" section and as set forth in Section 8-5-10, "Temporary Traffic Control," B.R.C., 1981. Plans shall include adequate provision for the detour of vehicular, bicycle, and pedestrian traffic.

(e) Transportation Striping and Signage Plan, when construction plans include transportation traffic control measures, such as stop signs, centerline striping, and trail signage. The plan is to be prepared in compliance with the current edition of the "Manual on Uniform Traffic Control Devices," and should include the following standard construction notes:

(i) Contact the City of Boulder Sign Shop (303-413-7122) for location of all signs prior to installation and for sign layout/details prior to ordering.
(ii) All sign sheeting to be Class XI (DG3 material) with 3M 1150 overlay film.
(iii) All signs shall be 0.100 gauge aluminum.
(iv) All sign posts to be 12 gauge 2 inch unistrut.
(v) All sign bases to be 12 gauge 2-1/4 inch unistrut.
(vi) Sign post lengths will vary, but 7 foot minimum clearance from bottom of sign to ground level is required.
(vii) All sign mount hardware to be Gator Lock System.

(f) Construction Phasing Plan, when projects are planned to be constructed in phases. The plan is to illustrate the entire project site and delineate and label each separate phase.

(g) Landscaping Plan, when construction plans include streetscaping improvements

or landscaping that has an impact on public rights-of-way or public easements. The plan is to be prepared in compliance with Subsection 3.02, "Landscaping Plan."

(5) **Survey Information:** Construction plans shall refer horizontally to the Colorado State Plane Coordinate System NAD83, and are to include at least two horizontal and two vertical control points presenting appropriate *x*, *y*, and *z* coordinates. Electronic base map and survey control monument information is available from the City and should be used as a basis for construction plan drawings.

(a) Horizontal control monuments reflected on drawing sheets and survey lines are to correspond to City-recognized horizontal control points. Horizontal locations for design features are to be presented in terms of survey line stationing and offset or *x*, *y* coordinates.

(b) Vertical elevation control points reflected on drawing sheets are to be tied to City-recognized benchmarks with reference to the City's vertical control network. Vertical elevations for design features are to be presented as a *z* coordinate.

(E) Plan and Profile Drawings

(1) **Required Elements:** Plan and profile drawings are required as part of the construction plan to ensure accurate and functional construction by the contractor when the construction is for public improvements. Plan and profile drawings are to be prepared on standard engineering plan and profile grid sheets and shall contain the following elements:

(a) Drawing border at least one-half inch from all edges of the drawing;

(b) Title block located inside the border in the lower portion of the sheet that includes the following information:

(i) Project name, location, and sheet title;

(ii) Name, address, and telecommunication numbers of the engineering consultant preparing the drawing, and the name of the supervising professional Engineer;

(iii) Date designed, drawn, surveyed, and checked;

(iv) Date prepared, and dates of all revisions;

(v) Drawing number and total number of drawings; and

(vi) Name of electronic file;

(c) North orientation arrow and scale;

(d) Certification space: a 2-inch by 2-inch space near the title block reserved for the seal and signature of the Engineer;

(e) Approval space: a 3-inch by 3-inch space in the lower-right corner of each drawing sheet reserved for the City's approval stamp;

(f) Revisions information space: space for noting all revisions, separate from the original plan preparation date, that includes revision numbers, a brief description of what was revised, and the date of the revision;

(g) Survey information;

(h) Property boundaries, lot lines, public rights-of-way, and public easements, which are to be clearly labeled by type and dimension. Dedications previously recorded are to be referenced by applicable film and reception numbers;

(i) Subdivision block, and lot numbering; and

(j) Street names.

(2) **Plan Drawing:** The "plan view" is to be located on the upper half of the drawing sheet and drawn to a scale of 1 inch equals 20 feet. This view contains the following information:

(a) Existing and proposed public improvements and structures, including without limitation all grading, transportation, landscaping, City-operated and non-City-operated public utilities (including telephone, gas, electric, cable television, fiber optics), irrigation ditches, and other significant features.

(b) Match lines connecting information between drawings.

(c) Utility information required in Section 4.03, "Utility Plan," and the following:

(i) Pipe type, size, class and joint restraint.

(ii) Separation distance between existing and proposed water and wastewater mains and services, with horizontal and vertical location of sewer crossings requiring special construction.

(iii) Angles at alignment changes.

(iv) Horizontal and vertical locations and sizing of water service lines and meters with ties to property lines.

(v) Horizontal and vertical locations, sizing, and types of valves, fittings, control devices, and fire hydrants.

(vi) Horizontal and vertical locations and sizing of manholes, cleanouts, and service lines for sanitary sewers.

(vii) Horizontal locations of soil borings.

(viii) Horizontal locations of structures.

(d) Stormwater information required in Section 7.04, "Final Drainage Report and Stormwater Plan," and the following:

(i) Existing and proposed contours of at least 2-foot intervals.

(ii) Existing and proposed storm drainage facilities and details, including storm sewers, inlets, manholes, culverts, swales, detention ponds and drainageways.

(iii) Horizontal and vertical locations and sizing of manholes and inlets for storm drainage.

(iv) Horizontal and vertical location of existing and proposed drainage outfall points.

(e) Survey, transportation, and surface improvements information including without limitation:

(i) Survey lines and stations based on center line or flowline stationing, and equated to flowline at bubbles, cul-de-sacs, horizontal curves, and other departures from normal street cross sections.

(ii) Stations and elevations of flowlines at all existing and proposed curb returns, such as horizontal points of curvature (PC's), points of tangency (PT's), and points of compound curvature (PCC's); at the high or low point on all vertical curves; at inlets (including invert); and at intervals of no more than 50 feet along the streets.

(iii) Existing and proposed curb return radii.

(iv) Handicap access ramps.

(v) Complete horizontal curve data: radius (*R*), delta (*D*), arc length (*L*), and tangent length (*T*).

(vi) All crown lines, where they depart from the normal cross sections (transitions to existing roadways), with appropriate transition starting elevation.

(vii) Centerline stations at all intersecting streets.

(viii) Stations of drainage facilities, including inlets, manholes, and storm water outfalls, and directional drainage flow arrows.

(ix) Full width of right-of-way, intersecting roadways, street cross sections, sidewalks and trails, existing curb cuts, and other relevant features along all roadways abutting the project.

(x) Traffic control devices, including striping, markings, signage, and signals.

(3) **Profile Drawing:** The "profile view" is to be located directly below the plan view along a matching survey line and stationing and is to be drawn at a horizontal scale of 1 inch equals 20 feet and a vertical scale of 1 inch equals 5 feet. This view shall contain the following information:

(a) Original and proposed ground elevations.

(b) Stationing sequence, left to right.

(c) Elevations labeled on both left and right sides of the drawing sheet.

(d) Match lines.

(e) Elevations based on center line, flow line, or invert of pipe. (Top of pipe is acceptable only for existing utilities.)

(f) Stations and elevations of existing and proposed grade breaks.

(g) Crossings of existing and proposed utilities.

(h) Elevations of manhole inverts and rims, and service line inverts.

(i) Elevations of inlets, top of curb, flowline, inverts, and connection locations.

(j) Slopes or grades of wastewater and stormwater sewers.

(k) Existing and proposed finished grades over utilities.

(l) Street profiles, including:

(i) Stations and elevations of existing and proposed horizontal PC, PT, PCC, PRC.

(ii) Vertical curves with VPI, VPC, VPT, high point or low point (not middle ordinate) stations and elevations.

(iii) Center line stations of all intersecting streets.

(iv) Grades for all profiles.

(v) Curb flowlines at 25-foot minimum intervals, and at all vertical sags or crests.

(vi) Curb return profiles to ensure positive drainage at ramp locations.

(4) **Detail Drawings:** Detail drawings are required for construction details not provided in Chapter 11, "Technical Drawings." Detail drawings illustrate construction details for critical design features such as concrete paving sections, mechanical pipeline connections, and detention ponding release structures. Detail drawings are to include dimensioning, materials, specifications, and specific construction notes appropriate to each construction detail.

(5) **Cross-Sectional Drawings:** These drawings are required with all construction plans that include varying or transitional features, such as street sections, fill slopes, and drainage channels. Cross-Sectional drawings reflect dimensions, elevations, stationing, and any other detailed information necessary to ensure accurate construction.

(F) Submittal and Approval of Construction Plans and Drawings

(1) **Submittal:** An applicant for construction approval shall submit at least three drawing sets of any required construction plans to the Director for review and approval, including:

(a) Original black-lined drawing set prepared by the Engineer to be stamped and approved by the City and returned to the Engineer

(b) 2 Sets of black-lined prints drawing set signed, sealed, and dated on each drawing sheet by the Engineer to be maintained on file with the City as the record set of the construction plan approval documents and for use by the City right-of-way inspector.

(2) **Approval:** The Director will review construction plans for compliance with these Standards. If acceptable, a City approval stamp signed and dated by the Director will be placed on each drawing sheet of the construction plans.

(3) **Effective Period:** Construction plan approval expires 1 year following the date of approval, unless construction has been initiated. An applicant for construction approval may resubmit the construction plan for reapproval, subject to review for compliance with standards in effect at the time of resubmittal.

(4) **Errors and Omissions:** The Engineer shall be responsible for correcting any error or

omission in the construction plans or drawings. City approval of the construction plans in no way relieves the Engineer of any responsibility for errors or omissions in the plans.

(G) As-Built Drawings

(1) **Requirements:** As-built drawings reflect the actual in-place construction of public improvements.

(a) The applicant shall submit as-built drawings for final construction approval within 60 days from the date construction was completed and prior to City acceptance of any public improvements.

(b) The applicant shall ensure that every sheet of the approved construction plans reflects the as-built drawings conditions.

(2) **Preparation:** As-built drawings shall be prepared by the Engineer responsible for the original construction plan approved by the City. Drawings shall be prepared as follows:

(a) In compliance with the requirements in Sections 1.03(D), "Construction Plans," and 1.03(E), "Plan and Profile Drawings."

(b) In compliance with the requirements in Section 7.17(B), "Stormwater As-Built Drawings."

(c) Based on completed field inspections, accurate measurements, survey data, and testing results, materials, and equipment records.

(d) To reflect any variations from the approved construction plans in the public improvements actually constructed.

(3) **Transfer of Responsibility:** If the Engineer responsible for the original construction plan is replaced prior to preparing as-built drawings, the replacement Engineer shall agree in writing to accept the responsibility for the design certified by the original Engineer under the approved construction plan prior to City acceptance of the constructed public improvements.

(H) Submittal and Approval of As-Built Drawings

(1) **Submittal:** An applicant for construction approval shall submit at least two drawing sets of any required as-built drawings to the Director of Public Works for review and approval. As-built drawing sets shall contain a complete black-lined print drawing set of the as-built drawing set reflecting the as-built conditions and signed, sealed, and dated on each drawing sheet by the Engineer.

(2) **Approval:**

(a) The Director will review the as-built drawings for compliance with these Standards. If acceptable, a City approval stamp, signed and dated by the Director, will be placed on each drawing sheet of the as-built drawings.

(b) The Director will not approve any construction, place in service, release financial guarantees, or issue utility connections for any public improvements for which acceptable as-built drawings have not been submitted.

(3) **Variations and Discrepancies:** If any substantial variations or discrepancies, particularly with respect to location, design slopes, grades, dimensions, capacities and clearances, are

discovered between the approved construction plans and the public improvements actually constructed, the Engineer shall propose and recommend a solution or alternative solutions to the City for review and approval. If no proposed alternative will satisfy the requirements of these Standards, the contractor shall reconstruct the deficient public improvements to comply with the approved construction plans.

(4) **Errors and Omissions:** The Engineer shall be responsible for the correction of any error or omission in the as-built drawings. City acceptance of the as-built drawings in no way relieves the Engineer of any responsibility for errors or omissions in the drawings.

1.04 Alternative Materials and Methods of Construction

(A) Use

The provisions of these Standards are not intended to prevent the use of any materials or methods of construction, design, or compliance not specifically prescribed in these Standards, provided that the alternative materials or methods of construction, design, or compliance have been approved and their use authorized by the Director.

(B) Approval

The Director may approve an alternate material or method of construction, design, or compliance, provided the proposed design is satisfactory and complies with the provisions of these Standards and that the material, method, or work offered is, for the purpose intended, at least the equivalent of that prescribed in these Standards in suitability, strength, effectiveness, durability, safety, and sanitation.

(C) Proof of Claims

The Director will require that sufficient evidence be submitted to substantiate any claims that may be made regarding an alternate material or method of construction, design, or compliance. The details of any action granting approval of an alternate material or method will be recorded and entered in the files of the City.

1.05 Alterations, Modifications, and Waivers

(A) Practical Difficulties

When practical difficulties are involved in executing the provisions of these Standards, the Director may alter, modify, or waive the strict application of these Standards, according to the process described herein.

(B) Criteria

No alteration, modification, or waiver of the strict application of any provision of these Standards shall be granted unless the applicant clearly demonstrates and the Director finds that the following conditions exist:

(1) The strict application of the provisions of these Standards would deprive an individual of

the reasonable use of land or structure, and

(2) Special circumstances peculiar to such land or development justify the requested alteration, modification, or waiver, and

(3) Any alteration, modification, or waiver would result in a solution consistent with the goals of the underlying zoning district, a Boulder Valley Comprehensive Plan goal, a specific neighborhood plan, or an adopted design guideline, and

(4) Any alteration, modification, or waiver represents the minimum variance from these Standards that will accomplish the intended purpose, and

(5) Any alteration or modification will at least equal the suitability, strength, effectiveness, fire resistance, durability, safety, and sanitation performance requirements prescribed in these Standards, and

(6) Any alteration, modification, or waiver will not harm the adjacent land owners, the neighborhood, or the welfare of the public at large, and

(7) Any alteration, modification, or waiver will not create an additional maintenance or financial burden for the affected property owners or the City.

(C) Application Requirements

(1) An applicant for an alteration, modification, or waiver to these Standards shall submit a written request to the Director. The request shall state in detail the specific sections and subsections of these Standards requested to be altered, modified, or waived, and the request shall describe in detail why the requested waiver, alteration, or modification meets the criteria in Section 1.05(B), above.

(2) The Director may require additional documentation to support the request and shall require that sufficient evidence be submitted to substantiate any claims that may be made regarding alterations, modifications, or waivers to these Standards. Sufficient evidence may include verification by a Colorado registered professional Engineer, possessing relevant expertise in the area.

(D) Decision

(1) The Director will advise the applicant, in writing, of the decision on the requested alteration, modification, or waiver. The Director's decision is a final action that is administrative and may be appealed through the judicial process. In granting any alteration or modification to these Standards, the Director may impose specific conditions necessary to ensure that the criteria described in Section 1.05(B), above, are, and will remain, satisfied.

(2) The Director of Public Works will consult with the Planning Director when evaluating issues that potentially impact urban design. The details of any decision granting approval of an alteration, modification, or waiver to these Standards will be entered in the form of written findings. A written log of all decisions granting alterations, modifications, or waivers to these Standards will be kept current in the office of the Director of Public Works and will be available for public inspection.

CHAPTER 2

TRANSPORTATION DESIGN

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2.01 General

(A) Intent

The Transportation Design Standards are intended to provide for an integrated transportation system for all transportation modes, including pedestrian, bicycle, transit, and motor vehicle.

(B) Transportation Master Plan

All improvements proposed to the city's transportation system shall conform with the goals and policies in the Transportation Master Plan (TMP).

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of transportation improvements and may refer to one or more of the references listed in the References Section of these Standards.

(D) Functional Street Classification

Public streets shall be designed and improved to conform to the applicable functional street classification as defined on the "Street Function Class and Proposed Street Facilities" map of the TMP.

2.02 Traffic Study

(A) Traffic Assessment

The Director will require an applicant to submit a Traffic Assessment in order to adequately assess the impacts of any development proposal on the existing and planned transportation system. The Assessment shall include a peak hour trip generation study projection (Refer to 2.03(J)) and may require additional information as determined by the Director.

(B) Traffic Study Requirements

For any development proposal where trip generation from the development during the peak hour of the adjacent street is expected to exceed 100 vehicles for nonresidential applications, or 20 vehicles for residential applications the Director will require an applicant to submit a Traffic Study to evaluate the traffic impacts of the development proposal. The Traffic Study may include the information required in Subsections (A) through (K), of Section 2.03, "Traffic Study Format," of these Standards at the discretion of the Director.

(C) Responsibilities for Traffic Studies

An applicant for construction approval shall be responsible for assessing all traffic impacts associated with a proposed development, with the city serving in a review and approval capacity.

(D) Preparation

A Traffic Study shall be prepared by an Engineer with adequate experience and expertise in transportation engineering. The Engineer shall be identified in the Traffic Study.

(E) Coordination with City

Transportation consultants and Engineers preparing Traffic Studies shall discuss proposed development projects with the Director prior to initiating the study. Issues to be discussed include, without limitation, the TMP, definition of the study area, relevant subarea, area, and subcommunity plans, methods for projecting build-out volumes, background traffic conditions, trip generation, directional distribution of traffic, trip assignment, and assessment of potential transportation hazards. These aspects of the Traffic Study shall be approved by the Director prior to study preparation.

(F) Submittal

A Traffic Study shall be prepared in conformance with, and including, the information required in Section 2.03, "Traffic Study Format," of these Standards.

2.03 Traffic Study Format

(A) Study Requirements

The information provided in the Traffic Study shall include the following sections as outlined below. The study shall be typed and bound and clearly identify the data and information in the appropriate sections. In addition, the study shall contain a table of contents, lists of figures, and tables, and shall identify any map pockets and included drawings.

(B) Introduction

The Traffic Study shall provide an introduction with an overview and discussion of the project or development proposal.

(C) Site Location and Zoning

Include a vicinity map detailing the property location, a conceptual site plan reflecting the boundaries of the project or development, and information detailing the designated zoning district, general terrain and physical features of the site and the surrounding area.

(D) Study Area Boundaries

Include the Study Area Boundaries as determined based on discussions with the Director and include all roadways and transportation routes providing access to the site and the surrounding transportation system.

(E) Existing Area Street System Description

Describe and include roadway orientations, functional classifications and geometries, intersection geometries, and traffic controls, including without limitation signage and striping, speed limits, parking restrictions, sight distance, transit routes, the presence of bicycle and pedestrian facilities, and any other related traffic operations information and improvements approved or planned by government agencies. For identified improvements scheduled by government agencies, include the nature of the improvements, extent, implementation schedule, and the agency or funding source responsible.

(F) Existing and Projected Roadway and Intersection Traffic Volumes

Include diagrams that map existing traffic volumes, and each variation of projected traffic volumes, for all roadways and intersections within the study area. Also provide diagrams that map the intersection and roadway geometries and traffic control within the study area.

(G) Existing and Proposed Site Uses

Include an identification of the existing land use and proposed land use or the highest potential land use based on zoning and maximum trip generation where a specific use has not been determined. If rezoning is proposed, the study shall provide a comparison between the highest trip generation uses for the existing zoning and the highest trip generation uses for the proposed zoning.

(H) Existing and Proposed Land Uses in Vicinity of the Site

Document any vacant land or potential redevelopment that may result in a change in traffic volume conditions within the study area during each time period studied. Perform and provide trip generation on these parcels and include the trips generated from these parcels in the trip volume diagrams and level of service analyses for each appropriate time period studied.

(I) Transportation Demand Management Strategies

Include an outline of transportation demand management strategies to mitigate traffic impacts created by proposed development and implementable measures for promoting alternate modes of travel, including but not limited to the following:

(1) **Site Design:** Incorporate design features that facilitate walking, biking, and use of transit services to access a proposed development, including features such as transit shelters and benches, site amenities, site design layouts, orientations and connections to increase convenience for alternate modes and reduce multiple trips to and from the site, and direct connections to existing offsite pedestrian, bicycle, and transit systems.

(2) **Programs and Education:** Incorporate alternate modes programs, such as providing transit passes to employees and residents, van pooling to the site by a major employer, ride-sharing, parking pricing, and planned delivery services, and educational measures such, as promoting telecommuting, distributing transit schedules and trails maps, signing alternate travel routes, and providing an onsite transportation coordinator or plan to educate and assist residents, employees, and customers in using alternate modes.

(J) Trip Generation

Traffic estimates for the proposed project and potential developed or redeveloped properties in the study area shall be obtained by performing trip generation using the procedures outlined in the most current edition of the *Trip Generation Manual* of the Institute of Transportation Engineers (ITE). If adequate *Trip Generation Manual* data is not available for a specific land use, the procedures used to estimate trip generation data shall be approved by the Director. Include the following specific trip generation information:

(1) **Summary Table:** List each land use that requires trip generation analysis, including the project plus developed or redeveloped land uses within the study area. For each trip generation summary, include land use type, amount, intensity, average trip generation rates for total daily traffic and peak hour traffic (a.m., noon and/or p.m. peak hour traffic generation may be required), and the resultant total trips generated for each time period and each land use.

(2) **Calculations:** Calculation of projected trip generation for any land use, used to determine study area impacts, shall be based on the following:

(a) Trip generation formulas (or rates, if formulas are not available) published in the most recent version of the *Trip Generation Manual*. Trip generation reports from other industry publications may be considered but are subject to the approval of the Director.

(b) A local trip generation study, following procedures outlined in the most recent version of the *Trip Generation Manual*, if no published rates are available and similar land uses can be studied.

(c) Additional data or studies from other similar jurisdictions. Trip generation obtained in this fashion is subject to the review and approval of the Director.

(3) **Trip Generation Reductions:** Credit for any trip reductions is subject to review and approval in advance by the Director. Anticipated trip reduction assumptions should be discussed and approved by the Director prior to the preparation of the Traffic Study. Trip reductions typically fall into one of two categories: those that reassign some portion of the trip generation from the surrounding roadway network (passerby and diverted trip reductions), and those that remove trips generated from the land use trip generation (internal and modal split reductions).

(a) Use of passerby and diverted trip reductions may be evaluated and considered in reducing the additional estimated total trip generation of a new land use. However, passerby and diverted trip reduction factors are not to be applied directly to reduce trip generation and turning movement volumes at driveways serving the studied land use. These factors are subject to the approval of the Director.

(b) Internal trip reductions and modal split assumptions may reduce the total trip generation of a land use. These factors considered in the Traffic Study shall supply analytical support and detailed documentation to demonstrate how the estimates were derived and incorporated and are subject to the approval of the Director.

(K) Trip Distribution/Assignment and Modal Split

Trip distribution/assignment of any generated traffic estimates shall be clearly summarized and illustrated for each access route entering and exiting the generating land use, using the study area transportation system as a basis. Include the following specific trip distribution/assignment information:

(1) **Trip Distribution:** The trip distribution for each site shall be identified and illustrated with a graphical figure detailing the percentages making each movement, at each intersection in the study area. The trip distribution shall be logically based upon factors such as the site's location within the city's existing traffic volume data in the study area, market analyses, applied census data, and/or professional engineering judgment. Trip distribution assumptions are subject to the approval of the Director.

(2) **Trip Assignment:** Trip assignment shall be done by applying the trip generation totals for each time period studied, to the trip distribution percentages developed. The trip assignment shall develop anticipated traffic volumes for each of the movements identified by the trip distribution and each of the time periods identified in the analyses. The resulting traffic volumes shall be illustrated with graphical figures detailing the anticipated volumes making each movement, at each intersection in the study area, during each time period studied.

(L) Existing and Projected Traffic Volumes

(1) **Traffic Volume Scenarios:** Five traffic volume scenarios and three separate times of the day may be required to be included in a Traffic Study analysis. The applicant shall meet with the Director to determine the scenarios and time periods to be studied, prior to the development of the Traffic Study. The number of scenarios and time periods to be studied are subject to the approval of the Director. The potential scenarios and time periods include the following:

(a) Scenario 1 - Existing Conditions: An analysis of existing traffic conditions will be required in the Traffic Study. Existing Conditions analysis should attempt to model traffic conditions at the time the Traffic Study is being prepared. Traffic counts that are older than the year the study is being prepared shall be factored up or adjusted to existing year volumes.

(b) Scenario 2 - Anticipated Project Completion Year Without Project Volumes: Include an analysis of the anticipated traffic conditions during the year the project is intended to be finished and traffic is generated. The analysis shall anticipate the increase in background traffic volumes and the generation of other related projects that are not present in the existing condition, but would likely be completed and generating trips in this time period. The trip generation for the proposed project shall not be included in this scenario. If the project is intended to be completed the same year that the Traffic Study is being prepared, then this scenario is the same as Scenario 1 - Existing Conditions.

(c) Scenario 3 - Anticipated Project Completion Year With Project Volumes: This scenario is the same as Scenario 2, except that the project volumes are assigned to the roadway network and included in the analyses.

(d) Scenario 4 Future Buildout Conditions Without Project Volumes: An analysis of the anticipated traffic conditions during buildout, using the projected buildout year defined in the city's TMP. The analysis shall anticipate the increase in background traffic volumes and the generation of other related projects that are not present in the existing condition, but would likely be completed and generating trips in this time period. The trip generation for the proposed project should not be included in this scenario.

(e) Scenario 5 Future Buildout Conditions With Project Volumes: This scenario is the same as Scenario 4, except that the project volumes are assigned to the roadway network and included in the analyses.

(2) **Traffic Volume Projections:** The traffic volume projections shall identify existing and projected daily traffic counts and peak hour turning movement counts for each access point, intersection and street identified in the Traffic Study area for each of the aforementioned scenarios required in the study.

(3) **Time Periods:** Each scenario may be required to look at three different time periods (the a.m., noon and p.m. peak hour conditions). The Director will determine which time periods and scenarios are required for each Traffic Study depending upon the project's size, location, types of land uses and other pertinent factors.

(4) **Raw Traffic Count Data:** Include all raw traffic-count data for average daily and peak hour conditions and traffic analysis worksheets in the appendices of the Traffic Study for reference. Computer techniques and associated printouts may be used for this part of the report.

NOTE: All total daily traffic counts must be actual machine counts, not based on factored peak hour sampling. Latest available machine counts from the city, and other agencies, may be acceptable if not more than 2 years older than the year the Traffic Study is being prepared. Data older than the year the Traffic Study is being prepared shall be factored up to current year numbers, using growth rates approved by the Director.

(M) Transportation Service Standards

Include a discussion and analysis assessing the impacts of the project or development proposal on the existing and planned transportation system in the study area with respect to the following traffic impact and mitigation objectives:

(1) **Transportation Master Plan Objectives:** TMP service standards' objectives include the following:

(a) No long-term growth in auto traffic over current levels described as a 0 percent increase in vehicle miles traveled.

(b) Reduction in single occupant vehicle travel to 25 percent of total trips.

(c) Continuous reduction in mobile source emission of air pollutants, and no more than 20 percent of roadways congested at LOS F.

(2) **Level of Service Design Guide:** LOS standards objectives include:

(a) Minimum LOS D design guide for peak hour conditions for all movements. Project impacts that maintain LOS D or better for all intersections and street segments may not be required to provide LOS-related traffic mitigation improvements.

(b) LOS E and lower peak hour conditions require the implementation of one or more transportation management strategies consistent with the goals and objectives of the TMP. A transportation management strategy plan required to address and mitigate these conditions may include travel demand management,

land use intensity reduction, site design, layout and access modifications, parking reduction measures, or transportation infrastructure improvements.

(N) Level of Service Analysis

(1) The Traffic Study shall provide LOS analyses for all study area intersections (signalized and unsignalized) and mid-block roadway segments using methodologies outlined in the current *Highway Capacity Manual*. The analyses should be performed for Scenarios 1 through 5, described in Section 2.0 3(L), "Existing and Projected Traffic Volumes," and for each time period (a.m., noon and/or p.m. peaks) that is required in the Traffic Study, unless otherwise required by the Director.

(2) Level of service analyses shall consider the appropriate infrastructure, lane usage, traffic control and any other pertinent factors for each scenario to be studied. Intersections with planned improvements, discussed in city planning documents, may have those improvements shown in the level of service analyses.

(3) Signalized intersection level of service analyses shall use the existing timing and phasing of the intersections for all scenarios. If the analyses are to deviate from existing timings or phasing, then a detailed signal progression analyses for the affected corridor shall also be provided.

(4) The results of the level of service analyses for each scenario and each time period shall be summarized into one or more tables that illustrate the differences in level of service for each scenario. At a minimum, these tables shall list the level of service results for each intersection to include the level of service for each approach and the total intersection level of service, as well as the appropriate delay values for each approach and the total intersection. These tables shall highlight any locations where the addition of project traffic has caused any approach of any intersection to fall below the LOS D standard for the city.

(O) Traffic Counts and Analyses Worksheets

Provide capacity analysis calculations based on the planning or operational analysis techniques contained in the current *Highway Capacity Manual* or subsequent highway capacity techniques established by the Federal Highway Administration, including the following:

(1) **Raw Traffic Count Data:** Include all raw traffic count data for average daily, hourly Average daily trip (ADT), and peak hour conditions and traffic analysis worksheets in the appendices of the Traffic Study for reference. Computer techniques and associated printouts may be used for this part of the report.

(2) **Level of Service Analyses:** Include all level of service analyses performed for intersections and roadway links. If signal timing or phasing changes are proposed for traffic mitigation and the signal is currently part of a coordinated system, a progression analysis will be required to ensure that adequate progression is maintained or provided. All progress analysis and assumptions to be used shall be reviewed and approved by the Director.

(P) Traffic Control and Signals

The Traffic Study shall discuss and analyze any traffic control measures that may be necessary to serve a proposed project or development. Any traffic control measures are to be evaluated based on the requirements established in the *Manual on Uniform Traffic Control Devices* (MUTCD) and by the city, and will be applied as necessary to ensure safe and efficient operation of the city's transportation system. The analysis shall demonstrate the need for traffic control measures considering the objectives and policies of the TMP and alternative site designs in order to minimize or mitigate traffic impacts from the proposed project or development. The following traffic control measures are to be addressed:

(1) **Regulatory Signage, Markings and Islands:** These traffic control measures shall be applied as necessary in conformance with the MUTCD and city standards and policies.

(2) **Traffic Signals:** The installation of new traffic signals is not encouraged by the city and all possible alternatives to signalization shall be evaluated before the installation of a new traffic signal will be considered. The need for new traffic signals will be based on warrants contained in the MUTCD and on city policies. In determining the location of a new signal, safety and community traffic circulation and progression will be the primary considerations. If a traffic signal is suggested as part of a mitigation package, and the intersection lies within a series of coordinated traffic signals, then a progression analysis may be required to ensure that adequate progression may still be provided. Generally, a spacing of one-half mile between all signalized intersections is to be maintained, to achieve optimum capacity and signal progression. Pedestrian and bicycle movements shall be considered in all cases and adequate pedestrian clearance is to be provided in the signalization design.

(3) **Intersection and Access Locations:** To provide flexibility and safety for the existing roadway system and to ensure optimum two-way signal progression, an approved traffic engineering analysis shall be made to properly locate all proposed intersections that may require signalization, and any accesses to the proposed development.

(Q) Hazard Assessment

The Traffic Study shall include a Hazard Assessment if the development has immediate frontage on a High Risk Network street (as detailed in the most recent version of the Vision Zero Action Plan). The applicant must evaluate if future conditions being proposed by the development create a new potentially hazardous condition or worsen an existing potentially hazardous condition or identified crash pattern. If a potentially hazardous condition has been identified, proven safety countermeasures to mitigate the hazard are to be included. The Hazard Assessment shall include, but is not limited to, the following sub-sections:

(1) Existing Conditions and Proposed Project

(a) Summarize existing conditions (including the past five years of fatal and serious injury crashes in the project vicinity) and the proposed project as defined by the Traffic Study requirements and relevant to identifying existing and new potential hazards (e.g., study area, existing and planned transportation system, multi-modal trip generation, distribution/assignment, modal split, traffic volumes, traffic control, and

signals).

(2) Analysis

(a) Applicant must analyze if future conditions being proposed by the development exacerbate existing or create new potentially hazardous conditions for public transit operations and for people walking, bicycling, driving, or using a mobility device or scooter. The methodology for analysis should account for the amount, movement type, sightlines, and speed of projected vehicle trips and projected changes to the public right-of-way in relation to the presence of public transit vehicles or people walking, bicycling, driving, or using a mobility device or scooter.

(b) Analysis must:

(i) Address the project's direct and indirect physical changes to the existing baseline conditions

(ii) Describe the intensity (e.g., number of vehicle trips), location (e.g., driveway, particular streets), and other project features that may be relevant to address the significance criterion. Be specific (e.g., the project would generate 120 vehicle trips into the driveway during the p.m. peak hour), do not generalize (e.g., the project would generate a modest number of vehicle trips).

(iii) The impact analysis shall assume the project will comply with laws and regulations. The analysis shall describe how compliance would occur, what it would entail, and how it may reduce impacts

(iv) Table 2-1 provides a sample of the circumstances, which may result in potentially hazardous conditions for people walking, bicycling, driving, or using a mobility device or scooter. This is not an exhaustive list of circumstances, under which, potentially hazardous conditions would occur. Additional hazardous conditions may be identified at the Director's discretion.

Table 2-1: Sample of Potentially Hazardous Conditions

Potentially Hazardous Condition
Adds a new site access or modifies an existing site access by adding new movements that were not previously permitted
Increases automobile volumes crossing sidewalks, paths, or trails
Increases corner radius and thereby increases the speed of turns or pedestrian/bicycle crossing distance

Increases the number of automobile lanes
Increases crossing distances
Adds unprotected left turn movement
Increases the volume of pedestrians across an uncontrolled mid-block crosswalk
Adds obstructions or slopes that diminish the sightline between road users

(3) Mitigation

(a) If a potentially hazardous condition is identified, the site development plan must identify and implement feasible mitigation measures using proven safety countermeasures to avoid or reduce the impact. The Engineer shall describe the location, nature, and extent of proposed mitigations to ensure compatibility with the City's transportation system and the goals of the TMP. Mitigations may include site design, layout and access modifications, parking reduction measures, or transportation infrastructure improvements.

(b) Proven safety countermeasures can be found in resources including the Boulder Vision Zero Action Plan, and national guidelines such as the FHWA Proven Safety Countermeasures, the Crash Modification Factors Clearinghouse, and NACTO Publications such as the Urban Street Design Guide, Urban Bikeway Design Guide, and Transit Street Design Guide.

(c) Hazard Assessment and proposed mitigation measures are subject to the approval of the Director.

(R) Noise Attenuation

If residential development is planned adjacent to a roadway designated collector or greater, the city may require noise attenuation measures. A discussion and analysis of noise attenuation measured using the methods in the *Fundamentals and Abatement of Highway Traffic Noise Textbook* is to be included in all traffic studies for residential developments adjacent to roadways designated collector or greater.

(S) Recommendations

(1) The Traffic Study shall include a section in the report that provides any recommendations of the Engineer. These recommendations shall include the Engineer’s recommended location, nature and extent of proposed transportation improvements associated with the project or development to ensure safe and efficient roadway operations and capacity, and compatibility with the city's transportation system and the goals of the TMP.

(2) These recommendations are to be supported with appropriate documentation and discussion of the technical analyses, assumptions and evaluations used to make the determinations and findings applied in the Traffic Study. In the event that any Traffic Study analyses or recommendations indicate unsatisfactory levels of service on any study area roadways, a further description of proposed improvements or mitigation measures to remedy deficiencies shall be included.

(3) These proposed improvements or mitigation measures may include projects by the city or the Colorado Department of Transportation for which funds have been appropriated and obligated. These proposals may also include improvements to be funded and constructed by the applicant as part of project or development construction. Assumptions regarding future roads, widths and lane usages in any analyses are subject to the approval of the Director.

(4) In general, the recommendation section shall include:

(a) Proposed and Recommended Improvements: Provide a detailed description and sketch of all proposed and recommended improvements. Include basic design details showing the length, width and other pertinent geometric features of any proposed improvements. Discuss and analyze whether speed change lanes are necessary to serve a project of development adjacent to a collector or arterial street. Discuss whether these improvements are necessary because of development traffic or whether they would be necessary due to background traffic. Specify the approximate timing necessary for each improvement.

(b) Level of Service Analysis at Critical Points: Provide another iteration of the LOS analyses that demonstrate the anticipated results of making recommended improvements, such as movement LOS, operational and safety conditions, and conformance with the city's transportation system goals and TMP. In association with LOS analyses for recommended improvements, include a comparison of these results with the background LOS analyses without the proposed project or development. Where appropriate, this step is to be provided for both near term (year of project completion) and buildout scenarios.

(T) Conclusion

Include a conclusion in the report that provides a clear and concise description of the study findings and recommendations and serves as an executive summary.

(U) Revisions to Traffic Study

(1) Following city review, the Director may require revisions to a Traffic Study based on the following considerations:

(a) Completeness of the study,
(b) Thoroughness of the level of service and impact analyses and evaluations,
(c) Compatibility of the study with the proposed access design, project or development plan and local transportation system,

(d) Compliance with local and state regulations and design standards, and
(e) An analysis of study deficiencies, errors, or conflicts.

(2) Revisions may also be required as a result of public process with surrounding neighborhoods and land uses or review by City Council or the Planning Board. Additional details requiring Traffic Study revisions may include, but are not limited to, the following:

(a) An enlarged study area,
(b) Alternative trip generation scenarios,
(c) Additional level of service analyses, and
(d) Site planning and design issues.

2.04 Site Access

(A) Access Requirements

All accesses and curb cuts shall be designed and constructed in compliance with these Standards and the requirements set forth in Section 9-9-5, "Site Access Control," B.R.C. 1981.

(B) Access Permit Required

All accesses and curb cuts proposed and constructed on city streets and alleys require a permit, as set forth in Section 9-9-5, "Site Access Control," B.R.C. 1981.

(C) Location of Access

(1) **Spacing:** Table 21, "Access Spacing Requirements," shows the required spacing of access points and curb cuts. Minimum spacing from corners shall be measured from point of intersection of the street flowlines. Minimum spacing between accesses shall be measured at the property line.

Table 2-2: Access Spacing Requirements

Minimum Spacing (measured from edge of access)	Single Family Residential	Other Residential	Commercial	Industrial
Local Streets				
- from property line	7.5'	10'	10'	10'
- from corner	20'	50'	50'	50'
- between accesses	15'	20'	20'	20'
Collector Streets	Permitted only when no other access is available.			
- from property line		10'	10'	10'
- from corner		50'	50'	50'
- between accesses		20'	20'	20'
Arterial Streets	Permitted only when no other access is available.			
- from property line		75'	75'	75'
- from corner		150'	150'	150'
- between accesses		250'	250'	250'

(2) **Alignment:** Accesses shall intersect city streets at a 90-degree angle. Accesses to properties on opposite sides of a collector or arterial, where turning movements are not controlled by a center median or access island, shall either be aligned, or offset by at least 150 feet on collectors, or at least 300 feet on arterials. Greater offsets may be required if left-turn storage lanes are required.

(2) **Relocation of Existing Access Points and Curb Cuts:** Relocation, alteration, or reconstruction of any existing access points and curb cuts shall meet the requirements of these Standards.

(D) Sight Distance

All access points and curb cuts shall provide adequate sight distance as set forth under Section 9-9-7, "Sight Triangles," B.R.C. 1981.

(E) Restriction of Turning Movements

Along streets designated arterial or greater, or where necessary for the safe and efficient movement of traffic, the city will require access points and curb cuts to provide for only limited turning movements, as follows:

(1) **Access With Barrier Island - Left-Turn Restrictions ("**Pork Chop**"):** Where restricted turning movements are required by the city, and where the abutting street does not have a median, a barrier island will be required:

(a) Islands shall have a minimum area of 150 square feet, be bounded by vertical curb, and have an appropriate concrete center surface treatment, approved by the Director.

(b) Barrier island lanes shall be at least 12 feet wide, have a radius of at least 20 feet, and be designed to accommodate the largest vehicle using the access on a daily basis. The island shall provide congruent curb ramps or cut through for sidewalks. The pedestrian crossing over the barrier island shall be raised. The dimensions of a raised crossing shall be designed considering standards for accessible design and site conditions, including topography, stormwater flow, and location of utilities. The minimum width of the island along the abutting roadway frontage shall be 30 feet for right-in, right-out only islands, and 15 feet for islands allowing right-in, right-out and left-turning movements.

(2) **Access With Median Divider Barriers – Left-Turn Restrictions:** Median barriers may be permitted where a median design can improve traffic circulation and safety, or overall site access. Where permitted, medians shall be at least 4 feet wide, and shall extend at least 25 feet beyond the right-of-way.

(F) Traffic Control

All accesses shall be designed and constructed with appropriate traffic control and signage conforming to the MUTCD, B.R.C. 1981, and these Standards.

(G) One-Way Access Lanes

One-way access lanes may be permitted where restricted access is limited to one turning movement, or where the one-way access improves traffic circulation and safety. One-way access lanes shall be at least 12 feet wide, have at least radius of 20 feet, and be designed to accommodate the largest vehicle using the access on a daily basis.

(H) Speed Change Lanes

Speed change lanes shall be required on Colorado state highways as designated in the Colorado State Highway Access Code in accordance with the standards of Section 4.8 of the Colorado State Highway Access Code. For all collectors or arterials that are not Colorado state highways, the Traffic Study shall make recommendations on the need for speed change lanes, based on the criteria contained in the Colorado State Highway Access Code. When required by the Director based on the criteria in the Colorado State Highway Access Code, design of speed change lanes shall conform with Subsection 2.07(D), "Horizontal Alignment," of these Standards.

(I) Access and Curb Cut Type

(1) **Driveway Ramp and Curb Cut:** All new accesses and curb cuts shall be designed as driveway ramps and curb cuts, using the standard ramp driveway details provided in Chapter 11, except as allowed in Subsection (2), along streets where no curb and gutter exists, or for single family lots where roll-over curbs have been provided.

(3) **Radii Curb Returns:** Radii curb return accesses may be required or permitted by the Director under the following conditions:

(a) The access is located along an arterial or collector.
(b) Access volumes indicate a need for a radii curb return where the ADT exceeds 500 or where speed change lanes would be required.
(c) The access is designed to restrict turning movements, requiring the installation of an access island or center median.
(d) The roadway has no curb and gutter.
(e) The access serves an industrial property, or provides for commercial deliveries, where large truck movements are required.
(f) The Director determines that a radii access is necessary to ensure adequate traffic safety and operation.
(g) The access is for a new public street

Table 2-3: Access Design Specifications

	Single Family Residential	Other Residential	Commercial	Industrial
Width (in feet)				
- Minimum	10	10	15	20
- Maximum	20	35	35	35
- One-Way Lane	N/A	12-18	12-20	14-24
Radii (in feet)				
- Minimum	N/A	15	15	20
- Maximum	N/A	30	30	40
Access Grades				
Initial Grade (to a point 10				

ft beyond ROW)				
- Minimum	(+) 3%	(+) 1%	(+) 1%	(+) 1%
- Maximum	(+) 8%	(+) 6%	(+) 6%	(+) 6%
Final Grade (G2)				
- Minimum	(+/-) 3%	(+/-) 1%	(+/-) 1%	(+/-) 1%
- Maximum	(+/-) 14%	(+/-) 8%	(+/-) 8%	(+/-) 8%
Max Grade Break	(+/-) 10%	(+/-) 6%	(+/-) 6%	(+/-) 6%

(J) Access and Curb Cut Width

Access and curb cut widths shall be consistent with Table 2-2, "Access Design Specifications," of these Standards. Access design for Colorado state highways shall conform to the Colorado State Highway Access Code. All other access widths shall be determined using turning templates, as designated by the Director, for a 10 MPH design speed for the largest vehicle expected to use the access on a daily or routine basis. The width of each access shall be the minimum width that is necessary to serve the property and use. No more than 50 percent of the street frontage shall be occupied by the access driveway, except for access to a cul-de-sac or flag lot. All access widths are measured from edge of pavement to edge of pavement (or curb to curb) at the throat of the driveway (or edge of the right-of-way) and are not inclusive of drive cut transitions or curb return radii.

(K) Access and Curb Cut Radii

Access and curb cut radii shall meet the specifications shown in Table 2-2, "Access Design Specifications," of these Standards. All radii are measured from the flowline (front face of the curb) or from the edge of the pavement where no flowline exists.

(L) Access and Curb Cut Grades

Access and curb cut grades shall be consistent with Table 2-2. The initial grade (G1) shall be a positive grade, beginning at the back of the sidewalk, the back of the driveway ramp or pan section, or the edge of the pavement (where no curb and gutter exists), and shall continue at least 10 feet beyond the right-of-way. The final grade (G2) may be positive or negative, depending on the access conditions. The maximum grade break (or change in slope) shall apply at all grade changes. Additional grade changes may occur at intervals of at least 20 feet.

(M) Driveways

(1) **Vehicle Storage:** Adequate driveway storage capacity for both inbound and outbound vehicles to facilitate safe, unobstructed, and efficient traffic circulation and movements from the adjacent roadway and within the development shall be provided, except for single-family or duplex residential driveways on local streets. Adequate driveway length will be subject to approval by the Director and shall extend at least 24 feet beyond the right-of-way before accessing the first off-street parking space or parking lot aisle.

(2) **Internal Circulation:** Developments with off-street parking facilities shall provide onsite vehicular circulation allowing access to all portions of the site without using the adjacent street system unless a joint access or parking easement with one or more of the adjacent property owners has been dedicated.

(3) **Backing Into the Right-of-Way Prohibited:** Driveways shall be designed to contain all vehicle backing movements onsite, except for single-family or duplex residential uses on local streets.

(4) **Minimum Back-Up Distance for Detached Single-Family Residential Driveways Accessing Public Alleys:** Driveways shall provide for a minimum distance of 24-feet from the rear of the parking stall or face of garage to the far edge of the adjacent alley right-of-way or turn around area as required by Chapter 9-9-6, “Parking Standards,” B.R.C. 1981.

(5) **Shared Driveways (Detached Single-Family Residential Only):** Shared driveways to access detached single-family residential lots may be permitted pursuant to an approved site review or subdivision as set forth in Chapter 9-9-14, “Site Review,” B.R.C. 1981 or Chapter 9-12, "Subdivision," B.R.C. 1981, if they meet the following criteria:

(a) The shared driveway is no more than 100 feet long, except in districts zoned RL-1 (Residential-Low 1), RE (Residential-Estate), and RR1 (Residential-Rural 1) and RR 2 (Residential-Rural 2), where the shared driveway may extend up to 300 feet long if each lot accessing the shared driveway exceeds 10,000 square feet.

(b) The number of units served shall be no more than three lots or houses that have less than 30 feet of usable frontage on the accessing street.

(c) Adequate turnaround for vehicles is provided either on an individual lot or lots.

de) The driveway is properly engineered and constructed to mitigate any adverse drainage conditions and is appropriately surfaced for the type of development, usage, and zoning district.

ef) The driveway is at least 12 feet wide.

(f) For units not fronting on the accessing street, addressing shall be located near the entrance to the shared driveway insuring visibility of the numbering from the street.

(g) A public access easement, a minimum fifteen feet in width, for the benefit and use of all properties and property owners accessing the shared driveway has been dedicated and recorded to ensure legal access rights in perpetuity for each property served.

(hi) Driveway spacing conforms with the requirements in Table 21, “Access Spacing Requirements,” of these Standards.

2.05 RightofWay Requirements

Dedication or reservation of public right-of-way required as part of any project or development proposal shall comply with the requirements set forth in Section 9-9-8, “Reservations, Dedication, and Improvement of Rights-of-Way,” B.R.C. 1981.

2.06 Base Street and Alley Standards

(A) Base Street Standard

Except for residential streets approved pursuant to Chapter 9-12, "Subdivision," B.R.C. 1981, and Section 2.09, "Residential Streets," all new streets shall provide at a minimum the base street standard components listed in Table 2-3, "Base Street Standard Components."

(B) Base Alley Standard

Except for residential streets approved pursuant to Chapter 9-12, "Subdivision," B.R.C. 1981, and Section 2.09, "Residential Streets," all new alleys shall provide at a minimum the base alley standard components listed in Table 2-4, "Base Alley Standard Components."

Table 2-4: Base Street Standard Components

Street Component	Base Standard
Right-of-Way	60' Minimum Width
Paved Street Section	36' Minimum Width, Curb Face to Curb Face
Travel Lanes	Two Travel Lanes, Two-Way Traffic
Curb and Gutter	Required Both Sides
Parking	Parking Allowed Both Sides
Sidewalks	6' Preferred Width (5' Minimum), Detached, Required Both Sides
Streetscape Planting Strips*	8' Width Required Both Sides

*NOTE: In commercial streetside retail zones where 12foot wide attached sidewalks may be provided, streetscape planting strips may be created using street trees in planting pits with tree grates (15-foot width between back of curb and back of walk).

Table 2-5: Base Alley Standard Components

Alley Component	Base Standard
Right-of-Way	20' Minimum Width
Paved Street Section	18' Minimum Width, Pavement Edge to Pavement Edge
Travel Lanes	Two-Way Traffic Allowed
Parking	Parking on Alley Not Permitted

2.07 Street Geometric Design

(A) Minimum Requirements

Except for State Highways and the geometric design variations allowed for residential streets approved pursuant to Chapter 9-12, "Subdivision," B.R.C. 1981, and Section 2.09, "Residential Streets," all city streets shall be designed in conformance with this section. The design standards outlined in this section are minimum design standards, and all street design shall meet or exceed these standards. On streets designated collector or arterial in the TMP, the Director may specify standards to be applied to street design that may exceed the minimum standards in this section based on functional need to ensure safe and efficient operation of the street.

(B) Right-of-Way

The right-of-way width required for new streets shall comply with the requirements of Section 9-9-8, "Reservations, Dedication, and Improvement of Rights-of-Way," B.R.C. 1981, and shall include without limitation the following elements:

(1) The paved roadway section including without limitation travel lanes, turning and speed change lanes, transit lanes, bicycle lanes, and parking lanes;
(2) Curbs and gutters or drainage swales;
(3) Roadside and median landscaping areas;
(4) Sidewalks and multi-use paths; and
(5) Any necessary utility corridors.

(C) Lane Width

Street lanes shall meet the width specifications shown in Table 2-5, "Preferred Street Lane Widths," of these Standards.

Table 2-6: Preferred Street Lane Widths

Design Criteria		Street Characteristics		
		With Parking Lane	No Parking Lane	With Fixed-Route Bus Transit Service and No Parking Lane
		Preferred	Preferred	Preferred
General Purpose Travel Lanes*		10'	10'	11' (Outside lane)
Auxiliary Lanes*		10'	9'	10'
Conventional Bike Lanes		7'	6.5'	7'
Contra-Flow Bike Lanes (On One-Way Streets)		7'	6.5'	N/A
Buffered Bike Lanes	Bike Lane	7'	6.5'	6'
	Buffer	3'	3'	2'
Separated Bike Lanes	Bike Lane	7' (for parking protected bike lanes, a painted 3' buffer is between curbside of parking lane and bike lane)	7'	7'
	Buffer	3' (with vertical element)	3' (with vertical element)	3' (with vertical element)
Two-Way Separated Bike Lanes	Bike Lane	12' Two-way bike lane (for parking protected bike lanes, a painted 3' buffer is between curbside of parking lane and bike lane)	12' Two-way bike lane (buffer is between curbside of parking lane and bike lane)	N/A
	Buffer	3'	3'	N/A

		(with vertical element)	(with vertical element)	
Parking Lanes		8’ (measured from curb face, including gutter pan)	N/A	8’ (measured from curb face, including gutter pan)

*NOTES: Travel, auxiliary lane and bike lane dimensions do not include gutter pan width. Auxiliary lanes include, without limitation, turning and speed change lanes.

(D) Horizontal Alignment

(1) **Conformance to Street Plan:** Horizontal alignment shall conform to the pattern of streets in the Boulder Valley Comprehensive Plan, TMP, and adopted right-of-way plans and shall provide continuous alignment with existing, planned, or platted streets with which they will connect.

(2) **Extension to Property Line:** All streets shall be extended to the property lines across the property to be developed, unless the street to be constructed has been approved by the city as a cul-de-sac or other no-outlet street.

(4) **Minimum Horizontal Curve:** Street curvatures shall meet the minimum specifications shown in Table 2-6, “Minimum Horizontal Street Curve Specifications,” of these Standards.

Table 2-7: Minimum Horizontal Street Curve Specifications

Design Criteria	Local Street	Collector Street	Arterial Street
Minimum Design Speed	20 mph	35 mph	40 mph
Minimum Centerline Radius	100 feet	300 feet	500 feet
Minimum Reverse Curve Tangent	50 feet	100 feet	200 feet
Minimum Intersection Approach Tangent	100 feet	200 feet	300 feet

Table 2-7a: Separated Bike Lane Minimum Horizontal Curve Specifications

Design Criteria	Flat, level terrain	Congested, urban area	Intersection approach
Minimum Design Speed	15 mph	12 mph	8 mph
Minimum Centerline Radius*	42 feet	27 feet	12 feet

*Radius assumes a 20-deg lean angle of the bicyclist.

(4) **Design Horizontal Curve:** The design horizontal street curvature shall meet or exceed the minimum horizontal curvature and be calculated using the following equation:

$$R = V^2 / 15 * (e-f)$$

Where: E = rate of superelevation per foot
F = side friction factor

Side Friction Factors	
Design Speed (mph)	Side Friction Factor (f)
20	0.26

V = vehicle speed in MPH
R = radius of curve in feet

25	0.23
30	0.22
35	0.20
40	0.18
45	0.16

(5) Intersections and Street Spacing

(a) **Angles:** All streets shall intersect at right angles (90°).

(b) **Minimum Street Spacing:** Spacing between streets, as measured from centerline to centerline, shall equal or exceed the minimum distances shown in Table 2-7, "Minimum Street Spacing," of these Standards.

(c)

Table 2-8: Minimum Street Spacing

Street Type	Minimum Street Spacing
Local	150 feet
Collector	300 feet
Arterial	500 feet

(c) **Street Spacing for Signalized Intersections:** Signalized intersections, where feasible, shall be spaced at half-mile intervals. Closer signal spacing may be approved by the Director based on context-sensitive design. Signalized intersections shall comply with the TMP and Low-Stress Walk and Bike Network Plan to ensure signalized intersections along arterial and collector streets provide controlled crossing where existing and proposed walking and bicycling network streets cross those arterial and collector streets.

(d) **Receiving Width:** The minimum receiving width is 20 feet. This may include both an opposing and receiving vehicle through lane and a paved shoulder and/or bicycle lane.

(e) **Corner Radii:** The smallest feasible actual curb radii shall be selected for corner designs. Corner design shall account for the effective turning radius, the actual curve of a turning vehicle. This shall include the additional turning area provided by on-street parking, bicycle lanes, medians, and other roadway features. Figure 2-1 and Figure 2-2 demonstrate the relationship between the effective radius and actual curb radius. Table 2-8 shall be used to determine actual versus effective turning radii for SU-30 design vehicles.

The effective radius shall be analyzed for the design vehicle; the default design vehicle is the SU-30 for all intersections. The Director may require a different design vehicle based on functional need to ensure safe and efficient operation of the street (for example, a bus or transit route, or a semi-tractor and trailer on streets with industrial land uses).

The Director may require a larger effective curb radii to provide no encroachments at locations served by transit and where the transit agency operators have policies that prohibit drivers from encroaching into adjacent lanes. The Director may require a mountable truck apron for locations where large trucks turn infrequently, but there is limited space for encroachment. The truck apron design shall provide a smaller effective radius for the design vehicle and a larger effective radius to accommodate larger vehicle turn movements. Figure 2-3 is an example of a truck apron.

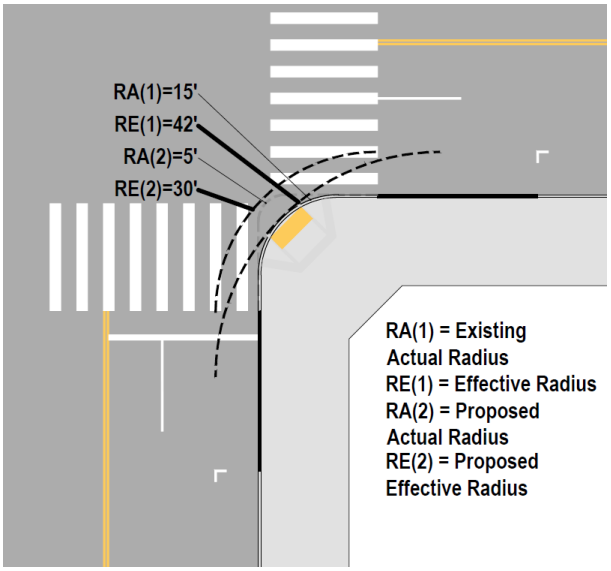


Figure 2-1: Actual and Effective Radius At A Conventional Intersection Corner

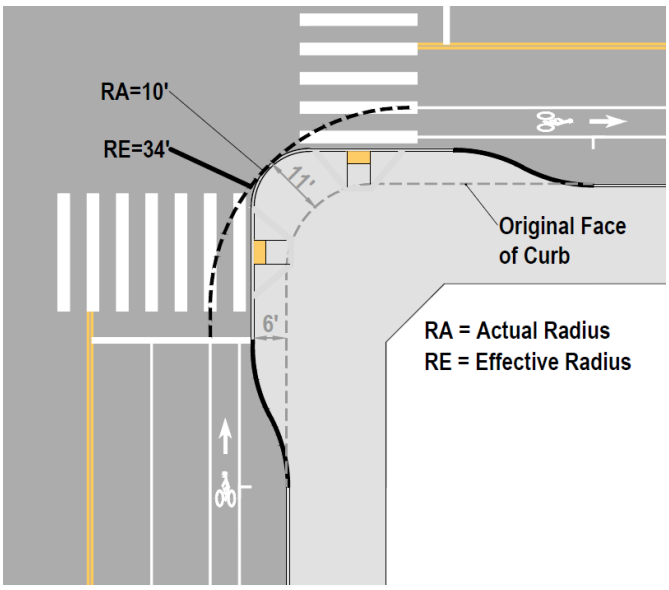


Figure 2-2: Actual and Effective Radius At An Intersection Corner With A Curb Extension

Table 2-9: Relationship between Effective and Actual Radius for the Default Design Vehicle (SU-30)

			Street B			
		Parking	No	No	Yes	Yes
		Bike Lane	No	Yes	No	Yes
Street A	Parking	Bike Lane				
	No	No	RA = 30’ (RE = 30’)	RA = 25’ (RE = 30’)	RA = 25’ (RE = 30’)	RA < 10’ (RE = 30’)
	No	Yes	RA = 25’ (RE = 30’)	RA = 15’ (RE = 30’)	RA < 10’ (RE = 30’)	RA < 5’ (RE = 30’)
	Yes	No	RA = 25’ (RE = 30’)	RA < 10’ (RE = 30’)	RA < 5’ (RE = 30’)	RA < 5’’ (RE = 35’)
	Yes	Yes	RA < 10’ (RE = 30’)	RA < 5’ (RE = 30’)	RA < 5’ (RE = 35’)	RA < 5’ (RE = 45’)

**When the difference between the effective and actual corner radii becomes larger, or when the effective radius cannot be reduced to what is necessary for the control vehicle, the director may require a curb extension.*

(f) **Allowable turning encroachments for curb radii design**: The following shall be used to reduce effective and actual curb radii. The SU-30 design vehicle turns may encroach into other lanes as follows:

i. For turns onto local streets from arterial, collector, or local streets, the design vehicle is allowed to utilize the entire width of the departing and receiving lanes, including oncoming travel lanes, to negotiate the turn.

ii. At intersections where the minor leg is stop controlled and the major leg is uncontrolled, turns are allowed to use the entire width of both the minor leg departing or minor leg receiving lanes, including oncoming travel lanes, to negotiate the turn.

iii. At signalized intersections that have a “No Right on Red” restriction, turning vehicles are allowed to utilize multiple lanes on the receiving street to complete their turn.

(g) **Additional Corner Radii Design Considerations:** The following turning scenarios shall be used to reduce the effective and actual curb radii:

i. Emergency vehicles are allowed to utilize the entire street pavement width for departing and or receiving lanes to negotiate turns, including all adjacent and oncoming travel lanes.

ii. WB-40 and larger design vehicles are allowed to utilize adjacent lanes on the departing and receiving streets at all intersections; large trucks may use the entire street pavement width on local streets.



Figure 2-3: Example of A Mountable Truck Apron At An Intersection

(6) **Road Width Transition Tapers:** Where two street sections or different widths are to be connected, a transition taper is required between the outside traveled edge of the two sections. The length of the transition taper shall be calculated using the following equation:

L = WS

Where: S = Speed in MPH
L = Length in feet
W = Width of offset in feet

This transition is not to be used in the design of left turn storage lanes or speed change lanes.

Design of tapers for on-street bike lanes shall use a minimum length as calculated using the formula below:

$$L = \frac{WS^2}{60}$$

Where: L = Longitudinal lane shift (ft), minimum 20 ft
W = Lateral width of offset (ft)

S = Target bicyclists operating speed (mph)

If the bikeway is delineated by paint-only and the off-tracking of a bicycle pulling a trailer would not put the trailer into a motor vehicle lane, a maximum taper ratio of 2:1 (longitudinal:lateral) may be required by the Director.

(7) **Left Turn Lanes**

(a) **Storage Length:** Left turn lane storage length for unsignalized intersections shall be determined based on traffic volumes using the Leisch nomographs provided in the ITE "Guidelines for Major Urban Street Design." The left turn storage length for an unsignalized intersection shall not be less than 25 feet. Unsignalized intersections shall only use single lane turn lanes.

For signalized intersections, left turn lane storage length shall be determined utilizing the Highway Capacity Manual. The minimum left turn lane storage length is 80 feet. Single lane left turn storage shall be maximized to the extent feasible and shall be exhausted before consideration of dual turn lanes. If storage length requirements cannot be met in a single lane the Director may, after considering the impacts to the pedestrian and bicycle crossing distance and expected left turn queuing impacts to safety and intersection operations, approve a dual or triple left turn lane configuration. In a location where dual left turn lanes are approved, the lane storage length shall be based on at least 60 percent of the single lane storage length..

(b) **Lane Change Taper:** Left turn lane change tapers shall be calculated using the equation for bay tapers in Subsection (8).

(8) **Speed Change Lanes:** Speed change lanes required for transitional access to turning lanes shall be designed according to the design standards provided in the ITE "Guidelines for Major Urban Street Design," as follows:

(a) **Bay Tapers:** Bay tapers are required for the lane transition from the travel lane into a turn lane. The bay taper length shall be calculated using the following equation:

$$\mathbf{L = WS / 3}$$

Where: S = Speed in MPH
L = Length in feet
W = Width of offset in feet

(b) **Approach Tapers:** Approach tapers are required to transition the position of travel lanes to accommodate turn lanes. The approach taper length shall be calculated using the following equation:

$$\mathbf{L = WS^2 / 60}$$

Where: S = Speed in MPH

L = Length in feet
W = Width of offset in feet

(9) **Cul-de-sacs:** Where allowed, cul-de-sacs shall have a minimum pavement diameter of 90 feet, curb face to curb face, and a minimum right-of-way diameter of 115 feet, except for residential streets approved pursuant to Chapter 9-12, "Subdivision," B.R.C. 1981, and Section 2.09, "Residential Streets." Cul-de-sacs are prohibited on arterial and collector streets, and are strongly discouraged on local and residential streets. The Director may permit cul-de-sacs where there is no other possible street or driveway access to a property from a public right-of-way, or if a cul-de-sac would avoid direct property access to a collector or arterial.

(E) Vertical Alignment

(1) **Minimum Street Grade:** All street grades shall equal or exceed the minimum street grade of 0.5 percent.

(2) **Maximum Street Grade:** Street grades shall not exceed the maximum street grades shown in Table 2-9, "Maximum Street Grades," of these Standards.

Table 2-10: Maximum Street Grades

Street Type	Maximum Street Grade
Local	8%
Collector	6%
Arterial	5%
Intersection Approach (Minimum 50')	4%
Signalized Intersection Approach (Min. 50')	2%

(3) **Design Controls for Vertical Curves:** Design control for sag and crest vertical curves (based on a design speed of 30 mph) shall meet the specifications shown in Table 2-10, "Vertical Curve Design Control," of these Standards. For design speeds in excess of 30 mph, design control shall be in accordance with the current edition of "A Policy on Geometric Design of Highways and Streets," prepared by the American Association of State Highway and Transportation Officials.

Table 2-11: Vertical Curve Design Control

Algebraic Difference in Grades	Sag Curve Minimum Vertical Curve Length	Crest Curve Minimum Vertical Curve Length
0.5 - 1.0 %	50 feet	100 feet
1.0 - 3.0 %	100 feet	100 feet
3.0 - 5.0 %	200 feet	150 feet
5.0 - 7.0 %	300 feet	200 feet
7.0 - 8.0 %	300 feet	300 feet
Min. Vert. Sight Distance	N/A	250 feet

(4) **Vertical Sight Distance:** Vertical curve sight distance shall equal or exceed 250 feet. Greater vertical sight distance may be required by the Director to ensure safe travel and street crossings for all transportation modes.

(F) Sight Distance

All streets and alleys shall provide adequate sight distance as set forth under Section 9-9-7, "Sight Triangles," B.R.C. 1981.

(1) **Design Sight Distance for Separated Bike Lanes:** Departure sight triangles shall be used to provide adequate sight distance for a stopped driver on a minor roadway to depart from the intersection**.**

(a) **Parking Restrictions**: Separated bike lanes and access driveways shall be designed so that parking is prohibited within 20 feet of a driveway in locations where a parking lane is designated between bike lane motor vehicle lane.

(b) **Two Stage Crossing**: Where side streets intersect the separated bike lane, intersections shall be designed as two-stage crossings for motor vehicles.

(c) **Departure Sight Triangle:** Use the following equation to compute the departure sight triangle between a passenger vehicle and user of the bike lane.

$$ISD_{bike} = 1.47\, V_{bike}\, t_g$$

Where:

ISD_{bike}	=	intersection sight distance (length of the leg of sight triangle along the bikeway) (ft)
V_{bike}	=	design speed of bikeway (mph)
t_g	=	time gap for passenger vehicle to cross bikeway (s), use 5.5 seconds

Table 26a, "Separated Bike Lane Minimum Horizontal Curve Specifications," shall be used to establish the V_{bike} value.

AASHTO *Green Book* Case B sight distance shall be used to calculate the departure sight triangle between the motorist and the intersecting motorist travel lanes.

(G) Medians

Raised medians are required on new arterial streets. Raised medians, where feasible, shall extend past the pedestrian crosswalk to allow for a pedestrian refuge zone.

(1) **Median Widths:** Medians shall be at least 4 feet wide, curb face to curb face. If left turn lanes are installed in the median, the median width adjacent to the left turn storage lanes shall be 4 feet and the median width at the start of the left turn lane bay taper shall be at least 14 feet wide, curb face to curb face. Median design widths shall conform to Table 2-11, "Median Width Design Standards," of these Standards.

Table 2-12: Median Width Design Standards

Function	Minimum Width	Recommended Width
Separation of Opposing Traffic	4 feet*	10 feet*
Pedestrian Refuge or Traffic Control Device Location	6 feet*	14 feet
Medians Separating Left Turn Lanes	14 feet	20 feet

* NOTE: Cannot accommodate left-turn lanes

(2) **Landscaping in Medians:** Landscaping in medians shall comply with the requirements of Chapter 3, "Streetscaping," of these Standards.

(H) Vertical Clearance of Structures

At least 17.5 feet of vertical clearance shall be provided for all overhead structures. Vertical clearance is measured from the crown of the street to the lowest portion of the structure on all streets and alleys.

2.08 Sidewalks

(A) Required

Sidewalks are required on both sides of all new streets, except for residential streets that were approved without required sidewalks pursuant to Chapter 9-12, "Subdivision," B.R.C. 1981, and Section 2.09, "Residential Streets."

(B) Conformance with the Transportation Master Plan

Off-street sidewalks may be required as part of any project or development proposal in conformance with the TMP.

(C) Compliance with Americans with Disabilities Act (ADA)

All public sidewalks shall comply with the requirements of the ADA's "Standards for Accessible Design," which includes without limitation sidewalk widths, grades, locations, markings, surface treatments, and access ramps.

(D) Minimum Widths

Sidewalk widths shall conform to the dimensions shown in Table 2-12, "Minimum Sidewalk Widths," of these Standards.

Table 2-13: Minimum Sidewalk Widths

Minimum Sidewalk Width			
	Adjacent Land Use		
Street Type	Commercial/Retail	Commercial/Industrial	Residential
Local	12	5	4
Collector	12	5	5

Arterial	12	8	8

Note: All off-street multi-use/bike paths designated in the Transportation Master Plan shall be 12 feet wide.

(E) Vertical Grades

The vertical grade of a sidewalk shall not exceed 8.33 percent, a ratio of 12 feet horizontal to 1 foot vertical (12:1).

At sidewalk locations adjacent to transit stops or transfer points, the Director may require wider sidewalk sections to provide for adequate passenger storage areas.

(F) Vertical Clearance

A minimum 8-foot vertical clearance shall be provided between all sidewalk and multi-use path surfaces and any overhead encroachments.

2.09 Residential Streets

(A) Purpose

(1) The residential street standards were developed to allow a variety of choices in the creation of new transportation corridors within the urban environment under conditions that will not compromise the safety and function of the city street system. Traditionally streets have provided the following:

(a) Corridors for pedestrian, bicycle, transit, and motor vehicle movement;
(b) Parking for vehicles;
(c) Fire, police, and emergency access;
(d) Locations for public utilities networks including water supply, sewage, electricity, telecommunications and gas services, and refuge disposal; and
(e) Postal and other delivery services.

(2) These Standards recognize that streets, if appropriately designed, may provide additional community amenities including landscape buffers, attractive public gathering spaces, opportunities for neighborhood interaction, public art, view corridors, and potential avenues for new technologies.

(B) Scope

(1) Location of Streets

(a) These standards are intended to be used for new streets in undeveloped areas of the city.
(b) Where infill development in the existing developed portions of the city requires the creation of new streets, these alternative standards may be used if the Director finds, after completing the review process described in Section (C) below, that the new streets will not impair the functions of the surrounding transportation system nor negatively impact the character of the surrounding existing development.

(c) Further, the Director may determine that these standards are appropriate for redesigning and reconfiguring existing streets. Because the public cost of retrofitting, reconfiguring, or redesigning existing streets is often expensive, decisions about reconstruction of individual streets in accordance with these standards shall be made pursuant to the city's Capital Improvements Program process.

(2) **Methods of Review**

(a) Permitted: The following street types may be developed without review:

(i) Residential collector street
(ii) Residential street
(iii) Residential alley

(b) By Director Review: Residential streets listed in paragraph (B)(2)(a) and the street types listed below may be developed upon approval by the Director under the criteria outlined in Section (C) below.

(i) Rural residential street
(ii) Access street
(iii) Access lane

(c) By Site Review: Those underlined criteria and specifications in the following residential street standards may be appropriate for modification under certain limited circumstances. Developments requesting such modifications shall meet all of the requirements of Section 9-2-14, "Site Review," B.R.C. 1981, in addition to the criteria outlined in Subsection (C), "Director Review," below.

(3) **Cumulative Standards:** These street standards are intended to be used in combination with Section 2.07, "Street Geometric Design," of these Standards. Where the standards in this section are silent, the criteria or specifications contained in Section 2.07 shall control.

(C) Director Review

(1) **Application:** As part of a subdivision application, the applicant for residential street construction approval shall include plans that depict the building envelopes of all proposed structures, and the location of proposed trees, street furniture, fire hydrants, meter pits, utility cabinets, or pedestrians in the right-of-way.

(2) **Criteria:** The Director will consider the following factors in determining whether an alternative street design is appropriate in a particular location:

(a) Urban Design: The street should contribute to the creation of an attractive community and to a clearly defined sense of place. Streets shall be designed with due attention to building spacing and setbacks, green spaces, attractive materials, plantings, and landscaping. Pavement and right-of-way widths that are less than

the Residential Street standard should provide a benefit to the community that includes improved safety, improved site design, the creation of street canopies through landscaping, and secondary lot access through the use of alleys. Rural Residential streets shall be consistent with the existing character of the area, or with an approved subcommunity or area plan.

(b) Street Function: The street should be designed according to its function. This may require a diversity of street types, each serving a role in a hierarchical system. The street pattern and any reduced pavement or right-of-way widths should provide acceptable levels of accessibility, safety and convenience for all street users, including emergency service providers. The pattern shall discourage residential streets from operating as pass through traffic routes for externally generated traffic, while minimizing the length of time local drivers need to spend in a low-speed environment.

(c) Connectivity: The neighborhood street pattern should be simple, and logical, with the following characteristics:

(i) "No outlet" streets will be highly discouraged and allowed only when street connectivity is unachievable:
(ii) The street pattern provides for safe and convenient movements for pedestrians, bicycles, and motor vehicles, including transit.

(d) Design Speed: The design of the streets will control vehicular speeds under normal driving conditions to that specified in the residential street standards, while maintaining reasonable access for emergency vehicles.

(e) Minimize Maintenance Costs: The street will not create additional city obligations for maintenance and repair that exceed a standard street section.

(f) Adequate Parking: The site design provides for adequate onstreet parking to serve the area.

(g) Infill Streets: In the case of infill development, the residential street design will not impair the functioning of, and will have a compatible transition to, the surrounding street system and will not negatively impact the character of the surrounding existing development. No additional density may result from approval of the reduced rights-of-way provided for in the case of Access Streets, Access Lanes, or Residential Alleys.

(D) Residential Street Sections

Five residential street sections and a residential alley may be applied to the design of residential neighborhoods as part of subdivisions approved pursuant to Chapter 9-12, "Subdivision," B.R.C. 1981. Residential streets shall be designed in compliance with the standards outlined in Table 2-13, "Residential Street Design Standards," "Technical Drawings 2.63 - 2.68," Chapter 11, of these Standards, and the requirements of this Section.

(1) **Residential Collector Street:** The residential collector street collects and distributes neighborhood traffic from residential streets to community collector and arterial

transportation systems and provides access to individual properties. The residential collector street is designed for residential streets where anticipated traffic volumes range from 1,000 to 2,500 vehicle trips per day. In addition to the requirements outlined in Table 213, "Residential Street Design Standards," and "Technical Drawing 2.63," Chapter 11, the residential collector street shall be designed to meet the following minimum standards:

(a) Parking: On-street parking is allowed on both sides.
(b) Bicycle Facilities: Additional street and right-of-way width shall be provided where on-street bicycle lanes are required by a city-adopted subcommunity or area plan, the TMP, or the BVCP.
(c) Provision of Alleys: Where alleys are provided or required to be provided under a City-adopted subcommunity or area plan, onsite parking spaces shall be accessed from the alley and not the street.
(d) Emergency Response: Residential collectors exceeding 500 feet in length from any intersection shall provide a secondary emergency access at 500-foot intervals.

(3) **Residential Street:** The residential street is designed to provide access to individual properties as well as access to the higher classification street network. The residential street provides for neighborhood circulation and may carry neighborhood traffic and through movements. The residential street shall be designed to meet the minimum standards shown in Table 2-13, "Residential Street Design Standards," and "Technical Drawing 2.64," Chapter 11, of these Standards.

Table 2-14: Residential Street Design Standards

Design Standards	Residential Collector	Residential Street	Rural-Type Residential Street	Access Street	Access Lane	Residential Alley
Design Speed	25 mph	25 mph	20 mph	15 mph	10 mph	10 mph
Design Traffic Volumes (Vehicle Trips Per Day)	1,000 -2,500	500 - 1,000	500 - 1,000	400	250	N/A
Minimum Right-of-Way	60'	60'	60'	40'	30'	16'
Minimum Pavement Section	32'	30'	22' plus 2' gravel shoulders	26'	20'	12'
Sidewalk	5'	4'	4' where required	4'	N/A	N/A
Streetscape Planting Strip	8'	8'	N/A	N/A	N/A	N/A
Minimum Centerline Radius	300'	150'	150'	100'	100'	100'
Minimum Curb Radius	20'	20'	20'	10'	10'	10'
Maximum Length Between Connecting Streets	500'	500'	500'	350'	350'	N/A
Maximum Street Length - No Outlet	500'	500'	500'	150'	150'	500'
Maximum Street Length - Loop or Circle Street	500'	500'	500'	500'	500'	500'
Minimum Turn-Around Area	35' Radius	35' Radius	30' Radius or “Y” or “T” Turn	30' Radius or “Y” or “T” Turn	25' Radius or “Y” or “T” Turn	25' Radius or “Y” or “T” Turn
Emergency Response Set Up Area Intervals	N/A	N/A	N/A	150'	150'	N/A
Sidewalk Placement	Detached Required	Detached Required	Adjacent to Property Line Where Required	Attached	N/A	N/A
Curb and Gutter	Required	Required	N/A	Required	N/A	N/A
On-Street Parking	Allowed	Allowed	Allowed	Allowed	Allowed	Not Allowed
Minimum Lot Frontages	N/A	N/A	60’ no alley 40’ w/ alley	60' no alley 40' w/alley	60'	N/A
Maximum Number of Units to be Accessed	N/A	N/A	N/A	25 single family	15 single family	N/A

NOTE: Residential street standards that are underlined may be varied through Section 9-2-14, “Site Review,” B.R.C. 1981.

(a) Parking: Parking is allowed.

(b) Bicycle Facilities: Additional street and right-of-way width shall be provided where on-street bicycle lanes are required by a City-adopted subcommunity or area plan, the TMP, or the BVCP.

(c) Provision of Alleys: Where alleys are provided or required to be provided under a City-adopted subcommunity or area plan, onsite parking spaces shall be accessed from the alley and not the street.

(d) Emergency Response: Residential streets exceeding 500 feet from any intersection shall provide a secondary emergency access at 500-foot intervals.

(3) **Rural Residential Street:** The rural residential street is designed to provide access to individual properties as well as access to the higher classification street network. The rural residential street provides for neighborhood traffic and through movements and is designed to carry traffic volumes in the range of 500 to 1,000 vehicles per day. The rural residential street shall be provided where prescribed by a city-adopted subcommunity or area plan to maintain the rural character of an area or neighborhood. The rural residential street is a curbless paved street section, with gravel shoulders for parking and open roadside ditches for drainage. In addition to the requirements outlined in Table 213, "Residential Street Design Standards," and "Technical Drawing 2.65," Chapter 11, the rural residential street shall be designed to meet the following standards:

(a) Parking: Allowed on both sides of the street.

(b) Turnaround Standard (No Outlet Streets): If a "Y" or "T" turnaround is proposed in place of a standard cul-de-sac bulb turnaround, the "Y" or "T" turnaround shall be designed 60 feet long and 20 feet wide. The turnaround area (including sidewalks if required) shall be contained within the dedicated right-of-way.

(c) Provision for Future Sidewalks: If sidewalks are not required at the time of initial street construction, adequate space in the right-of-way shall be reserved for a future sidewalk and commitments from adjacent property owners to participate in assessment districts shall be obtained, so that sidewalks can be added and funded in the future when they are appropriate.

(d) Sidewalk Placement (Where Required): Sidewalks shall be required where vehicular traffic volumes are anticipated to exceed 1,000 trips per day, on routes to school, and as prescribed by a city-adopted subcommunity or area plan. Sidewalks shall be placed outside of the paved roadway and drainage ditch, and inside the right-of-way line.

(e) Roadside Drainage Ditches: Side slopes along roadside drainage ditches shall be 4:1, and driveway culverts, at least 12 inches in diameter with flared end sections or headwalls, shall be installed by owners at driveways.

(f) Land Use Requirements: Lot frontages shall be at least 60 feet wide, unless alley access is provided. Lot frontages with alley access shall be at least 40 feet wide.

(g) Provision of Alleys: Where alleys are provided or required to be provided under a city-adopted subcommunity or area plan, onsite parking spaces shall be accessed from the alley and not the street.

(h) Emergency Response: Rural residential streets exceeding 500 feet from any intersection shall provide a secondary emergency access at 500-foot intervals.

(4) **Access Street:** The access street provides public access to no more than 25 single-family dwelling units, where anticipated vehicular volumes would not exceed 400 trips per day. The access street is narrow, to ensure slower speeds for vehicular travel, and provides sidewalks along both sides of the street. In addition to the requirements outlined in Table 2-13, "Residential Street Design Standards," and "Technical Drawing 2.66," Chapter 11 of these Standards, the access street shall comply with the following minimum standards:

(a) Parking: Parking is allowed.

(b) "L" Intersections: "L" intersections may be permitted as part of subdivision and are subject to approval by the Director. Where permitted, "L" intersections shall have at least a 150-foot-long tangent street section from the intersection to the closest curvature and a minimum corner radius of 50 feet.

(c) Circle or Loop Street: If a circle or loop street is proposed as part of subdivision, the street shall connect to a higher classification street, or connect to two separate perpendicular or offset higher classification streets.

(d) Turnaround Standard (No outlet streets): If a "Y" or "T" turnaround is proposed in place of a standard cul-de-sac bulb turnaround, the "Y" or "T" turnaround shall be designed with a 60-foot length, 20-foot width. The turnaround area (including sidewalks if required) shall be contained within dedicated right-of-way.

(e) Land Use Requirements: A residential access street shall connect to a higher classification street. Lot frontages shall be at least 60 feet wide, unless alley access is provided. Lot frontages with alley access shall be at least 40 feet wide.

(f) Provision of Alleys: Where alleys are provided or required to be provided under a city-adopted subcommunity or area plan, onsite parking spaces shall be accessed from the alley and not the street.

(g) Emergency Response: Access streets exceeding 175 feet from any intersection shall provide a fire apparatus setup area at 150-foot intervals. The setup area shall provide at least 30 foot long, 25-foot-wide clear zone, and is subject to approval by the Fire Department.

(5) **Access Lane:** The access lane provides public access to no more than 15 single family dwelling units, where anticipated vehicular traffic volumes would not exceed 250 trips per day. The access lane is a narrow "shared street" for all modes of travel (vehicular,

bicycle, and pedestrian), without curb and gutter or sidewalks, and must connect with a higher classification street. In addition to the requirements outlined in Table 213, "Residential Street Design Standards," and "Technical Drawing 2.67," Chapter 11, the access lane shall comply with the following minimum standards:

(a) Parking: Parking is allowed.

(b) "L" Intersections: "L" intersections shall have a minimum 150-foot long tangent street section from the intersection to the closest curvature and a minimum corner radius of 50 feet.

(c) Circle or Loop Street: A circle or loop street shall connect to a higher classification street or connect to two separate perpendicular or offset higher classification streets.

(d) Turnaround Standard (No outlet streets): A "Y" or "T" turnaround shall be designed with a 60-foot length, 20-foot width. The turnaround area (including sidewalks if required) shall be contained within dedicated right-of-way.

(e) Land Use Requirements: An access lane shall connect to a higher classification street. Lot frontages shall be at least 60 feet wide.

(f) Right-of-Way Landscaping: Landscaping other than ground cover or low shrubbery shall be placed outside of the right-of-way.

(g) Emergency Response: Access streets exceeding 175 feet from any intersection shall provide a fire apparatus setup area at 150-foot intervals. The setup area shall provide a minimum 30-foot long, 25-foot-wide clear zone, and is subject to approval by the Fire Department.

(6) **Residential Alley:** The residential alley is to provide secondary vehicular access to the rear of lots in detached single-family dwelling subdivisions with narrow street frontages, in order to limit curb cuts from the street and increase on-street parking. Alleys are most beneficial when lot widths are narrower than 50 feet. In addition to the requirements outlined in Table 2-13, "Residential Street Design Standards," and "Technical Drawing 2.68," Chapter 11 of these Standards, the residential alley shall be designed to meet the following minimum land use requirements: Backup distance for parking and garage access from the alley shall be 24 feet, including the 16-foot alley right-of-way width, and the remaining backup distance shall be provided on the lot being served.

2.10 Emergency Access Lanes

(A) Emergency Access Required

All industrial, commercial, and residential developments shall provide adequate emergency vehicle access. Adequate emergency access is a minimum 20-foot-wide unobstructed fire apparatus access road with an unobstructed vertical clearance of 15 feet, and meets all applicable standards as set forth in Chapter 10-8, "Fire Prevention Code," B.R.C. 1981.

(B) When Emergency Access Lane is Required

When adequate emergency access is not available from a public street, an applicant for construction approval shall construct an emergency access lane. Emergency access lanes must accommodate all emergency vehicles, including fire equipment.

(C) Secondary Emergency Access

Secondary emergency access lanes shall be provided to structures whenever the distance to the nearest public street equals or exceeds 500 feet. Secondary access lanes shall conform to all design requirements specified for emergency access lanes.

(D) Local Emergency Access Lane Standards

In addition to the emergency access standards set forth in Chapter 10-8, "Fire Prevention Code," B.R.C. 1981, an emergency access lane shall equal or exceed the following standards:

(1) **Direct Route:** Emergency access lanes shall provide the shortest practical direct access to points of concern, and be entirely contained within a minimum, continuous 20-foot-wide emergency access easement or public right-of-way.

(2) **Distance From Structure:** Emergency access lanes shall be provided whenever a structure is located more than 150 feet from fire apparatus access.

(3) **Surface:** An emergency access lane shall consist of either of the following:

(a) Two concrete strips at least 4 feet wide, with a 4-foot separation between them. Vegetation other than grass shall not be permitted in the separation area.
(b) A minimum continuous paved surface width of 12 feet.

(4) **Radius:** An emergency access lane shall provide a minimum turning radius of 25 feet, or the radius needed to accommodate an SU-30 vehicle.

(5) **Turnarounds:** If the length of the emergency access lane exceeds 150 feet (without an outlet accessible to emergency vehicles), then a turnaround with a minimum radius of 45 feet shall be provided.

(6) **Grade:** The grade for an emergency access lane shall not exceed five percent. Exceptions may be allowed with specific approval from the City of Boulder Fire Chief where this standard cannot be met due to topographical conditions.

(7) **Vertical Clearance:** Vertical clearance from the surface of the emergency access lane shall be at least 15 feet.

(E) Unobstructed Access

Emergency access lanes shall be kept free and clear of all obstructions. If the Director or Fire Chief determines that barriers are needed to prevent automobile traffic from using an emergency access lane, then the applicant for construction approval shall install traffic bollards. Traffic bollard designs shall provide for immediate access of emergency vehicles, without requiring these vehicles to stop and maneuver around, or unlock, any structures. The Director and Fire Chief shall have final approval of all bollard designs.

(F) Access Identification

Signs and pavement markings will be required if necessary, by the Director and Fire Chief to delineate and identify emergency access lanes. All signage for emergency access lanes shall conform with the specifications in the MUTCD.

2.11 Bicycle Facilities and Multi-Use Path Design

(A) Conformance with Low-Stress Walk and Bike Network Plan

The arrangement, type, and location of all bike lane and multi-use path facilities and routes shall conform with the "Low-Stress Walk and Bike Network Plan" section in the TMP. The Director shall specify the standards for design and construction of new bike lane and multi-use path facilities consistent with these Standards and considering public health, safety, and welfare and generally accepted engineering principles. The Director may refer to the Transportation References in these Standards. These Standards shall also apply to marked and signed contraflow bike lanes to meet bicycle connectivity goals identified in the Low-Stress Walk and Bike Network Plan where the right-of-way is constrained.

(B) On-Street Bike Lanes - Streets Without On-Street Parking

An on-street bike lane is separated from the motor vehicle travel lane by a single white line. On-street bike lanes on new streets without on-street parking shall be at least 5 feet wide, exclusive of the curb pan, or 6.5 feet from the face of any curb. On existing streets where on-street bike lanes are being added and available right-of-way or improvements space is restricted, the Director may approve a reduced width of the bike lane; the reduced width shall be at least 5 feet wide, inclusive of the curb pan.

(C) On-Street Bike Lanes - Streets With On-Street Parking

An on-street bike lane on a street with on-street parking is separated from the motor vehicle travel lane or parking lane by a single white line. On-street bike lanes on new streets with on-street parking shall be at least 6 feet wide, exclusive of the parking lane. On existing streets where on-street bike lanes are being added and available right-of-way or improvements space is restricted, the Director may approve a reduced width of the bike lane; the reduced width shall be at least 5 feet wide, exclusive of the parking lane.

(D) Buffered Bike Lanes

A buffered bike lane is separated from the motor vehicle travel lane by a painted buffer space creating a greater separation between the bike lane and adjacent travel lane. The buffer shall be marked with 2 solid white lines, and the markings shall otherwise conform with MUTCD standards. The buffered space shall be at least 2 feet wide. On streets without on-street parking the bike lane shall be at least 5 feet wide, or 6.5 feet from the face of the curb. Bike lanes on new streets with on-street parking shall be at least 5 feet wide, exclusive of the parking lane. On existing streets where buffered bike lanes are to be added and right-of-way or improvement space is limited, the Director may modify this standard considering safety concerns or approve an on-street bike lane.

(E) Separated Bike Lanes (One-Way and Two-Way)

A separated bike lane is physically separated from the motor vehicle travel lane through vertical or horizontal elements and is distinct from the sidewalk. Separated bike lanes have different

forms but all share common elements. Where on-street parking is allowed, the separated bike lane shall be located to the curb side of the parking (in contrast to on-street and buffered bike lanes). Separated bike lanes may be one-way or two-way and may be at street level, at sidewalk level, or at an intermediate level. If located at sidewalk level, a curb or median shall separate the separated bike lane from the motor vehicle travel lane, and different pavement color or type shall separate the separated bike lane from the sidewalk. If located at sidewalk level, the separation may include a landscaped area. If located at street level, the separated bike lane shall be separated from the motor vehicle travel lane by raised medians, on-street parking, or flexible delineators. Flexible delineators shall conform with MUTCD standards. Raised medians shall conform to "Technical Drawing 2.42C," Chapter 11 of these Standards. The Director may require additional markings, signage, and other improvements to ensure safe and efficient operation of the city's transportation system.

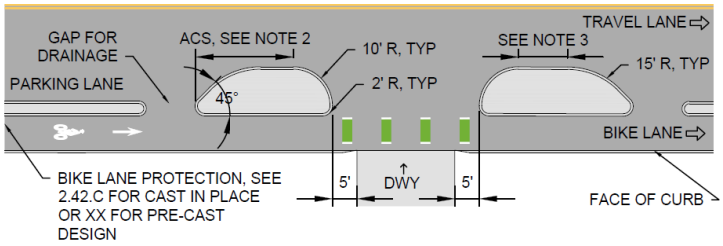
On streets without on-street parking, a vertical separation shall create a buffer between the bike lane and the travel lane that is at least 3 feet wide, and the bike lane shall be at least 5 feet wide, or 6.5 feet from the face of the curb. On streets with on-street parking, the separation shall be a 3-foot-wide horizontal buffer between the bike lane and the parking lane, and the bike lane shall be at least 5 feet wide.

On existing streets where separated bike lanes are to be added and right-of-way or improvement space is limited, the Director may modify this standard considering safety concerns and the efficient operation of the city's transportation system.

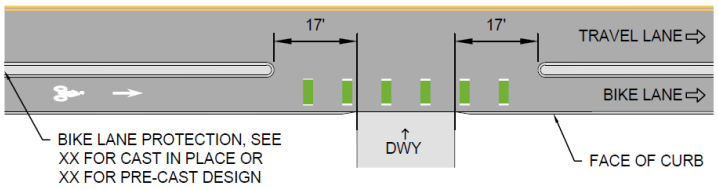
(F) Typical Bicycle Facility Layouts

The following are examples of typical bicycle facility layouts and shall be used as guidance for separated bike lane facilities. The existing street context and site constraints of each location shall be taken into account when designing these facilities and engineering judgement may be used to implement the intent of these example bicycle facility layouts.

(1) One-Way Street Level Separated Bike Lanes at Driveways

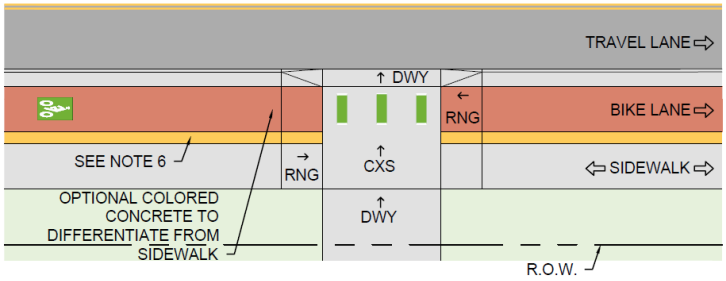


STREET LEVEL BIKE LANE AT DRIVEWAY/CURB CUT WITH PARKING

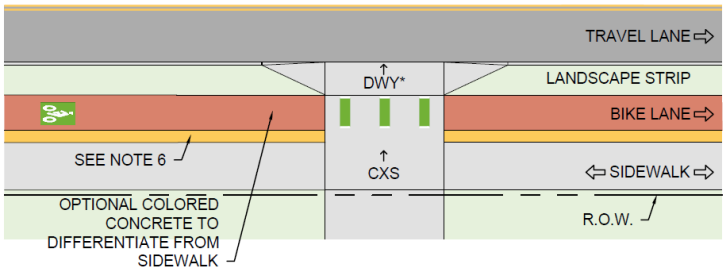


STREET LEVEL BIKE LANE AT DRIVEWAY/CURB CUT WITHOUT PARKING

(2) Sidewalk Level One-Way Separated Bike Lanes at Driveways



SIDEWALK LEVEL BIKE LANE AT DRIVEWAY/CURB CUT (CONSTRAINED)

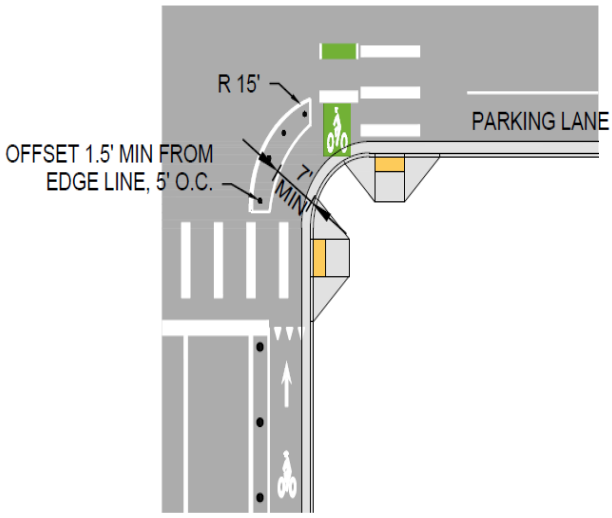


SIDEWALK LEVEL BIKE LANE AT DRIVEWAY/CURB CUT

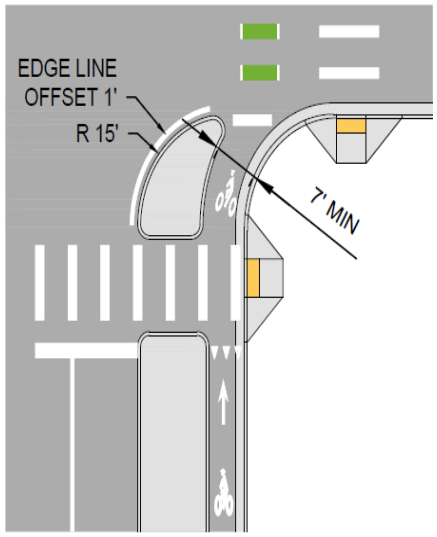
(a) Typical approach clear space (ACS) for driveways and alleys shall be 20 feet as shown; in constrained locations the approach clear space may be measured from edge of driveway.
(b) In constrained locations the far-side buffer tangent may be reduced to 5 feet.
(c) See Section 2.07, Table 2.5 of these Standards for standard lane widths.
(d) Bike lane tapers preferred at 7:1 shift, minimum 3:1 shift in constrained locations where speed is ≤ 13 mph.

(e) For bike lanes at sidewalk elevation without buffer treatment, 1-foot minimum directional indicator strip required within the sidewalk; typically located 1 foot from the edge of the bike lane.
(f) Accessible ramp slope (RMP) = 7.8% (8.3% max).
(g) Accessible cross slope (CXS) = 0.5-1.5% (2% max).
(h) Accessible running slope (RNG) = 5% max.
(i) Driveway slope (DWY) = 12% max.

(3) Street Level Separated Bike Lanes at Intersection in Retrofit Conditions

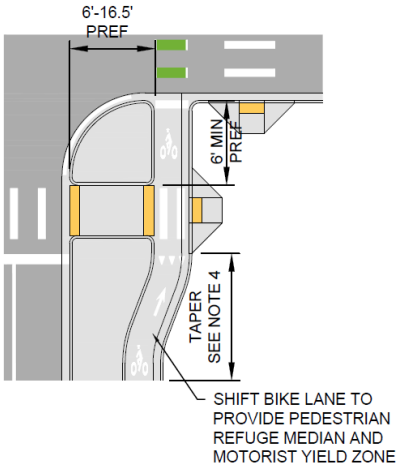


RETROFIT PROTECTED CORNER
TREATMENT WITH PAINT AND POST

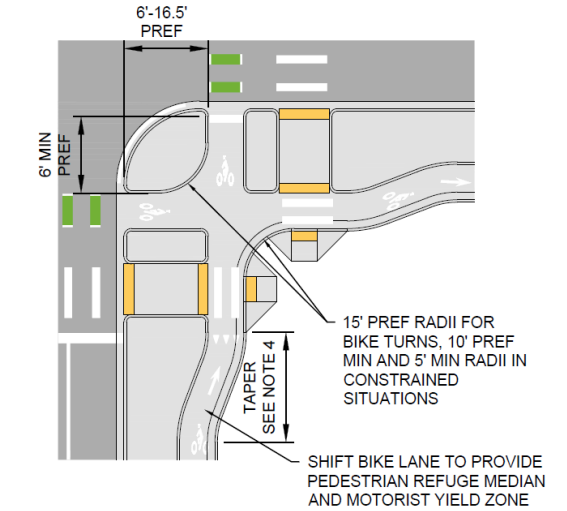


RETROFIT PROTECTED CORNER
TREATMENT WITH CONCRETE

(4) Street Level Separated Bike Lanes at Intersections in New or Retrofitted Conditions



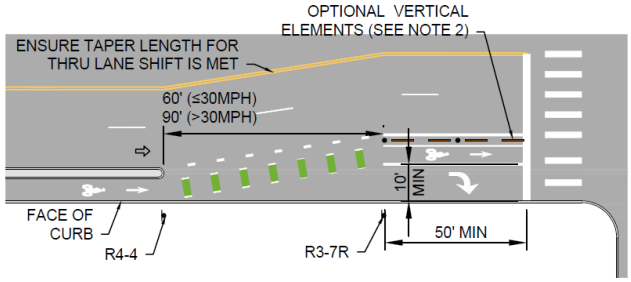
RECONSTRUCTED PROTECTED CORNER TREATMENT WITH CONCRETE



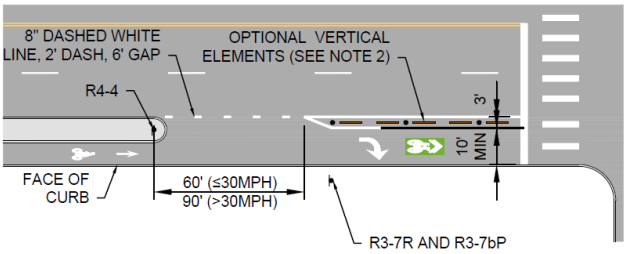
RECONSTRUCTED PROTECTED CORNER TREATMENT WITH CONCRETE (INTERSECTION BIKE FACILITIES)

(a) Design plans shall be consulted for variations.
(b) Size and shape of corner treatments are dependent on intersection characteristics.
(c) See Section 2.07, Table 2.5 of these Standards for standard lane widths.
(d) Bike lane tapers preferred at 7:1 shift, minimum 3:1 shift in constrained locations here speed is ≤ 13 mph.

(5) One-Way Separated Bike Lane and Right Turn Lane

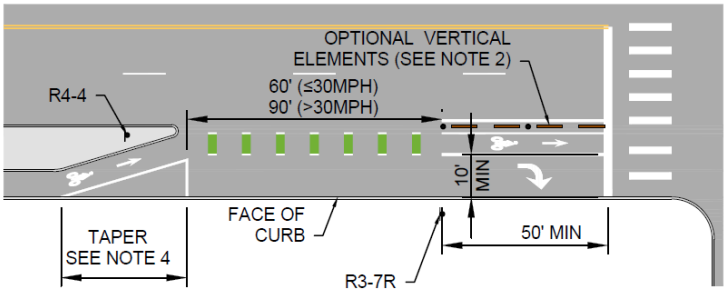


BIKE/TURN LANE - EXCLUSIVE TREATMENT (NO PARKING)

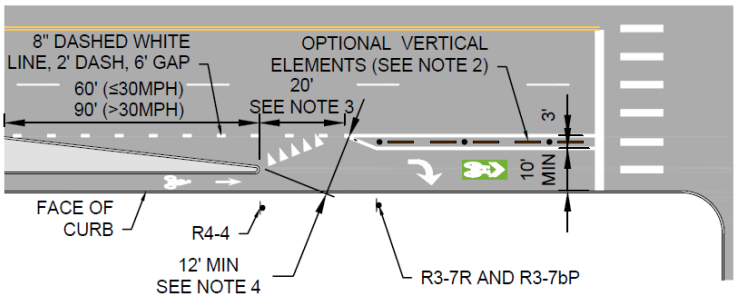


BIKE/TURN LANE - MIXING ZONE TREATMENT (NO PARKING)

(6) One-Way Separated Bike Lane and Right Turn Lane



BIKE/TURN LANE - EXCLUSIVE TREATMENT (WITH PARKING)



BIKE/TURN LANE - MIXING ZONE TREATMENT (WITH PARKING)

(a) Design plans shall be consulted for variations

(b) Vertical elements may be excluded or modified as needed to accommodate truck and/or transit vehicles, with a 13-foot minimum where high bus volume is anticipated.

(c) Bike lane tapers preferred at 7:1 shift, minimum 3:1 shift in constrained locations where speed is ≤ 13 mph.

(d) See Section 2.07, Table 2.5 of these Standards for standard lane widths.

(e) A ramp up to sidewalk may be provided for people on bicycles prior to vehicular mixing zone to provide a low stress alternative.

(G) Off-Street Multi-Use Paths

Design for off-street multi-use paths shall conform to Chapter 5 of the AASHTO Guide for the Development of Bicycle Facilities, 4th edition. The paths shall be at least 10 feet wide with an inside edge radius of at least 15 feet and shall conform to "Technical Drawing 2.02D," Chapter 11, of these Standards.

(H) Bicycle Parking

Bicycle parking shall be located in a visible and prominent location that is lit at night and physically separated from automobile parking to prevent vehicles from intruding into the bike parking area. All bicycle parking constructed in the City of Boulder shall conform to the provisions in the Section 9-9-6(g), "Bicycle Parking," B.R.C. 1981 or as adopted in any subcommunity or area plan.

(1) **Bicycle Parking in Sidewalk Area of Public Right-of-Way:** Bicycle parking racks located in the sidewalk area of the public right-of-way shall be designed using

either the inverted "U" rack standard or the inverted "U" racks on rails standard. A minimum aisle of 5 feet shall be provided for bikes to maneuver in when accessing the rack. All racks shall be attached to a concrete base using a high security tamper proof anchor such as a mushroom head carbon steel expansion anchor "spike" #5550 as manufactured by Rawl or an equivalent theft-proof device.

(a) Inverted "U" Rack: The inverted U rack is designed to park two bicycles, facing opposite directions, parallel to the rack. For the rack to meet its design specification of parking two bikes, it must be installed according to the specifications below, otherwise it will be considered to provide parking for one bike. The inverted "U" standard may be installed with the following conditions:

(i) Where the "U" rack is installed oriented parallel to a wall or curb, at least 3.0 feet shall be provided between the parallel wall or curb and the center of the rack. Where a bike rack is located near a curb with "head-in" automobile parking, a minimum distance of 5 feet from the curb to the center of the rack is required to avoid damage to bicycles or racks by automobiles extending across the curb over the sidewalk.

(ii) Where the "U" rack is installed oriented perpendicular to a wall or curb, a minimum distance of 4 feet from the wall or curb to the center of the rack will be provided to allow two bikes to access and use the rack.

(iii) Where placed side-by-side, "U" racks shall be placed at least 3.5 feet apart to accommodate ease of access to the racks.

(iv) Where placed in a series of 2 or more and parallel to a wall, inverted "U" racks will be separated by a minimum distance of 10 feet between the centers of the racks to allow access to both sides of the rack.

(v) The location of a bike rack shall maintain a minimum unobstructed sidewalk width of 6 feet from any bicycle parked properly in the rack.

(vi) The location of a "U" rack shall maintain a minimum unobstructed distance of 3 feet from any pedestrian curb ramp to any bicycle parked properly in the rack.

(b) Inverted "U" Racks on Rails: The inverted "U" racks on rails are designed to park four to ten bicycles, with two bikes facing opposite directions parked on either side and parallel to each inverted "U" rack. These racks allow locking of frame and wheel with a U-lock and support bikes with two points of contact. For the rack to meet its design specifications of parking bikes from both sides, it must be installed according to the conditions of the inverted "U" rack listed above; otherwise it will be considered to provide no more than half of its designed parking capacity.

(2) **Onsite Bicycle Parking:** Bicycle parking should generally be provided within 50 feet of the main building entrance. Racks must be installed according to the guidelines in (1) above to reach their designed parking capacity. Otherwise, they shall be credited with no more than half their design capacity. Bicycle parking racks or lockers located on development or project sites or in parking lots outside of public right-of-way shall generally be selected from the following standards:

(a) Inverted "U" Rack: The inverted "U" rack is recommended for most bike rack

installations and is one of the standards for bicycle parking in public rights-of-way as required in Subsection G.(1) above. Each rack provides space for two bicycles and allows flexibility in parking by providing two supports for attaching locks. The "U" rack may be used individually where space is limited, or, in circumstances requiring a larger amount of bike parking, inverted "U" racks on rails may be used to park four to ten bikes. Inverted "U" racks and inverted "U" racks on rails shall meet the specifications for the dimensions and installation shown in Chapter 11, "Technical Drawings," of these Standards

(b) Other Bike Rack Styles: Another rack style may be approved by the Director if it meets the following criteria:

(i) Provides at least two contact points between the rack and the bike to securely support the bike;
(ii) Provides at least a 2 foot by 6-foot parking space for each bike without the need to lift the handlebars of one bike over those of another to park;
(iii) Allows the frame and one wheel to be locked to the rack with a standard high security, U-shaped shackle lock; and
(iv) The rack is uncomplicated and intuitively simple for the bicyclist to use.

(c) Lockers: Bicycle lockers provide secure weatherproof storage for bike parking. Lockers are recommended for employee and longer-term parking and require adequate space, since they require more area than bicycle racks. Lockers must meet the following standards:

(i) The locker must be securely anchored to the ground using tamper-resistant anchors.

(ii) There must be an aisle at least 5 feet wide behind all bicycle lockers to allow room for bicycle maneuvering.

(iii) All bicycle lockers must meet one of the following dimensions:

(1) The locker space has a minimum depth of 6 feet and an access door that is a minimum of 3 feet wide.[85]

(2) A locker provided in a triangle locker layout for two bicycle parking spaces must have a minimum depth of 6 feet and an access door that is a minimum of 3 feet wide on each end.

(3) On-Street Bike Parking (Bike Parking Corrals): The Director may approve on-street bike corrals in commercial areas where sidewalk space is limited and in locations with high pedestrian volumes. In approving the design and construction of bike corrals, the Director shall consider public safety and the efficient operation of the city's transportation system.

2.12 Street Lighting

(A) Scope

The provisions of this section shall apply to streetlighting in public streets and alleys.

(B) Private Development

Installation, relocation, or removal of streetlighting may be proposed by an applicant or may be required by the Director as part of a development approval under Title 9, "Land Use Code," B.R.C.1981.

(C) City Projects

The Director decides whether and where streetlighting may be provided, relocated, or removed considering the standards in this Section 2.12.

(D) Street Types

In determining whether streetlighting shall be installed or relocated in or removed from the public right-of-way, the Director shall consider the ANSI/IES RP-8-22, Illuminating Engineering Society Recommended Practice: Lighting Roadway and Parking Facilities (IES), as modified by the following standards:

(1) Arterial Streets: Corridor lighting may be required or provided based on IES standard practices.
(2) Collector Streets: Streetlighting may be required or provided only at intersections and identified pedestrian crossings.
(3) Other Streets (Local): Streetlighting may be required or provided only at identified pedestrian crossings.
(4) Alleys: Streetlighting may be required or provided in alleys in commercial areas with significant night-time pedestrian activity. Streetlighting is not provided in other alleys.

(E) Design Standards

(1) Design: Streetlighting shall have an LED light bulb within a full cut-off fixture that is installed in a horizontal position as designed. Streetlight poles shall be steel poles or wood poles. The pole material shall be determined by the Director and shall be generally consistent with the poles in the surrounding area. Relocation of a pole requires installation of a current pole design of the city.

(2) Location: Poles shall be located so that the center of the pole is three feet behind the face of the curb. The Director may approve a different pole location that is between three feet and six feet behind the face of the curb where necessary to accommodate the needs of other public right-of-way uses in the sidewalk area. Streets with a detached multi-use path or sidewalk may have streetlighting between the curb and multi-use path or sidewalk provided there are two feet of horizontal clearance between the nearest face of the pole and the edge of the multi-use path or sidewalk. Where a multi-use path or sidewalk are attached to the street's curb and gutter, streetlighting shall be placed with two feet of horizontal clearance between the nearest face of the pole and the edge of the multi-use

path or sidewalk.

(F) Installation

The city will acquire, own, and install all streetlighting that is to be installed in public streets or alleys as part of a private development or a city project. The city also performs relocation and removal of streetlighting. An applicant shall coordinate any construction of improvements in the public street or alley with the City's installation, relocation, or removal of the streetlighting.

(G) Easements

Adequate rights-of-way, public access easements, or utility easements shall be dedicated to the City to allow the City to install, access, maintain, repair, and reinstall streetlighting and their associated facilities, such as cables, conduit, and pull boxes. The Director will determine the type and size of dedication based on the location of the streetlighting.

(H) Fees

An applicant for a private development including new installation, relocation, or removal of streetlighting in a public street or alley shall pay the applicable streetlighting fee prescribed by Section 4-20-77, "Streetlighting Fee," B.R.C. 1981, at the time of submittal of construction plans for approval under Section 1.03, "Submittal Requirements for Construction Approval" or, if no such submittal is required, prior to issuance of a building permit.

2.13 Transit Stop Facilities

New transit stops and enhancements to existing transit stops shall be designed in accordance with RTD's "Bus Infrastructure Standard Drawings" and with consideration of NACTO's "Transit Street Design Guide."

2.14 Traffic Calming Design

(A) Scope

This section includes guidelines for the implementation of traffic calming elements on public streets. All elements shall be designed and installed in accordance with the provisions of Chapter 2 of this document and in conformance with the MUTCD. The Vision Zero Action Plan shall be consulted when determining if and what traffic calming measures are implemented.

Traffic calming measures are intended to slow motorized vehicles and increase safety for bicycle and pedestrian users. Measures may also prioritize the movement of bicycles and pedestrians at crossing or conflict points.

(B) Traffic Circles

The Director may require the installation of a traffic circle where the Director finds that the operations or safety of the intersection or the adjoining streets would benefit from such device.

Figure 2-4 illustrates the typical layout and standard dimensions of a traffic circle and Table 2-14 Offset and Opening Width Dimensions and Table 2-15 Center Island Diameter Dimensions shall guide the design of the traffic circle. Final dimensions shall be approved by the Director based up site specific considerations for the safety of all users, the ability for all modes to traverse the intersection, and the efficient operation of the transportation system.

In locations where crossing streets are not the same width, curb extensions may be used on the wider street to create consistent approach widths.

In locations where the circulating width is less than 20 feet, the Director may require a mountable truck apron if the director finds that the expected truck traffic at the intersection will negatively impacts safety or intersection operations.

Any objects, including plantings and trees, in the traffic circle shall provide a clear zone of visibility between 36 inches high and 80 inches high from the top of the travel path surface.

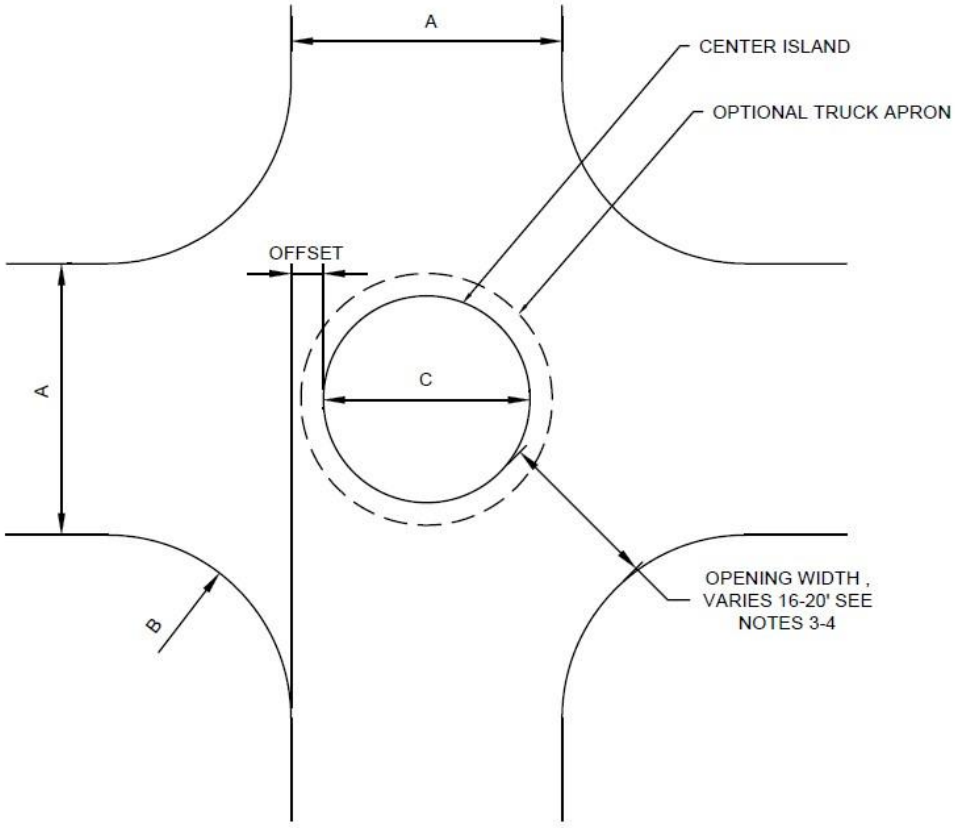


Figure 2-4: Typical Layout and Standard Dimensions of Traffic Circle

Table 2-15: Offset and Opening Width Dimensions

Offset	Opening Width

5.5’ (Max)	16’ (Min)
5.0’	17’
4.5’	18’
4.0’	19’
3.5’ or less	20’ (Max)

Table 2-16: Center Island Diameter Dimension for Different Street Widths and Curb Return Radii

A Street Width	B Curb Return Radius	C Center Island Diameter
28’	15’ 20’ 25’	18’ 20’ 22’
30’	15’ 20’ 25’	20’ 22’ 24’
36’	15’ 20’ 25’	27’ 29’ 33’
40’	15’ 20’ 25’	32’ 34’ 38’

(C) Raised Crossings

The Director may require the installation of a raised crossing where the Director finds that the crossing meets the criteria from the city’s Pedestrian Crossing Treatment Installation Guidelines for additional crossing treatments.

Figure 2-5 through 2-7 illustrate typical layouts for raised crossings, Figure 2-8 illustrates typical section of a raised crossing, and Table 2-XXX Dimensions of Approach Ramp Length For Various Roadway Longitudinal Slopes and Target Grade Breaks and Table 2-16 Target Grade Breaks For Different Roadway Classifications shall guide the design of the raised crossing. Final dimensions and geometry shall be approved by the Director based up site specific considerations for the safety of all users, the ability for all modes to traverse the intersection, and the efficient operation of the transportation system.

The width of the top of raised crosswalks should match the width of the connecting sidewalk, shared use path, or desired crosswalk, and in no case be less than 10-feet in width.

Installation of a raised crossing shall include modifications to existing street paving, cold plane and overlay asphalt, or reconstruction of paving to provide a smooth transition and street crown and shall match adjacent paving materials and thickness.

In locations where positive drainage cannot be achieved the design shall include drain inlet(s) as necessary to convey stormwater drainage and meet street drainage requirements of Chapter 7.

All crosswalks shall have a minimum of 2 feet spacing from poles, hydrants, and other vertical

obstructions.

Crosswalk cross slopes should be no greater than 2%, however, at mid-block locations the cross slope may match the existing street grade. Crosswalk cross slope may be 0% if longitudinal slope is sufficient to self-drain

Crosswalk longitudinal slopes should not exceed 5%

Grade breaks should be determined based on existing roadway speeds and desired speed reduction and should conform with Table 2-17. Generally, higher grade breaks correspond to higher speed reduction.

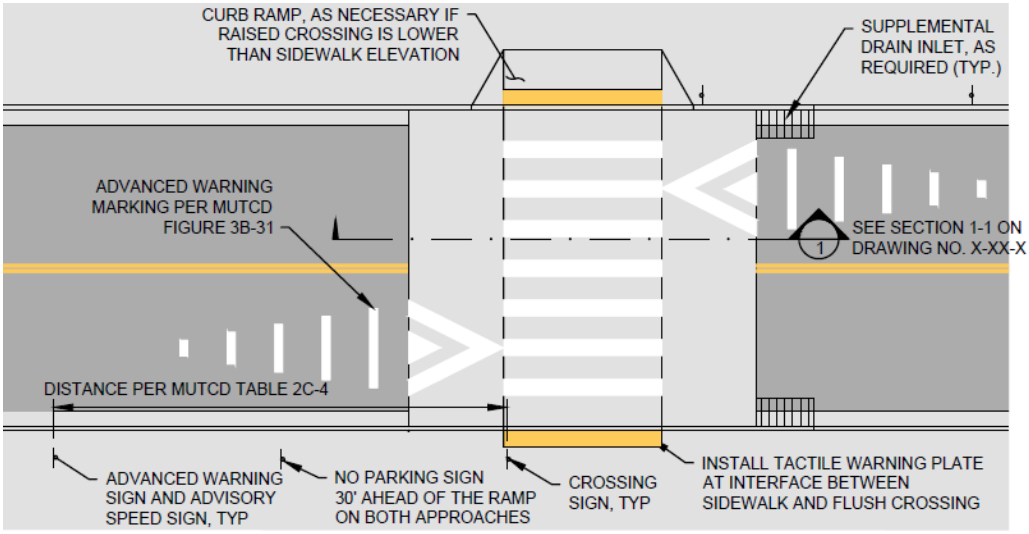


Figure 2-5: Typical Layout of Raised Crossing at Mid-Block Location

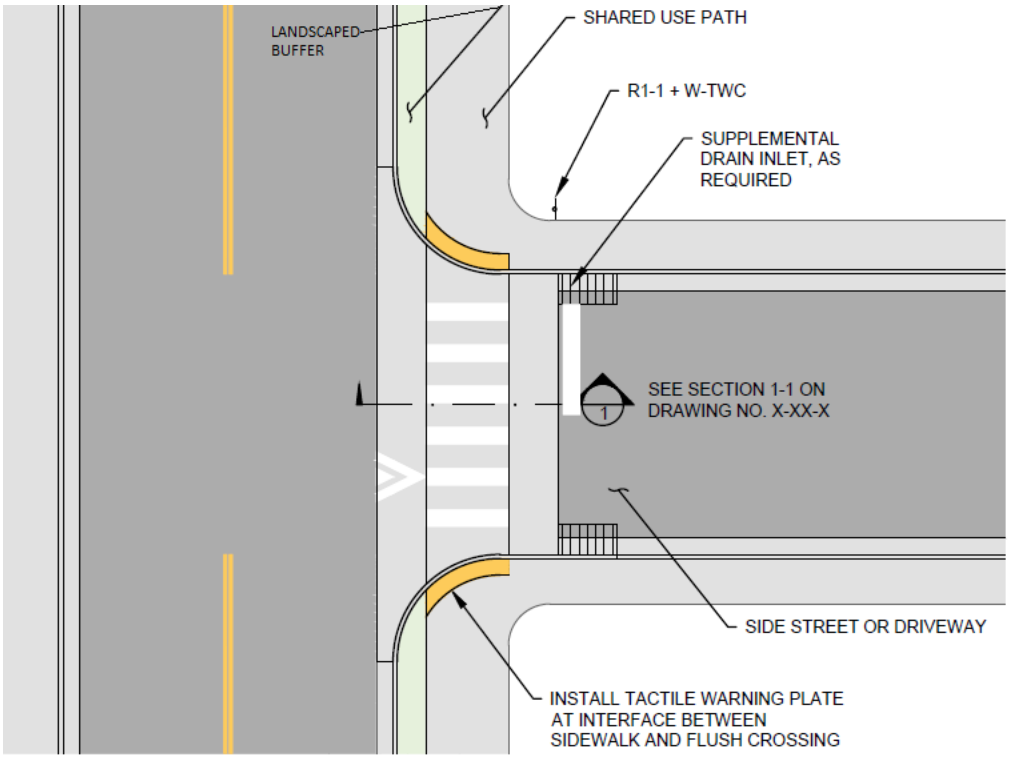


Figure 2-6: Typical Layout of Raised Crossing at Intersection Leg Location

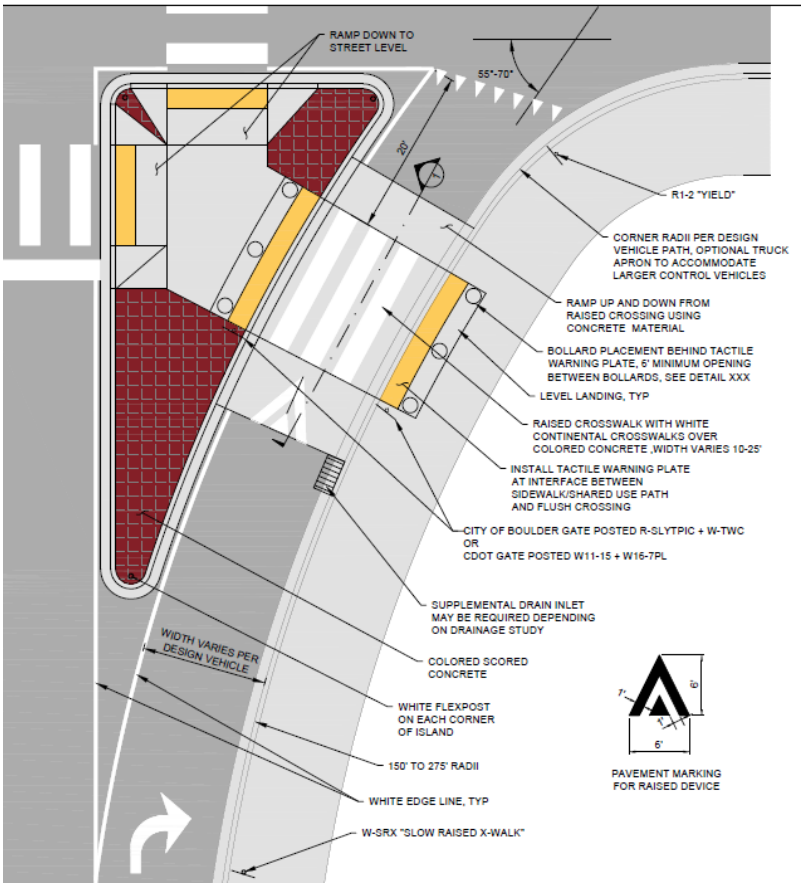


Figure 2-7: Typical Layout of Raised Crossing at Channelized Right Turn Location

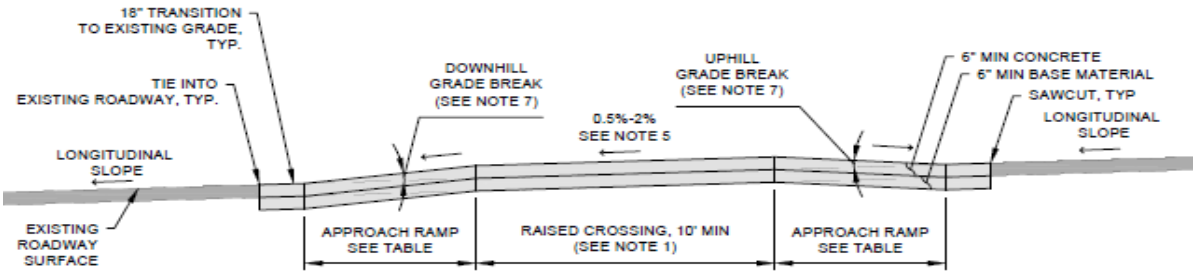


Figure 2-8: Raised Crossing Typical Section

Table 2-17: Dimensions of Approach Ramp Length For Various Roadway Longitudinal Slopes and Target Grade Breaks

Roadway Longitudinal Slope	Approach Ramp Length			
	5-6% Grade Break		8-10% Grade Break	
	Uphill	Downhill	Uphill	Downhill
0%	5.0-5.5’ (3.0’-4.0’)	5.0-5.5’ (3.0’-4.0’)	3.0-3.5’ (2.0’-2.5’)	3.0-3.5’ (2.0’-2.5’)
2%	5.0-5.5’ (3.0’-4.0’)	5.0-5.5’ (3.0’-4.0’)	3.0-3.5’ (2.0’-2.5’)	3.0-3.5’ (2.0’-2.5’)
4%	5.0-5.5’ (3.0’-4.0’)	8.0-10.0’ (6.5’-7.5’)	3.0-3.5’ (2.0’-2.5’)	5.0’-6.0’ (4.0’-5.0’)
6%	5.0-5.5’ (3.0’-4.0’)	11.0-13.5’ (9.5’-11.5’)	3.0-3.5’ (2.0’-2.5’)	6.5’-8.5’ (5.5’-7.0’)
Note: Primary ramp lengths assume a 6-inch tall raised crossing. Ramp lengths in parenthesis assume a 4-inch tall raised crossing.				

Table 2-18: Target Grade Breaks For Different Roadway Classifications

Roadway Classification	Grade Break Range	
	Min	Max
Local	8%	10%
Collector	5%	6%
Arterial	5%	6%

CHAPTER 3
STREETSCAPE DESIGN AND TREE PROTECTION

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3.01 General

(A) Intent

The Streetscape Design and Tree Protection Standards are intended to improve public safety by preventing sight distance and facility obstructions, mitigating sidewalk and street damage, promoting suitable landscape species selection for streetscapes, and minimizing tree and landscape maintenance costs.

(B) Scope

These Standards apply to public and private streetscapes and , include the planting, maintenance, pruning and spraying, protection, and removal of trees and landscaping materials located, standing, or growing within or upon any City of Boulder public right-of-way. Tree protection standards also apply to any existing private trees required to be preserved as a part of a development approval under Title 9 of the B.R.C. 1981. The requirements of this chapter are in addition to and supplement those set forth in Chapter 10, "Streetscape & Landscape Standards," and applicable streetscape drawings in Chapter 11, "Technical Drawings," of these Standards and the B.R.C. 1981.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, in order to protect the public health, safety, and welfare, the Director of Public Works in consultation with the Director of Parks and Recreation will specify the standards to be applied to the design and construction of streetscapes and the planting of trees and may refer to one or more of the references listed in the References Section of these Standards.

(D) City Approval Required

All work associated with the planting, maintenance, and removal of trees and landscaping materials located, standing, or growing within or upon any City of Boulder public right-of-way is subject to City of Boulder approval or permit issuance as set forth in Chapter 8-5, "Work in the Public Right-of-Way and Public Easements," and Chapter 6-6, "Protection of Trees and Plants," B.R.C. 1981.

3.02 Landscaping Plan

(A) Landscaping Plan Required

An applicant for construction approval involving a project or development where streetscaping improvements are to be provided or potentially impacted by the installation or construction of public improvements, or where prescribed by a City-adopted subcommunity, area, or special improvement plan, shall submit a Landscaping Plan in compliance with these Standards and those set forth in Chapter 6-6, "Protection of Trees and Plants," Chapter 9-9, "Development Standards," and Chapter 9--12, "Subdivision," B.R.C. 1981.

(B) Tree Protection

The Landscaping Plan shall include design details and notes, construction activity controls and measures, and any necessary provisions or restrictions to ensure the protection of existing trees as required in Section 6-6-6, "Protection of Trees and Plants," B.R.C. 1981, and Section 3.05, "Tree Protection for Construction Sites" of these Design & Construction Standards. For projects larger than one single family dwelling, a separate Tree Protection Plan in addition to the required

Landscaping Plan shall be required. All tree protection measures shall be installed and monitored by a certified arborist.

(C) Landscaping Plan Requirements

The Landscaping Plan shall be prepared in compliance with the requirements in Section 1.03, "Submittal Requirements for Construction Approval" of these Standards and Section 9-9-12, B.R.C. 1981, and shall include but are not limited to the following elements:

(1) Location, species, and size of all existing trees and landscaping materials, and identification of any required tree protection measures as outlined in Section 3.02(B), "Tree Protection" of these Standards.

(2) Design location, species, and size of all trees and landscaping materials proposed to be planted, removed, or relocated.

(3) Location of existing and proposed public utilities and transportation improvements and public rights-of-way boundaries.

(4) When a drainage report is required in accordance with Chapter 7 of these Standards, the Landscaping Plan shall display drainage flow arrows and the location of open channels, storm inlets, and stormwater control measures to indicate the interaction between plantings and drainage.

(5) Specifications and construction notes for proposed trees and landscaping materials, including without limitation, plant variety types, number and size of plants to be installed, location, sizing, and design details for irrigation systems, planting and maintenance requirements for specific species, tree protection systems and measures, and tree grate type and installation details.

3.03 Street Trees and Plants

(A) Tree Selection

(1) Trees proposed to be planted in non-paved public rights-of-way shall be selected from the "Approved Tree List" unless an alternative tree selection has been reviewed by the Director of Parks and Recreation and approved by the Director of Public Works. Alternative species and varieties should be thornless, cottonless, minimally fruiting, minimally seeding, and single-stem tree-form varieties.

(2) Trees to be planted in non-paved medians or landscape planting strips shall be selected using the minimum planting strip width requirements for the tree species listed in the "Approved Tree List" for the available planting strip width.

(3) Trees shall not be planted in planting strips that are less than 4 feet in width. For detached sidewalk landscaped planting strips, the planting strip width is measured from the back edge of curb to the front edge of the sidewalk.

(4) Evergreen trees shall not be selected for placement in public rights-of-way

medians or landscaping strips, due to the potential for overcrowding, sight obstructions, and icing.

(5) Whenever possible, trees should be selected from species noted as having xeric or minimum moisture level requirements as noted in the "Approved Tree List."

(6) A variety of trees, as required in Table 3-1, "Limitations on Individual Tree Species," shall be selected for planting within any given site or street corridor, including street medians and curbside landscape strips, to prevent uniform insect or disease susceptibility associated with planting a single genus or species. A maximum of three plantings of the same tree species type are allowed to be planted in a row.

(7) Trees proposed for the public rights-of-way in the Downtown Area shall follow the guidelines outlined in the most recently adopted version of the Downtown Urban Design Guidelines.

Table 3-1: Limitations on Individual Tree Species

(The following table applies to all genus and species unless otherwise approved by the Director)

Number of Trees in the Site or Corridor	Maximum Percentage of Any Genus or Species
≤3	100% Genus
4 to 8	50% Genus
9 to 15	33% Genus
16 to 50	20% Species, 30% Genus
≥51	10% Species, 20% Genus
Note: Any exceptions to the above diversity percentages must be approved by the City Manager. Tree availability at the time of construction may impact tree diversity requirements. Genus and species substitutes, as well as revisions to tree diversity requirements will be reviewed on a project by project basis by the City Manager.	

(B) Tree Placement in Non-paved Medians and Landscape Planting Strips

(1) Tree placement shall be designed and based on the expected mature height and canopy spread for the selected species, to prevent unnecessary competition or overcrowding of trees.

(2) Trees shall not be placed where the expected mature height and canopy spread could obstruct sight distance of any public sign, driveway, alley, or intersection, as set forth in Section 9-9-7, "Sight Triangles," B.R.C. 1981, or where the physical obstruction of any sidewalk, trail, alley, or street lane could occur.

(3) New or transplanted trees shall not be placed within 10 feet of existing underground water, sewer, or storm water utility lines. New underground utilities should not be placed within 10 feet of existing trees without the prior review and approval of the Director.

(4) Trees shall not be placed within 10 feet of any utility pole, streetlight, or pedestal. When tree placement is allowed under overhead utility lines, only those tree species listed as "Small Maturing Trees" on the "Approved Tree List" shall be planted.

(5) Trees shall not be placed within 15 feet of any ditch embankment, and ditch owners should be consulted prior to any tree planting within ditch easements.

(6) Trees shall be located at least 10 feet away from buildings and offset from building entrances. When available space is limited, only species with columnar or fastigiate forms shall be planted.

(7) Trees shall be planted in the center of right-of-way planting strips, or appropriately placed for mature height and spread, to ensure tree health, prevent root damage to sidewalks and street facilities, and to avoid a sight distance obstruction.

Trees shall not be placed in the right-of-way where the planting strip extends less than 4 feet to the property line from the back edge of an attached sidewalk, the edge of the pavement, or the curb.

(8) Tree spacing for trees placed in landscaped planting strips shall comply with the "Spacing Between Trees" requirements listed in the species headings in , "Approved Tree List." Tree placement should meet the recommended tree spacing and shall not be less than the minimum tree spacing requirements unless approved by the Director.

(C) Tree Placement in Paved Areas Using Tree Grates and Planting Pits

(1) Trees within grates and planting pits shall be placed in compliance with the design standards for tree spacing and shall be planted in a 4 ft. x 10 ft. two-piece Neenah Foundry, or approved equal, grate. Tree spacing for tree grates shall comply with the "Spacing Between Trees" requirements listed in the "Approved Tree List."

Table 3-3: Tree Grates and Planting Pits Standards

Tree Species Size	Tree Spacing	Minimum Tree Grate Area (Width x Length)	Minimum Soil Volume*
Small Tree	15 Ft. minimum,	20 Sq. Ft. minimum, 4 Ft. min. width (Ex. 4 ft. x 5 ft.)	600 Cu. Ft. minimum, 3 Ft. min. depth
Medium Tree	25 Ft. minimum,	32 Sq. Ft. minimum, 4 Ft. min. width (Ex. 4 ft. x 8 ft.)	900 Cu. Ft. minimum, 3 Ft. min. depth
Large Tree	30 Ft. minimum,	40 Sq. Ft. minimum, 4 Ft. min. width (Ex. 4 ft. x 10 ft.)	1200 Cu. Ft. minimum, 3 Ft. min. depth

*Where soil volumes between trees overlap, up to 25% of the required soil volume per tree may be shared.

(2) Tree grates, tree guards, and planting pits shall be provided in locations where a hard surface or paved area is required to adequately accommodate pedestrians, including without limitation downtown or commercial sidewalks, malls, and plazas. The tree grate allows air and moisture to reach tree roots and limits compaction of the soil around the tree to maintain healthy growth.

(3) Trees within tree grates shall not be placed where the expected mature height and canopy spread could obstruct sight distance of any public sign, driveway, alley, or intersection, as set forth in Section 9-9-7, “Sight Triangle,” B.R.C. 1981, or where the physical obstruction of any sidewalk, trail, alley, or street lane could occur.

(4) Trees within tree grates shall not be placed within 10 feet of any existing underground water, sewer, or storm water utility line or within 10 feet of any utility poles or pedestal. When tree placement is allowed under overhead utility lines, only those tree species listed as “Small Maturing Trees” on the “Approved Tree List,” shall be planted.

(5) Trees within tree grates should be located at least 10 feet away from buildings and offset from building entrances. Below grade parking structures are considered buildings and shall satisfy this requirement.

(6) Adequate growing space between the tree trunk and first ring of the tree grate shall be provided to allow the tree to grow properly without girdling. The opening in the center of the tree grate through which the tree grows shall provide 4-6 inches of clearance from the tree trunk and be at least 18 inches in diameter. The tree shall be centered within the tree grate opening.

(7) The soil surface within a planting pit and beneath a tree grate shall be level with the bottom of the sidewalk slab. This is to avoid problems with root flares lifting grates as the tree grows and allows the roots to find air and water. Trees are then to be planted so that the top of the root ball is 2" above the finished grade of the soil.

(8) Planting pits shall be 3 feet deep and have the same surface area as the required tree grate area and may not be deepened unless warranted by the depth of the root ball of the tree to be planted. A planting pit shall not be deepened to increase pit volume as an alternative to providing the minimum tree grate surface area.

(9) Tree grates shall be flush with the finish grade of adjacent pavement.

(10) All tree grates shall be installed per the manufacturer's specifications. Grates shall be supported by a frame which has anchors embedded in the surrounding concrete. Final frame dimensions shall be 1/16 to 1/8-inch larger than the grate dimension on all sides to allow the grate to drop into the frame seat. Frame sections are to be bolted together and cast into the surrounding concrete. Frames must be level and the seat for the grate must be in a true, flat, plane to prevent rocking of the grate. The seat for the grate shall be cleaned prior to setting the grate. To ensure proper fit, the grate or a template shall be placed in the frame before concrete is poured so that the final installation will be square and level.

(11) Tree grates are to be of the pedestrian safe style with slot openings 3/8-inch in width or less and designed to accommodate a tree guard.

(12) Tree guards shall have an 18" opening to match the tree grate and shall be installed per the manufacturer's specifications.

3.04 Tree Removal and Relocation

(A) Permit Required for Tree Removal or Relocation

(1) An applicant for construction approval shall not remove or relocate any tree existing within any public right-of-way without first having a Landscaping Plan approved, obtaining a right-of-way permit under Chapter 8-5 "Work in the Public Right-of-way and Public Easements," B.R.C. 1981, and receiving any approvals required under Chapter 6-6, "Protection of Trees and Plants," B.R.C. 1981.

(2) An applicant for construction approval may not request City approval nor propose as part of a Landscaping Plan for a project or development the removal or relocation of a tree in the public right-of-way unless:

(a) The site cannot feasibly be developed, through design or construction alternatives, without removing or relocating the tree, and the applicant mitigates the loss of the tree,

(b) The tree is determined by the city to be undesirable as outlined in Section 3.04(B), "Undesirable Trees for Public Rights-of-Way,' below, or

(c) The city is requiring the removal of a tree as part of construction approval.

(3) Where tree mitigation is required for tree removal pursuant to Chapter 6-6, "Protection of Trees and Plants," B.R.C. 1981., trees required to be planted as part of standard project or development approval will not be counted towards the required mitigation.

(4) Mitigation shall be satisfied when all fees are paid and replacement trees are planted. Mitigation fees shall be determined by the Director and due prior to issuance of building permits. If replacement is appropriate, a Landscaping Plan showing the location, species and size of all plant material shall be required.

(B) Undesirable Trees for Public Rights-of-Way

The city may determine that certain trees located within the public right-of-way are undesirable and may recommend or require removal of these trees if:

(1) The trees are less than 1 inch in caliper, usually representing volunteer trees or suckers that seldom conform to selection and placement standards and are smaller than would be required for new plantings.

(2) The trees are smaller than 12 inches in diameter and are Cottonwood (any Poplar species), Siberian Elm, Russian Olive, Silver Maple, Tree-of-Heaven, Willow, and evergreens that create sight obstructions, clump forms, or multi-stem trees.

(3) Trees that have been severely damaged or are in poor general health, as determined by the city under generally accepted forestry standards. Trees damaged or in poor general health as the result of actions or inaction of the adjacent property owner requires the loss be mitigated by such property owner per Chapter 6-6, "Protection of Trees and Plants," B.R.C. 1981.

(4) Trees that, due to their species, location, or density would not conform to the existing streetscape standards for tree placement or spacing as outlined in these Standards.

(C) Tree Removal

(1) Trees shall only be removed in compliance with a Landscaping Plan approved by the city as set forth in these Standards. Trees shall be required to be removed if greater than 40% of the canopy or root system is damaged or removed during construction as determined by the Director under generally accepted forestry standards.

(2) All trees to be removed shall be marked with an "X" in blue permanent marking and approved by the City prior to removal.

(3) All tree removal shall include stump grinding to a minimum depth of 12 inches.

(D) Tree Relocation (Transplanting)

(1) Trees with a "transplanting ease" rating of 1 or a 2, as defined in the *Tree and Shrub Transplanting Manual*, are considered eligible for transplanting, subject to city approval. All transplanting shall be in a location approved by the city.

(2) Trees eligible for transplanting shall meet the following requirements:

(a) Be 8 inches or less in caliper, unless approved by the city, and

(b) Have a root ball size of 1 foot per 1 inch of trunk caliper, evenly distributed on all sides from the center line of the trunk. For example, a tree with a 4-inch caliper shall have a root ball with a 4-foot diameter, evenly distributed with 2 feet on all sides from the centerline of the trunk.

(3) Transplanting shall be done only by a certified arborist with a valid contractor license pursuant to Chapter 4-28, "Tree Contractor License," B.R.C. 1981and in accordance with a Landscaping Plan approved by the city.

(4) The applicant for construction approval shall ensure that the transplanted tree survives without significant loss of tree value in compliance with the tree protection standards set forth in Chapter 6-6, "Protection of Trees and Plants," B.R.C. 1981.(5) Transplanting periods:

(a) Transplanting shall be done between December 1 and April 30 for all trees, except for trees identified in the *Tree and Shrub Transplanting Manual* as unsuitable for early spring transplanting.

(b) Trees identified as unsuitable for early spring transplanting shall be transplanted only between September 15 and October 30.

3.05 Tree Protection For Construction Sites

(A) Tree Protection Required

(1) An applicant for construction approval shall protect trees and plants in the public right-of-way and on any project or construction site where public improvements are proposed.

(2) An applicant for construction approval shall submit a landscaping plan incorporating proposed tree protection measures for any existing trees located in the public right-of-way and on site at any project or construction site where public improvements are proposed in compliance with these Standards. For

projects larger than one single family dwelling, a separate Tree Protection Plan in addition to the required Landscaping Plan shall be required.

(3) The Landscaping Plan shall identify any potential detrimental effects to existing trees that might result from proposed construction activities within 20 feet of the dripline of any existing trees located on site or in the adjacent public right-of-way. The plan shall include the species, size, and location of all existing trees that are 2-inches or larger caliper size. If no existing trees are present that require protection, this shall be noted on the Landscaping Plan. Existing trees approved to be removed or relocated shall be clearly identified on the Landscaping Plan and Tree Protection Plan.

(4) The applicant for construction approval shall notify the city within 24-hours of any suspected damage to trees resulting from construction activities. If damage occurs during construction, the applicant shall have the damaged tree evaluated immediately by a certified arborist with a valid contractor license pursuant to Chapter 4-28, "Tree Contractor License," B.R.C. 1981.

(5) If greater than 25% of the canopy or root system is damaged or removed during construction, the tree shall be evaluated for safety and future health by a certified arborist with a valid contractor license pursuant to Chapter 4-28, "Tree Contractor License," B.R.C. 1981. A complete copy of the evaluation shall be submitted to the Director. Mitigation shall be required if the tree is deemed unsafe and is required to be removed.

(6) Prior to issuing a right-of-way permit or building permit or upon discovery of any damage to existing trees located in the public right-of-way and identified in the Landscaping Plan, the Director may require an applicant for construction approval to provide an escrow of funds or other financial guarantee that is acceptable to the Director for the full value of any such trees, as determined by the Director in accordance with the Guide for Plant Appraisal published by the Council of Tree and Landscape Appraisers, for the duration of construction activities and the public improvement warranty period. If, upon completion of construction activities and the public improvement warranty period, any damaged trees have not been restored by a qualified arborist or replaced by trees of an equivalent or greater value, the Director may cause such restoration or replacement to be completed and collect against the financial guarantee.

(7) Upon discovery of any violation of the Landscaping Plan or any damage to existing trees located in the public right-of-way and identified in the landscaping plan, the Director may issue a stop work order and halt all construction activities pending restoration, mitigation, or replacement of the damaged trees to the satisfaction of the Director.

(B) Tree Protection Procedures

(1) **Protective Maintenance:** An applicant for construction approval shall provide maintenance and care for existing trees required to be protected on site

and in the public right-of-way adjacent to any project or construction site during construction activities and the public improvement warranty period, as provided in Section 9-12-14 “Public Improvement Warranty” B.R.C. 1981, to ensure that existing trees survive and are not damaged.

(2) **Watering**: The applicant for construction approval shall water trees identified for protection in the Tree Protection Plan in accordance with the following: Water trees 1”-3” in diameter weekly at a rate of 10 gallons/inch of diameter; water trees 4”-9” in diameter 3x per month at a rate of 10 gallons /inch of diameter; and water trees 10” in diameter or larger 2x per month at the rate of 15 gallons/inch of diameter. The above schedule shall be followed April through September; October through March the trees shall be watered once per month following the above amounts.

(3) **Soil Compaction Prevention:**

(a) To prevent soil compaction, designated routes for equipment and foot traffic by work crews shall be determined prior to commencing construction activities and as indicated in the Landscaping Plan and Tree Protection Plan.

(b) These planned routes shall be marked at the site before construction commences with durable fencing material that is at least 4 feet high. Flagging tape or any other material that may be torn down, moved, or evaded is not acceptable.

(c) The contractor shall inform all construction crew members on the site of access routes and will ensure that only these routes are used.

(d) To prevent tree root smothering, no soil stockpiles, supplies, equipment, portable toilets, or any other material shall be placed or stored within a tree dripline or within 15 feet of the tree trunk, whichever distance is greater.

(e) Soil around a tree dripline may be required to be aerated during and after construction activities. This is necessary even when compaction results from heavy foot traffic. A certified arborist with a valid contractor license pursuant to Chapter 4-28, "Tree Contractor License," B.R.C. 1981shall perform the vertical aeration or soil fracturing. . Conventional turf aeration is not acceptable.

(f) When foot traffic or equipment use is unavoidable within the dripline, the area within the dripline shall be mulched with wood chips to a depth of 6 inches before construction activity begins. A 6-inch mulch depth shall be maintained for the duration of the project, then removed when construction activities are completed.

(4) **Root Protection:**

(a) Tree roots shall not be cut unless cutting is unavoidable.

(b) When root cutting is unavoidable, a clean, sharp cut shall be made to avoid shredding or smashing. Root cuts should be made back to a lateral root.

(c) Root cutting shall only be performed by a certified arborist with a valid contractor license pursuant to Chapter 4-28, "Tree Contractor License," B.R.C. 1981.

(d) Whenever possible, tree roots should be cut between late fall and bud opening, when root energy supplies are high, and conditions are least favorable for disease causing agents.

(e) The Director shall be notified of any cutting of the following roots:

(i) Two roots having a diameter of more than 3 inches, or

(ii) Four roots having diameters between 2 and 3 inches.

(f) Trenches shall be hand dug within the dripline.

(g) Whenever possible, roots 2 inches or larger in diameter shall be tunneled or bored under and shall be covered to prevent dehydration. Exposed roots shall be covered immediately with soil or burlap and kept moist.

(h) Power tools shall not be used to prune roots, with the exception of arboriculturally approved root cutting- equipment used under the supervision of the City. Only the following approved tools shall be acceptable: scissorstype hand pruners and loppers, except -anviltypes, and -arboristtype- pruning saws.

(i) Supplemental watering, in addition to the requirements of section 3.05 B(2), shall be provided if the tree lacks an operational sprinkler system. The applicant or abutting landowner shall provide the watering. Watering shall commence immediately after roots have been cut or damaged at the following rates:

i. 1”-3” diameter: water weekly at a rate of 10 gallons/inch of diameter;
ii. 4”-9” diameter: water 3x per month at a rate of 10 gallons/inch of diameter; and
iii. 10” diameter or larger apply water 2x per month at the rate of 15 gallons/inch of diameter.

The above schedule should be followed April through September; October through March the trees shall be watered once per month following above amounts.

(j) Sidewalk and paving surfaces shall be sufficiently contoured to avoid cutting surface tree roots. Whenever possible, tree roots shall bridge or float over with walks.

(k) To allow maximum aeration and water penetration to roots, walk materials other than concrete may be selected (e.g., brick, flagstone, honeycomb block, chips, gravel) subject to City approval. Under no circumstances shall impervious material make contact with or completely encircle a tree trunk.

(l) Auger tunneling, not trenching, shall be used for utility placement within the dripline of tree measuring over 6 inches in diameter.

(m) If roots are cut, the Director may require supplemental deep root watering..

(n) Trees impacted by construction activities shall not be fertilized for a period of 1 year following the cessation of construction activities. Thereafter, for the next 2 years, a light annual fertilization using a slow release nitrogen source is acceptable.

(5) **Tree Fencing:**

(a) Fencing material shall encircle any tree, including those on adjacent properties, whose outer dripline edge is within 20 feet of any construction activities.

(b) Fencing material shall be a bright, contrasting color, durable, and at least 4 feet high. Fence posts shall be comparable to metal T-posts or heavier posts and placed at least 1.5 feet below ground.

(c) Fencing material shall be placed at the dripline or at least 15 feet from any tree trunk, whichever distance is greater, and maintained in an upright position throughout the duration of construction activities.

(d) The applicant for construction approval shall indicate fencing locations on the landscaping tree protection plan.

(e) Objects, such as wood pallets or metal railings, shall not lean against or come into contact with any tree trunk.

(6) **Grade Changes:** Grade changes, such as removing topsoil or adding fill material, shall not occur within the dripline of any existing tree. If necessary, as part of project or site development and approved by the Director, retaining walls and tree wells may be used to maintain the existing grade within the dripline of any tree when constructed prior to site grading changes near the tree. A landscaping plan containing an illustrated design scheme of the tree protection improvement shall be approved by the city prior to initiating any grade changes

near existing trees.

(7) **Transplanting:** Any proposed or required transplanting shall conform with the requirements in Section 3.04(D), “Tree Relocation (Transplanting).”

(8) **Chemical/Foreign Material Disposal:**

(a) Disposing of chemicals or foreign material anywhere on site or in the public right-of-way is prohibited. This shall include, but is not limited to: paint, stain, solvents, concrete or any construction material onsite, and rinse water from any cans or tools containing chemicals.

(b) Soil samples may be taken to determine the presence of chemicals or foreign materials for any planter containing proposed or existing plant material.

(9) **Pruning:** Pruning shall not occur during construction activities or the public improvement warranty period, except to remove dead or damaged branches or to prevent branch damage that could occur during construction, without the prior approval of the Director. Any approved pruning must be completed by a certified arborist with a valid contractor license pursuant to Chapter 4-28, "Tree Contractor License," B.R.C. 1981.

3.06 General Landscaping and Maintenance Requirements

(A) Protecting Existing Improvements

An applicant for construction approval shall preserve and protect all trees, plants, monuments, structures, and public improvements from damage due to construction activities.

(1) **Utilities:** The applicant shall ask the appropriate utility company to stake exact locations and depths of all water, sewer, electric, gas, or telephone lines prior to excavation, and shall take the necessary precautions to protect underground lines from damage. If damage occurs, the applicant shall pay all repair costs.

(2) **Existing Trees:** Protection shall comply with Section 3.05, “Tree Protection for Construction Sites.”

(3) **Responsibility for Damages:** The applicant shall be responsible for any damage to trees, plants, fences, buildings, roadways, sidewalks, and public and private property resulting from the applicant’s activities. The city may require an applicant to provide, at no cost to the city, durable fencing to prevent damage to fragile plant materials or structures. Damage to trees in shall be calculated in accordance with the Guide for Plant Appraisal published by the Council of Tree and Landscape Appraisers. If the applicant or an agent thereof damages a tree to such an extent that it must be removed and replaced, the applicant shall be responsible for the cost of removing and replacing the damaged tree with a tree approved by the Director, plus the difference in value between the full appraised

value of the removed tree minus the cost of removal and replacement.

(4) **Omissions and Discrepancies:** Omissions from any approved landscaping plan or specifications that affect the intent of the plans or specifications, or that are customarily performed, shall be performed as if fully and clearly set forth and described in the plans and specifications.

(B) Maintenance

(1) Landscape maintenance shall begin immediately after each area is planted and shall continue following Director acceptance through the applicable warranty period, or in perpetuity, as set forth in Section 9-9-12(d)(2) "Landscape and Screening Maintenance and Replacement," Section 9-12-13 "Subdivider Financial Guarantees," and Section 9-12-14 "Public Improvement Warranty," B.R.C. 1981.

(2) Landscape maintenance shall include, without limitation, watering, weeding, cultivating, mulching, tightening and repairing of guys, removal of guy wires and tree stakes after the first full growing season, removal of tree wrap prior to April 1, removing dead branches, resetting plants to proper grade or upright position, replacing dead plants and protecting the site from damage or vandalism.

(3) If required by the Director, the applicant for construction approval shall furnish written maintenance instructions to the Director for the care and maintenance of all newly planted areas for the applicable warranty period. These instructions shall include, but are not limited to: irrigation, staking, pruning, insect and disease control, and fertilizing.

CHAPTER 4
GENERAL UTILITIES DESIGN

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4.01 General

(A) Intent

The General Utilities Design Standards are intended to provide for an integrated public utilities system for all public utilities, including water, wastewater, storm drainage, gas, electric and telecommunications systems.

(B) Utilities Master Plans

All improvements proposed to the City's public utilities system shall conform with the goals, policies, and standards adopted in the Water Utility Master Plan, Wastewater Utility Master Plan, and Comprehensive Flood and Stormwater Master Plan.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of public utilities improvements and may refer to one or more of the references listed in the References Section of these Standards.

4.02 Utility Connection Plan

(A) Required

The Director of Public Works may require the preparation of a Utility Connection Plan in order to assess the feasibility of providing utility service to any project or development and identify impacts of any development application on the existing and planned public utility systems. A Utility Connection Plan may be prepared in lieu of a Utility Plan for projects or developments that meet all of the standards below:

(1) City utilities required to serve the site are located directly adjacent to the subject property.

(2) No extension, enlargement, or improvement of public mains is required to serve the site.

(3) No change in use is proposed which may alter the utility needs of the site.

(B) Plan Requirements

The Utility Connection Plan shall include the following project or development information:

(1) **Title Block:** Include the label "Utility Connection Plan" and name of project or development application, and the original preparation date and dates of any revisions.

(2) **Site Location Data**: Include vicinity map and north arrow,

(3) **Drawing Scale:** The drawing scale shall be between 1 inch equals 20 feet and 1 inch equals 100 feet, placed on the minimum number of plan sheets possible.

(4) **Property and Street Information:** Include the location of existing and proposed lot lines, block and lot numbers, and street names.

(5) **Construction Note:** Include the statement that "Utilities shall comply with the City of Boulder Design and Construction Standards."

(6) **Existing and Proposed Utilities:** Include the location, type and size of all existing and

proposed utilities mains and service lines. Utilities to be identified include without limitation: water, wastewater, storm drainage, flood control, gas, electric, telecommunications, drainageways, and irrigation ditches within and adjacent to the project or development site. Include and assign identification numbers to all existing and proposed manholes, inlets, fire hydrants, meter settings and pits, and provide "direction of flow" arrows on gravity pipelines.

(7) **Easements and Rights-of-Way:** Include the location, dimensions, and dedication type of all existing and proposed easements and rights-of-way for all utilities improvements. If available, reference existing easements to appropriate recorded film and reception numbers.

(8) **Structures and Trees:** Include the location and dimensions of all existing and proposed structures, including without limitation buildings and fences, trees 1½ inch caliper or greater, and major landscape features.

(9) **Floodplain:** Delineate any 100-year floodplain boundaries that impact the project or development site and identify the floodplain designation, base flood elevations and floodplain mapping source used to determine the floodplain.

(10) **Storm Water Plan Combination:** The Director may approve a combined "Utility Connection and Storm Water Plan," reflecting storm water design information, prepared in compliance with the requirements outlined in Chapter 7, "Storm Water Design," of these Standards.

(11) Applications for Annexation or Out-of-City Utility Service for a single family residential dwelling may provide the required information on a scaled Improvement Location Certificate or Improvement Survey Plat.

4.03 Utility Plan

(A) Required

The Director may require an applicant to submit a Utility Plan as a condition of any development application in order to adequately assess the availability of utility service and impacts of any development application on the existing and planned public utility systems. The Utility Plan shall provide an overview of the proposed project or development application and identify whether the proposal is:

(1) Eligible for utility service and has access to available public utility systems.

(2) Consistent with current Utilities Master Plans, meets the minimum design standards for system layout, and is compatible with and allows for the perpetuation of the existing utility systems.

(3) Located within any mapped 100-year floodplain.

(B) Plan Requirements

The Utility Plan shall include the following project or development information:

(1) **Title Block:** Include the label "Utility Plan" and name of project or development application, and the original preparation date and dates of any revisions.

(2) **Site Location Data:** Include vicinity map, north arrow, relationship of the property to range, township, and section lines.

(3) **Survey Information:** Include the elevation and location of City-recognized benchmarks

with reference to local, USGS and NGVD data.

(4) **Drawing Scale:** The drawing scale shall be between 1 inch equals 20 feet and 1 inch equals 100 feet, placed on the minimum number of plan sheets possible.

(5) **Property and Street Information:** Include the location of existing and proposed lot lines, block and lot numbers, and street names.

(6) **Construction Note:** Include the statement that "Utilities shall comply with the City of Boulder Design and Construction Standards."

(7) **Existing and Proposed Utilities:** Include the location, type and size of all existing and proposed utilities mains and service lines. Utilities to be identified include without limitation: water, wastewater, storm drainage, flood control, gas, electric, telecommunications, drainageways, and irrigation ditches within and adjacent to the project or development site. The locations of existing underground utility mains and service lines and the invert and surface grade elevations of all manholes, inlets and culverts shall be field verified to the Director's satisfaction (by "pothole" excavations, if necessary) and accurately delineated and dimensioned. Include and assign identification numbers to all existing and proposed manholes, inlets, fire hydrants, valves, pipe lengths, meter settings and pits, and provide "direction of flow" arrows on gravity pipelines. Proposed invert and surface grade elevations shall be provided for all proposed manholes, inlets and culverts.

(8) **Site Topography:** Include existing and proposed contour lines showing at least 2-foot contour intervals, and reflecting spot elevations at various locations, "cut and fill" areas, and surface drainage systems.

(9) **Easements and Rights-of-Way:** Include the location, dimensions, and dedication type of all existing and proposed easements and rights-of-way for all utilities improvements. If available, reference existing easements to appropriate recorded film and reception numbers.

(10) **Structures and Trees:** Include the location and dimensions of all existing and proposed structures, including without limitation buildings and fences, trees 1½ inch caliper or greater, and major landscape features.

(11) **Maintenance Access:** Include the location and dimensions for existing and proposed "all-weather" maintenance access drives for 14-ton maintenance equipment to reach manholes and inlets not located in existing or proposed streets.

(12) **Floodplain:** Delineate any 100-year floodplain boundaries that impact the project or development site and identify the floodplain designation, base flood elevations and floodplain mapping source used to determine the floodplain.

(13) **Storm Water Plan Combination:** The Director may approve a combined "Utility and Storm Water Plan," reflecting storm water design information, prepared in compliance with the requirements outlined in Chapter 7, "Storm Water Design," of these Standards.

(C) Utility Plan Approvals

(1) The Utility Plan shall reflect proposed utility infrastructure and utility service to development applications and may serve as the basis for approving site review and preliminary subdivision proposals.

(2) A final version of the Utility Plan shall be included in all Construction Plans proposing the construction of utility infrastructure to reflect overall system layout and design configurations.

(3) The Utility Plan may serve as the Construction Plan under the following conditions:

(a) The proposed utility improvements include only private service line (water, wastewater, or storm sewer) or fire line connections to individual properties.

(b) The proposed utility improvements include only water main extensions or fire hydrant runs on individual properties.

(c) Standard construction notes are included on the Utility Plan, and no other Construction Plans for other public improvements are required.

(4) The Director may waive the requirement that the Utility Plan be prepared by an Engineer for development applications that include only private utility (water, wastewater and storm drainage) service lines or fire lines to individual properties.

4.04 Utilities Easements

(A) General

(1) All City-operated public utilities, including without limitation, water, wastewater and storm drainage systems, shall be located within public rights-of-way or public utility easements.

(2) Public utility easements shall be at least 25 feet wide. Wider easements may be required where the depth of a utility, or number of utilities occupying the easement, requires additional width to satisfy standards for utility separations, trenching excavations, or adequate maintenance access.

(3) Public utility easements shall provide a minimum parallel separation of 6 feet between the edge of any utility line and the easement boundary.

(4) Public utility easements are to be placed longitudinally along one side of any property line in a manner that no portion of any easement falls on both sides of a parallel property line.

(5) Structures and landscaping proposed in public utility easements shall comply with the standards as set forth in Chapter 8-5, "Work in the Public Right-of-Way and Public Easements," and Chapter 8-6, "Public Right-of-Way and Easement Encroachments, Revocable Permits, Leases, and Vacations," B.R.C. 1981.

(6) The Director may allow water service taps from water mains in easements only if free and unobstructed vehicle access is permanently guaranteed for all-weather water meter reading, valve access, and maintenance. Where the Director allowed a service tap from a water main in an easement, the property owners shall ensure all city owned and maintained utilities are accessible and surface features such as valve covers, manholes, and meter pits are visible and not covered by landscape materials, concrete or asphalt. Proposals will be reviewed on a case-by-case basis and are subject to prior approval by the Director.

(B) Easements Crossing Single-Family Residential Lots

Public utility easements crossing single-family residential lots may be allowed only for the following:

(1) Completing required water system looping in cul-de-sac type applications where water mains would otherwise dead-end.

(2) Installation of fire hydrants.

(3) Continuing a wastewater main that would otherwise dead-end in cul-de-sac type applications.

(4) Conveying storm water drainage and overflows from back-draining cul-de-sac or street sump type applications.

4.05 Pipe Strength

All utility pipe shall be of adequate strength to support the trench and AASHTO HS-20 highway loadings.

4.06 Separation of Utilities

(A) Parallel (Horizontal) Separation

Parallel separations between utility mains and services to provide for adequate trench excavations and maintenance operations shall be as follows. All distances are measured from outside of pipe to outside of pipe:

Table 4-1: Utility Separation Requirements

	Water	Sewer	Storm	Electric, Telecommunications, and/or Gas
Water		10-ft	5-ft	5-ft
Sewer	10-ft		10-ft	10-ft
Storm	5-ft	10-ft		5-ft
Electric, Telecommunications, and/or Gas	5-ft	10-ft	5-ft	18-inches

(B) Pipe Crossings (Vertical) Separation

(1) The minimum vertical separation between water and wastewater line crossings, as measured outside of pipe to outside of pipe, shall be 18 inches. The water line shall be constructed above the wastewater line.

(2) The minimum vertical separation between water and storm drainage line crossings shall be 18 inches, measured from outside of pipe to outside of pipe.

(3) The minimum vertical separation between wastewater and storm drainage line crossings, as measured outside of pipe to outside of pipe, shall be 6 inches. In addition, the following applies:

(a) If the storm drainage line is constructed below the wastewater line, pressure-class pipe will be required for both utility lines to prevent possible wastewater contamination of storm drainage.

(b) If the vertical separation between the wastewater and storm drainage line is less than 18 inches, structural support will be required, subject to the Director's approval.

(4) The minimum vertical separation between City public utility pipelines or conduits and all gas, electric, and telecommunications utilities shall be 12 inches.

(C) Drainageway and Irrigation Ditch Crossings

Utility crossings of natural and improved drainageways and irrigation ditches listed in Table 4-2, "Local Drainageways and Irrigation Ditches," shall meet the following conditions:

(1) **Water Main Crossings:** The water main shall be placed at least 4.5 feet below the invert of the drainageway or irrigation ditch and shall be placed in a steel sleeve in conformance with the applicable standard drawings in Chapter 11, "Technical Drawings" of these Standards.

(2) **Wastewater and Storm Drainage Main Crossings**

(a) The wastewater or storm drainage main shall be placed at least 3 feet below the invert of an open drainageway or irrigation ditch or at least 18 inches below the invert of a drainageway or irrigation ditch culvert, and the main shall be placed in a steel sleeve in conformance with the applicable standard drawings in Chapter 11, "Technical Drawings," of these Standards.

(b) In open drainageway or irrigation ditch crossings, the Director may allow the wastewater or storm drainage main to be encased in concrete instead of placement in a steel sleeve, and the concrete encasement shall conform with the applicable standard drawings in Chapter 11, "Technical Drawings," of these Standards.

(c) When a drop manhole is used to obtain the required vertical separation for a drainageway or irrigation ditch crossing, the drop manhole shall be located at least 20 feet from the end of a steel sleeve.

(3) **Other Utility Line Crossings**

(a) Other utility lines, including without limitation, gas, electric, and telecommunications lines, shall be placed at least 30 inches below the invert of a drainageway or irrigation ditch.

(b) Other utility lines shall be placed in a Schedule-40 steel casing, extending horizontally at least 10 feet beyond each side of the drainageway or irrigation ditch, measured from top of bank to top of bank.

Table 4-2: Local Drainageways and Irrigation Ditches

Anderson Ditch	Elmer's Two Mile Creek	Skunk Canyon Creek
Bear Canyon Creek	Farmer's Ditch	South Boulder Creek
Bluebell Creek	Fourmile Canyon Creek	Sunshine Creek
Boulder Creek	Goose Creek	Two Mile Canyon Creek
Boulder and Whiterock Ditch	Gregory Creek	Viele Channel
Boulder and Left Hand Ditch	Howard Ditch	Wellman Canal
Dry Creek	King's Gulch	Wonderland Creek
Dry Creek #2	New Anderson Ditch	
Dry Creek #2 Ditch	North Boulder Farmer's Ditch	

(D) Separation of Utilities from Trees

Trees proposed to be planted in public utility easements and rights-of-way shall be located at least 10 feet away from existing and proposed utilities and shall not block vehicle access along the easement. All utility construction near existing trees shall abide by the tree protection

requirements specified in Chapter 3, "Streetscape Design," of these Standards.

(E) Special Conditions for the Separation of Utilities

If the required horizontal or vertical separation of utilities cannot be obtained as required in this section, the Director may apply special conditions to the design of utilities separations, to ensure the safety, protection and integrity of the utility system, as follows:

(1) **Parallel Separation**

(a) If 10 feet of parallel separation between water and wastewater lines cannot be obtained, the wastewater line may be laid closer to the water line, provided the following conditions exist:

(i) The wastewater line is constructed of pressure-class pipe, in conformance with these Standards, until the required horizontal separation is obtained, and

(ii) The water line is located at least 18 inches above the wastewater line, as measured from the top of the wastewater pipe to bottom of the water pipe.

(b) If 5 feet of parallel separation between water and storm drainage lines cannot be obtained, the storm drainage line may be laid closer to the water line, provided the storm drainage line is constructed of pressure-class pipe, in conformance with these Standards, until the required horizontal separation is obtained. The storm drainage line does not need to be pressure tested.

(2) **Crossings Separation**

(a) If 18 inches of vertical separation between either water and wastewater line crossings, or water and storm drainage line crossings, cannot be obtained, the wastewater or storm drainage line shall be constructed of pressure-class pipe, in conformance with these Standards, for at least 10 feet beyond each side of the water line crossing. This distance shall be measured along the wastewater or storm drainage line from the center of the water line. The storm drainage line does not need to be pressure tested.

(b) If the water line cannot be constructed above the wastewater line at water and wastewater line crossings, the wastewater line shall be constructed of pressure-class pipe, in conformance with these Standards, for at least 10 feet beyond each side of the water line crossing. This distance shall be measured along the wastewater line from the center of the water line.

(c) If either 18 inches of vertical separation between water and wastewater line crossings, and water and storm drainage line crossings, or 6 inches of vertical separation between wastewater and storm drainage line crossings cannot be obtained, special structural support shall be required to prevent settlement and potential pipe damage at the crossing. Structural support design shall be subject to the Director's approval.

(3) **Pressure-Class Pipe for Crossings:** When pressure-class pipe is required to satisfy the requirements prescribed in this section, the following will apply:

(a) Pipe materials and quality shall be suitable for water main construction in accordance with specifications prescribed in these Standards.

(b) Individual pipe sections shall be at least 18 feet long and placed at the crossing so that the ends are located 9 feet beyond each side of the water line crossing.

(c) The inside diameter of the pressure-class crossing pipe shall be of equal size or nearest diameter larger than the non-pressure-class wastewater or storm drainage pipe inside diameter for the length until the required separation between utilities is obtained. Pressure-class pipe installations shall include watertight transition couplings.

(d) Both the water and wastewater lines shall be pressure tested.

4.07 Undergrounding of Utilities

New, replacement, or relocated electrical utilities and telecommunication and cable television systems shall be installed underground as set forth in Section 9-12-12, "Standards for Lots and Public Improvements," B.R.C. 1981.

4.08 Abandonment, Repair and Upgrade of Service Lines and Taps

(A) General

Inactivity, damage, age of materials, redevelopment, or changes in service requirements for the premises may require repair, removal or abandonment of a utilities service line or stub-in. Repair, removal and abandonment of a utilities service line or stub-in shall comply with the standards of this section.

(B) Abandonment

An abandoned service line shall be disconnected at the corporation with the main.

(C) Witnessing

Service line abandonments and repairs shall be witnessed by City inspection staff.

(D) Tap Upgrade

When an existing service line must be upgraded, the existing main tap shall be upsized and re-used wherever possible.

(E) Water Services

When a water service line is abandoned or repaired, the following will apply:

(1) **Services 2 Inches and Smaller:** For a water service line that is a 2-inch line or smaller, the water service connection shall be excavated where the corporation stop is inserted into the water main. The corporation stop shall be closed, the service tubing or piping shall be removed from the corporation stop, and a section of the water service line at least 12 inches long shall be cut off. A plug or cap shall be placed on the corporation stop to prevent leakage. If the service line has a meter, the meter shall be returned to the City for final testing and reading. The meter pit/vault, if present, shall be removed in its entirety, or, if left in place, shall be cut off at least 18 inches below finished grade and filled with sand or other fill material. If the corporation stop is leaky or corroded, the corporation stop shall be removed and a "Ford" FS1 repair sleeve or an equivalent sleeve, approved by the Director, shall be installed while the main is shut off.

(2) **Services Larger than 2 Inches:** For a water service line that is larger than 2 inches, the water service connection shall be excavated over the service tee on the water main. The tapping valve shall be closed, a length of service pipe at least 12 inches long shall be

removed, and the tapping valve shall be plugged or capped. The valve box shall be removed in its entirety or, if left in place, shall be cut off at least 18 inches below finished grade and filled with granular pipe bedding material (squeegee) as specified in Chapter 9, "Utilities Standards," of these Standards. If the service line has a meter, the meter shall be returned to the City for final testing and reading. The meter vault, if present, may be removed in its entirety, or abandoned in place by filling it with sand or granular pipe bedding material (squeegee) as specified in Chapter 9, "Utilities Standards," of these Standards. If practicable, the manhole shall be cut off at least 18 inches below grade. In the event a wet tapped valve is leaky or corroded, the valve shall be removed and a "Ford" FS1 repair sleeve or an equivalent sleeve, approved by the Director, shall be installed while the main is shut off. Valves on tees that are leaky or corroded shall be removed and replaced with a blind flange.

(3) **Copper Lines:** Water service line repairs and connections on copper lines may use flare to flare or grip-tite compression fittings as specified in Chapter 9, "Utilities Standards," of these Standards.

(F) Sewer Services

When a sewer service line is abandoned or repaired, the following will apply:

(1) **Abandonment:** A sewer service line shall be abandoned by excavation of the connection with the main, removal of the section of main with the connection tap, and replacement of that section of the main with PVC non-pressure pipe and couplings as specified in Chapter 9, "Utilities Standards," of these Standards. Manhole taps may be plugged at the manhole with the service line left intact.

(2) **Repair:** Sewer service line repairs that require the coupling of two pipe sections to create a joint shall use couplings for non-pressure pipe as specified in Chapter 9, "Utilities Standards," of these Standards.

CHAPTER 5
WATER DESIGN

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5.01 General

(A) Intent

The Water Design Standards establish minimum design standards for providing and maintaining the public water utility distribution system.

(B) Water Utility Master Plan

All improvements proposed to the City's public water utility system shall conform with the goals, policies, and standards adopted in the Water Utility Master Plan.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of public water utility improvements and may refer to one or more of the references listed in the References Section of these Standards.

5.02 Utility Report

(A) Requirement

The Director of Public Works may require the preparation of a utility report in order to assess the impacts and service demands of any project or development proposal connecting to the public water distribution system. The utility report shall be prepared by the Engineer and include a technical report, preliminary plan, and connection and isolation plan as outlined in the following subsections.

(B) Report

The utility report shall provide an overview of the proposed project or development, proposed water utility improvements, water service demands, system impact and feasibility, and basic design requirements, and include the following information:

(1) **Water Demands:** Include estimated water demands based on occupancy and building type for the following conditions:

  (a) Peak Hour (gallons-per-minute),

  (b) Peak Day (gallons-per-minute),

  (c) Insurance Service Office (ISO) Fire Flows (gallons-per-minute), and

  (d) Irrigation (gallons-per-minute).

(2) **Conformance with Water Utility Master Plan:** Describe how the proposed water utility improvements conform with the adopted Water Utility Master Plan.

(3) **System Layout:** Describe the proposed distribution system layout, including locations for connections with the existing water utility system.

(4) **Network Analysis:** Include a distribution network analysis as required by the Director, performed through an EPANet or MWH InfoWater computer simulation, identifying any

systems impacts based on proposed demands and providing design solutions to ensure perpetuation of future water utility system growth and maintain system pressures and flow rates.

NOTE: Computer simulations of hydraulic analyses are to be performed using electronic input data for the existing water system provided by the City on EPANet software. Computer analyses are to be submitted in both hard copy and electronic format.

(5) **Main Sizing:** Indicate the required sizing of proposed distribution mains based on water demands.

(6) **Design Alternatives:** Discuss alternative system layouts and methods of providing water service, including an evaluation of each alternative and reasons for selecting the recommended design.

(7) **Special Conditions:** Identify any special conditions, such as the presence of erosive soils, conflicts with other utilities, unusual installation depths or oversizing requirements, that require special provisions for improvements construction.

(C) Preliminary Plan

A preliminary plan shall be included in the utility report to provide a plan view and reference for the proposed improvements, and identify issues addressed in the report. The preliminary plan is to include the following:

(1) **Preliminary Design:** Illustrate proposed methods and alternatives for providing site water distribution and service.

(2) **Property Boundaries:** Reflect legal boundaries of the proposed project or development site, including existing and proposed property and lot lines, existing and proposed rights-of-way and utility easements, and boundaries of abutting properties.

(3) **Topography:** Include site topography at 2-foot interval contours, and the elevation and location of City-recognized benchmarks with reference to local, USGS and NGVD data.

(4) **System Area:** Define and delineate the system area included in the network analysis.

(5) **Existing Utilities:** Illustrate existing water utilities, including fire hydrants and valves, within 400 feet of the proposed development.

(6) **Unusual Features:** Identify unusual features, such as creeks, drainage facilities, railroads, and irrigation ditches, that might influence the location of underground utilities.

(7) **Proposed System Layout:** Illustrate the general layout of the proposed water distribution mains, valves, and fire hydrant locations, including construction phasing.

(D) Connection and Isolation Plan

A connection and isolation plan shall be provided in the utility report to identify proposed connection points with the existing water systems and design conditions for providing required system isolation for maintenance and flushing. The connection and isolation plan is to include the following:

(1) **Valve Locations:** Identify all valves necessary to isolate a point of connection for the proposed water system onto the existing system. Existing system valves should be inspected for location and accessibility.

(2) **Thrust Restraint:** Determine and include design and construction requirements for sufficient thrust restraint for existing water mains and valves at proposed connection points (“stub outs” and terminal extensions) to allow construction while the existing water system remains in service.

(3) **System Isolation:** Identify water main sections that can be isolated within the proposed and existing water systems that provide for emergency maintenance and identify discharge points for system flushing.

5.03 Water Main Extensions

(A) Water Utility Master Plan

Where major water distribution mains, 12 inches or larger in diameter, are proposed to be constructed in the Water Utility Master Plan, an applicant for construction approval shall provide for the construction of the main as part of any development proposal, when the major distribution main is:

(1) Located within a proposed development.

(2) Located within 1,000 feet of a proposed development and it is feasible to include construction of this main in the proposed development.

(3) Required to provide adequate distribution service for the proposed development.

(B) Main Extension Agreements

(1) When construction of a major distribution main is required, and the diameter of the major distribution main is larger 12 inches and the minimum diameter required for local distribution mains to serve the proposed development, an applicant for construction approval may enter into a "main extension agreement" with the City for reimbursement of public improvements costs associated with the over-size construction of the major distribution main, as prescribed under Sections 11-1-42, “Agreement to Extend Water Mains,” and 11-1-43, “Reimbursement of Costs for Water Main Extension,” B.R.C. 1981.

(2) When construction of an offsite major or local water distribution main is required to extend water service to a proposed development, an applicant for construction approval may enter into a "main extension agreement" with the City for reimbursement of offsite public improvements, as prescribed under Sections 11-1-42, “Agreement to Extend Water Mains,” and 11-1-43, “Reimbursement of Costs for Water Main Extension,” B.R.C. 1981.

5.04 Design Flow

(A) Water Distribution Mains

(1) The water distribution system (mains and looping) shall be designed to provide a minimum residual pressure of 20 pounds per square inch (psi), at ground surface, under peak day demand flow, plus the required ISO fire flow.

(2) The water distribution system shall be designed to provide a minimum of 40 psi under peak hour demand flow, without fire flow.

(3) The water distribution system shall be designed so that water main flow velocities do not exceed 4 feet per second under peak hour demand without fire flow and 8 feet per second

under peak day demand with fire flow.

(4) Pressure and flow capacity data for both existing and future conditions for the City's major water distribution system is to be obtained from the Utilities Division for use in the design and analysis of proposed improvements.

(5) Table 5-1 indicates water demand forecasting for peak day conditions.

Table 5-1: Peak Day Water Demands

Development Type	Peak Day Demand
Residential	
Low Density	180 gpcd
Medium Density	150 gpcd
High Density	75 gpcd
Commercial	10,000 gpad
Industrial	12,000 gpad

(6) Table 5-2 indicates water demand peaking factors for forecasting demands.

Table 5-2: Peak Hour Factors

Development Type	Maximum Hour	Maximum/Day
Residential		
Low Density	5.1	5.1
Medium Density	5.0	2.5
High-Density	5.0	2.0
Commercial	2.5	2.5
Industrial	1.5	1.5

(7) Water design flows that reduce the water system pressures below the acceptable levels or increase water system flow velocities above the acceptable levels specified in this section or elsewhere in these Standards are considered detrimental to the overall system. In these situations, the Director will deny project approval, or require the developer to provide additional water system improvements, both onsite and offsite, to ensure no reduction in levels of service.

(B) Water Services

Design flows for water services shall be determined in conformance with the most current International Plumbing Code as adopted by the City.

5.05 Materials and Installation

Construction of water-related public improvements shall be in compliance with these Standards. All pipe shall be of adequate strength to support the trench and AASHTO HS-20 highway loadings. The type of pipe to be installed shall comply with these Standards, and shall be based upon applicable design flows, pressures, site conditions, corrosion protection, and maintenance requirements.

5.06 Corrosion Protection

Corrosion protection will be required for all water system improvements where corrosive soil conditions are encountered. The Engineer shall perform a soils resistivity survey to evaluate the corrosion potential of soils in proposed projects or developments, and recommend any necessary corrosion protection measures, such as alternative pipe type or cathodic protection. The Director will review the soils resistivity survey and Engineer's recommendations and the service history for water system corrosion in the area and determine the pipe type or protection to be used prior to construction plan approval.

5.07 Transmission Mains

(A) Specifications

(1) **Size:** All water mains 16 inches or larger in diameter shall be classified as "transmission mains."

(2) **Location:** All transmission mains shall be installed in public rights-of-way or easements, as prescribed in Section 4.04, "Utilities Easements," of these Standards.

(3) **Depth:** All transmission mains shall have no less than 4.5 feet and no more than 10 feet of cover, measured from the top of pipe to the final surface grade.

(4) **Separations and Crossings:** All transmission main separations and crossings of other City utilities shall be designed in compliance with Section 4.06, "Separation of Utilities," of these Standards.

(B) Taps

(1) **Minimum Tap Size:** No main extension or fire hydrant taps smaller than 6 inches in diameter shall be installed in any transmission main.

(2) **Service Line Taps Prohibited:** Service line taps shall not be installed in any transmission main.

(3) **Pressure Taps:** Unless approved by the Director, all taps installed onto a transmission main shall be made under "wet tap" conditions, using a tapping tee and valve, to allow the transmission main to remain in service.

(C) Valves

(1) **Separation:** Valve separation along transmission mains shall be no greater than 1,200 feet, measured along the alignment of the transmission main.

(2) **Valve Locations:** Valves shall be installed at the following locations:

(a) At all connections with transmission mains. Where a distribution main connects with a transmission main, a valve shall be installed on the distribution main at the transmission main.

(b) Where necessary to ensure that no more than three valves must be closed to isolate any section of a transmission main. Two valves shall be installed at all tee-type connections, and three valves shall be installed at all cross-type connections.

(c) Where possible, valves shall be aligned with extensions of property lines or right-

of-way lines. Valves shall not be placed in locations that may be subject to routine parking or storage and shall not be placed within public sidewalks, multi-use paths, or on-street bike lanes.

(D) Relief Valves

(1) **Air and Vacuum Release Valves:** Air and vacuum release valves shall be installed in transmission mains at all high points where an elevation differential of 20 feet exists along the main.

(2) **Pressure Blow-Off Assemblies:** Pressure blow-off assemblies shall be installed in transmission mains at all low points where an elevation differential of 20 feet exists along the main.

(E) Ground Water Barriers

(1) **Required:** Where there exists a possibility that ground water may be diverted by the construction of new transmission mains, ground water barriers shall be constructed within the trench to prevent ground water migration or diversion along the water main.

(2) **Placement:** The Engineer shall determine the location and number of ground water barriers that will be necessary to mitigate any ground water impacts, subject to review and approval by the Director. Any necessary support material required to address ground water concerns, such as soils investigations, engineering calculations, and design details, shall be provided by the Engineer.

5.08 Distribution Mains

(A) Specifications

(1) **Size:** Distribution mains shall be at least 8 inches in diameter.

(2) **Locations**

(a) All water mains shall be installed in public rights-of-way or easements, as prescribed under Section 4.04, “Utilities Easements,” of these Standards.

(b) All platted lots, whether existing or proposed as part of a subdivision, shall front on a distribution main.

(3) **Depth:** All distribution mains shall have no less than 4.5 feet and no more than 10 feet of cover, measured from the top of pipe to the final surface grade. Where final grades have not been established, mains shall be installed deep enough to ensure acceptable cover below the future grade based on the best available information. Under no condition shall a main be installed with less than 4.5 feet of cover.

(4) **Separations and Crossings:** All distribution main separations and crossings of other City utilities shall be designed in compliance with Section 4.06, “Separation of Utilities,” of these Standards.

(B) Taps

(1) **Pressure Taps:** All taps approved onto a distribution main shall be installed under “wet tap” conditions, using a tapping tee and valve, which allows the distribution main to

remain in service at all times.

(2) **Tap Installation:** All taps approved onto an existing distribution main will be made by the City of Boulder Utilities Division and shall be paid for by the applicant.

(C) Valves

(1) **Where Required:** Valves shall be installed as necessary on distribution mains to ensure that:

(a) No more than 600 feet of water main will be located between isolation valve zones (i.e., sections of main that may be taken out of service for maintenance activities).

(b) No more than two fire hydrants will be located between isolation valve zones.

(c) No more than three valves will require closure to isolate any section of a distribution main. Two valves shall be installed at all tee-type connections, and three valves shall be installed at all cross-type connections.

(d) Valves are to be aligned with extensions of property lines or right-of-way lines where possible. Valves shall not be placed within public sidewalks, multi-use paths, or on-street bike lanes.

(2) **Emergency Access:** Valves shall be located to provide maximum accessibility for emergency access. Valves shall not be placed in locations that may be subject to routine parking or storage operations.

(D) Looping and Terminal Mains

(1) **Looping Required:** All distribution mains shall be looped into the existing and proposed water distribution system to ensure at least two feed sources and to maintain system strength, except as allowed under Section 5.08(E) below.

(2) **Maximum Terminal Length:** Where allowed, terminal (dead-end) distribution mains shall not be more than 600 feet long, measured along the entire centerline length of the terminal main from the connection main to the terminus.

(3) **Fire Hydrant on Terminal Mains:** All terminal mains shall have a fire hydrant at the terminus and no more than two fire hydrants in total. Fire hydrant installations shall be offset from the terminus to ensure that the hydrant can be removed for maintenance while the terminal main remains in service.

(4) **Service Taps:** Service taps along terminal mains shall not be located closer than 3 feet to the terminus nor located between the fire hydrant connection and the terminus.

(E) Extensions

(1) **Standards:** Water distribution main extensions are subject to the requirements in Section 11-1-41, "Extensions of Water Mains," B.R.C. 1981, and these Standards.

(2) **System Perpetuation:** Water mains shall extend to the far edge of the property being served or to the edge of the platted subdivision, whichever is greater, to ensure perpetuation of the water distribution system. The location, size, and configuration of the proposed development or subdivision, with respect to the existing water distribution system, may dictate that water mains be extended to the far edge of more than one

property or subdivision boundary to accommodate system perpetuation.

(3) **Exceptions:** Exceptions to this subsection may be granted only if development of the adjacent property is not contemplated within 5 years or is classified as Area III under the Boulder Valley Comprehensive Plan. In these cases, an easement for extending the system shall be granted by the property owner.

(F) Future Connections

(1) **Isolation Valve Required:** When future main extensions are provided for by "stub out" or terminal connections, the stub out or terminal main extension shall be valved so that only one valve must be closed when the future main is extended. The valve shall be restrained to the existing distribution main to allow closure of the stub out or terminal main section without creating a pressure separation of the valve from the in-service distribution main.

(2) **Valve Restraint:** Valve restraint may be ensured by the use of a direct swivel connector or adapter, or by providing a pipeline extension that can restrain the valve through frictional resistance. All future connections designed at perpendicular angles to the existing distribution main shall include a valve on the extension that is directly attached to the existing main. Where valve restraint through frictional resistance of extended pipe line sections is proposed, the Engineer shall determine the necessary pipe length required to provide adequate frictional resistance, subject to review and approval by the Director.

(3) **Testing:** When future connections are made, the entire main beyond the stub out or terminal main extension shall be flushed, chlorinated, and pressure tested.

(4) **Service Taps Prohibited:** No service taps shall be allowed on a stub out or on a terminal main beyond the isolation valve.

(G) Ground Water Barriers

(1) **Required:** Where there exists a possibility that ground water may be diverted by the construction of new distribution mains, ground water barriers shall be constructed within the trench to prevent ground water migration or diversion along the water main.

(2) **Placement:** The Engineer shall determine the location and number of ground water barriers that will be necessary to mitigate any ground water impacts, subject to review and approval by the Director. Any necessary support material required to address ground water concerns, such as soils investigations, engineering calculations and design details, shall be provided by the Engineer.

5.09 Water Services

(A) General

(1) **Standards:** Water services are water system extensions that are tapped onto the distribution system to provide water to consumers. Water services are subject to the requirements of these Standards and Section 11-1-20, "Taps or Connections to Water Mains," and Section 11-1-21, "Water Service Lines," B.R.C., 1981.

(2) **Water Meters:** Water services shall include the installation of a meter and shall be subject to the requirements of these Standards and the conditions of Sections 11-1-34,

"Meter and Appurtenances to be Purchased by User," Section 11-1-35, "Meter Size Requirements," and Section 11-1-36, "Location and Installation of Meters; Maintenance of Access to Meters," B.R.C. 1981.

(3) **Separate Services to Lots:** All platted lots, whether existing or proposed as part of a subdivision, shall front on and have a separate water service connection to a distribution main without crossing adjacent lots.

(4) **Service Alignment:** When the water service is located in the public right-of-way or easement, the service shall be installed perpendicular to the distribution main, up to and including the meter and pit. Where this is not possible, the water service alignment shall be subject to the determination of the Director.

(5) **Pressure Boosters Prohibited:** No pressure booster of any kind is allowed on any water service.

(B) Domestic Services

(1) **Separate Services to Structures:** Each principal structure shall be served by a separate water service line and meter connected to the distribution main. Where more than one principal structure is proposed on a single lot, an additional water service line and meter will be required for each additional principal structure.

(2) **Accessory Buildings or Structures:** An accessory building or structure, as defined under Subsection 9-16-1(c), "General Definitions," B.R.C. 1981, may draw limited service from a principal building or structure without a separate water service, subject to the following:

(a) If the accessory structure contains no toilet and no bathtub or shower fixtures, the accessory structure is limited to the following plumbing fixtures:

(i) Sink (one fixture),

(ii) Clothes washer connection (one set),

(iii) Hose bib or sill cock (one fixture),

(iv) Floor drain (one fixture), and

(v) Interceptor (one fixture).

(b) If the accessory structure is proposed to have a sink and toilet, the accessory structure shall not contain any additional sinks or toilets nor a bathtub or shower fixture, shall not be used as a separate dwelling unit, may not be located on a property that can be subdivided into separate lots, and shall be limited to the following additional plumbing fixtures:

(i) Sink (one fixture),

(ii) Toilet (one fixture),

(iii) Floor drain (one fixture), and

(iv) Interceptor (one fixture).

(c) An approved detached accessory dwelling unit, as defined under Subsection 9-16-1(c), "General Definitions," B.R.C. 1981, is not subject to this section's plumbing fixture limitations.

(d) The Director of Public Works may permit water hookups and meters separate

from a principal detached dwelling unit only upon finding that topography or other physical circumstances make utility connections to the principal structure impractical.

(3) **Services Crossing Lots:** Domestic water services crossing one lot to provide service to an adjacent lot may be approved if all of the following conditions are met:

(a) The service crossing is part of a proposed subdivision creating only two lots.

(b) A utility easement at least 10 feet wide is provided across, and situated entirely within, the boundaries of the proposed subdivision. The easement is to be granted to the City for the benefit of the property owner being served and is to be occupied by the water service line only, or by the water and wastewater service lines only if the water and wastewater service lines are installed in compliance the IPC, as adopted by the City.

(c) The Director determines that a water main extension is not necessary to perpetuate the system, or that future development of abutting properties cannot benefit from a main extension.

(d) The water service line is to be centered in the easement and be at least 5 feet from other utilities, except for a combined water/wastewater service installation as allowed under the IPC, as adopted by the City.

(C) Irrigation Services

(1) **Separate Service:** With the exception of single-family residential properties, all irrigation services shall have a separate service line and meter.

(2) **Property to be Served:** Irrigation service lines shall serve no more than one individual property, unless approved by the Director under the provisions of a homeowners association. Where irrigation services serve more than one individual property, the plant investment fee (PIF) and associated credit shall apply to the individual property where the water meter is located and the service originates.

(3) **Building Connection Prohibited:** Irrigation service shall not connect with any building or structure or with any other consumptive-use water service.

(4) **Reduced Pressure Assembly Required:** All irrigation systems with a separate, metered service line shall have a reduced pressure principle assembly installed in compliance with all applicable City regulations and standards.

5.10 Fire Protection

(A) Fire Hydrants

(1) **Standards:** All fire hydrants shall be installed in compliance with these Standards.

(2) **Easements:** All fire hydrants shall be installed within public rights-of-way or easements as prescribed in Section 4.04, "Utilities Easements." Easements shall be a minimum of 25 feet in width and extend at least 10 feet beyond the hydrant assembly.

(3) **Placement:** The placement of fire hydrants shall comply with the International Fire Code, as adopted with local amendments under Chapter 10-8, "Fire Code," B.R.C. 1981, and the following requirements:

(a) Fire hydrants shall be placed at the entrance or intersection for each street, with a hydrant place on each side of any divided roadway.

(b) In a single-family residential area, there shall be no more than 500 feet of fire access distance between hydrants. No dwelling unit shall be over 250 feet of fire access distance from the nearest hydrant.

(c) In all other areas, there shall be no more that 350 feet of fire access distance between hydrants. No exterior portion of any building shall be over 175 feet of fire access distance from the nearest hydrant.

NOTE: Fire access distance means the distance between two hydrants, or the distance from a hydrant to any external portion of any building, measured along public or private (but accessible to fire equipment) roadways or fire lanes, as would be traveled by motorized firefighting equipment.

(4) **Alignment with Property Lines:** Hydrants shall be aligned with an extension of the property line when located midblock.

(5) **Horizontal Clearances:** Hydrants shall be placed no farther than 5 feet behind the curb, outside of any fenced area, and have a 10-foot radius of clearance to adjacent obstacles (fences, walls, shrubs, trees, etc.).

(6) **Vertical Clearances:** Hydrants shall have the lowest water outlet not less than 18 inches or more than 30 inches above the final ground elevation.

(7) **Colors:** The hydrants' color shall be Rustoleum No. 831 "restful green" or "KWAL" hydrant green except for bonnet, weather caps, and nozzle caps, which must be Rustoleum No. 2766 "reflectorized white" unless otherwise specified by the Director of Public Works.

(B) Fire Sprinkler Lines

(1) **Dedicated Line:** A fire sprinkler line for any structure or building, other than a single-family or duplex residential structure, which is either required to be installed by the Boulder Fire Department or installed voluntarily by the applicant, shall be a separate dedicated fire sprinkler line tapped at the water distribution main. The minimum tap and valve diameter size for a dedicated fire sprinkler line shall be 4 inches. The property owner may choose to reduce the line diameter, as needed, beyond the City-maintained valve in the property owner-maintained portion of the fire sprinkler line. The City shall not be responsible for maintenance beyond the first valve on the line.

(2) **Maintenance Responsibility:** The property owner shall be responsible for maintaining all dedicated fire sprinkler lines beyond the valve at the main distribution line. It is the property owners' responsibility to ensure all City owned and maintained valves are visible and not covered by landscape materials, concrete or asphalt.

(3) **Service Taps Prohibited:** No taps will be approved onto a fire sprinkler line for any purpose other than the fire sprinkler system. Combination fire sprinkler/service lines for domestic or irrigation services will not be approved, except as allowed in Subsection (B)(4), below.

(4) **Combination Line:** A single-family or duplex residential structure may have a combination fire sprinkler/domestic service line from the City's water distribution main to the water meter, if the following conditions are met:

(a) The combination line shall be sized to convey maximum domestic service and fire sprinkler protection service flows. The combination line size shall be 1 inch in diameter; otherwise, the combination line shall be separated into a dedicated fire sprinkler line and separate domestic service line, each tapped at the distribution main.

(b) The combination line shall separate at the water meter pit into a domestic service line (with meter) and a dedicated fire sprinkler line (without meter, but with oriseal shutoff).

(c) Beyond the water meter pit, both the domestic and fire sprinkler water service lines may be placed in the same trench. However, they may not be tied back together in any manner, and they may not have any type of cross-connection either inside or outside the structure.

(d) The property owner is responsible for maintaining the domestic service and the fire sprinkler lines beyond the water meter pit.

NOTE: Section 5.11, "Cross-Connection Regulations," of these Standards, identifies the requirements for cross-connection control and backflow prevention as they apply to fire sprinkler systems.

5.11 Cross-Connection Regulations

(A) Purpose

The purpose of these standards is to protect the City water system from contamination or pollution by backflow due to cross connections from owner water systems, and to a continuing program of cross connection control to prevent the contamination or pollution of the City water system. For the purpose of this section, "Contamination" means any impairment of the quality of the potable water by pollution from sewage, industrial fluids or waste liquids, compounds or other materials to a degree which may create a hazard to the public health through poisoning or through the spread of disease.

(B) Additional Regulations

(1) Sections 11-1-3, "Rules and Regulations," and 11-1-25, "Duty to Maintain Backflow Prevention Assembly and Prevent Cross-Connection," B.R.C. 1981.

(2) The Colorado Cross Connection Control Manual

(C) General Requirements

(1) If a backflow prevention assembly is required by the City, the Director of Public Works may give notice in writing to the owner to install an approved backflow prevention assembly at each service connection to the premises. The owner shall install an approved assembly at each service connection to the premises at the owner's own expense.

(2) No provision of this section exempts the owner from the cross-connection control provisions for internal water distribution systems as contained in the International Plumbing Codes and other plumbing standards adopted by the B.R.C. 1981, or state or federal regulations regarding cross-connections.

(3) No person shall operate an industrial fluids system, auxiliary water supply, or an owner water system that allows for the occurrence of a cross connection to the water utility.

(4) There shall be no unprotected branches from the service line ahead of any meter or backflow prevention assembly located at the point of delivery to the owner's water system.

(5) No person owning, managing, installing or repairing any water system shall fail to comply with any of these rules.

(D) Installation Required

(1) A backflow prevention assembly approved by the Director of Public Works shall be installed immediately inside the structure being served, after the meter on private property, and before the first branch line leading off the service line wherever any of the following conditions exist:

(a) If a property has an auxiliary water supply which is not or may not be of safe bacteriological or chemical quality and which is not acceptable as an additional source by the Director of Public Works, the water utility shall be protected against backflow from the premises by installing a backflow prevention assembly in the service line appropriate to the degree of hazard.

(b) If a non-residential property that contains any liquid processes or fluids system or any other unapproved water system, the water utility shall be protected against backflow from the premises by installing a backflow prevention assembly in the service line appropriate to the degree of hazard.

(c) In all premises that contain internal cross connections that cannot be permanently corrected and controlled, or that contain intricate plumbing and piping arrangements, or where entry to all portions of the premises is not readily accessible for inspection purposes making it impracticable or impossible to ascertain whether or not dangerous cross connections exist, the water utility shall be protected against backflow from the premises by installing a backflow prevention assembly in the service line.

(2) Installation shall be as approved by FCC and URC, USC list including vertical and horizontal assembly orientation.

(3) Backflow prevention assemblies shall be installed in an accessible location to facilitate inspection, testing and maintenance without removal of the device. An adequate drainage area for the assembly must be provided for in the event that water is released. Installation clearance requirements shall meet requirements of the Colorado Cross-Connection Control Manual and allow removal of all parts from the assembly. Pit and vault installations are prohibited.

(E) Duty to Inspect, Test and Repair

The owner shall have certified inspections and operational tests made on the backflow prevention assembly upon installation and at least once per year thereafter. The Director of Public Works may require certified inspections at more frequent intervals. These inspections and tests shall be made at the expense of the owner. A backflow prevention assembly shall be repaired or replaced at the expense of the owner whenever an assembly is found to be defective.

(F) Specifications

(1) After written notification by the Director of Public Works, any property with a backflow incident shall be responsible for installation, inspection and testing, or repair of a backflow prevention assembly within 10-days. Backflow prevention devices shall be air-gap (“AG”) or

reduced pressure principle assembly (“RP”) except for Solar heating systems with make-up water which shall be “RP” devices.

(2) After written notification by the Director of Public Works, the owners and operators of the following types of existing facilities shall be responsible for installation, inspection and testing, or repair of a backflow prevention assembly within 30-days of such written notice. Backflow prevention devices shall be air-gap ("AG"), or reduced pressure principle assembly ("RP") unless otherwise noted.

- Automotive service station or repair shop
- Auxiliary water supply
- Commercial service line greater than four-inch diameter
- Carwash
- Food processing and Packing plant
- Greenhouse
- Hospital, inpatient and outpatient care
- Hotel or lodging facility
- Kennel - boarding only
- Laboratory - clinical and chemical
- Laundry or dry cleaning service
- Manufacturing and industrial facility (to be determined on an individual basis)
- Medical office
- Morgue and mortuary
- Multi-storied buildings (4 stories or more)
- Photographic studio and laboratory
- Sewage treatment plant
- School with laboratory
- Shell business development space
- Solar heating system with make-up water (“RP Only”)
- Swimming pool
- Veterinary office or clinic
- Water treatment plant

(3) Prior to final inspection of any new structure or alteration requiring a building permit, the owners and operators of the following types of facilities shall be responsible for installation, inspection, testing, or repair of a backflow prevention assembly. Backflow prevention devices shall be air-gap (“AG”), or reduced pressure principle assembly (“RP”) unless otherwise noted. Double Check Valve Assembly (“DC”) devices shall only be permitted where specifically approved below.

- Any establishment with a backflow incident
- Automotive Service station or repair shop
- Auxiliary water supply
- Commercial service line greater than 4-inch diameter
- Carwash
- Fire line -- no chemicals added (AG, RP, or DC)
- Fire line -- chemicals added
- Food processing and packing plant
- Greenhouse
- Hospital, outpatient care and long-term facility
- Hotel and lodging
- Kennel - boarding only
- Laboratory -- clinical and chemical
- Laundry and cleaning service
- Manufacturing and industrial facility (to be determined on an individual basis)
- Medical office
- Morgue and mortuary
- Multi-storied building (4 stories or more)
- Photographic studio and lab
- Sewage treatment plant
- School with laboratory
- Shell business development space
- Solar heating system with make-up water system (“RP” Only)
- Swimming pool
- Veterinary office
- Water treatment plant

(4) Any building or facility not listed in the foregoing table may be required by the Director of

Public Works to install a backflow prevention assembly. The compliance period and assembly required shall be determined by the Director of Public Works based on the degree of hazard.

(5) The compliance periods listed above may be modified by the Director of Public Works for good cause shown, and after submittal and approval by the Director of Public Works of a compliance plan.

(6) Compliance plans shall be enforceable against subsequent owners of non-residential property. If no approved compliance plan exists, then the property must be in compliance with this rule prior to any sale of the property.

(G) Records and Reports

A certified tester shall record the results of all inspections, tests and maintenance on a form prescribed by the Director. This report shall be submitted to the Director and the owner within ten days following the completion of the inspection, test, or maintenance of the assembly. The certified tester shall also attach a card to the backflow prevention assembly following each inspection, test, or maintenance activity to document and date the activities performed. Records of all inspections, test, or maintenance activities, including materials and parts changed, shall be kept by the certified inspector and the owner.

(H) Backflow Prevention Assemblies

(1) The term "approved backflow prevention assembly" or “approved assembly” means any of the following:

(a) an assembly that is in conformance with the laboratory and field performance specifications of the Foundation for Cross Connection Control and Hydraulic Research (FCC and HR) of the University of Southern California; or

(b) an assembly which has been approved, inspected and installed to the satisfaction of the Director of Public Works.

(2) All backflow prevention assemblies shall have a unique serial number attached to the assembly by the manufacturer.

(3) Backflow prevention assemblies currently installed which are not approved shall be replaced with an approved assembly within 30 days of written notice by the City. If the assembly fails an annual operational test or inspection, it shall be repaired or replaced with an approved assembly within 30 days of written notice by the City.

(I) Certified Tester Criteria

(1) Testing of backflow prevention assemblies on fire sprinkler systems shall require the certified Cross Connection Control and Backflow Prevention Device Tester to also be a certified Fire Sprinkler System Installer, or be supervised by a certified Fire Sprinkler System Installer registered with the City of Boulder Fire Department.

(2) Certified Cross Connection Control and Backflow Prevention Device Testers shall also be required to provide the following information in order to be listed on the Backflow Prevention Program’s list of certified testers in the area. Such information shall be sent or faxed directly from the laboratory to the Backflow Prevention Program office at 5605 N. 63rd St., Boulder, Colorado 80301; FAX: 303-530-1137.

(a) Copy of a current Cross Connection Control and Backflow Device Tester certificate.

(b) Test kit calibration certificate from an authorized manufacturers calibration/ repair laboratory or an ISO 9002 certified calibration/repair laboratory for instrument repairs or measurements. Documented calibration must be National Institute of Standards and Technology (NIST) traceable and meet the current ASME/ANSI B40.01 standards. The certified calibration report shall include the following:

(i) Indicate minimally the descending reading at 10, 7, 5, 2, 1 and 0 PSID with a minimum required tolerance range of ± 0.1 PSID,

(ii) Data as found (data prior to any adjustment of the test kit), and

(iii) After calibration data or returned information documented (data after adjustment, if required).

(c) Provide a certificate signed by a qualified agent of an insurance company that meets minimum limits required by Section 4-1-8(a) and (b), B.R.C. 1981.

CHAPTER 6
WASTEWATER DESIGN

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6.01 General

(A) Intent

The Wastewater Design Standards establish minimum design standards for providing and maintaining the public wastewater utility collection system.

(B) Wastewater Utility Master Plans

All improvements proposed to the City's public wastewater utility system shall conform with the goals, policies, and standards adopted in the Wastewater Utility Master Plan.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of public wastewater utility improvements and may refer to one or more of the references listed in the References Section of these Standards.

6.02 Utility Report

(A) Requirement

The Director of Public Works may require the preparation of a utility report in order to assess the impacts and service demands of any project or development proposal connecting to the public wastewater collection system. The utility report shall be prepared by the Engineer and include a technical report and preliminary plan as outlined in the following subsections.

(B) Report

The utility report shall provide an overview of the proposed project or development, proposed wastewater utility improvements, wastewater service demands, system impact and feasibility, and basic design requirements, and include the following information:

(1) **Wastewater Demands:** Include estimated wastewater demands based on projected land use, occupancy and building type for the following conditions:

  (a) Average-Day (gallons-per-minute),

  (b) Peak Flow or Maximum-Day (gallons-per-minute),

  (c) Minimum-Day (gallons-per-minute), and

  (d) Infiltration/Inflow (gallons-per-minute).

(2) **Compatibility with Wastewater Utility Master Plan:** Describe how the proposed wastewater utility improvements conform with the adopted Wastewater Utility Master Plan.

(3) **Service Area:** Describe the initial and ultimate area, measured in acres, that could be served by the new wastewater facilities.

(4) **Population Density:** Define the initial and ultimate population densities that could be served by the new wastewater facilities.

(5) **Industrial Wastes:** Define the estimated quantities and quality of any industrial wastes that could be discharged to the wastewater system.

(6) **System Layout:** Describe the proposed collection system layout, including locations for connections with the existing wastewater utility system.

(7) **Collection System Analysis:** Include a collection system analysis as required by the Director, identifying any system impacts based on proposed demands and providing design solutions to ensure perpetuation of future wastewater utility system growth and maintain system capacity and flow rates.

(8) **Main Sizing:** Indicate the required sizing of proposed collection mains based on wastewater demands.

(9) **Design Alternatives:** Discuss alternative system layouts and methods of providing wastewater service, including an evaluation of each alternative and reasons for selecting the recommended design.

(10) **Special Conditions:** Identify any special conditions, such as conflicts with other utilities, unusual installation depths or oversizing requirements, that require special provisions for improvements construction.

(11) **Wastewater Classification Survey:** Include all information requested in the City's "Wastewater Classification Survey."

(12) **Wastewater Effluent Characteristics:** Include information concerning the characteristics of proposed wastewater effluent, as described in 40 C.F.R., Part 122, Appendix D, Tables 2-5, at each connection to the City's wastewater collection system as required by the Director, including the following:

(a) Acidity-alkalinity,

(b) Phosphorus,

(c) pH,

(d) Sulfates and sulfides,

(e) Synthetic and organic compounds,

(f) Hazardous constituents,

(g) BOD_5 (total and soluble fraction, carbonaceous and nitrogenous demand),

(h) COD (total and soluble),

(i) TSS,

(j) Nitrogen (TNK, NO_3, NO_4, NH_4, organic), and

(k) Inorganics (salts, metals).

(C) Preliminary Plan

A preliminary plan shall be included in the utility report to provide a plan view and reference for the proposed improvements, and identify issues addressed in the report. The preliminary plan is to include the following:

(1) **Preliminary Design:** Illustrate proposed methods and alternatives for providing site wastewater collection and service.

(2) **Property Boundaries:** Reflect legal boundaries of the proposed project or development

site, including existing and proposed property and lot lines, existing and proposed rights-of-way and utility easements, and boundaries of abutting properties.

(3) **Topography:** Include site topography at 2-foot interval contours, and the elevation and location of City-recognized benchmarks with reference to local, USGS and NGVD data.

(4) **System Area:** Define and delineate the system area included in the network analysis.

(5) **Existing Utilities:** Illustrate existing utilities, including manholes, within 400 feet of the proposed development.

(6) **Unusual Features:** Identify unusual features, such as creeks, drainage facilities, railroads, and irrigation ditches, that might influence the location of underground utilities.

(7) **Proposed System Layout:** Illustrate the general layout of the proposed wastewater collection mains and manhole locations, including construction phasing.

(8) **Emergency Maintenance Access:** Identify methods and routes for providing emergency and maintenance access to all proposed manholes.

6.03 Wastewater Main Extensions

(A) Wastewater Utility Master Plan

Where major wastewater collection mains, 12 inches or larger in diameter, are proposed to be constructed in the Wastewater Utility Master Plan, an applicant for construction approval shall provide for the construction of the main as part of any development proposal, when the major collection main is:

(1) Located within a proposed development.

(2) Located within 1,000 feet of a proposed development and it is feasible to include construction of this main in the proposed development.

(3) Required to provide adequate collection service for the proposed development.

(B) Main Extension Agreements

(1) When construction of a major collection main is required, and the diameter of the major collection main is larger 12 inches and the minimum diameter required for local distribution mains to serve the proposed development, an applicant for construction approval may enter into a "main extension agreement" with the City for reimbursement of public improvements costs associated with the over-size construction of the major distribution main, as prescribed under Sections 11-2-26, “Agreement to Extend Sanitary Sewer Mains,” and 11-2-27, “Reimbursement of Costs for Sanitary Sewer Main Extension,” B.R.C. 1981.

(2) When construction of an offsite major or local wastewater collection main is required to extend collection service to a proposed development, an applicant for construction approval may enter into a "main extension agreement" with the City for reimbursement of offsite public improvements, as prescribed under Sections 11-2-26, “Agreement to Extend Sanitary Sewer Mains,” and 11-2-27, “Reimbursement of Costs for Sanitary Sewer Main Extension,” B.R.C. 1981.

6.04 Design Flow

(A) Wastewater Collection Mains

(1) Wastewater collection mains shall be designed to convey the peak flow.

(2) Wastewater collection mains shall be designed to ensure transport of suspended materials and preclude material deposits considering minimum-day flows.

(3) The peak flow shall be determined using average-day forecasts adjusted by a peaking factor and including the allowed and any existing system infiltration or inflow.

(4) Flow capacity and loading data of existing and future conditions for the City's major wastewater collection system shall be obtained from the Utilities Division for use in designing and analyzing proposed improvements.

(5) The minimum-day flow shall be determined using average day-forecasts adjusted by a minimum flow factor and including the allowed and any existing infiltration or inflow.

(6) Average-day flow forecasts shall include the ultimate area, population density, existing wastewater flow, anticipated industrial discharge, and any allowed infiltration/inflow, that produces the greatest wastewater flow rates.

(7) Surface water, ground water, or cooling water shall not be discharged into the wastewater collection system. Prohibited connections include roof drains, storm inlets, foundation perimeter drains, area drains for open patios or driveway entrances to parking structures, and ground water sump systems.

(8) Floor drains internal to covered parking structures, that collect drainage from rain and ice drippings from parked cars or water used to wash-down internal floors, shall be connected to the sanitary sewer using appropriate grease and sediment traps.

(9) Table 6-1 indicates wastewater discharge forecasting for average-day conditions:

Table 6-1: Average Day Load by Development Type

Development Type	Average Day Load
Residential	100 gpcd
Average Persons per Single-Family Unit	3.2
Average Persons per Multi-Family Unit	2.0
Non-Residential	
Commercial	5000 gpad
Industrial	4500 gpad
Infiltration	200 gidm**

NOTES: * The Industrial Average-Day Load Indicates Non-Water Intensive Industrial Development
** Gallons Per Inch-Diameter-Mile

(10) The average day forecast loads indicated in Table 6-1 represent minimum forecast loads in determining design flows. Where proposed development is known (based on specific applications or use), and the anticipated wastewater loads exceed the minimum forecast demands, the greater load shall be used to determine design flows.

(11) Table 6-2 indicates the wastewater peak flow and minimum flow factors for forecasting discharges. These flow factors are used with the preceding average day load estimates as defined in Section 6.04 A(10) of these Standards to determine minimum required wastewater main capacity:

Table 6-2: Factors for Forecasting Wastewater Discharges

Collection Main Diameter	Minimum Flow Factor	Peak Flow Factor
10 inches and smaller	0.25	4.0
12 to 15 inches	0.30	3.5
18 to 27 inches	0.33	3.0
30 inches and larger	0.40	2.5

(12) Final design flow determinations shall include any documentation and calculation of population densities, building areas, pumped discharge flow rates, existing wastewater flow rates, existing or anticipated industrial discharges, peak flow, minimum flow, and infiltration/inflow flow rates.

(B) Wastewater Services

Design flows for wastewater services shall be determined in conformance with the most current International Plumbing Code (IPC), adopted by the City.

6.05 Materials and Installation

Construction of wastewater-related public improvements shall be in compliance with these Standards. All pipe shall be of adequate strength to support trench and AASHTO HS-20 highway loadings. The type of pipe to be installed shall comply with these Standards, and shall be based upon applicable design flows, pressures, site conditions, corrosion protection, and maintenance requirements

6.06 Collection Mains

(A) System Design

(1) **Gravity Flow:** The wastewater collection system shall be designed for gravity (open) flow conditions, using a manning's roughness coefficient of 0.013 to account for various pipe materials and joints, service connections, and future interior pipe conditions.

(2) **Peak Flow Depth:** Collection mains shall normally be designed to carry the peak flow with a flow depth of no more than one-half of the full pipe.

(3) **Pressurized Flow Prohibited:** Pressurized, surcharged, or depressed (inverted siphon) wastewater mains are prohibited in the City's wastewater collection system.

(B) Size

(1) **Minimum Diameter:** Collection mains shall be a minimum eight (8) inches in diameter.

(2) **Size Changes:** All changes in pipe size shall require a manhole at the size change.

(C) Locations

(1) **Easements:** All wastewater mains shall be installed in public rights-of-way or easements, as prescribed under Section 4.04 of these Standards.

(2) **Lot Frontage:** All platted lots, whether existing or proposed as part of a subdivision, shall front on a collection main.

(D) Depth

(1) **Minimum and Maximum Cover:** All collection mains shall have a minimum depth of

cover of three (3) feet, and a maximum depth of cover of eighteen (18) feet, measured from the top of pipe to the final surface grade.

(2) **Shallow Cover Protection:** Where collection main depths are less than four (4) feet, and the main is located under a right-of-way, street, driveway, parking lot, or other areas where live loading is a concern, special pipe materials (such as ductile iron pipe) or other structural measures (such as concrete encasement) shall be provided.

(3) **Provision for Basements:** Proposed collection mains shall be designed with adequate depth to provide wastewater service to basements, where possible and appropriate.

(E) Slope

(1) **Minimum and Maximum Slopes:** Table 6-3 indicates minimum and maximum allowable collection main slopes:

Table 6-3: Minimum and Maximum Allowable Collection Main Slopes

PIPE DIAMETER (Inches)	MINIMUM SLOPE (%, ft/100 ft)	MAXIMUM SLOPE (%, ft/100ft)
8"	0.400	7.5
10"	0.332	5.5
12"	0.247	4.5
15"	0.193	3.5
18"	0.144	2.5
21"	0.113	2.0
24"	0.092	1.8

(2) **Velocities:** Collection mains shall be designed with an adequate slope to provide flow velocities of two (2) feet per second during peak flow conditions. Minimum allowable slope shall provide half-full pipe flow velocities of two (2) feet per second. Maximum allowable slope shall provide half-full pipe flow velocities of 10 feet per second. The design slope will usually be greater than the minimum allowable slope, where less than half-full or full pipe peak flow conditions occur.

(3) **Slope Between Manholes:** All collection mains shall be laid at a constant slope between manholes.

(4) **Slope Changes:** All changes in slope shall require a manhole at the slope change connection.

(F) Alignment

(1) **Straight Alignment Required:** All collection mains shall be laid in a straight alignment between manholes.

(2) **Alignment Changes:** All changes in alignment require a manhole at the alignment change connection.

(3) **Curvilinear Mains Prohibited:** Curvilinear collection mains will not be allowed.

(G) Separations and Crossings

All collection main separations and crossings of other City utilities shall be designed in compliance with Section 4.06, “Separation of Utilities,” of these Standards.

(H) Taps

All taps approved onto an existing collection main will be made by the City of Boulder Utilities Division and shall be paid for by the applicant.

(I) Ground Water Barriers

(1) **Required:** Where there exists a possibility that ground water may be diverted by the construction of new wastewater collection mains, ground water barriers shall be constructed within the collection main trench to prevent ground water migration or diversion along the wastewater main.

(2) **Placement:** The Engineer shall determine the location and number of ground water barriers that will be necessary to mitigate any ground water impacts, subject to review and approval by the Director. Any necessary support material required to address ground water concerns, such as soils investigations, engineering calculations and design details, shall be provided by the Engineer.

(J) Extensions

(1) **Standards:** Wastewater collection mains are subject to the requirements of Section 11-2-25, "Extensions for Sanitary Sewer Mains," B.R.C. 1981, and these Standards.

(2) **System Perpetuation:** Wastewater mains shall extend to the far edge of the property being served or to the edge of the platted subdivision, whichever is greater, to ensure perpetuation of the wastewater collection system. The location, size, and configuration of the proposed development or subdivision, with respect to the existing wastewater collection system, may dictate that wastewater mains be extended to the far edge of more than one property or subdivision boundary to accommodate system perpetuation.

(3) **Exceptions:** Exceptions to this subsection may be granted only if development of the adjacent property is not contemplated within 5 years or is classified as Area III under the Boulder Valley Comprehensive Plan. In these cases, an easement for extending the system shall be granted by the property owner.

6.07 Manholes

(A) Location

(1) **Where Required:** Manholes shall be required at the upper end of each collection main line, and at all changes in grade, slope and alignment. Where feasible, manholes are to be installed at street intersections, or aligned with an extension of property lines in midblock and easement locations and should be located outside of bike lanes, sidewalks, multi-use paths and wheel lines of streets.

(2) **Maximum Separation:** Manholes shall be required along collection mains at distances not greater than 400 feet.

(3) **Service Connections:** Manholes shall be required at all service connections for wastewater service lines six (6) inches in diameter and larger.

(4) **Monitoring Facilities:** Manholes for monitoring facilities shall be required on service lines for industrial users or non-residential users, as prescribed under Section 11-3-16, "Monitoring Facilities," B.R.C. 1981. Where monitoring facilities are required, service lines shall be a minimum of 6 inches in diameter to facilitate sampling.

(5) **Avoidance of Submerged Conditions:** Manholes shall not be placed in detention basins, drainage ditches, or areas subject to localized ponding. Placement of manholes in floodplains should be avoided if possible.

(B) Flow Channels

(1) **Required:** Flow channels shall be required in all manholes, connecting the inverts of the upstream and downstream pipe sections. The flow channel shall be U-shaped, and shall meet the following minimum heights:

(a) One-half of the diameter (or to pipe centerline) on collector pipes less than 15 inches in diameter.

(b) Three-fourths of the diameter on collector pipes 15 inches and larger in diameter.

(2) **Slope:** The slope of the flow channel shall be:

(a) The design slope through the manhole, for continuous slope, straight alignment pipe lines.

(b) The slope (approximately five (5) percent) resulting from a two-tenths (0.2) feet drop through the manhole (to account for energy losses inside the manhole), for manholes at changes in alignment and grade.

(c) The slope resulting in the manhole by matching the eight-tenths (0.8) depth point of the upstream and downstream pipe sections, for manholes at changes in pipe size.

(C) Drop Manholes

(1) **Avoidance:** Drop manholes shall be avoided whenever possible.

(2) **Where Provided:** Where there are no available alternatives, drop manholes shall be required where the invert of the upstream pipe section entering the manhole is greater than two (2) feet above the invert of the downstream pipe section exiting the manhole.

(D) Maintenance Access

Direct access by maintenance vehicles shall be provided to each manhole. The access drive shall be an all-weather surface, such as asphalt or concrete paving, adequate gravel base or turf block, and shall be capable of supporting maintenance vehicles weighing up to 14 tons. The access drive shall be free of obstructions and landscaping.

(E) Covers

(1) **Where Required:** Manholes that are not located within a public street, alley or driveway section shall be installed with a bolting-type cover to ensure safety and prevent vandalism.

(2) **Submerged Conditions:** Where manholes must be located within the 100-year floodplain or in a location where runoff may accumulate and pond, they shall be installed with a hinged, gasketed, and locking frame and cover assembly. The assembly shall be an “East Jordan Iron Works” ERGO or ERGO XL assembly. The manhole ring shall be bolted to the manhole cone to prevent possible damage due to surcharge.

6.08 Wastewater Services

(A) General

(1) **Standards:** Wastewater services are private wastewater system extensions that are connected or tapped onto the wastewater collection main to provide wastewater service to the consumer, and are subject to the requirements of Section 11-2-13, "Taps or Connections to Sanitary Sewer Mains," and 11-2-14, "Sanitary Sewer Service Lines," B.R.C. 1981, and these Standards.

(2) **Industrial and Prohibited Discharges:** Wastewater services and discharges are subject to the requirements of Chapter 11-3, "Industrial and Prohibited Wastewater Discharges," B.R.C. 1981.

(3) **Separate Services to Lots:** All platted lots, whether existing or proposed as part of a subdivision, shall front on and have a separate wastewater service connection to a collection main without crossing adjacent lots.

(4) **Service Alignment:** Wastewater services shall be installed perpendicular to the collection main, for that portion of the service line that is located in the public right-of-way or easement. Where this is not possible, the wastewater service alignment shall be subject to the determination of the Director.

(5) **Separation from Water Service:** Wastewater services shall maintain a minimum separation of ten (10) feet from water services, for that portion of the service line that is located in the public right-of-way or easement.

(6) **Prohibited Connections:** No storm water, surface water, or ground water may be discharged into the wastewater service. Prohibited connections include roof drains, storm inlets, foundation perimeter drains, area drains for open patios or driveway entrances to parking structures, and ground water sump systems.

(7) **Floor Drains in Parking Garages:** Floor drains internal to covered parking structures, that collect drainage from rain and ice drippings from parked cars or water used to wash-down internal floors, shall be connected to the wastewater service using appropriate grease and sediment traps.

(8) **Maintenance Access:** Wastewater services shall be provided with a two-way cleanout outside and adjacent to the building being served and where there is a change in alignment of the service. Cleanouts shall be constructed as follows:

(a) No cleanouts shall be installed within the public right-of-way.

(b) Cleanouts shall be constructed of the same diameter pipe as the wastewater service.

(c) Cleanouts shall not be located in detention ponds, ditches, swales, or other areas of stormwater runoff or ponding.

(d) Cleanouts shall be fitted with a threaded watertight cap that prevents the inflow of stormwater or irrigation water.

(e) The cleanout shall allow maintenance access for cleaning and inspection in both the upstream and downstream direction.

(B) Connections

(1) **Tap:** Wastewater service connections to newly constructed collection mains shall require the installation of a tee or wye, in conformance with these Standards. A directional fitting shall be used at all tap connections.

(2) **Installation:** All connection taps approved onto an existing wastewater collection main shall be made by the City of Boulder Utilities Division and shall be paid for by the applicant.

(3) **Standard Connections:** Wastewater service connections shall be tied into the collection main between manholes and shall be spaced a minimum of eighteen inches apart and a minimum two feet away from any manhole.

(4) **Manhole Connections:** Service connections to manholes shall be avoided, except where any of the following conditions exist:

(a) The service size is six inches in diameter or larger (which requires the installation of a manhole).

(b) The service connection is tied to a terminal manhole, located at the end of a cul-de-sac or easement, and there is no possibility of extending the collection main in the future.

(c) The service connection elevation cannot be tapped above the springline of the sanitary sewer main.

NOTE: Under these conditions, a flow channel shall be provided in the manhole from the service connection to the manhole flow channel, and the service shall enter the manhole at no greater than 6 inches above the manhole base.

(C) Service Lines

(1) **Separate Services to Structures:** Each principal structure shall be served by a separate wastewater service line connected to the collection main. Where more than one principal structure is proposed on a single lot, an additional wastewater service line will be required for each additional principal structure.

(2) **Accessory Buildings:** An accessory building or structure, as defined under Section 9-1-3, "Definitions," B.R.C. 1981, may receive limited service from a principal building or structure without a separate wastewater service, subject to the following:

(a) If the accessory structure contains no toilet and no bathtub or shower fixtures, the accessory structure is limited to the following plumbing fixtures:

(i) Sink (one fixture),

(ii) Clothes washer connection (one set),

(iii) Hose bib or sill cock (one fixture),

(iv) Floor drain (one fixture), and

(v) Interceptor (one fixture).

(b) If the accessory structure is proposed to have a sink and toilet, the accessory structure shall not contain any additional sinks or toilets nor a bathtub or shower fixture, shall not be used as a separate dwelling unit, may not be located on a property that can be subdivided into separate lots, and shall be limited to the following additional plumbing fixtures:

(i) Sink (one fixture),

(ii) Toilet (one fixture),

(iii) Floor drain (one fixture), and

(iv) Interceptor (one fixture).

(c) An approved detached accessory dwelling unit, as defined under Subsection 9-16-1(c), "General Definitions," B.R.C. 1981, is not subject to this section's plumbing fixture limitations.

(d) The Director of Public Works may permit wastewater hookups separate from a principal detached dwelling unit upon finding that topography or other physical circumstances make utility connections to the principal structure impractical.

(3) **Services Crossing Lots:** Wastewater service lines crossing one lot to provide service to an adjacent lot may be approved if all of the following conditions are met:

(a) The service crossing is part of a proposed subdivision creating only two lots.

(b) A utility easement at least 10 feet wide is provided across, and situated entirely within, the boundaries of the proposed subdivision. The easement is to be granted to the City for the benefit of the property owner being served and is to be occupied by the wastewater service line only, or by the water and wastewater service lines only if the water and wastewater service lines are installed in compliance with the IPC.

(c) The Director determines that a wastewater main extension is not necessary to perpetuate the system, or that future development of abutting properties cannot benefit from a main extension.

(d) The wastewater service line is to be centered in the easement and be at least 5 feet from other utilities, except for a combined water/wastewater service installation as allowed under the IPC.

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STORMWATER DESIGN

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7.01 General

(A) Intent

The Stormwater Design Standards are intended to provide for a comprehensive and integrated stormwater utility system to convey and manage stormwaters in order to mitigate safety hazards and minimize property losses and disruption due to heavy storm runoff and flooding, maintain travel on public streets during storm events, enhance water quality of storm runoff by mitigating erosion, sediment and pollutant transport, control and manage increased runoff due to local development, establish effective long-term management of natural drainageways, and provide for ongoing and emergency maintenance of public stormwater systems. These standards are intended to prevent pollution and degradation of state waters.

The City is an operator of a Phase II Municipal Separate Storm Sewer System (MS4) and is required by the State of Colorado to hold a permit to discharge stormwater from its municipal separate storm sewer system to the waters of the State. The Stormwater Design Standards establish standards implementing the requirements of the MS4 Permit and Chapter 11-5, "Stormwater and Flood Management Utility," B.R.C. 1981.

(B) Comprehensive Flood and Stormwater and Greenways Master Plans

All improvements proposed to the City's stormwater system shall conform with the goals, policies, and standards outlined in adopted Comprehensive Flood and Stormwater and Greenways Master Plans.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, to protect the public health, safety, and welfare, the Director will specify the standards to be applied to the design and construction of stormwater improvements and may refer to one or more of the references listed in the References Section of these Standards.

(D) Floodplains

Where improvements are proposed within a designated 100-year floodplain, as defined on the current FEMA Flood Insurance Rate Map (FIRM) or floodplain mapping adopted by the City, an applicant for construction approval shall satisfy and comply with all applicable regulations and requirements as set forth in Chapter 9-3, "Overlay Districts," B.R.C. 1981.

(E) Stormwater Quality and Erosion Control

The USDCM, Volume 3, "Best Management Practices," "Colorado Department of Transportation M-Standards, and/or City of Boulder, "Wetlands Protection Program Best Management Practices" manual shall be applied to address stormwater quality management and erosion control for all proposed projects and developments. An applicant for construction or development approval shall also satisfy and comply with all applicable regulations and requirements as set forth in Chapter 11-5, "Stormwater and Flood Management Utility," B.R.C. 1981. All stormwater reports and plans shall include necessary analyses, mitigation measures, and improvements needed to meet these stormwater quality and erosion control standards.

(F) Wetlands Protection

Where improvements are proposed within a delineated wetland or wetland buffer area, as defined under the City's wetland protection ordinance, an applicant for construction approval shall satisfy and comply with all applicable regulations and requirements as set forth in Section 9-3-9, "Stream, Wetlands, and Water Body Protection," B.R.C. 1981, including any necessary identification, analyses, avoidance and mitigation measures, and improvements needed to address wetlands protection requirements.

(G) Streets

The primary function of streets is for safe traffic movement; therefore, streets shall be designed and constructed to accommodate runoff and convey it to downstream drainage facilities in order to minimize its interference with traffic. When the stormwater runoff accumulation in the street exceeds allowable limits, storm sewers or other drainage facilities are required to collect and convey the excess runoff.

(H) Irrigation Ditches and Laterals

Where a project or development is proposed adjacent to or impacts an existing irrigation ditch, an applicant for construction approval shall meet the following standards:

(1) No storm runoff shall be conveyed into an irrigation ditch or lateral without written approval and permission from the affected irrigation ditch company or lateral owner.

(2) An adequate right-of-way or drainage easement for maintaining the affected irrigation ditch shall be dedicated to the City.

(3) The irrigation ditch or lateral shall not be relocated, modified, or altered without written approval and permission from the affected irrigation ditch company or lateral owner.

(4) The irrigation ditch or lateral shall not be used for the following purposes:

  (a) Basin boundaries to eliminate the contribution of the upper basin area in the evaluation of runoff conditions. Irrigation ditches shall not be assumed to intercept stormwater runoff.

  (b) Outfall points for new development where runoff into irrigation ditches and laterals has increased in flow rate or volume, or where historic runoff conditions have been changed, without written approval and permission from the affected irrigation ditch company or lateral owner.

(I) Multiple Functions of Major Drainageways

Boulder Creek's numerous tributaries are part of a comprehensive natural open drainageway system. These drainageways provide open corridors and serve multiple functions, including without limitation, stormwater drainage and flood conveyance, wetlands and water quality enhancement, environmental protection and preservation, open space and wildlife areas, and recreational activities and trail corridors. Stormwater improvements impacting these drainageways shall be designed and constructed to respect, restore and enhance these functions in order to maintain the creek corridor ecology, environment and aesthetic value of such drainageways.

(J) Definitions

The words defined in this subsection and used in this Chapter have the meanings established in

this section unless the context clearly indicates otherwise:

Applicable development site means (1) any new development or redevelopment site resulting in land disturbance of greater than or equal to one acre, including a site that is less than one acre that is part of a larger common plan of development or sale that would disturb or has disturbed one acre or more, or (2) any development site for which a stormwater detention pond is required under these Standards.

Common plan of development or sale means a plan or sale where multiple separate and distinct construction activities may be taking place at different times on different schedules in a contiguous area, within 1/4 mile, but remain related through such plan or sale.

Construction activity means an activity that disturbs the ground surface and associated activities that include, without limitation clearing, grading, excavation, demolition, installation of new or improved haul roads and access roads, staging areas, stockpiling of fill materials, and borrow areas. Activities from initial ground breaking through final stabilization are construction activities regardless of ownership. Construction activities do not include routine maintenance to maintain the original line and grade, hydraulic capacity, or original purpose of a facility. Activities to conduct repairs that are not part of routine maintenance, activities for replacement, and activities for repaving where underlying or surrounding soil is exposed, cleared, graded, or excavated are all construction activities for the purposes of this chapter.

Control measure means an activity, practice, or structural control used to prevent or reduce the discharge of pollutants to waters of the State. The two categories of control measures are:

> *Control measure for post-construction stormwater quality*, also referred to as a stormwater control measure (SCM), means a permanent device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters.
>
> *Control measures for erosion and sediment control* means a device, practice, or method implemented on a construction site to remove, reduce, retard, or prevent pollutants or pollutant-laden water from discharging off the site. These control measures may be structural (e.g., wattles/sediment control logs, silt fences, earthen dikes, drainage swales, sediment traps, subsurface drains, pipe slope drains, inlet protection, outlet protection, gabions, sediment basins, temporary vegetation, permanent vegetation, mulching, geotextiles, sod stabilization, slope roughening, maintaining existing vegetation, protection of trees, and preservation of mature vegetation) or non-structural (e.g., schedules of activities, prohibitions of practices, pollution prevention and educational practices, and maintenance procedures).

Detention pond means a structural control intended to store increased runoff from developed property and release this runoff at the historic rate that existed prior to development or redevelopment.

LID technique means low impact development technique.

Low Impact Development (LID) technique means a non-structural land development planning and site layout strategy intended to reduce stormwater volume, peak discharge, and pollutant load.

MS4 Permit means the Municipal Separate Storm Sewer System Phase II discharge permit issued by the Colorado Department of Public Health and Environment pursuant to Regulation 61, Colorado Permit Discharge System, 5 CCR 1002-61, and the Colorado Water Quality Control Act, C.R.S.§ 25-8-101, *et seq.*, as that permit may be amended in the future.

New development means a vegetative or non-vegetative change in the existing land surface, including without limitation construction activities, compaction associated with stabilization of structures, road

construction, construction or installation of a building or other structure, and creation of impervious surfaces, and land subdivision for a site that does not meet the definition of redevelopment.

Receiving Pervious Area (RPA) means a vegetated pervious area that receives stormwater from an impervious area, thus un-connecting the impervious area from directly discharging stormwater to a local stream, lake, or to the public stormwater utility system.

Redevelopment means the creation or addition of impervious area or paved surface on a site that is already substantially developed with 35% or more existing imperviousness, including without limitation expansion of a building footprint, addition or replacement of a structure, structural development, and construction or replacement of paved surface area.

Stormwater utility system means the municipal storm sewer system that includes without limitation the conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, human-made channels, or storm drains) that discharge to state waters and is owned or operated by the City and designed or used for collecting or conveying stormwater, and is not a combined sewer or part of a publicly owned treatment works.

Stormwater Quality Design Standard means a performance metric from the MS4 Permit that must be demonstrated to be achieved to document compliance with City of Boulder stormwater requirements for applicable development sites. Stormwater Quality Design Standards are volume reduction, Water Quality Capture Volume (WQCV), pollutant removal, and constrained redevelopment site standards, as defined in Subsection 7.16(D).

Treatment area means a single drainage basin or group of drainage basins for which a proposed design completely satisfies a single Stormwater Quality Design Standard.

Unconnected Impervious Area (UIA) means an impervious area that discharges to a RPA and, therefore, does not discharge directly to a local stream, lake, or the stormwater utility system.

Water Quality Capture Volume (WQCV) means the volume equivalent to the runoff from an 80^{th} percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated.

7.02 Conceptual Drainage Report and Stormwater Plan

(A) General

(1) If a project is determined to be of sufficient size or complexity, the Director may require the preparation of a Conceptual Drainage Report and Stormwater Plan by the Engineer to assess feasibility of stormwater utility system improvements. The purpose of the Conceptual Drainage Report and Stormwater Plan shall be to demonstrate that required stormwater utility system facilities can be accommodated on the development site and to identify and plan for impacts to neighboring properties and stormwater utility systems.

(2) The Director reviews Conceptual Drainage Reports and Stormwater Plans for local-level purposes, including conformance with these Standards pertaining to stormwater utility systems.

(3) Measured or calculated parameters provided in all submitted Conceptual Drainage Reports and Stormwater Plans shall be reported using the English System of Measurement unless Metric System units are the standard expression for the parameter.

(a) Land or surface area shall be reported in square feet (ft^2, sf, or sq.ft.) for projects

having a land disturbance area less than one acre and shall be reported to the nearest tenth of an acre (acre or ac.) for projects having a land disturbance of one acre or greater.

(b) Water volume shall be provided in cubic feet (ft^3 or cu.ft.).

(c) Soil volume shall be provided in cubic yards (yd^3 or cu.yd.).

(d) Water discharge (also stated as flow rate or flow) shall be provided in cubic feet per second (ft^3/s or cfs).

(e) Infiltration rate shall be reported in inches per hour (in/hr).

(B) Conceptual Drainage Report

The Conceptual Drainage Report shall provide a response for each of the elements listed in the Preliminary Drainage Report narrative requirements, as set forth in Subsection 7.03(B) of these Standards, or if more data is necessary identify the data collection efforts necessary to complete the Preliminary Drainage Report.

(C) Conceptual Stormwater Plan

The Conceptual Stormwater Plan shall address each of the elements listed in the Preliminary Stormwater Plan requirements, sufficient to provide an overall drainage plan, as set forth in Subsection 7.03(C) of these Standards, or if more data is necessary identify the data collection efforts necessary to complete the Preliminary Stormwater Plan.

7.03 Preliminary Drainage Report and Stormwater Plan

(A) General

(1) The Director may require the preparation of a Preliminary Drainage Report and Stormwater Plan by the Engineer. The Preliminary Drainage Report and Stormwater Plan will be used to assess the impacts and public improvement needs of any proposed project or development site. Approval of the Preliminary Drainage Report and Stormwater Plan shall not be construed as approval of specific design details.

(2) The Director reviews Preliminary Drainage Reports and Stormwater Plans for local-level purposes, including conformance with these Standards pertaining to stormwater utility systems.

(3) Measured or calculated parameters provided with the Preliminary Drainage Report and Stormwater Plan shall be consistent with Subsection 7.02(A)(3) of these Standards.

(B) Preliminary Drainage Report

The Preliminary Drainage Report shall define the proposed development site, describe existing conditions, and propose needed stormwater facilities to meet the requirements of these Standards. The Preliminary Drainage Report shall include, at a minimum, narratives addressing the items listed in this subsection except for those items not applicable to the proposed development site. The Preliminary Drainage Report shall include visual representations and/or refer to the Preliminary Stormwater Plan sheet with the corresponding content (see Subsection 7.03(C) of these Standards for Preliminary Stormwater Plan requirements). The Preliminary Drainage Report

narrative shall include the following information:

(1) **Cover Page:** Provide a cover page that includes the site name, site address, submittal and revision dates as applicable, site owner, and preparing Engineer.

(2) **Site Description**

(a) Site Location Description

(i) County, city, township, range, section, and ¼ section.

(ii) Site vicinity and legal boundaries map.

(iii) Adjacent developments and associated land use.

(iv) Roadways located within or adjacent to the site.

(b) Property Description

(i) Site area and proposed area of disturbance in acres.

(ii) Existing and proposed site use.

(iii) Land surface (vegetation type, topography, slope, buildings, etc.)

(iv) Easements within or adjacent to the site.

(c) Drainage Description

(i) Major and minor drainageways.

(ii) Natural drainage features (e.g., streams, lakes, ponds, wetlands, and buffer areas).

(iii) Irrigation ditches.

(iv) Regulatory floodplain extents.

(v) Known drainage issues.

(vi) Hydrologic soil group map and description.

(vii) Geotechnical and groundwater site investigation results.

(viii) Preliminary Infiltration Feasibility Screening results and map (see Subsection 7.16(A) of these Standards).

(3) **Drainage Basin Description**

(a) Major Drainage Basin

(i) General description of major drainage basin characteristics and flow patterns.

(ii) Flow conveyance from site to receiving major drainageway.

(iii) Reference to all applicable planning studies for the major drainageway and, if applicable, describe requirements of these plans for the development site.

(iv) Impact of site development on upstream and downstream properties.

(v) Impact of site development on downstream natural and constructed open channels and piped stormwater utility systems and the measures proposed to reduce or eliminate those impacts.

(b) Site Drainage Basin(s)

(i) Existing and proposed basin and sub-basin characteristics for the site, including land cover, area, flow patterns, and discharge points for each basin/sub-basin.

(ii) Acceptance and conveyance of off-site stormwater into and through the proposed development site.

(iii) Overview of all existing and proposed conveyance, detention, and water quality facilities, including rationale, for each basin/sub-basin.

(4) **Drainage Design Criteria**

(a) Regulation Applicability

(i) Detention requirements (see Section 7.12 of these Standards).

(ii) Construction stormwater management requirements (see Section 7.13 of these Standards).

(iii) Post-construction stormwater quality requirements (see Section 7.15 of these Standards).

(iv) Stream, Wetland, and Waterbody Protection Requirements as set forth in Chapter 9-3, "Overlay Districts," B.R.C. 1981.

(v) Other applicable criteria and permits.

(b) Site Planning and Constraints

(i) Description of previous drainage studies or master plans for the site and adjacent areas and influence on proposed stormwater utility system design.

(ii) Description of site constraints caused by structures, utilities, etc. and influence on proposed stormwater utility system design.

(iii) Description of Low Impact Development (LID) techniques utilized for stormwater management with reference to completed form(s) as provided by the Director and included as an appendix (see Section 7.14 of these Standards).

(c) Hydrologic and Hydraulic Criteria

(i) Design storm(s).

(ii) Runoff calculation methods.

(iii) Detention storage and discharge calculation method.

(iv) Velocity and capacity calculation method(s) for inlets and conveyances.

(v) Water surface profile and hydraulic grade line (HGL) calculation methods.

(d) Post-Construction Stormwater Quality Criteria

(i) Selected treatment approach and design standards (see Section 7.16 of these Standards).

(5) **Stream, Wetland, and Waterbody Impacts**

(a) Description of floodplain impacts.

(b) Required modification studies.

(6) **Stormwater Conveyance Design**

(a) Description of proposed conveyance system.

(b) Conveyance path to major drainageway and capacity evaluation.

(7) **Detention and Post-Construction Stormwater Quality Design**

(a) Description of each proposed facility (identifier, type, drainage area, size, treatment volumes, components, and function).

(b) Description of design compliance with detention and post-construction stormwater quality requirements with reference to completed form(s) as provided by the Director and included as an appendix (see Section 7.15 of these Standards).

(8) **Conclusions**

(a) Drainage plan effectiveness.

(b) Compliance with requirements.

(c) Exclusions and variances.

(9) **References:** Reference all standards, criteria, guidance documents, master plans, and technical reports used.

(10) **Appendices**

(a) Completed form(s) documenting post-construction water quality compliance (Section 7.15 of these Standards).

(b) Completed form(s) documenting low impact development approaches (Section 7.14 of these Standards).

(C) Preliminary Stormwater Plan

The purpose of the Preliminary Stormwater Plan is to provide visual representations of existing and proposed site conditions to support the Preliminary Drainage Report narrative. The Preliminary Stormwater Plan shall be included with the Preliminary Drainage Report, submitted as a single PDF document. All Preliminary Stormwater Plan sheets shall be prepared on 24-inch by 36-inch paper with appropriate scale ranges. The Preliminary Stormwater Plan shall include plan sheets addressing, at a minimum, the following items, except for those items not applicable to the proposed development site:

(1) **Overall Drainage Plan**

(a) Title block, legend, north arrow, and scale.

(b) Existing topographic contours.

(c) Property boundary.

(d) Major drainage basin boundaries with area, design point, and existing flow rate labels.

(e) Drainage flow arrows depicting flow patterns to, from, and within the site.

(f) Existing stormwater detention and water quality facility boundaries.

(g) Easement boundaries.

(h) Existing waterways (streams, lakes/ponds, wetlands, and irrigation facilities).

(i) Land cover (vegetation and impervious surfaces).

(j) Key map depicting extents of detailed drainage plan sheets.

(2) **Detailed Drainage Plan/s**

(a) Title block, legend, north arrow, and scale (scale range of 1 inch = 20 feet to 1 inch = 100 feet).

(b) Existing (screened) and proposed (solid) topographic contours (2 feet max interval).

(c) Location and elevation of all waterways, regulated buffer areas, and 100-year floodplain.

(d) Property, right-of-way, and easement boundaries.

(e) Drainage basin/sub-basin boundaries with area, design point, and flow/release rate labels.

(f) Proposed outfall points and conveyance facilities to major drainageway with design point and flow/release rate labels.

(g) Existing and proposed structure boundaries.

(h) Existing and proposed stormwater conveyance facilities with size, slope, and material designation (storm sewers, culverts, open channels, inlets, and discharge points).

(i) Existing and proposed stormwater detention and water quality facilities with drainage area, surface area, side slope/wall, and component labels.

7.04 Final Drainage Report and Stormwater Plan

(A) General

(1) The Director may require the preparation of a Final Drainage Report and Stormwater Plan by the Engineer. The report and plan will be used to assess the impacts and public improvements needs of any proposed project or development site.

(2) The Director reviews Final Drainage Reports and Stormwater Plans for local-level purposes, including conformance with these Standards pertaining to stormwater utility systems.

(3) Measured or calculated parameters provided with the Final Drainage Report and Stormwater Plan shall be consistent with Subsection 7.02(A)(3) of these Standards.

(B) Final Drainage Report

The Final Drainage Report shall describe the to-be-constructed drainage conditions for the site. The Final Drainage Report shall include, at a minimum, all required narratives of the Preliminary Drainage Report, as set forth in Subsection 7.03(B) of these Standards, and the items listed in this

subsection, except for those items not applicable to the proposed development site. The Final Drainage Report shall include visual representations and/or refer to the Final Stormwater Plan (Subsection 7.04(C) of these Standards) or construction drawings (Subsection 7.04(D) of these Standards) with the corresponding content.

The Final Drainage Report shall include a cover page, following the format set forth in Subsection 7.03(B) of these Standards and a certification page with the following statement prepared by a Professional Engineer licensed in the State of Colorado:

> I hereby certify that this Final Drainage Report and Final Stormwater Plan for [Site Name] was prepared by me, or under my direct supervision, in accordance with sound engineering practice and all applicable state, federal and local regulations, including the provisions of the City of Boulder Design and Construction Standards.
>
> Registered Professional Engineer (Affix Seal)
>
> State of Colorado No. _____

The Final Drainage Report shall include the following information:

(1) **Site Description:** Updated narratives for all items listed in Subsection 7.03(B)(2) of these Standards.

(2) **Drainage Basin Description:** Updated narratives for all items listed in Subsection 7.03(B)(3) of these Standards.

(3) **Drainage Design Criteria:** Updated narratives for all items listed in Subsection 7.03(B)(4) of these Standards.

(4) **Stream, Wetland, and Waterbody Impacts**

- (a) Description of floodplain impacts.
- (b) Required modification studies.
- (c) Applicable permits obtained.

(5) **Stormwater Conveyance Design**

- (a) Description of proposed conveyance system.
- (b) Conveyance path to major drainageway and capacity evaluation.
- (c) Storm sewer, culvert, and inlet design (location, size, tributary area, and peak flows).
- (d) Open channel design (location, size, tributary area, and peak flows).
- (e) Outfall design (location, peak flows, and energy dissipation).
- (f) Street drainage (see Section 7.10 of these Standards).
- (g) Easement requirements.
- (h) Maintenance requirements.

(6) **Detention and Post-Construction Stormwater Quality Design**

- (a) Description of each proposed facility (identifier, type, drainage area, size, treatment volumes, components, and function).
- (b) Description of design compliance with detention and post-construction stormwater

quality requirements with reference to completed form(s) as provided by the Director and included as an appendix (see Section 7.15).

(c) Inlet design (description of pretreatment measures and energy dissipation).

(d) Basin and outlet design (storage volumes and release rates, including overflow spillway).

(e) Description of vegetation coverage and planting plan.

(f) Description of filter media selection and underdrain configuration.

(g) Easement requirements.

(h) Description of maintenance requirements with reference to Inspection and Maintenance Guide included as an appendix (see Section 7.18 of these Standards).

(7) **Conclusions:** Updated narratives for all items listed in Subsection 7.03(B)(8) of these Standards.

(8) **References:** Updated references for all items listed in Subsection 7.03(B)(9) of these Standards.

(9) **Appendices**

(a) Completed form(s) documenting post-construction water quality compliance (Section 7.15 of these Standards).

(b) Completed form(s) documenting low impact development approaches (Section 7.14 of these Standards).

(c) Inspection and Maintenance Guide (Section 7.18 of these Standards).

(d) Hydrologic calculations.

(e) Hydraulic calculations.

(f) Stormwater conveyance calculations.

(g) Detention and permanent water quality calculations.

(h) Critical reference information copied to create standalone document.

(C) Final Stormwater Plan

The Final Stormwater Plan shall detail the to-be-constructed drainage conditions for the site and follow the submittal requirements of the Preliminary Stormwater Plan, as set forth in Subsection 7.03(C) of these Standards.

(1) **Overall Drainage Plan:** Updated plan depicting all items listed in Subsection 7.03(C)(1) of these Standards.

(2) **Detailed Drainage Plan(s):** Updated plan(s) depicting all items listed in Subsection 7.03(C)(2) of these Standards.

(D) Stormwater Construction Plans and Drawings

Construction Plans and Drawings shall be submitted for review in conjunction with the Final Drainage Report. Preparation of Construction Plans and Drawings shall be consistent with Section

1.03 of these Standards. The following elements pertaining to site stormwater design shall, at a minimum, be included in the Construction Plans and Drawings.

(1) **Stormwater Conveyance Construction Drawings**

(a) Plan drawing(s) depicting all proposed storm sewer and open channel conveyances following the requirements of Subsection 1.03(E)(2) of these Standards.

(b) Profile drawing(s) depicting all proposed storm sewer and open channel conveyances following the requirements of Subsection 1.03(E)(3) of these Standards.

(2) **Detention and Post-Construction Stormwater Quality Construction Drawings**

(a) Plan drawing(s) depicting each proposed detention and post-construction stormwater quality facility following the requirements of Subsection 1.3(E)(2) of these Standards and, at a minimum, the following components, if proposed:

(i) Inlet and outlet structure locations and energy dissipation measures, including emergency spillways,

(ii) Proposed contours for treatment surface area and side slopes/walls,

(iii) Facility components (e.g. pretreatment, micropool, underdrain, etc.), and,

(iv) Vegetative cover.

(b) Profile and/or cross-sectional drawing(s) depicting each proposed detention and post-construction stormwater quality facility following the requirements of Subsection 1.3(E)(3) of these Standards and, at a minimum, the following components, if proposed:

(i) Inlet and outlet structure inverts,

(ii) Treatment area and side slope/wall surface elevations,

(iii) Filter media components and depths, and

(iv) Facility component elevations (e.g. pretreatment, micropool, underdrain, etc.).

(c) Detail drawing/s depicting each unique detention and post-construction stormwater quality facility component following the requirements of Subsection 1.3(E)(4) of these Standards and, at a minimum for the following components, if proposed:

(i) Pretreatment,

(ii) Outlet structure,

(iii) Underdrain, and

(iv) Other unique components.

7.05 Hydrology

(A) General

The methodologies and design standards for determining rainfall and runoff conditions for any development project are based on the standards prescribed in the USDCM, with local revisions as prescribed in these Standards.

(B) Storm Frequency

Table 7-1, "Design Storm Frequencies," indicates initial and major design storm frequencies to be used in the stormwater design or any project or development: Table 7-1: Design Storm Frequencies

Land Use	Initial Storm	Major Storm
Single Family Residential	2 Year	100 Year
All Other Uses	5 Year	100 Year
Detention Ponding Design	10 Year	100 Year

(C) Rainfall

The rainfall intensities to be used in computing runoff shall be determined using the USDCM, Volume 1 and the Boulder station of the NOAA Atlas 14 Point Precipitation Frequency Estimates.

(D) Runoff

(1) **CUHP Method:** For basins larger than 160 acres, the Colorado Urban Hydrograph Procedure (CUHP) method shall be applied in conformance with the USDCM using local rainfall conditions.

(2) **Rational Method:** For all basins smaller than 160 acres, the rational method, as described in the USDCM, shall be used to calculate runoff for both the initial and major storms.

(3) **Runoff Coefficient:** The runoff coefficient to be used with the rational method may be determined based on either zoning/land use classifications or types of surface classifications prescribed in the USDCM. A composite runoff coefficient may be calculated using land areas impacted by specific classifications.

(4) **Intensity:** The rainfall intensity used in the rational method shall be calculated per the USDCM using the NOAA Atlas 14 rainfall depth-duration-frequency data.

7.06 Materials and Installation

Construction of stormwater-related public improvements shall be in compliance with these Standards. All pipe and structures shall be of adequate strength to support trench and AASHTO HS-20 highway loadings. The type of pipe and structures to be installed shall comply with these Standards, and shall be based upon applicable design flows, site conditions, and maintenance requirements.

7.07 Open Drainageways

(A) General

(1) **Designated Major Drainageways:** The following list identifies designated major drainageways in the City for primary stormwater conveyance:

Designated Major Drainageways		
Bear Canyon Creek	Four Mile Canyon Creek	South Boulder Creek
Bluebell Canyon Creek	Goose Creek	Sunshine Canyon Creek
Boulder Creek	Gregory Canyon Creek	Two Mile Canyon Creek
Boulder Slough	King's Gulch	Viele Channel
Elmer's Two Mile Creek	Skunk Canyon Creek	Wonderland Creek
Dry Creek Ditch No. 2		

(2) **Design Approach:** Design of public improvements for local drainageways shall ensure opportunities to provide for open conveyance corridors that may serve multiple functions, including without limitation, stormwater drainage and flood conveyance, wetlands and water quality enhancement, environmental protection and preservation, open space and wildlife areas, and recreational activities and trail corridors. Stormwater improvements impacting local drainageways shall be designed and constructed to respect, restore and enhance these functions in order to maintain a natural ecology, environment and aesthetic value of such drainageways.

(B) Drainageway Types

(1) **Definition:** Drainageways in the City are defined as natural or artificial channels as follows:

(a) Natural channels include naturally developed creeks, streams and thalwegs, which have been geologically created through the erosion process over time. Boulder Creek is considered a natural channel.

(b) Artificial channels include those that are designed, constructed, or developed by human effort. Artificial channels may be unlined or lined (where non-erosive conditions for unlined design cannot be met). Artificial channels also include irrigation ditches, roadside ditches, and drainage swales.

(2) **Natural Drainageways**

(a) The hydraulic properties of natural drainageways vary along each stream reach and are to be maintained in a naturally occurring and environmental form. Natural drainageways typically have mild slopes, are reasonably stable, and are not in a state of serious degradation or aggradation.

(b) Where unstable conditions are created through the introduction of urbanized stormwater runoff, which alters the nature of flow peaks and volumes and may cause erosion, mitigation measures may be proposed in the natural drainageway to maintain a stabilized and naturally occurring condition. A detailed analysis will be required for all development proposals affecting natural drainageways in order to identify the impacts of changes in flow characteristics, erosion and sedimentation, wetland losses and water quality conditions.

(c) Analyses of natural drainageways shall be provided for each project or development application affecting the drainageway. When performed, the Engineer is to prepare cross sections of the drainageway, define water surface profile for the existing and proposed minor and major storm events, investigate the bed and bank material to determine erosion and sediment transport tendencies, identify impacts on the naturally occurring conditions and ecology and study the bank slope and stream bed stability. An analysis shall include engineering calculations to ensure that supercritical flow conditions do not result from proposed project or development activities. Natural channel improvements that would cause supercritical flow conditions shall not be permitted.

(3) **Unlined Artificial Drainageways**

(a) Unlined artificial drainageways provide improved channel bottoms that are covered with wetlands, grass, or other vegetation, and may be used where naturally occurring drainageways are not present or as proposed under an adopted stormwater master plan. Designs for unlined drainageways shall comply with these Standards and the USDCM.

(b) Unlined artificial drainageways are to provide conditions for slower flow velocities, reduced flow energy, increased flow retardance, and increased channel storage. The wetlands, grass, or other vegetation along stream beds and banks are intended to stabilize the channel, consolidate the soil mass of the bed, mitigate erosion, and control soil particles transport along the drainageway. Design of these improvements shall also consider opportunities for accommodating multiple functions along the drainageway, providing for a natural ecology, environment and aesthetic value.

(c) Structural measures such as rock linings used for revetments, drop structures, scour aprons, or trickle channels may be approved as a means of controlling erosion for unlined artificial drainageways.

(4) **Lined Artificial Channels**

(a) Where conditions for natural or unlined artificial drainageways are not available, including situations where limited right- of-way, supercritical velocities, or extremely erosive conditions exist, lined artificial channels may be constructed, subject to conformance with adopted stormwater master plans and the review, discretion, and approval of the City. Designs for lined artificial channels shall comply with these Standards and the USDCM. Lined artificial channels typically include rock-lined, grouted rip-rap, and concrete-lined stream beds and banks.

(b) Rock-lined (rip-rapped) or grouted rip-rap channels are generally discouraged but are much preferred to concrete lined channels. A rock-lined or grouted rip-rap channel may typically be steeper and narrower, due to the higher friction factors of rock, and may include steeper banks or side slopes. The lining shall be capable of withstanding all hydraulic and hydrodynamic forces which tend to overtop the bank, deteriorate the lining, erode the soil beneath the lining, and erode unlined areas, especially for the supercritical flow conditions. If project constraints suggest the use of a rock-lined or grouted rip-rap channels, the Engineer shall present the justification and design concept to the City for consideration.

(c) Concrete-lined channels are least desirable and may only be approved under severely restrictive circumstances. The concrete lining shall withstand all hydraulic and hydrodynamic forces which tend to overtop the bank, deteriorate the lining, erode the soil beneath the lining, and erode unlined areas, especially for the supercritical flow conditions. If project constraints suggest the use of a concrete lined channel, the

Engineer shall present the justification and design concept, including a discussion of non-concrete-lined alternatives and why they are not feasible, to the City for consideration.

(5) **Roadside Ditches and Drainage Swales:** Roadside ditches and drainage swales are open drainage systems that are not part of the major drainageway system and are used to convey minor and major stormwater runoff in projects and developments and along rural-type streets. The design of these drainage swales is similar to the design of unlined artificial drainageways on a reduced scale.

(C) Drainageway Flow Computation

Uniform flow and critical flow computations for drainageways shall be performed in accordance with the USDCM.

(D) Drainageway Design Standards

The design standards for drainageways involve a wide range of options intended to create safe, environmental, multipurpose, and aesthetic improvements. The following planning, evaluation, and design standards shall be applied:

(1) **Natural Drainageways**

(a) The drainageway and overbank areas necessary to pass 100-year storm runoff are to be reserved for stormwater purposes.

(b) Water surface profiles shall be defined to identify floodplain conditions.

(c) Flood fringe filling along naturally defined drainageways, which reduces drainageway flood storage capacity and increases downstream runoff peaks, is to be avoided unless approved as part of an adopted City stormwater master plan.

(d) Roughness factors (n), which are representative of unmaintained channel conditions, shall be used for the analysis of water surface profiles and to determine velocity limitations

(e) The Director may allow the placement of erosion control structures, such as drop structures, check dams, revetments, and scour aprons, where they may be necessary to maintain stabilized drainageway conditions, subject to the design requirement that the drainageway conditions remain as near natural as possible.

(f) Design parameters applicable to artificial drainageways, including without limitation, freeboard height, bed and bank slopes, and curvature, may not necessarily apply to natural drainageways. Significant site planning advantages may be realized by maintaining the natural drainageway, without structured improvements, by allowing drainageway overtopping onto reserved flooding areas designated as open space and wetlands and maintaining irregular waterway features that naturally control flow conditions, improve water quality, preserve stream ecology and enhance community and aesthetic values.

(2) **Unlined Artificial Drainageways:** Where not specified in these Standards, the design of unlined artificial drainageways shall conform with the USDCM.

(a) Longitudinal Channel Slopes: Channel slopes are dictated by velocity and Froude number requirements. Where natural slopes exceed design slopes, drop structures shall be provided to maintain design velocities and Froude numbers. Normally, grass lined channels will have slopes of 0.2 percent to 0.6 percent.

(b) Side Slopes: Maximum side slopes shall be no steeper than 4:1, unless specific drainageway conditions warrant steeper side slopes as determined by the Director.

(c) Depth: Maximum depth of flow, outside of any low flow or trickle channel, shall be 5 feet. Critical depth shall be determined for both the major and initial storms in order to ensure that supercritical flows do not occur.

(d) Bottom Width: Bottom width shall be consistent with the maximum depth and velocity standards, and shall accommodate low flows and the development of wetland and water quality enhancement systems.

(e) Horizontal Curvature: The center line curvature shall have a design radius twice the top width for design flow conditions, but not less than 50 feet.

(f) Roughness Coefficient: Meaning's "n," as adjusted by channel bottom conditions outlined in the USDCM, shall be applied.

(g) Cross Sections: Drainageway cross-sections may be almost any type suitable to the location and to the environmental conditions, subject to conformance with these Standards. Cross sections simulating naturally occurring drainageway corridors are strongly recommended.

(h) Channel Bottom: The channel bottom is to be designed to convey low flows and enhance water quality in conformance with environmental concerns and regulations. Acceptable channel bottoms, subject to City approval for specific site applications, may include without limitation wetlands or natural vegetation and low flow channels conveying a minimum 3 percent of the design storm flow.

(i) Easement/Right-of-Way: The minimum drainageway easement/right of way width shall include the bank to bank dimension of the drainageway section, including the normal flow depth and freeboard areas, and adequate maintenance access.

(j) Maintenance Access: Maintenance access shall be provided along the entire length of all major drainageways and shall connect with a public street to allow access by medium and large scale construction and maintenance equipment. An access road shall be at least 12 feet wide and designed to adequately support the loads of expected maintenance equipment. The maintenance road may be shared as a greenway trail, subject to approval by the City.

(k) Water Surface Profiles: Water surface profiles shall be determined for all drainageway designs using standard backwater methods, taking into consideration losses due to velocity changes produced by changing channel sections, drops, waterway openings, or obstructions. The water surface and energy gradient profiles shall be shown on the construction plans.

(3) **Lined Artificial Channels:** Where allowed by the City, lined artificial channels shall be designed in accordance with these Standards and the USDCM, including the following:

(a) Easement/Right-of-Way: The minimum drainageway easement/right of way width shall include the bank to bank dimension of the drainageway section, including the normal flow depth and freeboard areas, and adequate maintenance access.

(b) Maintenance Access: Maintenance access shall be provided along the entire length of all major drainageways and shall connect with a public street to allow access by medium and large scale construction and maintenance equipment. An access road shall be at least 12 feet wide and designed to adequately support the loads of expected maintenance equipment. The maintenance road may be shared as a greenway trail, subject to approval by the City.

(c) Water Surface Profiles: Water surface profiles shall be determined for all drainageway designs using standard backwater methods, taking into consideration losses due to velocity changes produced by changing channel sections, drops, waterway openings, or obstructions. The water surface and energy gradient profiles shall be shown on the construction plans.

(4) **Roadside Ditches and Drainage Swales:** The design of roadside ditches and drainage swales is similar to the standards for unlined channels with modifications for application to minor storm drainage. The standards are as follows:

(a) Capacity: Roadside ditches and drainage swales shall have a minimum capacity for the 10-year design storm.

(b) Flow Velocity: The maximum velocity for the design storm runoff peak is not to exceed 5 feet per second. The Froude number shall be less than 0.8.

(c) Longitudinal Slope: The slope shall be limited by flow velocity of the design storm. Swale widening or check drops may be required to control velocities.

(d) Freeboard: Freeboard above the design flow depth shall be at least 6 inches.

(e) Curvature: The minimum radius of curvature shall be 25 feet.

(f) Roughness Coefficient: Manning's "n," as adjusted by channel bottom conditions outlined in the USDCM, shall be applied.

(g) Depth: A drainage swale shall be at least 1 foot deep. A maximum depth for drainage swales shall not exceed 5 feet and shall be dictated by the design flow and cross-sectional standards.

(h) Side Slopes: Side slopes shall be no greater than 3:1; however, 4:1 side slopes or flatter are recommended for landscaped areas and to enhance water quality.

(i) Driveway Culverts: Along roadside ditches, driveway culverts shall be sized to pass the design storm flow without overtopping the driveway, having a minimum culvert diameter size of 18 inches in height with at least 6 inches of cover. Flared end sections or headwalls with appropriate erosion protection shall be provided. Given the depth constraints along roadside ditches, more than one culvert may be required to pass the design flow. Maintenance of all driveway culverts shall be the responsibility of the property owner served by the driveway.

(j) Discharge Points: Roadside ditches and open drainage swales shall discharge directly to the receiving water and shall not discharge to a piped storm sewer system for conveyance to the receiving water body. If discharge to a piped storm sewer system is necessary, a sediment sump and debris grate shall be provided immediately upstream of the discharge point to the storm sewer system. The grate shall be hinged to allow for maintenance access.

(k) Major Drainage Capacity

(i) The major drainage (100-year storm) capacity of roadside ditches is restricted by the maximum flow depth allowed at the street crown or by the ground surface at the edge of the street right-of-way.

(ii) The major drainage capacity of drainage swales is restricted to the maximum flow that can be passed without inundation to and damage of downstream properties.

(E) Hydraulic Structures

(1) **Where Required:** Hydraulic structures are used in open stormwater systems to control the flow of the runoff. The energy associated with flowing water has the potential to create damage to the drainage system, especially in the form of erosion. Hydraulic structures are intended to control the energy of stormwater flow and minimize the damage potential of stormwater runoff. Typical hydraulic structures may include without limitation the following:

(a) Channel drop and check structures,

(b) Rip rap and rock linings,

(c) Energy dissipaters and stilling basins,

(d) Channel rundowns,

(e) Bridges and culverts, and

(f) Irrigation ditch crossings.

(2) **Design Standards:** The standards to be used in the design of hydraulic structures shall be in accordance with these Standards and the USDCM.

7.08 Storm Sewers

(A) System Design

(1) **Where Required:** Storm sewers shall be required when the other parts of the minor stormwater system, primarily streets, curbs, gutters, and roadside ditches, no longer have the capacity for additional runoff in the initial storm event.

(2) **Gravity Flow Conditions:** Storm sewers shall be designed for gravity (open) flow conditions, using a "Manning's" roughness coefficient from Table 7-2, "Manning's "n" for Storm Sewers."

Table 7-2: Manning's "n" for Storm Sewers

Sewer Type	Manning's "n"
Concrete	0.015
Plastic	0.013
Corrugated Metal	0.013

(3) **Flow Depth:** Storm sewers are to be designed to carry peak flows at full pipe depth.

(4) **Pressure Flow Prohibited:** Pressurized surcharged or depressed (inverted siphon) stormwater mains are prohibited in the City's stormwater system.

(5) **Continuous Drainage System:** All stormwater drainage facilities shall be a component of a connected and continuous drainage system that does not end in a sump condition and does not discharge to irrigation ditches.

(B) Location

All storm sewer mains shall be installed in public rights-of-way or easements, in conformance with Section 4.04, "Utilities Easements," of these Standards.

(C) Depth

The cover for all storm sewer mains shall be at least 18 inches deep, measured from the top of pipe to the final surface grade, and shall be capable of withstanding AASHTO HS-20 highway traffic loadings.

(D) Size

Storm sewer mains shall be at least 18 inches in diameter, and storm sewer laterals shall be at least 15 inches in diameter.

(E) Slope

(1) **Minimum and Maximum:** Minimum allowable slope shall provide flow velocities of at least 2-feet per second and maximum allowable slope shall provide flow velocities no greater than 10feet per second during peak flow conditions.

(2) **Constant Slope:** All storm sewer mains shall be laid at a constant slope between manholes.

(F) Alignment

(1) **Straight Alignment:** All storm sewer mains shall be laid in a straight alignment between manholes.

(2) **Curvilinear Mains Prohibited:** Curvilinear storm sewer mains shall not be allowed.

(G) Separations and Crossings

All collection main separations and crossings of other City utilities shall be designed in compliance with Section 4.06, "Separation of Utilities," of these Standards.

(H) Taps

All taps approved onto an existing storm sewer main shall be made by the City of Boulder Utilities Division and shall be paid for by the applicant. A manhole shall be provided at all taps 6 inches in diameter or larger. Where taps are made to inlet boxes a manhole is not required.

(I) Ground Water Barriers

(1) **Required:** Where the possibility exists that ground water may be diverted by the construction of new storm sewer mains, ground water barriers shall be constructed within the storm sewer main trench to prevent ground water migration or diversion along the main.

(2) **Placement:** The Engineer shall determine the location and number of ground water barriers that will be necessary to mitigate any ground water impacts, subject to review and approval by the Director. Any necessary support material required to address ground water concerns, such as soils investigations, engineering calculations and design details, shall be provided by the Engineer.

(J) Extensions

Where required as part of any adopted City master plan or to satisfy stormwater design requirements as part of any proposed project or development, storm sewer mains shall be extended downstream to the major drainageway, and upstream to the far edge of the property being served, to ensure perpetuation of the stormwater collection system.

(K) Manholes

(1) **Location:** Manholes shall be provided at each storm sewer main connection with another storm sewer main or lateral line, at all changes in grade, slope, alignment and pipe size, at all tap connections 6 inches in diameter or larger, or every 400 feet at a minimum.

(2) **Size**

(a) Table 7-3, "Required Manhole Sizes," indicates required manhole sizes.

Table 7-3: Required Manhole Sizes

Sewer Main Diameter	Manhole Diameter
12 - 18 Inches	4 Feet
21 - 42 Inches	5 Feet
48 - 54 Inches	6 Feet
60 Inches and Larger	Special Detail

(b) Special Provisions: Larger manhole diameters or a junction structure may be required when sewer alignments are not straight through or more than one sewer line passes through a manhole.

(3) **Maintenance Access:** Direct access by maintenance vehicles shall be provided to each manhole. The access drive shall be an all-weather surface, such as asphalt or concrete paving, adequate gravel base or turf block, minimum 12 feet in width, and shall be capable of supporting maintenance vehicles weighing up to 14 tons.

(4) **Covers**

(a) Manholes that are not located within a public street, alley or driveway section shall be installed with a hinged, gasketed, and locking frame and cover assembly. The assembly shall be an "East Jordan Iron Works" ERGO or ERGO XL assembly.

(b) Manholes located within the 100-year floodplain, or in a location where runoff may accumulate and pond, shall be installed with a hinged, gasketed, and locking frame and cover assembly. The assembly shall be an "East Jordan Iron Works" ERGO or ERGO XL assembly.

(L) Hydraulic Design

(1) **Rational Method:** The rational method, as described in the USDCM, shall be used for the sizing of storm sewer systems.

(2) **Hydraulic and Energy Grade Line, and Design Losses:** Storm sewers shall be designed to convey the initial storm flow peaks without surcharging the sewer, and the final energy grade line shall be at or below the proposed ground surface. To ensure that this objective is achieved, the hydraulic and energy grade line shall be calculated by accounting for pipe friction losses and pipe form losses as provided in the USDCM.

7.09 Inlets

(A) Specifications

(1) **Design:** Except as modified in these Standards, storm sewer inlet design shall conform with the standards in the USDCM.

(2) **Required:** Storm inlets shall be provided at:

(a) Areas where street capacity (e.g., allowable design flow spread) would be exceeded without them,

(b) At sumps or areas prone to ponding,

(c) At median breaks (e.g., where traffic turns across the median),

(d) Upstream of speed mitigation and pedestrian structures that would otherwise cause a damming of stormwater runoff,

(e) Where nuisance flows would otherwise cross a driving lane, and

(f) Where curb and gutter ends.

(3) **Inlet Classification:** Inlets are classified as a sump or continuous grade condition. Sump inlets are inlets located in a low spot or submerged condition. Continuous grade inlets are inlets located along a continuous grade curb and gutter section where bypass flows may occur, and not in a low point.

(4) **Standard Inlets:** Table 7-4, "Standard Inlets," indicates the standard inlets permitted for use in the City.

Table 7-4: Standard Inlets

Inlet Type	Drainage Condition	Permitted Use	Percentage of Theoretical Capacity Allowed
Curb Opening Inlet - Type "R"	Continuous Grade or Sump	All Curb and Gutter Street Types	80% (5 Foot Length) 85% (10 Foot Length) 90% (15 Foot Length)
Combination (Curb Opening/Grated) Inlet	Continuous Grade or Sump	All Curb and Gutter Street Types	66%
Grated Area Inlet	Sump	Parking Lots, Alleys	60%

(5) **Reduction Factors:** In order to account for inlet capacity reductions caused by debris plugging, pavement overlaying, parked vehicles, and other blockage factors, inlet design shall be based on the "percentage of theoretical capacity allowed" as outlined in Table 7-4, "Standard Inlets," in these Standards.

(6) **Inlet Spacing**

(a) Spacing of storm inlets is dependent upon traffic requirements, contributing land use, street slope and distance to the nearest outfall system. The recommended sizing and spacing of the inlets is based upon the interception rate of 70 percent to 80 percent, which has been found to be more efficient than spacing using 100 percent interception rate.

(b) Using recommended inlet spacing, only the most downstream inlet is designed to intercept 100 percent of the flow. In addition to recommended interception rates, considerable improvements in overall inlet system efficiency can be achieved if the inlets are located in the sumps created by street intersections.

(7) **Inlet Grates:** All inlet grates located in a street, alley, parking lot travel lane, bike path, or sidewalk shall utilize a vaned grate on the inlet such as the Denver Type 16 inlet.

7.10 Street Drainage

(A) Function of Streets in the Drainage System

(1) **Primary Function of Streets:** The primary function of streets is for safe traffic movement; therefore, streets shall be designed and constructed to accommodate runoff and convey it to downstream drainage facilities in order to minimize its interference with traffic. Streets therefore provide an integral part of the stormwater system and are intended to transport local storm runoff within reasonable limits. When the stormwater runoff accumulation in the street exceeds allowable limits, storm sewers or other drainage facilities are required to collect and convey the excess runoff.

(2) **Continuous Drainage System:** All stormwater drainage facilities for streets shall be a component of a connected and continuous drainage system that does not end in a sump condition and does not discharge to irrigation ditches.

(B) Street Classification and Allowable Runoff Encroachment

(1) **Street Classification:** City streets are classified according to the average daily traffic carried and travel routes they provide. Higher category streets, such as arterials and collectors, are required to provide a greater level of access and through travel for emergency purposes during major storm events than lower category streets.

(2) **Allowable Runoff Encroachment:** A stormwater drainage system (storm sewer or open drainageway) shall be provided where the gutter runoff encroachment reaches the limits outlined in Table 7-5, "Allowable Street Drainage Encroachment."

Table 7-5: Allowable Street Drainage Encroachment

Street Classification	Minor Storm Maximum Encroachment	Major Storm Maximum Encroachment
Residential and Local Streets	No curb overtopping. Flow may spread to street crown.	Depth at flowline shall not exceed 18 inches.
Collector Streets	No curb overtopping. A minimum one travel lane width shall remain free of drainage encroachment.	Depth at flowline shall not exceed 18 inches.
Arterial Streets	No curb overtopping. A minimum two travel lanes width shall remain free of drainage encroachment.	Depth at crown shall not exceed 6 inches. Depth at flowline shall not exceed 18 inches.
Freeways	No flow encroachment is allowed.	Refer to CDOT Roadway Design Manual

NOTE: Flow encroachment shall not extend beyond property lines.

(C) Hydraulic Street Capacity

(1) **Allowable Capacity - Minor Storm:** The allowable minor storm capacity of each street section is to be calculated using the modified Manning's formula as described in the USDCM.

(2) **Allowable Capacity - Major Storm:** The allowable street capacity for the major storm shall be calculated using Manning's formula, dividing the street cross section into the pavement area and sidewalk/grass area, and computing individual flow contributions. An "n" value of 0.016 for pavement and 0.035 for the sidewalk/grass area shall be used.

(D) Cross Street Flow

The standards outlined in Table 7-6, "Allowable Cross Street Flow," of these Standards shall be used for allowable cross-street flow, where flow passes from one side of the street to the other. The allowable cross-street flow shall be determined using the methods prescribed in the USDCM.

Table 7-6: Allowable Cross Street Flow

Street Classification	Minor Storm Runoff	Major Storm Runoff
Residential and Local Street	Maximum Depth of 6 Inches in Cross Pan	Maximum Depth of 18 Inches Above Flowline
Collector Street	Where Allowed, Maximum Depth of 6 Inches in Cross Pan	Maximum Depth of 18 Inches Above Flowline
Arterial	Not Allowed	Maximum Depth of 6 Inches Over Street Crown

7.11 Culverts

(A) System Design

(1) **Required:** Culverts shall be provided for the conveyance of stormwater runoff under a roadway, railroad, driveway, or other crossings of an open drainage system (such as a drainageway or roadside swale). The size, shape, and type of culvert crossings shall be based on the projected runoff volumes, as well as existing topographic conditions. All culvert designs are subject to approval by the Director.

(2) **Culvert Types:** Typical culvert types include circular, elliptical, or arch pipe sections, and reinforced concrete box culverts.

(B) Hydraulic Design

All culverts shall be designed in accordance with the USDCM. All culvert designs are to include an analysis to determine whether inlet or outlet control conditions govern for both major and minor storm runoff conditions.

(C) Structural Design

The structural design of culverts shall conform to accepted structural engineering practices, the Colorado Department of Transportation design standards and standard specifications, any methods and criteria recommended by the manufacturer for a specific culvert type, and for conditions found at the construction site. As a minimum, all culverts shall be designed to withstand an AASHTO HS-20 traffic loading.

(D) Specifications

(1) **Size**

(a) Culvert design size shall be based upon the following:

(i) Runoff volumes for the appropriate design storm.

(ii) Required capacity based on roadway classification and allowable street overtopping, as prescribed in Section 7.10, "Street Drainage," of these Standards

(b) Culverts shall be at least 18 inches in diameter or height.

(2) **Inlet and Outlet Sections**

(a) All culverts shall be designed with headwalls and wingwalls, or flared end sections at the inlet and outlet. Flared end sections are allowed only on pipe culverts with diameters of 42 inches (or equivalent) or less.

(b) Erosion protection such as rip-rap, boulder energy dissipators, or adequate vegetation, shall be provided at the inlet or outlet where required to mitigate potential scouring or erosive flow conditions. The Engineer shall propose the erosion protection to be used, subject to approval by the Director.

(3) **Slope and Velocity**

(a) Culvert slopes shall be designed so that neither silting nor excessive velocities resulting in scour can occur. The minimum design velocity for minor storm conditions shall be 2 feet per second, to provide for self-cleansing of the culvert.

(b) The maximum culvert velocity is dictated by the channel conditions at the outlet, and the amount of erosion protection or energy dissipation that can be provided to prevent scour or damage.

(4) **Allowable Headwater**

(a) The maximum headwater / diameter (HW/D) ratio for the 100-year design flows shall be 1.5, and 1.0 for the 10-year design flow. These HW/D ratios are to be applied to culverts at street crossings and should not be applied to outlets from detention ponds or private driveways.

(b) Ponding above the top of a culvert is not permitted if such ponding could potentially cause property or roadway damage, culvert clogging, saturation of critical embankments, detrimental debris deposition, erosion, or inundation of existing or future utilities, structures, or buildings.

(5) **Trash Racks**

(a) The installation of a trash rack over a culvert entrance shall be provided as required by the Director where there exists the potential for debris clogging of the culvert or where there is a safety hazard concern for the possibility of people (especially children) being carried into the culvert.

(b) Trash racks shall be designed to maintain adequate culvert hydraulics, considering the potential for debris buildup and blockage which may render the culvert ineffective. Careful design considerations are to be applied, including without limitation application of the following standards:

(i) Materials: All trash racks shall be constructed with smooth steep pipe, having an outside diameter of at least 1 ¼ inches. Trash rack ends and bracing shall be constructed with steel angle sections. All trash rack components shall have a corrosion protective finish.

(ii) Design: Trash racks shall be designed without cross-braces, to minimize debris clogging, and be able to withstand the full hydraulic load of a completely plugged trichroic based on the highest anticipated depth of ponding. The trash rack shall be hinged and removable for maintenance purposes.

(iii) Bar Spacing: Bar spacing shall provide a maximum clear opening of 6

inches. The longitudinal slope of the trash rack shall be no steeper than 3:1, horizontal to vertical. The entire trash rack shall have a clear opening at least three times the culvert opening area.

(c) Hydraulics: Use the following equation to compute hydraulic losses through trash racks:

$$H_T = 0.11 * (TV/D)^2 * (\sin A)$$

Where: H_T = Head Loss through the Trichroic (feet)

T = Thickness of Trichroic Bar (inches)

V = Velocity normal to Trichroic (fps)

D = Center-to-Center Spacing of Bars (inches)

A = Angle of Inclination of Trichroic with Horizontal

The velocity normal to the trichroic shall be computed considering the rack to be 50 percent plugged.

7.12 Detention

(A) System Design

(1) **Intent:** Detention ponding facilities are intended to store increased runoff from developed property and release this runoff at the historic rate that existed prior to development or redevelopment. By providing detention ponding, increased runoff impacts on downstream facilities may be controlled and minimized to reduce potential damages and the need for greatly expanded stormwater conveyance facilities.

(2) **Requirements:** Detention ponding for stormwater shall be provided for all new development or redevelopment where the runoff coefficient for the site increased unless one of the following conditions are met:

(a) The project site is a single-family lot or a single-family lot split into two single-family lots that is not part of a larger development.

(b) Runoff for the project site for the initial and major storm events from the entire tributary basin can be conveyed directly to the major drainage system without adverse impact on upstream, surrounding, or downstream properties and facilities and stormwater detention to meet water quality mitigation measures is not required.

(3) **Maintenance:** The property owner shall be responsible for maintaining stormwater detention facilities.

(4) **Easement:** All stormwater detention facilities shall be located in a public easement. The easement shall grant to the City at a no charge a permanent right to inspect, maintain, and reconstruct the stormwater detention facilities. The easement shall be granted on a form provided by the Director. No owner of land or other applicant shall obtain a Final Drainage Plan, unless the owner first grants to the City the easement for all stormwater detention facilities. The City shall have no obligation to the property owner to inspect, maintain, or reconstruct the stormwater facilities.

(B) Design Frequency, Hydraulic Design, and Storage Requirements

(1) **Design Storms:** Detention ponds shall be designed in accordance with USDCM, Volume 2, Chapter 12.

(2) **Storage Volume:** The storage volume of runoff to be detained on-site shall be sized to contain 110 percent of the difference between the historic runoff and the initial and major storm runoff, as defined in Table 7-1, projected for the ultimate developed conditions of the entire parcel and tributary basin to be developed or redeveloped.

(3) **Undetained Site Releases:** On project sites where runoff from portions of the site cannot be detained due to topography or site conditions, free release of runoff may be approved with compensating detention storage design subject to the following conditions:

(a) Total maximum runoff from the entire parcel and tributary basin to be developed or redeveloped shall not exceed the historic runoff,

(b) Release rates from the detention ponds shall be reduced by the developed runoff rate from the undetained drainage area,

(c) The undetained drainage area may not exceed five percent of the entire parcel and tributary basin to be developed or redeveloped, and

(d) The release rate from the undetained area may not exceed 25 percent of the historic release rate from the entire parcel and tributary basin to be developed or redeveloped.

(C) Detention Pond Design

Except where inconsistent with the requirements in this Subsection 7.12(C), detention pond design shall follow all applicable criteria established in the USDCM, Volume 2 and Volume 3.

(1) **Surface Ponding Required:** All detention ponds shall be provided as open, surface grade improvements. Underground, enclosed, or roof top detention ponds shall not be permitted unless unusual site conditions and adequate detention performance and maintenance conditions are approved by the Director.

(2) **Location:** Detention ponds shall be located in open, pervious landscaped areas to enhance site drainage and soil percolation, and to improve water quality.

(3) **Side Slopes:** Side slopes for detention ponds shall be designed to provide for ease of maintenance and access. Landscaped side slopes are not to exceed 4:1, and vertical or steep walls used as side slopes are to be constructed of durable natural materials, such as rock or timber, with heights no greater than 30 inches to reduce safety hazards.

(4) **Pond Bottoms:** Pond bottoms are to be pervious and sloped to prevent the collection of standing water, unless a permanent pond or wetland bottom is provided for water quality enhancements. The use of combined water quality and detention facilities shall follow criteria specification provided in the USDCM, Volume 3, Chapter 12 and applicable water quality treatment approach criteria as specified in Section 7.17 of these Standards. Hard-lined trickle channels are not to be constructed in detention ponds unless approved by the Director to address specific drainage problems or safety and environmental hazards.

(5) **Overflow Release Feature:** All detention ponds shall include an overflow release feature to spill during storm events larger than the major design storm or when release outlets fail. This feature shall be designed to release overflows in a direction and manner that will not adversely affect properties downstream of the detention pond.

7.13 Construction Stormwater Management

(A) Intent

This section implements requirements of Section 11-5-6, “Stormwater Quality Management for Land

Development," B.R.C. 1981, for construction activities and sets standards for stormwater management plans (SWMP) and erosion control plans, their implementation, and the inspection and maintenance of control measures for erosion and sediment control**.**

(B) Stormwater Management Plan Requirements

A SWMP shall include a narrative and erosion control plans that identify the construction activities and their associated potential pollutant sources and address the selection, installation, implementation, and maintenance of control measures for erosion and sediment control that reduce the potential for the pollutant sources to enter the stormwater utility system or waters of the State. Control measures for erosion and sediment control shall prevent pollution and degradation of waters of the State. The SWMP shall include and be prepared, updated, and implemented consistent with the following requirements:

(1) **General Standards:** Control measures for erosion and sediment control shall be constructed and maintained in accordance with the SWMP, the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE, and the USDCM, Volume 3.

(2) **Preparation Standards:** The SWMP shall be prepared in accordance with the requirements of the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE and USDCM, Volume 3. The SWMP shall be prepared in accordance with methods, procedures, and practices that are based on scientific facts, reflect best industry practices and standards, are appropriate for the conditions and pollutant source, and provide appropriate solutions to meet the SWMP requirements of this section, including practice based and numeric effluent limits. The SWMP shall include the following elements:

(a) Protection for adjacent properties (including public right-of-way) from erosion and/or sediment deposition.

(b) Protection for public streets from the deposit of sediment from runoff or vehicles tracking mud.

(c) Stabilization for all disturbed areas as defined in the USDCM and CDPS requirements.

(d) Protection for all storm sewer inlets from the entry of sediment-laden water.

(e) Protection from encroachment by construction equipment, vehicles, and foot traffic into stormwater infiltration measures to eliminate the possibility of soil compaction and vegetation damage.

(f) Long-term stability of cut and fill slopes and the successful establishment of permanent vegetative cover on exposed soil.

(g) Selection, installation, implementation, and maintenance of control measures for erosion and sediment control.

(3) **Control Measures for Erosion and Sediment Control and Potential Pollutant Sources:** All control measures for erosion and sediment control shall meet the following requirements:

(a) Control measures for erosion and sediment control shall be installed and made operational prior to the start of construction activity. The control measures for erosion and sediment control shall prevent potential pollutants from leaving the

construction site during each phase of construction and shall be continued through final stabilization. Structural control measures for erosion and sediment control shall be maintained in operational condition through final stabilization.

(b) Control measures for erosion and sediment control shall be selected, designed, installed, implemented, and maintained to prevent potential pollutants such as, but not limited to, sediment, construction site waste, trash, discarded building materials, concrete truck washout, chemicals, sanitary waste, and contaminated soils in discharges to the stormwater utility system from leaving the construction site.

(c) The SWMP shall address pollutant sources associated with the following activities (if part of the construction activity), and control measures for erosion and sediment control shall be implemented if the source is determined to be present on the site:

(i) Land disturbance and soil storage,

(ii) Vehicle tracking,

(iii) Loading and unloading operations,

(iv) Outdoor storage of construction site materials, building materials, fertilizers, and chemicals,

(v) Bulk material storage,

(vi) Vehicle and equipment maintenance and fueling,

(vii) Significant dust or particulate-generating processes,

(viii) Routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, and/or oils,

(ix) Concrete truck/equipment washing, including the concrete truck chute and associated fixtures and equipment,

(x) Dedicated asphalt and concrete batch plants,

(xi) Other areas or operations where spills can occur, and

(xii) Other non-stormwater discharges including construction dewatering not covered under the CDPS General Permit for Construction Dewatering Discharges and wash water that may contribute pollutants to the stormwater utility system.

(d) The SWMP shall include control measures for erosion and sediment control detail drawings for both installation and maintenance. Controls measures should be consistent with USDCM, Volume 3 or Colorado Department of Transportation M & S (Miscellaneous and Signage) Standard Plans.

(4) **Protection of Control Measures for Post-Construction Water Quality:** Requirements for the design and construction of control measures for post-construction water quality are provided in Sections 7.14 through 7.18 of these Standards. The SWMP shall provide provisions to protect the water quality functions of these control measures for post-construction water quality (SCMs) during construction as listed below:

(a) Any area consisting of native, un-compacted soil where a SCM will be installed shall be protected from vegetation removal and encroachment by heavy equipment, vehicles, and foot traffic prior to grading and construction. If the area, prior to grading and construction, consists of previously compacted or fill soil, protection

from encroachment shall be provided after the soil has been amended or otherwise rehabilitated into an un-compacted condition to promote infiltration of stormwater. Methods and controls for protection of these areas shall be indicated in the SWMP.

(b) The use of the SCM area for construction or maintenance materials stockpiles or for storage of construction equipment, wastes, or pollutants is prohibited after construction of the SCM has commenced.

(5) **Erosion Control Plan:** The SWMP shall include an Erosion Control Plan. Erosion Control Plan drawings shall locate and identify all structural and non-structural control measures for erosion and sediment control for the proposed construction activities. The Erosion Control Plan shall be prepared in accordance with the requirements of the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE and include the elements listed in form(s) provided by the Director. Erosion Control Plans shall include, at a minimum, three site maps illustrating the initial, interim, and final phases of construction and their associated control measures for erosion and sediment control.

The following Standard Notes shall also be included on Erosion Control Plan(s):

(a) Temporary Erosion Controls: All temporary erosion control measures for erosion and sediment control shall be installed before any construction activities take place.

(b) Sediment Controls: Control measures for erosion and sediment control shall be implemented to prevent the release of sediment from construction sites. Vehicle tracking of sediment shall not be allowed to enter the stormwater utility system or waters of the State. Sediment shall not be tracked onto public streets and, if so, shall be immediately removed.

(c) Water Quality Impacts: Stormwater discharges from construction activities shall not cause or threaten to cause pollution, contamination, or degradation of waters of the State.

(d) Waste Controls. Solid waste, industrial waste, yard waste, and any other pollutants or waste on any construction site shall be controlled using control measures. Waste and/or recycling containers shall be provided and maintained by the owner or contractor on construction sites where there is the potential for release of waste. Uncontained waste that may blow, wash, or otherwise be released from the site is prohibited. Sanitary waste facilities shall be provided and maintained by the owner or contractor.

(e) Concrete Waste: Ready-mixed concrete, or any materials resulting from the cleaning of vehicles or equipment containing or used in transporting or applying it, shall be contained with appropriate control measures and ultimately removed for proper disposal. Release of these materials is prohibited.

(f) Chemical Storage: Bulk storage structures for petroleum products and other chemicals shall have adequate protection so as to contain all spills and prevent any spilled material from entering the stormwater utility system or waters of the State.

(g) Surface Cover Timing: Cover shall be applied within 14 days to inactive soil stockpiles and shall be maintained for stockpiles that are proposed to remain in place longer than 30 calendar days.

(h) Project Phasing: All earth disturbances shall be designed, constructed, and completed to limit the exposed area of any disturbed land to the shortest possible period of time.

(i) Dust Controls: Techniques shall be used to prevent dust, sediment, or debris from blowing off the site.

(j) Maintenance: Any damage or required maintenance to temporary and permanent controls measures shall be repaired or replaced as soon as possible, immediately in most cases.

(k) Removal: All control measures for erosion and sediment control shall be removed and disposed within 30 days after final site stabilization is achieved or after the temporary measures are no longer needed, whichever occurs first.

(l) Responsibility: The erosion control permittee shall be responsible for continued compliance with the requirements of Section 7.13 of the City's Design and Construction Standards during construction activity on the site.

(C) Inspection and Maintenance Requirements

The erosion control permittee shall be responsible for implementation of the SWMP or, if no SWMP is required, the Erosion Control Plan during construction, including inspection and maintenance of the control measures for erosion and sediment control in the approved SWMP and/or Erosion Control Plan. Prior to commencement of work, the erosion control permittee shall ensure that all general contractors, subcontractors, and utility agencies obtain a copy of and comply with the SWMP and/or Erosion Control Plan. The erosion control permittee shall amend the SWMP and/or Erosion Control Plan when site conditions change. The erosion control permittee shall keep the SWMP and/or Erosion Control Plan on site and shall implement and update the SWMP and/or Erosion Control Plan throughout construction and final stabilization of the site in accordance with the following requirements:

(1) If no SWMP is required, the erosion control permittee shall update the Erosion Control Plan to show currently implemented control measures for erosion and sediment control and installation dates.

(2) If a SWMP is required:

(a) An initial site inspection by the Director is required prior to commencing construction.

(b) The erosion control permittee shall amend the SWMP whenever there is a change in design, construction, operation, or maintenance that affects the potential for discharge of pollutants to the stormwater utility system or receiving waters, or if the SWMP proves to be ineffective in controlling pollutants in stormwater discharges associated with construction activities.

(c) The erosion control permittee shall inspect all control measures for erosion and sediment control per the frequency outlined in the General Permit for Stormwater Discharges Associated with Construction Activity issued by the CDPHE for the site. Inspections of control measures for erosion and sediment control shall be conducted by an individual who has successfully completed formal training in erosion and sediment control by an organization acceptable to the Director. The erosion control permittee shall provide a certification of successful completion of such training to the Director upon request.

(d) The erosion control permittee shall maintain records of inspection on site with the SWMP. Inspection records shall be available at the site at all times. The erosion control permittee shall make the inspection records immediately available to the Director upon request.

7.14 Land Development Planning Using LID Techniques

(A) Intent

All new development and redevelopment shall reduce pollutant impacts of the development site on receiving waters and reduce or control stormwater volumes by mimicking natural hydraulic conditions using LID techniques. LID techniques seek to minimize impervious areas and protect and create well-draining vegetated areas that promote infiltration and natural hydrologic processes thereby reducing stormwater runoff and pollutant quantities.

(B) Requirements for All Developments

(1) LID techniques shall be implemented for all new development and redevelopment consistent with the standards in this section.

(2) Compliance with the requirement to implement LID techniques, including the investigation and analysis of LID techniques and an explanation of the implementation choices made, shall be documented in the Preliminary and Final Drainage Reports when such reports are required. Otherwise, compliance shall be demonstrated in building permit construction documents, on form(s) as provided by the Director, submitted as part of the building permit application.

(C) LID Techniques

LID techniques shall be chosen and applied following the principles summarized in this subsection. Additional guidance on employing LID techniques is provided in USDCM, Volume 3, Chapter 1. The following LID techniques shall be investigated and implemented to the maximum extent practicable:

(1) **Conserve Existing Amenities:** Planning efforts shall account for and, where practicable, preserve or restore existing site features that naturally retain stormwater on site, including vegetated areas, high infiltrating soils, and natural surface drainage patterns, such as meadows and trees.

(2) **Minimize Impacts:** Planning efforts shall account for and minimize, where practicable, land disturbance, impervious surface addition, and soil compaction. This may include removing unnecessary impervious areas, minimizing driveway and sidewalk widths, and sequencing construction to minimize compacted areas.

(3) **Minimize Directly Connected Impervious Areas (MDCIA):** Planning efforts shall account for and minimize impervious areas, such as rooftops and pavement, that directly drain to the stormwater utility system or a local stream without prior stormwater control. This may include using or integrating receiving pervious areas into the site landscape, such as vegetated swales and buffers. Where practicable, site drainage patterns shall be designed to promote sheet flow to vegetated area and roof downspouts shall be disconnected from direct discharge to the storm sewer. Receiving pervious areas shall be designed to slow run-off and promote infiltration.

7.15 Post-Construction Stormwater Quality Requirements

(A) Intent

All new development and redevelopment shall reduce the pollutant impacts of the development site

on receiving waters. All applicable development sites shall implement post-construction stormwater quality management practices.

(B) Applicable Development Sites

(1) **Applicable Development Site:** Applicable development sites are required to implement control measures for post-construction stormwater quality in accordance with the requirements of Chapter 11-5, "Stormwater and Flood Management Utility," B.R.C. 1981, and this section, unless the Director has waived the applicable development site requirements pursuant to Subsection 7.15(B)(2) of these Standards.

(2) **Waiver:** The Director may waive the requirements for applicable development sites in this section if the applicant demonstrates that the requirement of paragraph (a) of this Subsection 7.15(B)(2) is met and that none of the circumstances described in Subsection 7.15(B)(2)(b)(i) through (vi) exist:

(a) One or more of the following criteria is met:

(i) Pavement Management Sites: The project proposes the rehabilitation, maintenance, and reconstruction of roadway pavement, which includes roadway resurfacing, mill and overlay, white topping, black topping, curb and gutter replacement, concrete panel replacement, and pothole repair. The purpose of the project must be to provide additional years of service life and optimize service and safety. The project must be limited to the repair and replacement of pavement in a manner that does not result in an increased impervious area, and the infrastructure must not substantially change. The types of projects that meet these criteria include day-to-day maintenance activities, rehabilitation, and reconstruction of pavement. "Roadways" include roads and bridges that are improved, designed, or ordinarily used for vehicular travel and contiguous areas improved, designed, or ordinarily used for pedestrian or bicycle traffic, drainage for the roadway, and/or parking along the roadway. Areas primarily used for parking or access to parking are not roadways, and do not meet these criteria;

(ii) Roadway Redevelopment: The project is the redevelopment of existing roadway and the project (1) adds less than one acre of paved area per mile of roadway to an existing roadway or (2) does not add more than 8.25 feet of paved width at any location to the existing roadway;

(iii) Existing Roadway Areas: The project is the redevelopment of existing roadway where the project does not increase the width of the original roadway to two times or more on average. Under this criterion, the applicable development site requirements may not be waived for the entire roadway project but only for the area of the existing roadway. The area of the added new roadway shall be considered an applicable development site;

(iv) Aboveground and Underground Utilities: The project is the installation or maintenance of underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity. The types of projects that meet these criteria include, but are not limited to, activities to install, replace, or maintain utilities under roadways or other paved areas that return the surface to the same condition;

(v) Large Lot Single Family Residential Projects: The project involves single-family residential lots greater than or equal to 2.5 acres in size per dwelling, with a total lot impervious area of less than 10 percent, and that are not part of a common plan of development,

(vi) Land Disturbance Only Projects: The project involves land disturbance to undeveloped land (land with no structures, such as buildings, and no pavement), and the land will remain undeveloped during and after the disturbance;

(vii) Stream Stabilization Projects: The project is a stream stabilization project; or

(viii) Sidewalk, Bicycle and Multi-Use Paths: The project adds, modifies, or maintains public sidewalk, bicycle path or multi-use path. Bike lanes that are a part of a roadway do not meet this criterion.

(b) The Director may not waive the requirements for applicable development sites of this section if any of the following circumstances are present:

(i) Brownfield: The proposed project is located on a site that is considered a brownfield or is otherwise known or believed to have pollutants in the soil or on the ground that, if discharged from the property in stormwater or groundwater, may cause harm to the general public or the environment;

(ii) TMDL: The proposed site will, after development, discharge stormwater to a waterbody that is included on the most recent State of Colorado Department of Public Health and Environment §303(d) List of Water-Quality-Limited Segments Requiring TMDLs or for which a Total Maximum Daily Load (TMDL) is in place;

(iii) Wetlands: The proposed site will, after development, discharge stormwater to a delineated wetland or wetland buffer area as defined in Chapter 9-3, "Overlay Districts," B.R.C. 1981;

(iv) History: A history of flooding or drainage problems is known to exist in, or downstream of, the drainage basin where the site is located, whether documented or undocumented;

(v) Master Plan: A City-approved stormwater master plan indicates a need for more stringent regulation of stormwater in the watershed where the proposed project is located in order to avoid, or alleviate, any flood, drainage, or pollution problems; or

(vi) Exacerbate Problems: There is reason to believe that construction of the proposed project may further exacerbate existing flood or drainage problems.

(c) Evidence supporting the waiver pursuant to the criteria of this section shall be provided on forms provided by the Director. The Director may require additional documentation to support the waiver request.

(d) In granting a waiver, the Director may impose specific conditions on the approval of the waiver necessary to ensure that the criteria in this section are, and will remain, satisfied.

(C) Requirements

Applicable development sites are subject to the following requirements:

(1) **Stormwater Quality Design Standard Compliance:** Each drainage basin or collection of drainage basins (treatment area) associated with an applicable development site shall meet one of the following Stormwater Quality Design Standards:

(a) Runoff Reduction Standard: Control measures for post-construction stormwater quality (SCMs) are selected, designed, and constructed to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated Water Quality Capture Volume (WQCV) would be if all impervious area for the applicable development site discharged without infiltration.

None of the treatment area may be excluded when using the Runoff Reduction Standard.

(b) Water Quality Capture Volume Standard: SCMs are selected, designed, and constructed to provide treatment and/or infiltration of the runoff from the entire treatment area for the 80th percentile, 0.6-inch storm event. Evaluation of minimum drain time shall be based on the pollutant removal mechanism and functionality of the SCM(s) implemented. Consideration of drain time shall include maintaining vegetation necessary for operation of the SCM (e.g., wetland vegetation).

Up to 20 percent, not to exceed one acre, of the treatment area may be excluded when using the WQCV Standard if the Engineer demonstrates that it is not practicable to capture runoff or implement a separate SCM before runoff drains to an offsite discharge point.

(c) Pollutant Removal Standard: SCMs are selected, designed, and constructed to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 milligrams per liter (mg/L) or less from the entire treatment area for the 80th percentile, 0.6-inch storm event.

Up to 20 percent, not to exceed one acre, of the treatment area may be excluded when using the Pollutant Removal Standard if it is demonstrated that it is not practicable to capture runoff or implement a separate SCM before runoff drains to an offsite discharge point.

(d) Constrained Redevelopment Site Standard**:** Applicable development sites having an existing impervious area greater than 35 percent and a proposed impervious area greater than 75 percent that can demonstrate the above design standards cannot be practicably met shall meet one of the following standards:

(i) Constrained Runoff Reduction Standard: SCMs are selected, designed, and constructed to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 30 percent of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration.

(ii) Constrained WQCV Standard: SCMs are selected, designed, and constructed to provide treatment and/or infiltration of the runoff from at least 50 percent of the treatment area, including at least 50 percent of the impervious area, for the 80th percentile, 0.6-inch storm event. Evaluation of minimum drain time shall be based on the pollutant removal mechanism

and functionality of the SCM(s) implemented. Consideration of drain time shall include maintaining vegetation necessary for operation of the SCM (e.g., wetland vegetation).

(iii) Constrained Pollutant Removal Standard: SCMs are selected, designed, and constructed to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less for at least 50 percent of the treatment area, including at least 50 percent of the impervious area, for the 80th percentile, 0.6-inch storm event.

(2) **Required Treatment Approach:** The selection of a required treatment approach shall be determined considering site constraints and infiltration feasibility following the procedure established in Section 7.16 of these Standards.

(3) **Compliance Documentation Required:** The selected treatment approach and the rationale for such approach selection shall be documented on form(s) as provided by the Director. The form(s) and any supporting data, maps, charts, or calculations shall be provided as part of the Preliminary and Final Drainage Reports.

(4) **Pretreatment Required:** Pretreatment devices shall be provided for all SCMs to reduce the inflow of trash, debris, and coarse sediment into the SCM. Allowed forms of pretreatment are grass buffers, grass swales, forebays, and inlet sumps. The Director may approve other pretreatment controls if the Director finds the proposed design adequately reduces the inflow of trash, debris and coarse sediment into the SCM.

(5) **Irrigation Plan Required:** Provisions shall be made to provide water to vegetated SCMs after vegetation installation and in accordance with the Final Drainage Report and as needed to maintain the health of the vegetation. The owner of the SCMs shall be responsible to replace vegetation that is damaged, dead, or otherwise shows signs of poor health to ensure the proper operation of the control measure. The use of native plants in SCMs and other vegetated areas is strongly encouraged as such plants are best suited for local seasonal and climatic conditions.

(6) **Easement:** All SCMs shall be located in a public easement. The easement shall grant to the City at a no charge a permanent right to inspect, maintain, and reconstruct the SCMs. The easement shall be granted on a form provided by the Director. No owner of land or other applicant shall obtain a Final Drainage Plan, unless the owner first grants to the City the easement for all SCMs.

7.16 Post-Construction Stormwater Quality Treatment Approach

(A) Selection and Design of SCMs

The Engineer for an applicable development site shall apply the SCMs that best address pollutants of concerns and can be implemented on the development site. Infiltration of rainfall and stormwater using volume reduction/green infrastructure SCMs is the preferred treatment approach because it most closely mimics the natural hydrology of undeveloped land and reduces the volume of stormwater that is discharged into the stormwater utility system and to local streams. Therefore, non-structural LID techniques, Receiving Pervious Areas (RPAs), and infiltration-based SCMs shall be used to the degree practicable whenever it is determined that infiltration is feasible. In contrast, the removal of pollutants using underground SCMs is the least desirable treatment approach due to concerns about the practicality and effectiveness of long-term SCM maintenance and the ability of these designs to address pollutants of concern. As a result, the pollutant removal design standard is only allowed when all other treatment approaches have been demonstrated to not

be feasible.

This subsection summarizes the required procedure and supporting criteria for the selection and design of SCMs on applicable development sites, which are established in the following subsections of this section:

(1) **Preliminary Infiltration Feasibility Screening:** Site conditions shall be documented prior to SCM design to support selection of an appropriate water quality treatment approach.

(2) **Treatment Approach Selection:** Selection of an appropriate SCM shall be based on the feasibility of onsite infiltration. The required treatment approach is selected based on the hierarchy provided in Figure 7-1. The purpose of this hierarchy is to promote the use of infiltration using green infrastructure as the preferred approach to permanent stormwater quality management.

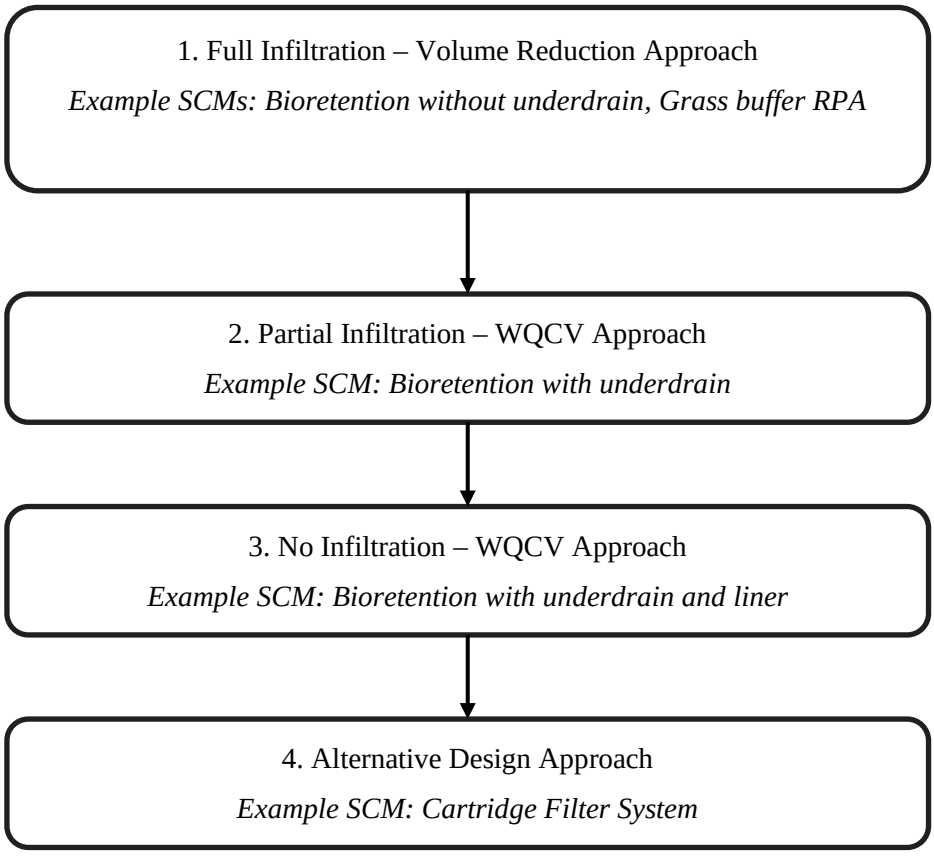


Figure 7-1: Water Quality Treatment Approach Hierarchy

(3) **Treatment Approach Design Criteria:** Upon selection of a treatment approach, the required design standard and criteria described in Subsection 7.16(D) of these Standards shall be followed to design and document SCM performance.

(4) **Soil and Infiltration Test Requirements:** The necessity of soil and infiltration testing is dependent on the treatment approach and SCM type. Subsection 7.16.(E) of these Standards explains soil and infiltration testing required to satisfy the Treatment Approach Design Criteria.

(B) Preliminary Infiltration Feasibility Screening

The Engineer shall investigate the site conditions to determine the treatment approach and the

Stormwater Quality Design Standards that will be applied to each treatment area. The preliminary infiltration feasibility screening shall be conducted as soon as possible in the design process. The preliminary infiltration feasibility screening does not require field infiltration testing, soil borings, and other detailed tests; however, if the full infiltration treatment approach is indicated to be feasible through this screening process, additional field testing may be required as described in Subsection 7.16(E) of these Standards. The preliminary infiltration feasibility screening shall meet the following requirements:

(1) Preliminary infiltration feasibility screening shall be conducted for each treatment area associated with the applicable development site prior to development of the Preliminary Drainage Report.

(2) The Engineer shall create hydrologic soil group (HSG) maps for each treatment area. Soil gradation assessments or field infiltration testing may be used to confirm HSG mapping or determine infiltration parameters for fill materials.

(3) The Engineer shall assess the following limitations to infiltration for each treatment area. If one of the following factors is determined to limit infiltration feasibility, documentation shall be provided with Preliminary and Final Drainage Reports:

   (a) Insufficient hydrologic storage capacity of the underlying soil attributable to shallow bedrock, hardpan layer, seasonal high-water table, or similar subsurface conditions. Underlying soil conditions are not a limitation for consideration of Unconnected Impervious Areas (UIA) to RPA.

   (b) The potential for groundwater contamination resulting from known or suspected soil contamination or from a proposed land use that is incompatible with the use of infiltration practices (e.g., a concrete batch plant or materials storage and loading site) or similar conditions.

   (c) Close proximity of SCM locations to drinking water wells or groundwater protection areas.

   (d) Limited or no suitable area for infiltration attributable to regulatory requirements for the proposed applicable development site, including building set-back or build-to requirements; location or area requirements for rights-of-way, parking, and driveways; floodplain regulations; or other state or local regulatory conditions.

   (e) Limited suitable area for infiltration attributable to the location of existing structures, pavement, utilities, or similar features that will remain; contractive or expansive soils in close proximity to buildings; or the location or extent of steep slopes, springs, seeps, wetlands, trees, or other natural features that will not or cannot be altered as a result of land development.

   (f) Close proximity to historical or archeological sites that could be damaged or otherwise negatively impacted by infiltration.

   (g) Flooding conditions that can be exacerbated by, or limit the function of, an infiltration-based SCM, including a history of frequent flooding at proposed SCM locations or a history of wet or flooded foundations, crawl spaces, or basements on or in close proximity to the applicable development site or its proposed SCM locations, and where these conditions will not be corrected by the proposed project.

(4) Infiltration feasibility screening results shall be documented in the Preliminary and Final Drainage Reports.

(C) Treatment Approach Selection

The treatment approach is the methodology that will be used to design a SCM, or collection of SCMs, to meet the required Stormwater Quality Design Standard. Four treatment approaches are described in Table 7-7, "Treatment Approach Selection Criteria," and correspond with criteria requirements presented in Subsection 7.16(D) of these Standards. A single SCM design approach shall be initially selected for each treatment area of the applicable development site using the results of the preliminary infiltration feasibility screening and the guidelines presented in Table 7-7, "Treatment Approach Selection Criteria." The selection of the treatment approach shall begin at the top of the table (with full infiltration) and proceed to the next level down if either the infiltration capacity or infiltration constraints criteria cannot be met. This process continues until both sets of criteria are met for the treatment area. One treatment approach shall be selected for each applicable treatment area.

The Full Infiltration – Volume Reduction approach has two categories depending on the type of SCM being evaluated in the drainage basin:

(1) **UIA to RPA:** This category is grass swales and grass buffers designed to infiltrate stormwater runoff via disconnection of impervious areas. Infiltration capacity for this category is dependent on identifying UIA:RPA pairs and confirming topsoil suitability.

(2) **Infiltration SCM:** This category is bioretention, sand filter, permeable pavement or other volume-based SCMs designed to retain runoff from the treatment area. Infiltration capacity for this category is dependent on confirming the infiltration rate of the underlying in-situ soil.

Table 7-7: Treatment Approach Selection Criteria

Treatment Approach	**Design Standard** Subsection 7.15(E)(1)	**Preliminary Infiltration Feasibility Screening** Subsection 7.16(B)	
		Infiltration Capacity	**Infiltration Constraints**
1. Full Infiltration - Volume Reduction **A. UIA to RPA** **B. Infiltration SCM** Subsection 7.16(D)(1)	Runoff Reduction	**A. UIA to RPA** UIA:RPA pairs have been identified and meet run-on ratio guidelines of USDCM, Volume 3, T-0 Volume Reduction. **B. Infiltration SCM** HSG A or B OR Field tests indicates infiltration rate is greater than one inch per hour.	Underlying soil, groundwater, and geological conditions have sufficient hydrologic capacity to infiltrate 60% of the WQCV. AND No other limitations to full infiltration are present in the treatment area.
2. Partial Infiltration - WQCV Subsection 7.16(D)(2)	WQCV	HSG C or D OR Field tests indicates infiltration rate is less than one inch per hour.	Underlying soil, groundwater, and geological conditions have sufficient hydrologic capacity to support infiltration of a portion of the WQCV. AND No other limitations to partial infiltration are present in the treatment area.
3. No Infiltration - WQCV Subsection 7.16(D)(3)	WQCV	N/A	Underlying soil, groundwater, and geological conditions prevent infiltration and require a lined system.
4. Alternative Design Subsection 7.16(D)(4)	Pollutant Removal OR Constrained Redevelopment Site	N/A	Physical site constraints or risk factors prevent the use of Treatment Approaches 1, 2, and 3 AND Alternative approach must be approved by the Director.

(D) Treatment Approach Design Criteria

The Engineer shall design the SCMs of the selected treatment approach consistent with the requirements of this subsection. Specific types of SCMs are not prescribed for the individual approaches. Any applicable SCM may be used, provided it meets the treatment approach requirements stated herein. In addition to these requirements, SCM designs shall follow the guidance provided in USDCM, Volume 3.

For any of the treatment approaches, a treatment train using a series of SCMs may be used to meet the Stormwater Quality Design Standard for a given treatment area. The series of SCMs must adhere to the requirements of the treatment approach selected for the treatment area and must ultimately, as a group of SCMs, meet the Stormwater Quality Design Standard associated with the treatment approach.

(1) **Full Infiltration – Volume Reduction Approach:** Full Infiltration is the preferred treatment approach and is required where feasible. Full infiltration designs retain stormwater onsite through the use of RPAs or infiltration SCMs that do not have underdrains. Plugged or capped underdrains may be specified. The following criteria are applicable to full infiltration SCM designs:

(a) Runoff Reduction Design Standard: Treatment areas using the Full Infiltration – Volume Reduction Approach shall meet, at a minimum, the requirements of the Runoff Reduction Design Standard of Subsection 7.15(C)(1)(a) of these Standards.

(b) Required Sizing Criteria: Preliminary and Final Drainage Reports must document sizing criteria and achieved volume reduction for each SCM following methods specified in USDCM, Volume 3. SCMs must be sized for the full tributary area.

(i) UIA to RPAs must comply with run-on ratio, topsoil suitability, and other related criteria as specified in USDCM, Volume 3, T-0 Volume Reduction.

(ii) Full infiltration SCMs with a storage component must comply with surface (filter) area, geometry, and drain time requirements as specified in the USDCM, Volume 3 for the appropriate SCM type.

(c) Field Infiltration Tests: Field infiltration tests are mandatory for full infiltration SCM designs following the standards in Subsection 7.16(E) of these Standards. Field infiltration test results must be documented in the Preliminary and Final Drainage Reports.

(d) Minimum Field Infiltration Rate: Full infiltration SCMs require a field infiltration rate measurement equal to one inch per hour or greater. If field infiltration rates are measured to be less than one inch per hour, a partial infiltration/WQCV approach shall be used consistent with the standards in Subsection 7.16(D)(2) of these Standards.

(e) Required Design Factor of Safety: Full infiltration SCMs shall utilize a minimum factor of safety of 2 when using the field-measured infiltration rate in drawdown time calculations.

(2) **Partial Infiltration – WQCV Approach:** This category of SCMs retains stormwater

on site to the extent practical by using underdrains or rate-controlled outlet structures. RPAs may be used as part of a treatment train to partial infiltration SCMs. The following criteria are applicable to partial infiltration designs:

(a) WQCV Design Standard: Treatment areas using the Partial Infiltration – WQCV Approach shall meet, at a minimum, the requirements of the WQCV Design Standard in Subsection 7.15(C)(1)(b) of these Standards.

(b) Required Sizing Criteria; Preliminary and Final Drainage Reports must document sizing criteria and achieved runoff volume capture for each SCM following the methods specified in the USDCM, Volume 3. SCMs must be sized for the full tributary area.

(i) UIA to RPAs must comply with run-on ratio, topsoil suitability, and other related criteria as specified in USDCM, Volume 3, T-0 Volume Reduction.

(ii) Partial infiltration SCMs must comply with surface (filter) area, geometry, and drain time requirements as specified in USDCM, Volume 3 for the appropriate SCM type. The use of underdrains or rate-controlled outlet structures are required components of partial infiltration designs.

(c) Field Infiltration Tests: The following field infiltration test requirements are applicable to Partial Infiltration – WQCV designs:

(i) For UIA-to-RPAs, topsoil suitability must be shown with a soil graduation test as specified in Subsection 7.16(E) of these Standards.

(ii) For partial infiltration SCMs with underdrain or rate-controlled outlet, a field infiltration test is not required except when expressly requested by the Director due to a unique design configuration.

(3) **No Infiltration – WQCV Approach:** No infiltration SCMs are lined systems required by the necessity to prevent infiltration due to underlying soil conditions, high groundwater table, or an otherwise immitigable risk as identified during the preliminary Infiltration feasibility screening. The following criteria apply to no infiltration designs:

(a) WQCV Design Standard: Treatment areas using the No Infiltration – WQCV Approach shall meet, at a minimum, the requirements of the WQCV Design Standard in Subsection 7.15(C)(1)(b) of these Standards.

(b) Required Sizing Criteria: Preliminary and Final Drainage Reports must document sizing criteria and achieved runoff volume capture for each SCM following methods specified in USDCM, Volume 3. SCMs must be sized for the full tributary area. No infiltration SCMs must adhere to and document compliance with surface (filter) area, geometry, and drain time requirements as specified in USDCM, Volume 3 for the appropriate SCM type.

(c) Field Infiltration Tests: Field infiltration tests are not required for no infiltration SCMs. Proof of a watertight liner may be requested at the time of installation by the Director based on necessity for risk mitigation.

(4) **Alternative Design Approach:** The Director may approve an alternative design approach only if the Engineer demonstrates in the Preliminary Drainage Report or a letter to the Director that none of the above three treatment approaches are feasible. The Preliminary Drainage Report or letter shall explain the alternative design approach. The

following criteria are applicable to alternative designs:

(a) Pollutant Removal or Constrained Redevelopment Site Standard. Alternative designs shall meet one of the following:

(i) Pollutant Removal Standard in Subsection 7.15(C)(1)(c) of these Standards,

(ii) Constrained Runoff Reduction Standard in Subsection 7.15(C)(1)(d)(i) of these Standards,

(iii) Constrained WQCV Standard in Subsection 7.15(C)(1)(d)(ii) of these Standards, or

(iv) Constrained Pollutant Removal Standard in Subsection 7.15(C)(1)(d)(iii) of these Standards.

(b) Required Sizing Criteria: Preliminary and Final Drainage Reports must document sizing criteria and applicable performance metrics for each SCM following methods specified in USDCM, Volume 3.

(i) For pollutant Removal or Constrained Pollutant Removal Standard designs, the Engineer shall submit TSS reduction metrics applicable to the proposed design. The use and reference of third-party testing data is required when proposing the use of a proprietary device.

(ii) Constrained Runoff Reduction Standard designs shall adhere to sizing criteria specified in Subsection 7.16(D)(1) of these Standards.

(iii) Constrained WQCV Standard designs shall adhere to sizing criteria specified in Subsection 7.16(D)(2) of these Standards.

(c) Field Infiltration Tests: The following field infiltration test requirements apply to alternative design approaches:

(i) Field infiltration tests are not required when using the pollutant removal or constrained site pollutant removal standard.

(ii) Constrained Runoff Reduction Standard designs shall adhere to field infiltration requirements specified in Subsection 7.16(D)(1) of these Standards.

(iii) Constrained WQCV Standard designs shall adhere to field infiltration requirements specified in Subsection 7.16(D)(2) of these Standards.

(E) Soil and Infiltration Test Requirements

Requirements for field infiltration testing depend on treatment approach and SCM type as detailed in Subsection 7.16(D) of these Standards. Field infiltration tests are required for all full infiltration SCMs with a storage component. For all UIA to RPA areas, the Engineer must show topsoil suitability with a soil gradation test. When preliminary infiltration feasibility screenings indicate C or D soils, field infiltration testing is optional to explore feasibility of a full infiltration design. Documentation of field infiltration test results must be submitted in Preliminary and Final Drainage Reports.

(1) **UIA to RPA Soil Test Requirement:** For all UIA to RPA areas, regardless of HSG, onsite topsoil sampling and testing must be conducted to confirm infiltration capacity.

Determination of HSG classification based on soil texture analysis shall follow specifications provided in USDCM, Volume 3, T-0 Volume Reduction. At least one soil gradation test shall be conducted for each proposed RPA. Proposed topsoil and soil amendment additions shall follow criteria specified in Chapter 10 of these Standards.

(a) Post-Construction Soil Tests: Depending on site conditions, the Director may require soil tests to confirm infiltration capacity and adequacy of soil chemistry to support vegetation growth for RPAs after construction is complete. When required, soil test results shall be provided with the submission of as-built drawings.

(2) **Full Infiltration SCM Field Test Requirements:** The following criteria apply to all full infiltration SCMs with a storage component using the Full Infiltration – Volume Reduction Approach of Subsection 7.16(D)(1) of these Standards:

(a) Soil Borings: Soil borings aid in interpretation of infiltration test results by providing information on groundwater conditions and soil stratification. Therefore, each infiltration test shall be accompanied by a soil boring test to a depth of 10 feet below the lowest planned infiltration elevation (the bottom of the infiltrating SCM). Soil borings performed for a civil site geotechnical analysis that are located within close proximity (less than 50 feet) to the footprint of the SCM may be used. An interpretation of soil boring test results with respect to infiltration shall be provided for each test. This description shall include an assessment of the anticipated seasonal high-water table based on date of soil boring with respect to rainfall patterns, and the presence of hydric soils, redoximorphic features, or other indicator of water table variation.

(b) Allowed Test Methods: Field infiltration tests shall utilize a double-ring infiltrometer or modified Philip Dunne infiltrometer following the specifications of ASTM D3385 or ASTM 8152, respectively. Alternative infiltration test methods may only be used with approval by the Director. The use of correlation methods based on soil texture applies only to RPA designs using the T-0 factsheet of USDCM, Volume 3. The use of regional soil maps is prohibited for infiltration design or verification purposes.

(c) Number of Tests Required: At least three infiltration tests shall be conducted for every SCM using the test spacing criteria established below. The Director may require additional tests for large SCMs, greater than 10,000 square feet, or when unique soil or geological conditions are known or suspected at the site.

(i) Generally, one infiltration test shall be conducted for every 3,000 to 10,000 square feet of area, depending upon the size of the SCM. Tests shall be spaced appropriately to provide sufficient infiltration rate information across the length and width of the SCM.

(ii) For small SCMs, at least one test shall be located within the SCM's footprint. The additional tests can be performed outside the footprint but must be located within 20 feet of the perimeter of the SCM and in soil formations that are representative of the conditions within the footprint of the SCM.

(iii) For SCMs that have an area greater than 10,000 square feet, one infiltration test shall be conducted for every additional 10,000 square feet

of surface area up to a maximum of five infiltration tests.

(d) Test Elevation: The elevation of infiltration tests shall be at or below the bottom (lowest planned infiltration elevation) of the SCM. SCMs that are designed for full infiltration shall not be placed on fill material without prior infiltration tests to confirm full infiltration design feasibility.

(e) Post-Construction Field Infiltration Tests: The Director may require field infiltration tests to confirm infiltration rates after construction is complete if soil compaction or clogging is known or suspected during construction. When required field infiltration test information shall be provided with the submission of as-built drawings.

(f) Drainage Report Requirements: The Preliminary and Final Drainage Report shall include the following information for each infiltration test performed.

(i) Test location and elevation;

(ii) Test method used;

(iii) Location of soil boring(s) used to aid test interpretation; and

(iv) Soil boring results and how they were used.

7.17 Post-Construction Stormwater Approval Requirements

(A) General

(1) Applicable development sites shall receive post-construction approval of the stormwater utility system by the Director prior to the issuance of a Certificate of Occupancy pursuant to a building permit or a Certificate of Completion for a use established pursuant to a development agreement under Chapter 9-2, "Review Processes," B.R.C. 1981. The Director will base approval on the system's conformance with the approved Final Drainage Report, the requirements of this section, and its readiness for post-construction operation.

(2) Post-construction approval of the stormwater utility system shall be granted if the following criteria are met:

(a) The stormwater as-built drawing provided for the applicable development site demonstrates conformance of the constructed stormwater utility system with the approved Final Drainage Report and readiness for full post-construction operation, and

(b) The site's stormwater utility system and all associated SCMs are determined, based on visual inspection by the Director, to be clean; free of sediment, debris, and other obstructions; undamaged; and ready for full post-construction operation.

If these criteria are not met, the Director may require the preparation, submittal, and approval of a revised Final Drainage Report and/or corrective actions at the applicable development site before granting post-construction approval. Corrective actions may include cleaning or repair of the stormwater utility system, SCMs, or detention ponds, including, but not limited to, the removal of sediment, debris, or other obstructions; the removal of construction-related

wastes or stockpiles; the installation of permanent slope stabilization or energy dissipation measures; the removal, replacement, or installation of vegetation; and soil amendment or soil media replacement in infiltration-based SCMs.

(3) Post-construction approval of the stormwater utility system by the Director indicates that the system was constructed in conformance with City requirements, is currently operating as expected, and stormwater as-built drawings have been approved. Approval also means that the system must comply with the requirements for post-construction inspection and maintenance established in Section 7.18 of these Standards and Chapter 11-5, "Stormwater and Flood Management Utility," B.R.C. 1981.

(4) In no way does post-construction approval imply City ownership, maintenance, operation, or any other liability for any accepted, privately-owned, stormwater utility system, SCM, or detention pond.

(B) Stormwater As-Built Drawings

The preparation of stormwater as-built drawings is required for all applicable development sites to document the as-constructed condition of SCMs. The as-built drawings shall indicate where the as-constructed condition differs from the final approved technical drawings following the provisions of Subsection 1.3(G) of these Standards. An engineering certification of elevations shall be included as an attachment to the stormwater as-built drawings.

The figures and drawings depicting the items listed below shall be included with the as-built requirements in Chapter 1 of these Standards to provide a reference for the information provided in the Final Drainage Report. Specific as-built drawings pertaining exclusively to the conditions of the SCM are required and shall depict both plan and profile views as described below:

(1) **Plan Drawing/s:** Illustrate and label in plan view the components of the SCM, including inlet and outlet locations, embankments, treatment surface area, utility easements, vegetated cover, and other critical drainage elements. Indicate where the as-constructed conditions differ from the final approved technical drawings.

(2) **Profile Drawing/s:** Illustrate and label in profile view the elevations of SCM components, including filter media depth, bottom elevation, embankment slopes, inlet/outlet inverts, and other critical drainage components. Indicate where the as-constructed conditions differ from the final approved technical drawings.

(C) Post-Construction Acceptance Inspection Required

(1) Each SCM must pass a post-construction inspection by the Director to confirm SCMs, including RPAs, are clean, have established vegetation, and are fully operational in keeping with their approved design. After these conditions are met, the SCM is considered fully functional and subject to Section 7.18 of these Standards.

(2) The post-construction acceptance inspection shall occur after submittal of the complete as-built drawings to the Director. No application for inspection is required, as submittal of the stormwater as-built drawings will signify the project's readiness for inspection. An inspection will not be performed in the event of submittal of incomplete drawings. Confirmation of information on the stormwater as-built drawings will also be included in the inspection.

(D) Vegetation Warranty Required

The Director may require a financial guarantee for vegetation installed within SCMs consistent with the requirements of Subsection 11-5-6, "Stormwater Quality Management for Land Development," B.R.C. 1981. The financial guarantee may be held for up to three years and will be released after an inspection confirms the vegetation within each SCM is in good health.

7.18 Post-Construction Stormwater Quality Inspection and Maintenance Requirements

(A) Applicability

The owner of SCMs of an applicable development site shall protect, inspect, maintain, repair, and reconstruct SCMs and associated drainage infrastructure on the property to ensure full, functional operation in accordance with the requirements in this section and pursuant to Chapter 11-5, "Stormwater and Flood Management Utility," B.R.C. 1981.

(B) Inspection and Maintenance Requirements for SCMs

(1) **Inspection and Maintenance Required:** The owner of SCMs shall inspect and maintain the SCMs as is necessary to ensure their full, functional operation at all times.

(2) **Inspection Frequency:** The owner of SCMs shall be responsible to inspect the SCMs as often as necessary to assess the need for maintenance. The optimum inspection frequency for SCMs varies depending on a number of factors including, but not limited to, the type of SCM, whether the SCM is vegetated, and activities that have occurred in the area draining to the SCM. SCMs shall be visually inspected:

(a) After storms and snow melt to assess whether stormwater in the SCM is draining as expected, and

(b) During property landscape maintenance activities to look for build-up or blockages of trash, debris, or sediment; check for damage; and determine current maintenance needs.

Documentation of these inspections is not required. However, the owner of SCMs shall document a detailed visual inspection of their SCM(s) in accordance with the frequencies defined in Table 7-8, "Required Inspection Frequency by SCM Type." The documented inspection shall be performed between May and August, when vegetation is not dormant and snow does not cover the SCM.

Table 7-8: Required Inspection Frequency by SCM Type

SCM Type	Documented Inspection Frequency
Bioretention (Rain Garden) Constructed Wetland Channel Constructed Wetland Pond Extended Detention Pond Grass Buffer Grass Swale Permeable Pavement Receiving Pervious Area (RPA) Retention Pond Sand Filter Other SCM Designs	Annually
Underground SCMs	Every 3 months

(3) **Inspection Documentation:** Inspections shall be documented using form(s) provided by the Director and located in the Inspection and Maintenance Guide for the SCMs in an appendix to the Final Drainage Report. Inspection documentation shall be kept by the owner of SCMs or their delegated representative for five years and shall be made available by the owner of SCMs or their delegated representative to the Director immediately upon request.

(4) **Performed Maintenance:** Routine maintenance shall be performed to ensure that SCMs are functioning as designed. Corrective action shall be performed immediately when an inspection indicates the need for maintenance. Routine maintenance varies by SCM type but generally requires the regular removal of trash and debris (e.g., dead leaves, sticks, tree limbs) from inflow, outflow, and water storage areas; removal of sediment at inflows; repair of eroded areas; and general vegetation maintenance (if vegetation is part of the SCM).

(5) **Transitional Regulations:** For any permanent stormwater quality facilities approved under the City of Boulder Design and Construction Standards in effect prior to the effective date of Ordinance 8324, the property owner shall be responsible for maintaining the stormwater quality facilities. The stormwater quality facilities shall be maintained as recommended in the USDCM and such that the design of the properties of the facility are preserved.

(C) Inspection and Maintenance Guide

An Inspection and Maintenance Guide shall be submitted as an appendix to the Preliminary and

Final Drainage Report. This guide shall be provided by the Engineer to the owner of SCMs upon completion of construction and signifies transfer of maintenance responsibilities from the erosion control permittee to the owner of the SCMs. The Inspection and Maintenance Guide shall provide inspection and maintenance guidelines specific to the SCM type and shall follow the format provided by the Director.

CHAPTER 8
TRANSPORTATION STANDARDS

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8.01 Adoption of the Colorado Department of Transportation (CDOT) Specifications with Modifications

The current edition of the "Colorado Department of Transportation Standard Specifications for Road and Bridge Construction" is hereby adopted by reference in these Standards as the City of Boulder transportation construction standards, except as specifically amended by the provisions of this chapter.

(A) Section 401, Plant Mix Pavements - General

(1) **Subsection 401.02, "Composition of Mixtures,"** is amended to incorporate the following additions:

(a) A job-mix formula shall be submitted to the Director of Public Works for approval prior to placing any hot bituminous pavement. The formula shall indicate the aggregate gradation, asphalt cement content, hydrated lime content, and optimum density. If requested by the Director, a sample of the aggregate and asphalt cement shall be submitted for approval (for test purposes) prior to placing any hot bituminous pavement.

(b) The job-mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate, and a single temperature for the mixture at the discharge point of the plant.

(c) When submitting the job-mix formula, the contractor shall supply certified test results on all asphalt cements, aggregates, and mixes used for hot bituminous pavement, and certify that all materials meet or exceed all required specifications and tests.

(d) The Director reserves the right to sample materials and mixtures throughout project construction to determine whether specifications and requirements have been met and to confirm the certified test results. The contractor is responsible for providing a bituminous mixture that meets the job formula and specifications.

(e) The contractor shall be responsible for providing adequate field testing of materials used on the project and providing copies of the test results to the City to assure compliance with these specifications.

(f) The top layer of hot bituminous pavement shall not contain any reclaimed asphalt material, unless approved by the Director.

(2) **Subsection 401.11, "Tack Coat,"** is amended to incorporate the following additions:

(a) A tack coat shall be evenly applied to all existing asphalt or concrete surfaces that will be in contact with asphalt prior to hot bituminous pavement placement. A slow-setting, diluted emulsion shall be used, diluted with one part water to one part asphalt emulsion. The rate of application shall be 0.1 gallons per square yard of diluted asphalt emulsion. Before dilution, the emulsified asphalt shall comply with AASHTO M140 or M208.

(b) Only the amount of tack coat necessary for the day's operation is to be placed on the surface. All traffic not essential to the work shall be kept off the tack coat.

(3) **Subsection 401.12, "Surface Conditioning,"** is amended to incorporate the following addition: All vegetation shall be removed from any existing surface to be overlaid.

(4) **Subsection 401.16, "Spreading and Finishing,"** is amended to incorporate the following additions:

(a) The bituminous mixture shall be placed with an asphalt paver if possible. The contractor shall receive permission from the Director to use placement methods other than a paver. The lift thickness shall be at least twice the maximum particle size for the hot bituminous pavement mix. The maximum lift thickness for the final lift shall be 2 inches, unless otherwise approved by the Director.

(b) Areas to be patched shall be excavated and squared to a neat line, leaving the sides of the excavation vertical. Prior to placement of the patch, the exposed sides of the existing pavement shall be thoroughly coated with slow-setting Emulsified Asphalt. Hot bituminous pavement shall then be placed and compacted in succeeding layers; no layer shall be more than 3 inches deep.

(B) Section 403, Hot Bituminous Pavement

(1) **Subsection 403.02, "Materials,"** is amended to incorporate the following additions:

(a) Design mixes shall be established using the Marshall Method of compaction. The method will be applied based on street classification according to Table 8-1, "Marshall Method by Street Classification."

Table 8-1: Marshall Method by Street Classification

Design Method	Laboratory Compaction	Street Classification
Marshall Method, ASTM D 1559 Asphalt Institute MS-2	50 blows per side	Local, Collector, and Minor Arterial (ESAL < 1 million)
Marshall Method, ASTM D 1559 Asphalt Institute MS-2	75 blows per side	Major Arterial (ESAL < 1 million)

(b) The design mix for hot bituminous pavement shall conform to Table 8-2, "Hot Bituminous Pavement Design Mix," and Table 8-3, "Minimum Voids in the Mineral Aggregate (VMA)."

(c) The addition of any recycled material is subject to approval by the Director prior to use in any asphalt mix. All mixes including recycled material shall meet all standard specifications and contain no more than 10% recycled material.

(d) Hot bituminous pavement for patching shall be Grading C with AC-10 asphalt cement.

(e) A minimum of one percent hydrated lime by weight of the combined aggregate shall be added to all aggregate for hot bituminous pavement.

Table 8-2: Hot Bituminous Pavement Design Mix

Property	Test Method	Value
Voids, Percent	MS-2; AASHTO T269	3-5
Stability, Minimum	MS-2; AASHTO T245	1800
Flow (0.01")	MS-2: AASHTO T245	8-16
Aggregate retained on the No. 4 Sieve with at least two Fractured Faces % Min.	CP-45	70
Accelerated Moisture Susceptibility Tensile Strength Ratio (Lottman) Min.	AASHTO T283	80
Minimum Dry Split Tensile Strength, PSI	AASHTO T283	30
Voids in Mineral Aggregate, VMA, % Min.	MS-2	See Table 8.01-3
Grade of Asphalt Cement		AC-10

Table 8-3: Minimum Voids in the Mineral Aggregate (VMA)

Nominal Maximum Size*, Inches (mm)**	Design Air Voids **		
	3.0%	4.0%	5.0%
1 ½ (37.5)	11	12	13
1 (25.0)	12	13	14
¾ (19.0)	13	14	15
½ (12.5)	14	15	16
3/8 (9.5)	15	16	17

* The Nominal Maximum Size is defined as one sieve larger than the first sieve to retain more than 10%.
** Interpolate specified VMA values for design air voids between those listed.

(C) Section 608, Sidewalks and Multi-Use Paths

(1) Subsection 608.03(e), "Joints," is amended to incorporate the following additions:

All jointing of bikepath, bikeway, and bike trail concrete pavement shall be saw cut at the nearest contraction joint and shall be removed and replaced full width. No partial removal and replacement will be allowed. No longitudinal joints will be allowed in either sidewalk or bikepath concrete pavements.

(D) Section 610, Median Cover Material

(1) **Subsection 610.02, "Materials,"** is amended to incorporate the following additions:

Patterned concrete shall be colored concrete and meet the requirements of Section 601 with the following exceptions:

Field Compressive Strength (28 days), psi (Not a specification requirement)	4500
Cement Content, lbs./cu. Yd., minimum	610
Max. Water/cement ratio lbs. Water/lbs. Cement	0.44
Entrained and Entrapped Air, percent	4 - 8
Slump, AASHTO T 119, inches	2 – 5
Coarse Aggregate, AASHTO M43	Size No. 8
Fine Aggregate, AASHTO M6, percent of total aggregate	50 - 78

(2) An approved water reducing admixture shall be used in the mix.

(a) The coloring agent shall be integral to the concrete mixture.

(b) The color and pattern shall be as defined in the plans as approved by the City.

(c) Colored wax curing membrane shall be as recommended by the supplier of the coloring agent.

(3) **Subsection 610.03, "Construction Requirements,"** is amended to incorporate the following additions: Patterned concrete may be used for median cover material. Construction shall conform to the requirements of CDOT Subsection 608.03 with the following exceptions:

(a) While the concrete is still plastic, a special pattern forming tool shall be applied to the concrete surface to form the specified pattern. All tears and voids resulting from the pattern forming shall be repaired.

(b) Curing shall include application of two coats of colored wax curing membrane. The first coat shall be applied within 2 hours of finishing. The second coat shall be applied between 10 and 20 days following the first application.

(E) Section 703, Aggregates

Subsection 703.04, "Aggregate for Hot Plant Mix Bituminous Pavement," paragraph 3 is deleted and replaced with the following revision:

(1) The aggregate from individual sources shall have a percentage of wear of not more than 40 when tested in accordance with AASHTO T96 after 500 revolutions. The aggregate from individual sources shall contain no more than a 1 percent deleterious material including clay lumps, vegetable matter, friable particles, and other deleterious substances tested in accordance with AASHTO T112.

(2) For quarries or sources which contain minerals which are not of similar composition, the abrasion and friable particle requirements shall be applied to each mineral composition.

(3) All aggregate shall meet the sodium or magnesium sulfate test in accordance with AASHTO M29.

Subsection 703.05, "Aggregate for Cover Coat Material", is incorporated for the purpose of

Narrow Trenching, and any other uses determined by the Director.

(F) Section 612, Delineators and Reflectors

Subsection 612.02, "Materials," is amended to incorporate the following additions: All delineators shall be "safe hit" reflective delineators and shall be anchored according to manufacturer's recommendations.

(G) Section 614, Traffic Control Devices

(1) **Subsection 614.02, "Sign Posts and Sign Structures,"** is amended to incorporate the following additions:

(a) All signs must be mounted on "TELESPAR" posts or approved equal. These installations shall be per manufacturer's recommendations and be constructed in two sections including the base and the post.

(b) The post size shall conform to manufacturers recommendations according to the total sign area square footage and wind loading, but in no instance shall post size be less than 2" square, 12 gauge material, affixed to base by means of two (each) drive rivets with washers on the back side of post and right or left side of post, at a length to accommodate the proper mounting height of sign to be affixed per the MUTCD.

(c) The "TELESPAR" sign base shall be 2 ¼ x 36 inches in length and shall be driven into the ground 33 to 34 inches with 2 to 3 inches exposed above final grade.

(d) Sign Bolts: Sign shall be affixed to post with a minimum of two (each) 5/16 x 2-¾ inch bolts with locking nut and vandal proof (Gator Lock or approved equal) hardware on each side (front/back) with nylon washer or equivalent behind the Gator lock on the sheeting side.

(e) Banded Sign Mount: All banding material shall be ¾ inch wide stainless Steel banding. Hardware for installation of signs less than 30" attached to a signal/light pole shall consist of a buckle bracket. For 30"or greater signs, Sign Fix is required to be mounted on the sign and a slider bracket to affix sign to the banding.

(f) Other Sign Mounts: Utility wood poles can be used when the location is appropriate for signs with prior approval from the Director. The mounting hardware shall be lag bolts with washers, with nylon washer or equivalent against the sheeting side.

(g) Cantilever Mount: Cantilever mounts shall be approved by the Director prior to being used.

(h) CDOT Breakaway Post System: Signs placed in rights-of-way under the jurisdiction of CDOT shall provide a breakaway system in accordance with

CDOT standards (M & S Standards section S-614-5).

(2) **Subsection 614.04, "Sign Panels,"** is amended to incorporate the following additions:

(a) All reflective sheeting shall be ASTM D 4956-04 Type XI Diamond Grade Cubed (DG3) or equivalent approved by the Director.

(b) All sign blanks shall be constructed using 0.100 gauge aluminum material.

(c) All public street name signs shall be constructed using extruded aluminum alloy 6063-T6, or approved equal, with 0.091 inch thick web, 0.250 inch thick edges, and square corners. All non-extruded signs shall be mounted on 0.100 gage aluminum with rounded radius corners. All public street name signs shall be constructed using reflective sheeting stated above and have a blue background with white lettering.

(H) Section 627, Pavement Marking

Subsection 627.03, "General," is amended to incorporate the following additions:

(1) White and yellow skip markings shall be 4 inches wide and 10 feet long with a 30 foot gap between.

(2) All crosswalk lines shall be applied longitudinally, and shall be 24 inches wide by 10 feet long.

(3) On concrete surfaces all curing compound shall be removed prior to the installation of any pavement marking.

(4) Maintenance Striping

(a) All lane, center, and channelizing lines shall be striped with epoxy pavement markings at 15 mm thickness with glass beads.

(b) All crosswalk lines installed on asphalt surfaces shall be provided using pre-formed plastic pavement markings 3M A270 E/S series tape. On concrete surfaces, an equivalent pre-form thermoplastic marking can be used if approved by the Director.

(b) All lane use arrows on concrete surfaces shall be Premark Brand Elongated Series Contrast Arrows.

(c) All lane use arrows on Asphalt Surfaces shall be pre-formed plastic pavement markings, 3M Elongated L270 ES Series.

(d) Adherence to manufacturer's installation recommendations (method) is required.

(5) New Striping

(a) Approval of final lay-out is required prior to placement of pavement markings

(b) On concrete surfaces all curing compound shall be removed prior to the installation of any pavement markings.

(c) Adherence to manufacturer's installation recommendations is required.

(d) All lane use arrows on concrete surfaces shall be Premark Brand Elongated Series Contrast Arrows.

(e) All lane use arrows on Asphalt Surfaces shall be pre-formed plastic pavement markings, 3M Elongated L270 ES Series.

(I) Section 713, Traffic Control Materials

(1) **Subsection 713.04, "Sign Panel Backgrounds,"** is amended to incorporate the following addition: Aluminum sign panels may also have a Class II (A-1) anodic coating clear finish as defined in the "Aluminum Association Standards for Anodically Coated Aluminum Alloys for Architectural Applications."

(2) **Subsection 713.06, "Messages,"** is amended to incorporate the following additions:

(a) All street name signs on non-signalized intersections shall be 9 inches wide with 6 inch, upper-case, series D capital letters, together with 4 ¾ inch, lower-case, series D letters for the name of the street, and a 3 inch, upper-case, series D capital letter together with 2 ¼ inch, lower- case, series D letters for "Avenue," "Street," 3 inch block numbers below the abbreviation of "Ave.," "St.," etc. The "Ave" etc. and block numbers shall be centered on the sign with a 1 inch separation between them. When block numbers are not used, "Ave", "St", "Rd", etc. shall be 6 inch upper case with 4 /4 inch lower case letters series D. On numbered streets, a 6 inch, series D number shall be used with 4 ¾ inch, lower-case, series D letters for "th", "st" and "nd" to be held in line with the number that it follows.

(b) All reflective sheeting for street name sign faces shall be Type XI 3M - Diamond Grade Cubed sheeting or approved equal.

(3) **Subsection 713.08, "Glass Beads for Traffic Markings,"** is amended to incorporate the following addition: Glass beads shall be applied on Epoxy Pavement Markings Lane Lines at a rate of 15 to 18 pounds per gallon.

(4) **Subsection 713.13**, "Preformed Plastic Materials," is amended to incorporate the following additions:

(a) Preformed Plastic: material shall be 3M Stamark Series A270 ES for all transverse & longitudinal lines. All lane use symbols shall be 3M Stamark Series L270 ES.

(b) Preformed Plastic: (New Concrete Application) "white only" material shall be 3M Stamark Series A380I-5 ES (contrast) for all longitudinal skip lines or channelizing lines.

(5) **Subsection 713.14**, "Preformed Thermoplastic Material," is amended to incorporate the following additions:

(a) Preformed Thermoplastic; Materials shall be alkyd based materials for transverse & longitudinal lines, or approved equivalent.

(b) All materials shall be 90 mm thick with beads. Only preformed thermoplastic marking material listed on CDOT's approved products list may be used.

(6) **Subsection 713.19,** Methyl Methacrylate Pavement Marking,"
Methyl Methacrylate material shall be approved by the Director prior to being used on transportation facilities in the public right-of-way.

(J) Section 408, Joint and Crack Sealant

(1) **Subsection 408.02, "Materials,"** is amended to incorporate the following addition: Use of Mastic One or equivalent materials, for Narrow Trenching restoration, shall be listed on the CDOT approved products list. The contractor shall provide to the city, material certifications and manufacturer's instructions for heating and application prior to use.

8.02 Traffic Signals

All traffic signal design and construction shall be performed in accordance with the Section 2-2-11, "Traffic Engineering," B.R.C. 1981 and these Standards.

8.03 Traffic Signs and Markings

(A) Required

The applicant shall be responsible for the installation of all traffic control devices, street name signs, and pavement markings prior to opening or reopening any public transportation facility.

(B) Signing and Striping Plan

A complete signing and striping plan shall be submitted as part of project or development construction plans, to be approved by the Director prior to installation. The plan shall specify the locations, types, and combinations of approved signs, pavement markings, and barricades required for each project or development.

(C) Conformance with MUTCD

All signs, sign materials, and barricade warning lights shall conform to the standards set forth in the current edition of the "Manual on Uniform Traffic Control Devices (MUTCD)", and these Standards.

(D) Materials

The quality of material used in traffic signs, type and quality of all vandal-proof sign hardware, and quality of all metal square sign posts shall be in conformance with these Standards, subject to approval by the Director.

(E) Private Street Signs

Private streets shall be signed as such and shall include the message "NO CITY MAINTENANCE", and be installed on the same support as the street name sign. Any private street name signs should be fabricated and installed according to the specifications for a public right-of-way street name sign except that the sign shall have white lettering on a green background.

8.04 Temporary Traffic Control Plan

(A) Required

The Director of Public Works may require a Temporary Traffic Control (TTC) Plan for any work that impacts a public right-of-way or easement.

(B) Intent

The purpose of this section is to establish standards and methods for handling traffic to be applied when work or work activity in the public right-of-way or public easements impedes or obstructs any mode of transportation, including but not limited to pedestrian, bicycle, transit, or vehicular traffic. These standards are intended to ensure safe and effective work areas, and warn, control, protect, and accommodate all modes of transportation.

(C) Transportation Master Plan

All temporary traffic control plans shall comply with the goals, policies, and standards adopted in the Transportation Master Plan (TMP).

(D) Objectives

Primary objectives of a TTC plan are as follows:

(1) Prevent accidents and injury for both the public and for workers, by providing a safe work area;
(2) Prevent damage to public and private property, including damage to vehicles and construction equipment;
(3) Ensure well defined and safe traffic movements through work areas and temporary traffic control zones;
(4) Efficiently and equitably accommodate pedestrian, bicycle, transit, and vehicular traffic;
(5) Support mode prioritization goals established in the TMP;
(6) Provide effective communication with the public; and
(7) Ensure conformity with these standards for work zone temporary traffic control.

(E) Certification Requirements

(1) Traffic Control Plans shall be prepared by or under the direct supervision of a person certified as a Traffic Control Supervisor (TCS) by the American Traffic Safety Services Association (ATSSA) or with equivalent certification as approved by the Director.
(2) Traffic Control Plans shall be implemented under the direct supervision of a TCS, certified Traffic Control Technician (TCT), or person with equivalent certification as approved by the Director.

(F) Conformance with MUTCD

All traffic control plans, signs, sign materials, barricade warning lights, and other temporary traffic control measures shall conform to the "Manual on Uniform Traffic Control Devices" (current edition), except as specifically amended or supplemented by the provisions of these Standards.

(G) General Requirements

All proposed Traffic Control Plans shall include the following:

(1) The location of work

(2) A description of work to be performed

(3) A construction schedule identifying duration and extent of impacts

(4) A delineation of the proposed work area including any staging, storage, and delivery areas.

(5) Proposed measures to address impacts to vehicles, bicycles, pedestrians, multi-use path facilities, transit facilities, and persons with disabilities.

(H) Non Standard Closures

Traffic control plans which due to their location, duration, extent, hours of operation, or impact will result in more significant impacts to the traveling public require additional information to demonstrate that impacts have been avoided, minimized, and mitigated. The Director may approve the following Non Standard closures upon finding that the applicable criteria have been met:

(1) **Work Hours:** Plans which propose to close a vehicular travel lane on any weekday prior to 9 a.m. or later than 4 p.m., or on any weekend shall demonstrate that such impacts cannot be reasonably avoided or that the proposed schedule reduces impacts to the public compared to closure during normal work hours.

(2) **Multiple Vehicle Lanes:** Plans which propose to close all or multiple vehicle lanes in a single direction of travel shall demonstrate that such impacts cannot be reasonably avoided through alternative scheduling or phasing of work.

(3) **Vehicular Detours:** Plans which propose to detour traffic to another roadway shall demonstrate that such impacts cannot be reasonably avoided and that impacts to the detour route have been mitigated to the extent practicable. Impacts to the detour route shall be evaluated including, without limitation, intersection level of service, traffic speed and volume in residential neighborhoods and school zones, and impacts to all modes of transportation.

(4) **Flagging:** Plans which propose use of flaggers shall demonstrate that the duration or scope of work is such that more permanent control measures are not practical.

(5) **Transit Facilities:** Plans which propose impacts to a transit facility or transit stop must demonstrate that such impacts cannot be avoided and provide for appropriate detours and alternative stop locations.

(6) **Sidewalks:** The following special considerations shall be given to proposed closures of

sidewalks:

a) Adjacent to streets not classified as "Local" in the Transportation Master Plan;
b) Located in the CAGID or UHGID boundary areas;
c) Impacted for more than seven days;
d) Where no other sidewalk exists adjacent to the roadway;
e) Serving a school zone or transit stop, or
f) Requiring pedestrians to detour to a facility on a separate parallel roadway. Such proposed closures must demonstrate that impacts cannot be avoided through alternative construction methods, that the duration and extent of impacts has been minimized, and that an adequate detour has been provided.

(7) **Bicycle Lanes:** Special consideration shall be given to proposed closures of on street bike lanes along roadways with a posted speed limit of 40 mph or greater; or bike lanes that involve contra-flow lanes. Such proposed closures shall demonstrate that impacts cannot be avoided through alternative construction methods, that the facility cannot be reasonably relocated through reassignment of vehicle lanes or other existing facilities, that the duration and extent of impacts has been minimized, and that an adequate detour has been provided.

(8) **Multi-Use Paths:** Special consideration shall be given to proposed closures of sidewalk facilities which have been designated as multi-use paths. Such proposals shall demonstrate that impacts cannot be avoided through alternative construction methods, that the facility cannot be reasonably relocated through reassignment of vehicle lanes or other existing facilities, that the duration and extent of impacts has been minimized, and that an adequate detour has been provided. Detours routes must be of similar width and surface type to the permanent facility.

(9) **Signage:** Where detours or closures impact pedestrian, bicycle, or multi-use path facilities, additional signage as required by Director shall be utilized to supplement the requirements of the MUTCD.

8.05 Fire Lane Sign Specifications

(A) Size
Fire lane signs shall be 12 inches by 18 inches.

(B) Material
Fire lane sign material shall be 0.100-inch thick aluminum alloy 6061-T6 with 3M Diamond Grade Cubed (DG3) sheeting Type XI.

(C) Colors
Fire lane sign colors shall be red letters on a white background. The letter on the symbol shall be black.

(D) Wording
Fire lane signs shall including the wording "FIRE LANE" with an appropriate arrow and a no parking symbol ("P" with a slash).

8.06 Signing for Accessible Parking

Accessible parking signs required for accessible parking spaces shall meet the following standards:

(A) Materials

Sign materials shall conform to the standards set forth in the MUTCD and these Standards.

(B) Required Signs

Three signs shall be required for accessible parking spaces as follows:

(1) **Sign #1:** Sign #1 (R7-8) shall be 12 inches by 18 inches with green lettering on a white background. This sign shall read, "RESERVED PARKING", followed by a blue accessible symbol and a green arrow indicating the stalls restricted to accessible parking.

(2) **Sign #2:** Sign #2 shall be 24 inches by 18 inches with white lettering on a blue background. This sign shall read, "VEHICLES NOT DISPLAYING THE STATE AUTHORIZATION MAY BE TOWED AT OWNER'S EXPENSE. FOR PERMIT INFORMATION CONTACT THE LOCAL MOTOR VEHICLE OFFICE," and shall display a symbol of accessibility.

(3) **Sign #3:** Sign #3 shall be 12 inches by 6 inches with white numerical numbering on a blue background. This sign shall read in numerical value, "$112.00," centered with a white border.

(C) Sign Placement

The accessible parking signs shall be placed as shown on Technical Drawing 2.86, "Accessible Parking Sign Details," in Chapter 11 of these Standards, and are to be set directly facing or no more than 45 degrees from the line of travel of a vehicle entering the stall. These signs may be mounted on a post or may be mounted permanently on an adjacent wall using anchor bolts. Such signs shall be placed at the center of the end stalls of each accessible parking area and at every second stall in-between.

8.07 Signing for Parking Restrictions

(A) Size

Parking restriction signs shall be 12" x 18".

(B) Material

Sign material shall be 0.100-inch thick aluminum alloy 6061-T6 with 3M DG3 (Diamond Grade Cubed) sheeting Type XI.

CHAPTER 9
UTILITIES STANDARDS

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9.01 General

(A) Intent

The Utilities Standards are intended to complement the design standards specified in Chapter 4, "General Utilities Design," Chapter 5, "Water Design," Chapter 6, "Wastewater Design," Chapter 7, "Storm Water Design," and Chapter 11, "Technical Drawings," of these Standards, and provide minimum standards for the construction of public utilities improvements in public rights-of-way and public easements.

(B) Scope

These Standards apply to all city-operated public utility improvements within the City of Boulder service area. This chapter describes the construction of public utilities and other work within the public right-of-way and public easements including, but not limited to, work activities involved, materials used, installation methods, and required testing. The utilities construction requirements of this chapter are in addition to those set forth in Chapter 4, "General Utilities Design," Chapter 5, "Water Design," Chapter 6, "Wastewater Design," Chapter 7, "Storm Water Design," and Chapter 11, "Technical Drawings," of these Standards and the B.R.C. 1981.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, in order to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of utilities and may refer to one or more of the references listed in the References Section of these Standards.

(D) City Approval Required

All work associated with the construction of public utilities within or upon any City of Boulder public right-of-way or public easement is subject to City of Boulder approval or permit issuance as set forth in Chapter 8-5, "Work in the Public Right Of Way and Public Easements," B.R.C. 1981.

9.02 Excavation and Trenching

(A) General

(1) **Scope:** This section describes excavation and trenching, which includes the following:

(a) Necessary clearing, grubbing, and preparation of the site;

(b) Removal and disposal of debris;

(c) Excavation and trenching as required;

(d) The handling, storage, transportation, and disposal of all excavated material;

(e) Necessary sheeting, shoring, and protection work;

(f) Preparation of subgrades;

(g) Pumping and dewatering as necessary or required;

(h) Protection of adjacent property

(i) Backfilling;

(j) Pipe embedment;

(k) Placement of fills;

(l) Surfacing and grading; and

(m) Other relevant work.

(2) **Quality Assurance:** All tests required for the preliminary review of materials shall be made by an acceptable independent testing laboratory at the expense of the contractor. Two initial gradation tests shall be made for each type of pipe bedding, fill, or backfill material, and one additional gradation test shall be made for each additional 500 tons of each material. The contractor shall pay for all in-place field density tests, Proctor moisture-density tests, and relative density tests on the materials as required.

(B) Materials

(1) **General:** All bedding and backfill material shall be free of frozen material, organic material, and debris.

(2) **Pipe Bedding:** Bedding materials shall conform to the following requirements:

(a) Bedding Materials: Bedding materials shall not contain cinders or other material that may cause pipe corrosion.

(b) Concrete Arch Encasement: A concrete arch encasement is not required unless improper trenching or unexpected trench conditions require its use, as determined by the Director.

(c) Granular Bedding Material: Granular bedding material shall consist of well graded sand or squeegee meeting a fine aggregate standard shown in Table 9-1, "Granular Bedding Material." Instead of a material meeting the requirements in Table 9-1, the Director may approve 3/8-inch chips conforming to the grading and composition requirements of Course Aggregate No. 8 in Table 703-1, "Concrete Aggregate Gradation Table," of the CDOT Standard Specifications for Road and Bridge Construction, 2017, due to lack of availability of the materials meeting Table 9-1 requirements.

Table 9-1: Granular Bedding Material

Sieve Size	Percent Passing by Weight
3/8-inch	100%
No. 4	60-100%
No. 8	0-45%
No. 16	0-30%
No. 50	0-6%
No. 200	0-2%

(d) Compaction: All granular bedding material shall be compacted by vibrating or

slicing with a shovel and placed in layers no more than 6 inches thick.

(3) **Stabilization Material:** Stabilization material shall be placed on suitably prepared subgrades and compacted by vibration. Stabilization material shall be crushed rock or gravel; free from dust, clay, or trash; and graded 1 ½ inch to No. 4 as defined in ASTM C33 and shall be compacted to not less than 70 percent relative density as determined by ASTM D4253 and D4254.

(4) **Trench Backfill:** Trench backfill is material placed above the pipe bedding and shall meet specifications for Class 1 structural backfill material of Subsection 703.08 "Structural Backfill Material," of the CDOT Standard Specifications for Road and Bridge Construction (2017), or shall be flowable fill as specified in Subsection 9.02(B)(6) of these Standards.

(5) **Groundwater Barrier Material:** Groundwater barrier material shall be flowable fill or meet AASHTO soil classification SC or CL, free from stones, organic material or debris.

(6) **Flowable Fill:** Flowable fill, meeting the standards outlined in Table 9-2, "Flowable Fill Requirements," shall be used for trench backfill or for groundwater barriers.

(7) **Flashfill:** Use of Flashfill is permitted as an alternative material for trench backfilling, consistent with Subsection 206.03 of the CDOT Standard Specifications for Road and Bridge Construction (2023), as may be amended from time to time.

Table 9-2: Flowable Fill Requirements

Ingredients	Lbs./C.Y.	Kg/m^3
Cement	50	30
Coarse Aggregate (AASHTO No. 57 or 67)	1,700	1,009
Fine Aggregate (AASHTO M 6)	1,845	1,095
Water (39 gallons) (147L)	325 (or as needed)	193 (or as needed)

(a) Enough water shall be used so that the flowable fill flows into place properly without excessive segregation. Approximately 39 gallons of water per cubic yard (193 liters per cubic meter) of flowable fill is normally needed. Additional water shall not be added to the mixture at the project site.

(b) The contractor may use aggregate that does not meet the specifications in Table 9-2, "Flowable Fill Requirements," if the cement is increased to 100 pounds per cubic yard (60 kilograms per cubic meter) and the aggregate conforms to following gradation:

Sieve Size or Designation	Percent Passing
1 inch (25.0 mm)	100%
No. 200	0-10%

(c) The contractor may make the following substitutions in the flowable fill mix:

(i) Thirty pounds per cubic yard (18 kilograms per cubic meter) of cement and 30 pounds per cubic yard (18 kilograms per cubic meter) of fly ash for 50 pounds per cubic yard (30 kilograms per cubic meter) of cement, or

(ii) Sixty pounds per cubic yard (36 kilograms per cubic meter) of cement and 60 pounds per cubic yard (36 kilograms per cubic meter) of fly ash for 100 pounds per cubic yard (60 kilograms per cubic meter) of cement.

(d) The City reserves the right to review the use of recycled broken glass (glass cullet) as part or all of the aggregate.

(e) Compaction of flowable fill shall not be required

(f) The maximum layer thickness for flowable fill shall be 3-feet. Additional layers shall not be placed until the flowable fill has lost sufficient moisture to be walked on without indenting more than 2-inches. Any damage resulting from placing flowable fill in layers that are too thick or from not allowing sufficient time between placement of layers shall be repaired at the Contractor's expense.

(8) **Rock Backfill Material:** Rock backfill material shall be an imported graded material that meets either the 57/67 size requirements of ASTM C33 or the requirements for stabilization material specified in Subsection 9.02(B)(3) of these Standards.

(C) Execution

(1) **Site Preparation**

(a) All sites to be occupied by permanent construction shall be cleared of all logs, trees, roots, brush, tree trimmings, and other objectionable materials and debris. All stumps shall be grubbed. All waste materials shall be removed from the site and properly disposed.

(b) In natural areas where excavation will occur all topsoil shall be stripped or, in the absence of topsoil, the top 6 inches of surface material shall be stripped and stored separately from other excavated materials.

(c) For concrete walks, roadways, parking areas, and road crossings existing pavement shall be cut full depth to a true line before excavation. For Portland Cement pavements, cuts shall be made at existing joints.

(2) **Classification of Excavated Materials:** Excavated materials shall not be classified. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition, or condition thereof.

(3) **Unauthorized Excavation:** Undermining or tunneling under walls, footings, slabs on grade, foundations, sidewalks, concrete or bituminous asphalt pavements, or any other surface or subsurface facilities or structures shall not be permitted unless authorized by the Director. If unauthorized tunneling or undermining occurs, the contractor shall pay for all repairs and restorations the Director deems necessary. The repairs and restorations may include removing and replacing part or all of the affected facility or structure.

(4) **Stabilization of Subgrades**

(a) Subgrades for concrete structures and trench bottoms shall be firm, dense, thoroughly compacted and consolidated, and free from mud and muck.

(b) Subgrades for concrete structures or trench bottoms that are otherwise solid, but become mucky on top due to construction operations, shall be reinforced with crushed rock or gravel meeting the requirements for stabilization material, described in Subsection 9.02(B)(3) of these Standards and approved by the

Director.

(c) Stabilization material shall be spread and compacted to a depth of not more than 4 inches. However, if the required depth exceeds 4 inches, the subgrade for concrete structures or trench bottom shall be re-excavated and all mud and muck removed and replaced with stabilization material, as required by Subsection 9.02(B)(3) of these Standards and approved by the Director.

(d) This material shall be placed, and compacted, as prescribed in these Standards. The finished elevation of stabilized subgrades shall not be above subgrade elevations indicated on the drawings.

(5) **Blasting:** Blasting or other use of explosives for excavation will not be permitted.

(6) **Shoring**

(a) All excavations shall be properly shored and braced to meet federal, state and local laws governing safe working conditions. The shoring shall be arranged so that no stress is placed on any portion of the completed work until the general construction thereof has proceeded far enough to provide ample strength.

(b) Shoring shall be removed as the work progresses. Trench sheeting shall not be pulled before backfilling unless the pipe strength is sufficient to carry trench loads based on trench width to the back of sheeting, nor shall sheeting be pulled after backfilling.

(c) Where trench sheeting is left in place, such sheeting shall not be braced against the pipe but shall be supported in a manner that will preclude concentrated loads or horizontal thrusts on the pipe. Cross braces installed above the pipe to support sheeting may be removed after pipe embedment has been completed.

(d) The contractor shall pay to repair any damage to pipes or structures resulting from missing, failed or improper shoring, sheeting, or bracing or any negligence on the part of the contractor.

(7) **Water Control and Dewatering**

(a) Dewatering equipment shall be provided to remove and dispose of all surface water and groundwater entering excavations, trenches, or other parts of the work. Each excavation shall be kept dry during subgrade preparation and until the structure to be built or the pipe to be installed is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result.

(b) All excavations for concrete structures or trenches that extend down to or below the groundwater table shall be dewatered by lowering and keeping the groundwater level 12 inches or more below the bottom of the excavation.

(c) Surface water shall be diverted or otherwise prevented from entering the excavated areas or trenches to the greatest extent practicable without causing damage to adjacent property.

(d) The contractor shall be responsible for the condition of any pipe or conduit used for drainage purposes. All such pipe or conduit shall be left clean and free of sediment.

(8) **Trench Excavation:** Trenches shall be excavated so that pipes can be laid according to the profiles, grades, elevations, and minimum cover shown on the drawings or specified in these Standards. Trench subgrades shall be clean and free of loose material of any

kind.

(a) Excavation in Streets and Other Paved Surfaces: Excavations in streets with asphalt paving must be confined to the minimum width required to maintain a safe trench condition. The contractor shall pay for replacing any pavement damage resulting from their construction work. The Director will determine the limits of the damaged pavement needing replacement.

(b) Minimum Cover: Where pipe grades or elevations are not definitely fixed by the approved plans, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe as follows:

(i) Water lines require at least 4.5 feet of cover;

(ii) Sanitary sewers require at least 3 feet of cover; and

(iii) Storm sewers require at least 1.5 feet of cover.

(c) Trench Widths

(i) Trench widths shall be as shown below where the maximum trench width is measured at the top of the pipe barrel:

Pipe Diameter Inches	Maximum Trench Inches	Pipe Diameter Inches	Maximum Trench Inches
4	24	24	48
6	26	27	52
8	28	30	56
10	30	33	60
12	34	36	68
14	36	39	72
15	37	42	76
16	38	48	82
18	40	54	90
20	42	72	110
21	44		

(ii) If the stated maximum trench widths are exceeded, and if the Director determines that the combined dead- and live-loads will exceed the design loadings on the pipe, the Director may require the contractor to either cradle the pipe in concrete or use a pipe of a stronger class. Remedial measures shall be entirely at the contractor's expense.

(iii) As illustrated on Drawing No. 4.03 in Chapter 11, "Technical Drawings," of these Standards, the pipe trench shall be excavated to a depth below the bottom of the pipe, backfilled with the specified granular bedding material, and compacted to the requirements of these Standards.

(iv) Narrow Trenching Widths shall be 1 to 3 inches but no more than 1 inch greater than conduit size.

(d) Trench Walls

(i) The contractor may slope or bench trench sidewalls in areas where an increased trench width will not interfere with surface features or other utilities. Such sloping or benching shall terminate at least 1 foot above the top of the pipe barrel; from that point down, the trench wall shall be vertical.

(ii) The trenching operation, including the spoil bank and the sloping of trench sidewalls, shall be confined to the width of any permanent and temporary rights-of-way or easements.

(iii) A sufficient clear area shall be maintained away from the top edge of the excavation to avoid overloading that may cause slides or caving of the trench walls. The excavated material shall be kept trimmed to avoid inconveniencing the public and adjoining property owners. Unless otherwise authorized by the Director, all public thoroughfares and crossroads shall be kept open to traffic. When required by the Director, the contractor shall, at their own expense, provide open-cut bridging at street crossings, sidewalks, and other necessary points to prevent serious travel interruptions and to provide access to fire hydrants and public and private premises.

(e) Trench Preparation

(i) The trench shall be excavated only so far in advance of pipe laying as permitted by the Director. Trench preparation shall also conform to the details shown on the drawings in Chapter 11, "Technical Drawings," of these Standards.

(ii) Bell holes in the trench bottom shall be provided at each joint to permit the jointing to be made properly and to prevent the pipe from bearing on the pipe bells.

(iii) After excavation, the trench bottom shall be uniformly graded and hand-shaped so that the pipe barrel (exclusive of the joint) will have uniform and continuous bearing on thoroughly compacted pipe bedding material throughout the length of the pipe.

(iv) The trench grade shall permit the pipe spigot to be accurately centered in the preceding laid pipe joint, without lifting the pipe above the grade and without exceeding the permissible joint deflection. If raising the pipe subgrade is necessary, and approved by the Director, compacted bedding material may be used at the contractor's expense.

(f) Excavation Material: Excess excavated material shall be removed from the construction site and disposed of by the contractor.

(g) Rock Excavation: In the event of rock excavation, the bottom of the trench shall be lowered so that the bottom of the trench is 6 inches below the outside surface of the pipe. The space between the rock and the pipe shall be filled with granular bedding material. During its placement, the bedding material shall be shaped to provide support along the full length of pipe.

(9) **Installation of Pipe Bedding**

(a) Pipe bedding material shall consist of the material as specified in Subsection

9.02(B)(2) of these Standards. Bedding material shall be placed to provide the grade and elevation specified on the approved plans.

(b) After bedding material has been placed and approved, and after the pipe has been installed and approved, the additional granular bedding material shall be installed to an elevation 12 inches above the top of the pipe.

(10) **Installation of Trench Backfill**

(a) Backfilling during freezing weather shall not be performed, except by permission of the Director. No backfill shall be installed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill.

(b) Unless accurate results cannot be obtained, the compaction requirements shall conform to maximum dry density according to ASTM D698, Moisture- Density Relations of Soils (Standard Proctor). When the ASTM D698 test is not applicable, the percentage compaction requirements shall conform to ASTM D2049 Test for Relative Density of Cohesionless Soils.

(c) When required by the Director, the contractor shall excavate backfilled trenches for purposes of performing compaction tests at locations and depths determined by the Director. The contractor shall be responsible for reinstalling and recompacting the test excavations.

(d) All backfill above the bedding material shall be carefully placed and compacted. Except for the backfill requirements as set forth under Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981, approved backfill material shall be placed in loose lifts, not exceeding 8 inches thick, and shall be compacted by equipment and means approved by the Director. If the contractor wishes to use equipment and means other than what was approved for the project by the Director, the contractor shall submit, in writing, a request for approval of the proposed equipment and means to the Director for review and approval. Any approval by the Director, of an alternate method of compaction shall not relieve the contractor from providing a finished product that meets or exceeds all the intents and requirements of the approved plans and these Standards.

(e) All backfill shall be compacted to 95 percent of maximum laboratory dry density or 70 percent relative density. The material shall be within 2 percent of optimum moisture content.

(f) A loose layer of backfill material not more than 8 inches deep may be placed over concrete arch encasement or concrete reaction blocking after the concrete has reached its initial set, to aid curing. No additional backfill shall be placed over arch encasement or blocking until the concrete has been in place for at least 3 days.

(g) Backfill material for Narrow Trenching shall be flowable fill per subsection (B) or Table 9-2 of this section.

(11) **Structural Excavation and Backfill**

(a) All structural excavations shall provide adequate working space and clearances for the work to be performed therein and for installation and removal of concrete forms. In no case shall excavation faces be undercut for extended footings.

(b) The quality and moisture content of materials for backfill around and outside of

structures shall conform to the requirements for materials used for earthfills and embankments. Backfill materials shall be placed in loose lifts, not to exceed 8 inches in thickness, and shall be compacted to at least 95 percent of maximum dry density at optimum moisture content as determined by ASTM D698. Compaction of structure backfill by rolling will be permitted, provided the desired compaction is obtained and damage to the structure is prevented. Compaction of structure backfill by inundation with water will not be permitted.

(c) No backfill shall be deposited or compacted in water.

(d) Particular care shall be taken to compact structure backfill that will be beneath pipes, drives, roads, parking areas, walks, curbs, gutters, or other surface construction or structures. In addition, wherever a trench is to pass through structure backfill, the structure backfill shall be placed and compacted to an elevation not less that 12 inches above the top of pipe elevation before the trench is excavated. Compacted areas, in each case, shall be adequate to support the item to be constructed or placed thereon.

(12) **Restoration**

(a) Streets and Roadways: Any pavements disturbed during construction shall be repaired in accordance with the requirements as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981. All dirt and debris, including dust shall be removed from streets and paved surfaces within 3 days of the restoration of streets and paved surfaces. Initial removal of dirt and debris shall be made using a vacuum sweeper, after which the paved surfaces shall be cleaned using water hoses.

(i) Restoration associated with Narrow Trenching in roadways: Narrow trenching within asphalt roadway shall backfill using flowable fill and allow for 1'' minimum to 6'' maximum depth of Mastic One material to restore surface, where patch must be cleaned, material flush with existing asphalt pavement grade and top coated with black colored surface aggregate material per CDOT specs 703.05 – Aggregate for Cover Coat Material, for the purpose of surface grip. Narrow trenching within concrete paved roadways shall not be permitted unless otherwise approved by the director. Mastic One, or equivalent material, shall be listed on the CDOT approved products list.

(ii) Restoration associated with Narrow Trenching in Bike Lanes: Asphalt pavement within a designated bike lane shall be completed within 10 calendar days of backfilling and include, flowable fill, Mastic One, mill & overlay the full width of the bike lane, or from center of roadway to edge of concrete lip line. If trench abuts curb & gutter concrete lip line and the bike lane is greater than 3 feet wide, measured from edge of striping to edge of concrete lip edge, mill & overlay is not required, unless otherwise directed by the city. Pavement cuts for lateral tie-in's that extend beyond the width of the parallel trench require full width restoration of the bike lane.

(iii) Restorations associated with Underground Utility Potholing: All potholes must be filled with flowable-fill within 10 calendar days per mix design outlined in Table 9-2 of these standards and use of a concrete vibrator is required at time of flowable-fill backfilling operations. All surface

restorations within concrete must be restored with approved concrete mix. All surface restorations within asphalt must be restored using hot-mix asphalt. Temporary and Final restored surfaces must remain flush with adjacent roadway grade at all times. Any utility potholes that are found failing, and are still within the warranty period, must be restored by the contractor within the timeline the city determines necessary for the safety & security of the public.

(iv) Any street markings or striping removed, damaged or impacted, must be restored within 14 days, 10 for bike lanes, using approved materials.

(b) Fencing and Culverts: Restore all existing structures to conditions equal to or exceeding existing structures.

(c) Landscape

(i) After other outside work has been finished, and backfilling and embankments completed and settled, all areas that are to be graded shall be brought to grade at the indicated elevations, slopes, and contours. All cuts, fills, embankments, and other areas that have been disturbed or damaged by construction operations shall be surfaced with topsoil to a depth of at least 4 inches. Topsoil shall be of a quality at least equal to the existing topsoil in adjacent areas, free from trash, stones, and debris, and well suited to support plant growth.

(ii) Use of graders or other power equipment will be permitted for final grading and dressing of slopes, provided the result is uniform and equivalent to hand work. All surfaces shall be graded to secure effective drainage. Unless otherwise indicated, a slope of at least 1 percent shall be provided.

(iii) Final grading and surfacing shall be smooth, even, and free from clods and stones larger than 1 inch in greatest dimension, weeds, brush, and other debris.

(iv) The top portion of backfill beneath established lawn areas shall be finished with at least 12 inches of topsoil corresponding to, or better than, that underlying adjoining lawn areas.

(v) The Director will clarify restoration of other minor items as construction proceeds. Such items must be restored to equal or exceed existing conditions.

(13) **Cleanup:** The contractor shall maintain a clean site at all times. Prior to final inspection and acceptance, the contractor shall remove all rubbish and excess materials and leave the area in a neat, satisfactory condition.

(14) **Maintenance of Backfill:** All backfill shall be maintained in a satisfactory condition and all places showing signs of settlement shall be filled and maintained for a period of 2 years following the date of final acceptance of all work. When the contractor discovers or is notified by the City that any backfill is not in compliance with City standards, the contractor shall correct such conditions. Any utilities and road surfacing damaged by such settlement shall be repaired by the contractor to the satisfaction of the City. In addition, the contractor shall be responsible for the cost of all claims for damages due to settlement of backfilled areas.

9.03 Ductile Iron Pipe (DIP)

(A) General

(1) **Scope:** This section describes the furnishing and installation of ductile iron pipe and appurtenances for potable water mains, water services and fire lines in the pipe diameter size range of 4 inches to 30 inches.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Ductile Iron Pipe**

(a) Unless revised on the approved drawings, the ductile-iron pipe shall conform to ANSI A21.51, AWWA C151, Class 52 thickness. The interior of each length of pipe shall have a cement-mortar lining, conforming to the requirements set forth in ANSI A21.4, AWWA C104, of standard thickness. The exterior of the pipe shall be coated with standard coating approximately 1 mil thick.

(b) Unless otherwise specified, the pipe joint shall be the "push-on" type, made in accordance with ANSI A21.11, AWWA C111, and the gaskets shall be standard for buried water service and as provided by the pipe manufacturer.

(2) **Polyethylene Wrap**

(a) All ductile iron pipeline and fittings shall be wrapped in polyethylene film in accordance with the requirements of ANSI A21.5, AWWA C105 and in accordance with all recommendations and practices of the AWWA M4 l, Manual of Water Supply Practices - Ductile Iron Pipe and Fittings.

(b) The polyethylene wrap shall be overlapped 1 foot in each direction at all connections.

(c) The polyethylene wrap shall consist of three layers of co-extruded linear low-density polyethylene (LLD PE), fused into a single thickness of not less than 8 mils.

(d) The inside surface of the polyethylene wrap to be in contact with the pipe exterior can be infused with a blend of anti-microbial biocide to mitigate microbiologically influenced corrosion and a volatile corrosion inhibitor to control galvanic corrosion.

(e) Tube Size or Sheet Width: Table 9-3, "Tube Size and Sheet Width for Pipe Diameter," shows the tube size or sheet width for each pipe diameter.

Table 9-3: Tube Size and Sheet Width for Pipe Diameter

Nominal Pipe Diameter (Inches)	Flat Tube (Inches)	Minimum Sheet Width (Inches)
4"	16"	32"
6"	20"	40"
8"	24"	48"

10”	27”	54”
12”	30”	60”
14”	34”	68”
16”	37”	74”
18”	41”	82”
20”	45”	90”
24”	54”	108”

(C) Thrust Restraint

Where designated by the Engineer with expertise in thrust restraint systems, or where existing conditions do not permit the use of concrete thrust blocks, individual joint restraint systems shall be provided as follows:

(1) **Alternative A:** Full length tie rods between joints. “Star” systems fabricated from “Cor-Ten” steel or an equivalent according to the requirements of ASTM A-242 with a minimum yield stress of 46,000 psi. The number and diameter of tie rods shall be as shown on the detail drawings.

(2) **Alternative B:** Pacific States Lock Mechanical Joint with Tyton Joint Core, or equivalent fittings with ductile iron joint restraint features conforming to ANSI Standard A21.10. Push-on joints for such fittings shall be in accordance with AWWA Standard A121.11. Assembly of the joint portion of the product shall be in accordance with AWWA C600-77

(3) **Alternative C**

(a) Follower gland type systems may be used for 12-inch diameter pipe and smaller. Pipe clamps shall be fabricated from “Cor-Ten” steel or an equivalent according to the requirements of ASTM A-242 with a minimum yield stress of 46,000 psi. The number and diameter of tie rods shall be as shown on the detail drawings. The follower gland shall be manufactured of ductile iron conforming to ASTM A536. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee head bolts conforming to AWWA C111 and C153.

(b) The restraint mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability. Twist-off nuts, sized the same as tee head bolts, shall be used to ensure proper actuating of restraining devices. When the nut is sheared off, a standard hex nut shall remain. The device shall have a working pressure of at least 200-psi with a minimum safety factor of 2:1.

(c) Follower gland joint restraint devices shall be of the type listed below:

(i) “EBAA Iron, Inc.,” Megalug 1100 Series (4 -12 inches)

(ii) “Uniflange,”1400 Series (4 -12 inches)

(D) Connections to the Existing System

(1) **System Operation:** Operation of the existing system must at all times remain under the control of the Director. The contractor shall operate no valves or hydrants on the system without permission from the Director.

(2) **Connections:** All points at which the existing water systems are to be disconnected and connected to the new mains must be shown on the approved drawings.

(3) **Utility Service Interruptions:** The contractor shall take all precautions necessary to minimize interruption of all utility services and will be responsible for the restoration of the affected service. The contractor shall schedule existing valve locates with the Director at least 3 days before scheduling a shutoff.

(4) **Customer Notification:** Unless otherwise specified, at any time a customer on the existing system will be deprived of a supply of water, the contractor shall advise such customer in writing 24 hours in advance of when the supply will be disconnected and reestablished.

(E) Execution

(1) **Installation of Ductile Iron Pipe:** Except as specified herein or unless specifically authorized by the Director, all installation of pipe shall conform to the recommendations contained in "Installation Guide for Ductile Iron Pipe," published by the Ductile Iron Pipe Research Association. The contractor shall assure that a copy is available at the job site.

(a) Pipe Laying

(i) Pipe shall be laid with bell ends facing in the direction of laying, unless directed otherwise by the Director. Pipe shall be laid on the bedding with support over the full length of the pipe barrel.

(ii) Table 9-4, "Ductile Iron Pipe Deflection," shows the maximum allowable pipe joint deflections.

(iii) The information in the columns referring to the deflection and the approximate radii shall be adjusted for pipe lengths different than 18-foot lengths. Shorter pipe lengths will be required if a shorter radius is called for on the approved construction plans. Double hubs may be used to lay pipelines on curved alignment.

Table 9-4: Ductile-Iron Pipe Deflection

Size of Pipe (Inches)	Approximate Radius of Curve Produced by: Bend in One Joint (%)	Deflection in One 18-Foot Length (Inches)	Succession of 18-Foot Joints (Feet)
4 -12	4	15	250
14 - 24	2	7.5	510

(iv) Vertical deflections shall not exceed any of the above values.

(v) When pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Director.

(vi) The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe or cement lining so as to leave a smooth end at right angles to the axis of the pipe. The flame cutting of pipe by means of an oxyacetylene torch will not be allowed. The pipe end shall be beveled and free of sharp edges that could damage the gasket during installation.

(b) Mechanical Joints: Mechanical joints shall be installed per the manufacturer's specifications and guidelines.

(c) Push-On Joints: For push-on joints, the exterior 4 inches of the pipe at the spigot end and the inside of the adjoining bell and particularly the groove for the gasket shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter. The proper gasket supplied with the pipe shall be placed in the bell in compliance with the manufacturer's specifications and guidelines so it will spring into its proper place inside the pipe bell. A thin film of the pipe manufacturer's joint lubricant shall be applied to the gasket over its entire exposed surface. The spigot end of the pipe shall then be wiped clean and inserted into the bell to contact the gasket by crowbar, or by jack and choker slings. The location of the gasket shall be checked with a gauge or tool designed for that purpose to assure that the gasket is in the proper position.

(d) Installation of Polyethylene Wrap

(i) All pipeline and fittings shall be wrapped in polyethylene film in accordance with the requirements of ANSI A21.5, AWWA C105 and in accordance with all recommendations and practices of the AWWA M4 l, Manual of Water Supply Practices -Ductile Iron Pipe and Fittings.

(ii) The polyethylene wrap shall be overlapped 1 foot in each direction at all connections.

(iii) The polyethylene wrap shall consist of three layers of co-extruded linear low-density polyethylene (LLD PE), fused into a single thickness of not less than 8 mils.

(iv) The inside surface of the polyethylene wrap to be in contact with the pipe exterior can be infused with a blend of anti-microbial biocide to mitigate microbiologically influenced corrosion and a volatile corrosion inhibitor to control galvanic corrosion.

(2) **Installation of Thrust Restraint**

(a) Thrust blocks shall be poured between undisturbed solid ground and the fitting to be anchored. The area of bearing on the undisturbed trench wall shall be that shown on the thrust block detail or directed by the Director. The concrete shall be placed so that the pipe or fitting joints will be accessible for repair. A bond breaker shall be placed over the fitting before placing concrete.

(b) Full length tie rods between joints with pipe clamps shall be assembled using clamps on each side of pipe bells with tie rods extending the full pipe length for the dimensions shown on the drawings each direction from the restrained fitting, valve or joint. Clamps shall be installed tight enough to prevent twisting around the pipe. A washer shall be used at each clamp and tie rods shall be located on each side of the pipe. The tie rod nut should first be hand tightened with a 12-

inch wrench (approximately 50 to 100 foot-pounds torque). Threaded tie rods shall extend two full threads past each nut in the final position.

(c) Follower gland type joint restraint systems shall be assembled according to manufacturer's instructions.

(3) **Testing:** Testing of ductile iron pipe shall be as specified in Section 9.13, "Testing of Water Pipes," of these Standards.

(4) **Backfilling and Restoring Surface Conditions:** Surface conditions shall be backfilled and restored as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(5) **Disinfecting Potable Pipelines:** Ductile iron pipe shall be disinfected as specified Section 9.12, "Disinfecting Waterlines," of these Standards.

9.04 Polyvinyl Chloride (PVC) Pressure Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of polyvinyl chloride (PVC) pressure pipe and appurtenances for potable water mains, water services and fire lines in the pipe diameter size range of 4 to 12 inches.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **PVC Pressure Pipe**

(a) All PVC pipe shall meet the requirements of AWWA C-900-16, Polyvinyl Chloride Pressure Pipe and Fabricated Fittings (4 – 12 inches) and shall be Pressure Class 305 psi (DR 14), or shall meet the requirements of AWWA C-905-08, Polyvinyl Chloride Pressure Pipe and Fabricated Fittings (14 – 48 inches) and shall be Pressure Class 235 psi (DR 18).

(b) All pipe shall be suitable for use as a pressure conduit. Provisions must be made for expansion and contraction at each joint with a rubber ring. The bell shall consist of an integral wall section with a solid cross-section rubber ring which meets the requirements of AWWA C-900-07.

(c) Laying length of pipe shall be 20 feet for all sizes of pipe.

(d) Each length of pipe shall bear the date manufactured, type, grade, length, manufacturer's name, and NSF seal of approval.

(e) Pipe joints shall be made using an integral bell with an elastomeric gasket push-on type joint.

(f) Solvent cement joints are prohibited.

(g) The manufacturer shall furnish a certified statement that all specified tests and inspections have been made and the results thereof comply with the AWWA standards specified in this Subsection 9.04(B). A copy of the certification shall be sent to the City upon request.

(2) **Polyethylene Encasement**

(a) All pipeline fittings and appurtenances shall be encased in polyethylene film in accordance with the requirements of ANSI A21.5, AWWA C105.

(b) The finished polyethylene film shall have a minimum nominal thickness of 0.008-inch (8 mil), and the minus tolerance on thickness shall not exceed 10 percent of the nominal thickness. The film shall have at least 1200-psi tensile strength of with an elongation of 300 percent minimum. The dielectric strength shall be at least 800 volts per mil thick.

(3) **Tracer Cable:** Tracer wire shall be Type THHN, AWG size #12, UL listed with a single copper conductor, PVC insulation, and nylon jacket. Test stations at fire hydrants shall be CP Test Services, Glenn Series Glenn-4 with locking lid, 3½ x 4 inches, or approved equal.

(C) Thrust Restraint

(1) **Required:** All fittings and joints shall be restraint from movement due to hydraulic forces with concrete thrust blocks as shown in Chapter 11, "Technical Drawings," of these Standards except where existing conditions or other practical difficulties do not permit the use of concrete thrust blocks. Where the applicant demonstrates to the satisfaction of the Director that existing conditions or other practical difficulties do not permit the use of concrete thrust blocks, individual restraint systems shall be provided meeting one of the following:

(a) Alternative A - Full Length Threaded Tie Rods: Threaded rods shall be Type 316L stainless steel coated with an anti-galling compound. Connecting T-bolts and nuts shall be Type 316L stainless steel coated with an anti-galling compound or corrosion resistant fluorocarbon coating such as "NSS Industries" Cor-Blue or "Star Pipe Products" Core Blue. The number and diameter of tie rods shall be as shown on the approved plans.

(b) Alternative B - Follower Gland Type Mechanical Joint Restraint Systems: Follower gland type mechanical joint restraint systems may be used only for 16-inch diameter and smaller pipe. Restraint rings shall be manufactured of ductile iron conforming to ASTM A536, Grade 65-45-12 with a factory applied fusion epoxy coating. The mechanical joint follower gland shall be incorporated into the restraint. Connecting T-bolts and nuts shall be as required in Alternative A.

(c) Alternative C - Bolt-Through Positive Restraint Mechanisms: A bolt-through positive restraint mechanism may be used only for connecting 12-inch diameter and smaller mechanical joint valves and fittings. It shall not be used for pipe attachment or fire hydrant connections. Adaptor body shall be made of ductile iron, conforming to ASTM A536 80-55-06 with styrene butadiene rubber gaskets conforming to AWWA C111. Connecting T-bolts and nuts shall be as required in Alternative A.

(2) **Bell-And-Spigot Joints:** Restraint devices for PVC pipe bell-and-spigot joints may be used, if approved by the Director, for sizes 4 to 16 inches. Devices shall be of ductile iron conforming to ASTM A536. Connecting T-bolts and rods as required in Alternative A.

(3) **Mechanical Joint Restraint Required:** Mechanical joint restraint devices are required for the following installations:

(a) Fire hydrants;

(b) Fire line connections;

(c) Three inch and larger domestic line connections;

(d) Reducers;

(e) Vertical and horizontal offsets (all angles);

(f) Bends, line valves, and fittings;

(g) Bulkheads and plugs;

(h) Bored casing carrier pipe; and

(i) When the bearing capacity of the soil is not sufficient to provide adequate restraint, as determined by the Director.

(4) **Mechanical Joint Restraint Design Requirements:** The mechanical restraint mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability; or a series of machined serrations designed to grip the entire pipe surface; or a system that is integral to the gasket. For twist-off nut-type designs, the nuts shall be sized the same as T- bolts and be used to insure proper actuating of restraining devices. When the nut head is sheared off, a standard hex nut shall remain. All devices shall have a working pressure of at least 200 psi with a minimum safety factor of 2:1.

(5) **Follower Gland Type Joint Restraints:** Follower gland type joint restraint devices shall be of the type listed below:

(a) "EBAA Iron"

(i) Megalug 2000 Series for PVC (4 to 16 inches)

(ii) Megalug 1600 Series for PVC (4 to 12 inches) Pipe Bell Joints

(iii) Megalug 2800 Series for PVC (14 inches and larger)

(b) "Star Pipe Products"

(i) Domestic PVC Stargrip Series 4000 (4 to 12 inches)

(ii) Domestic 1100C Bell Restrainers Series 1100 for PVC Pipe Bell Joints

(c) "U.S. Pipe": MJ FIELD LOK Gasket with MJ FIELD LOK Gland, Series for PVC (4 to 12 inches)

(d) "Romac Industries": PVC RomaGrip Series, fusion bonded polyester coating is required if using C909 PVC

(6) **Bolt-Through Mechanical Joint Restraints:** Bolt-through mechanical joint restraint devices shall be of the type listed below:

(a) "Infact Corporation": Foster Adaptor (4 to12 inches) with fusion bonded epoxy coating. Standard foster adaptor accessory pak is required for restraining C153 compact fittings and valves

(D) Connections to the Existing System

(1) **System Operation:** Operation of the existing system must at all times remain under the control of the Director. The contractor shall operate no valves or hydrants on the system without permission from the Director.

(2) **Connections:** All points at which the existing water systems are to be disconnected and connected to the new mains must be shown on the approved construction plans.

(3) **Utility Service Interruptions:** The contractor shall take all precautions necessary to minimize interruption of all utility services and will be responsible for the restoration of the effected service. The contractor shall schedule existing valve locates with the Director at least 3 days before scheduling a shutoff.

(4) **Customer Notification:** Unless otherwise specified, at any time a customer on the existing system will be deprived of a supply of water, the owner-developer-contractor shall advise such customer in writing 24 hours in advance of when the supply will be disconnected and when the supply will again be available.

(E) Execution

(1) **Installation of PVC Pressure Pipe:** Unless specifically authorized by the Director, all pipe shall be installed as follows:

(a) Pipe Laying

(i) Pipe shall be laid with bell ends facing in the direction of laying. No deflection in the joints shall be allowed. Whenever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or to plumb valve operators, the pipe itself may be uniformly curved as shown in Table 9-5, "Pipe Laying."

Table 9-5: Pipe Laying

Approximate Pipe Size (Inches)	Offset in 20-Foot Length (Inches)	Radius of Curve (Feet)
4"	15"	120'
6"	15"	160'
8"	15"	250'
10"	15"	300'
12"	15"	400'

(ii) Pipe deflection for curvature shall not be permitted at temperatures less than 32° F ambient temperature.

(iii) When pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Director.

(iv) The cutting of pipe for inserting valves, fittings, or closure pieces shall be done in a neat and workmanlike manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. Bevel the end of the pipe with a beveling tool after the pipe is field cut. Place a clearly visible position mark at the correct distance from the end of the field cut pipe.

(v) Tracer wire shall be attached to the pipe as shown in Chapter 11, "Technical Drawings," of these Standards.

(b) Mechanical Joints: Mechanical joints shall be installed per the manufacturer's specifications and guidelines.

(c) Push-On Joints: For push-on joints, the exterior 4 inches of the pipe at the spigot end and the inside of the adjoining bell and particularly the groove for the gasket shall be thoroughly cleaned to remove oil, grit, tar (other than standard coating), and other foreign matter. A thin film of the pipe manufacturer's joint lubricant shall be applied to the gasket over its entire exposed surface. The spigot end of the pipe shall then be wiped clean and inserted into the bell to contact the gasket by crowbar, or by jack and choker slings. The location of the gasket shall be checked with a gauge or tool designed for that purpose to assure that the gasket is in the proper position. Position the completed joint so that the joint mark on the pipe end is in line with the end of the bell.

(2) **Installation of Thrust Restraint**

(a) Thrust blocks shall be poured between undisturbed solid ground and the fitting to be anchored. The area of bearing on the undisturbed trench wall shall be that shown on the thrust block detail or directed by the Director. The concrete shall be placed so that the pipe or fitting joints will be accessible for repair. A bond breaker shall be placed over the fitting before placing concrete.

(b) Full length tie rods between joints with pipe clamps shall be assembled using clamps on each side of pipe bells with tie rods extending the full pipe length for the dimensions shown on the drawings each direction from the restrained fitting, valve or joint. Clamps shall be installed tight enough to prevent twisting around the pipe. A washer shall be used at each clamp and tie rods shall be located on each side of the pipe. The tie rod nut should first be hand tightened with a 12-inch wrench (approximately 50-100 foot-pounds torque). Threaded tie rods shall extend two full threads past each nut in the final position.

(c) Follower gland type joint restraint systems shall be assembled according to manufacturer's instructions.

(3) **Installation of Tracer Cable:** Tracer wire shall be spirally wrapped around the pipe exterior, 2 wraps minimum per 20-feet of pipe, as it is installed in the trench or taped to the top of the pipe. Splices due to breaks in wire continuity shall be made by stripping insulation coating from each wire with wire stripper pliers. Wires shall be joined with a solderless connector, 3M Direct Bury Splice Kit or equivalent in suitability, strength, effectiveness, and durability as approved by the Director. The join shall be made in accordance with manufacturer instructions. The solderless connector shall be covered with Emmerson Electric Seal-A-Conn II putty or approved equal.

The wire shall form a continuous electrical circuit between any 2 contact points on the new pipeline, including branch lines and fire hydrant laterals. Wire shall be stubbed out to the point where the new pipe connects to the existing main unless otherwise directed by the Director. Where the wire terminates at a point where there is not an installed wire, the ends of the wire shall be stripped bare a minimum of 18-inches and grounded into the native soil material. Special care should be taken to avoid contact from the tracer wire to steel gas service lines.

(4) **Testing:** Testing of PVC pressure pipe shall be as specified in Section 9.13, "Testing of Water Pipes," of these Standards.

(5) **Backfilling and Restoring Surface Conditions:** Shall be as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(6) **Disinfecting Potable Pipelines:** PVC pressure pipe shall be disinfected as specified Section 9.12, "Disinfecting Waterlines," of these Standards.

9.05 Water Services

(A) General

(1) **Scope:** This section describes the furnishing and installation of water services and fire lines in the pipe diameter size range of 3/4 to 2 inches. For water services and fire lines greater than 2 inches in diameter refer to Section 9.03, "Ductile Iron Pipe," Section 9.04, "Polyvinyl Chloride (PVC) Pressure Pipe," Section 9.06, "Gate Valves," and Section 9.08, "Tapping Sleeves and Valves," of these Standards.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Pipe:** Pipe shall be Type K copper, soft drawn, in accordance with ASTM B88.

(2) **Curb Stops:** All curb stops shall be manufactured in accordance with AWWA C800-05, Underground Service Line Valves and Fittings, and shall be constructed of brass in accordance with ASTM-B62 (common trade name 85-5-5-5). Curb stop valves shall be ball type with a maximum working pressure of 300 psi and shall have compression fittings.

(3) **Corporation Stops**

(a) All corporation stops and threaded brass fittings shall be manufactured in accordance with AWWA C800-05, Underground Service Line Valves and Fittings, and shall be constructed of brass in accordance with ASTM-B62 (common trade name 85-5-5-5). All corporation stops shall be tested at the factory and shall meet the following minimum physical requirements:

(i) Tensile strength 30,000 PSI minimum.

(ii) Yield Strength 14,000 PSI minimum.

(iii) Elongation in 2 inches 20 percent minimum.

(b) Corporation stops shall be ball valve type designed for a maximum working pressure of 300 psi. The inlet side shall have AWWA taper thread (CC thread) and the outlet side shall have a compression fitting.

(c) Corporation stops shall be the following type or a corporation stop approved by the Director as equivalent in design and composition to the following types:

(i) Ford – FB1000-3-NLG.

(ii) Mcdonald – 74701BQ No lead brass.

(iii) Mueller – B25008N.

(4) **Water Meters**

(a) General: All water meter installations shall be in accordance with the following standards and the drawings in Chapter 11, "Technical Drawings," of these Standards for all water services:

(i) All meters shall be "Badger" meters.

(ii) No connections shall be made in the meter pit other than those related to the meter and bypass. Sprinkler system or backflow preventer connections shall be made no closer than 5 feet from the meter pit or vault on the downstream side of the meter.

(iii) The city will own and maintain the service line and fittings up to and including the meter.

(iv) Residential 3/4-inch meters with transponders shall be provided and installed by the City upon the contractor's request for a final meter inspection. All other meters and associated transponders shall be purchased by the contractor and then provided to the City for testing prior to installation.

(v) The contractor shall contact the City's Meter Shop prior to purchasing meters and transponders to verify the type of meter that will be required. The contractor shall also contact the City's Meter Shop to make an appointment for delivery of the meter(s) to the City for testing. The location of installation and manufacturer's information shall accompany the meter when delivered by the contractor to the City. The meter will be tested and a schedule set for picking up the meter within two working days by the contractor.

(b) 3/4-Inch and 1-Inch Meter Installations: 3/4-inch and 1-inch meter sets shall be installed in accordance with the following standards and the drawings in Chapter 11, "Technical Drawings," of these Standards:

(i) The meter shall be installed within right-of-way or a public easement.

(ii) No meter shall be set in a street, sidewalk, driveway alignment, or other traffic or concrete area except where existing conditions or other regulatory requirements prevent installation consistent with this requirement. Where existing conditions or other regulatory requirements prevent installation consistent with this requirement, the Director may approve an alternative design that minimizes the impact of meter maintenance and replacement activities on adjacent structures, infrastructure, and paved surfaces.

(iii) In attached sidewalk areas, the meter shall be located a minimum of 18 inches from the back of the sidewalk to the edge of the meter lid.

(iv) Where no sidewalk exists, the meter shall be located a maximum of 6 feet behind the back edge of the curb.

(v) In detached sidewalk areas, the meter shall be located a maximum of 6 feet behind the back edge of curb but no closer than 18 inches from the front edge of the sidewalk to the edge of the meter lid.

(vi) The dome or meter lid shall be level and 2 inches above the approved final grade.

(vii) The copper setter shall be a minimum of 15 inches and a maximum of 17 inches below the meter pit lid.

(viii) Meter pits shall be constructed of modified hi-density polyethylene. The size shall be as specified in the detail drawing in the appendix of this Chapter. Grade adjustment shall be made at the top of the pit using concrete rings. The trench floor under the concrete rings shall be compacted earth. The concrete pit shall not bear on the service pipe.

(ix) Lids shall be a 12-inch cast iron lid and bonnet and shall have a 2-inch diameter hole in the center to accommodate the transponder.

(x) Final inspections of the meter pit will be made at the time the meter is set. The permit applicant is responsible for any required adjustments to the copper setter or meter lid at that time.

(c) 1-1/2-Inch and 2-Inch Meter Installations: 1-1/2 -inch and 2-inch meter sets shall be installed in accordance with the following standards and the drawings in Chapter 11, "Technical Drawings," of these Standards:

(i) The meter model shall be Badger E112 SS 1 ½ Model 120 or Badger E2 SS 2 Model 170.

(ii) 1-1/2-inch and 2-inch meters shall be installed in a manhole.

(iii) A meter manhole shall be installed within the right-of-way or a public utility easement.

(iv) No meter manhole shall be set in a street, sidewalk, driveway alignment, or other traffic or concrete area except where existing conditions or other regulatory requirements prevent installation consistent with this requirement. Where existing conditions or other regulatory requirements prevent installation consistent with this requirement, the Director may approve an alternative design that minimizes the impact of meter maintenance and replacement activities on adjacent structures, infrastructure, and paved surfaces. If the meter manhole is approved for construction in streets or other traffic areas the manhole shall use a 24-inch cast iron ring and cover and shall be designed to accommodate and protect the transponder.

(v) In attached sidewalk areas, the meter manhole shall be located a minimum of 3 feet behind the sidewalk and in no case shall the manhole be located more than 25 feet from the back edge of curb.

(vi) Where no sidewalk exists, the meter manhole shall be located a maximum of 6 feet behind the back of curb.

(vii) In detached sidewalk areas, the meter manhole shall be located a maximum of 6 feet behind the back edge of curb but no closer than 18 inches from the front edge of the sidewalk to the edge of the meter lid.

(viii) Meter manhole lids shall be a maximum of 2 inches above the approved final grade.

(ix) A curb stop is required on the service line behind the back of curb and outside of the manhole.

(x) Meter manholes shall use a 24-inch aluminum ring and cover, and the outside of the aluminum ring shall have 8 mils of tar applied. Once the tar is set, a 12-inch wide by 6-inch-thick concrete collar shall be placed around the manhole ring.

(xi) The manhole cover shall have a 2-inch diameter recessed hole in the center of the cover for the transponder, and the cover shall have the lettering "Water Meter" cast into the lid.

(d) 3-Inch and Larger Meter Installations: 3-inch and larger meter sets shall be installed in accordance with the following standards and the drawings in Chapter 11, "Technical Drawings," of these Standards:

(i) 3-inch and larger meters shall be installed in a vault.

(ii) The entry hole through the roof of the vault shall be aligned perpendicular to the service line and adjacent to the water meter.

(iii) Vaults shall be sealed at all joints and made watertight.

(iv) Meter vault lids shall be a maximum of 2 inches above the approved final grade.

(v) In attached sidewalk areas, the meter vault shall be located a minimum of 5 feet behind sidewalk or back of curb and no more than 25 feet from the back of curb.

(vi) Where no sidewalk exists, the meter shall be located a maximum of 6 feet behind the back of curb.

(vii) In detached sidewalk areas, the meter shall be located a maximum of 6 feet behind the back edge of curb but no closer than 18 inches from the front edge of the sidewalk to the edge of the meter lid.

(viii) A curb stop is required on the service line behind the back of curb and outside of the vault.

(ix) The meter vault shall be installed within the right-of-way or a public utility easement.

(x) No meter manhole shall be set in a street, sidewalk, driveway alignment, or other traffic or concrete area except where existing conditions or other regulatory requirements prevent installation consistent with this requirement. Where existing conditions or other regulatory requirements prevent installation consistent with this requirement, the Director may approve an alternative design that minimizes the impact of meter maintenance and replacement activities on adjacent structures, infrastructure, and paved surfaces. If the meter manhole is approved for construction in streets or other traffic areas the manhole shall use a 24-inch cast iron ring and cover and shall be designed to accommodate and protect the transponder.

(xi) Meter vaults shall use a 24-inch aluminum cover and shall have the lettering "Water Meter" cast into the lid.

(xii) A 24-inch x 36-inch aluminum cover adaptor and ring shall be used to enlarge the access opening, and the adaptor shall have a 2-inch diameter hole for the transponder. The outside of the aluminum ring shall have 8

mils of tar applied. Once the tar is set, a 12-inch wide by 6-inch-thick concrete collar shall be placed around the manhole ring.

(xiii) PVC pressure pipe shall be used on the service line outside the vault except where the PVC pipe stubs through the vault walls. Ductile iron pipe shall be used inside the vault.

(xiv) For all 3-inch and 4-inch meter settings, 4-inch service pipe will be required on the city side of the meter. A reducer will be required before the meter and on the bypass for 3-inch settings. Insulators shall be provided between connections of dissimilar metals. Meter installations larger than 4 inches shall require submittal of drawings for approval by the Director.

(xv) A minimum of distance 5 times the pipe diameter of straight, unobstructed pipe is required upstream of the meter.

(xvi) Final inspections of the meter vault will be made at the time the meter is set.

(5) **Service Saddles:** Corporation stops require the installation of a bronze or brass bodied service saddle with 304L stainless steel double straps and studs, equivalent in design and composition to “Mueller” BR 2 S series or “McDonald" 3855 series for cast iron or PVC. All saddles require an AWWA tapered thread (CC) outlet. No direct taps to PVC pipe are allowed.

(6) **Insulators (Ferrous Pipes only):** Insulators shall be installed at the inlet end of the corporation stop and shall be Ford Service Insulators or an approved equivalent for service lines.

(C) Execution

(1) **General**

(a) Size as shown, lay to grades and lines in accordance with pipe manufacturer’s specifications. Thoroughly clean pipe interiors of foreign matter before placing into trench. Replace with new pipe any laid section of pipe found damaged or defective. All pipe fittings, valves, and appurtenances shall be installed according to manufacturer’s instructions. Corporation stops shall be installed with the appropriate tapping machine in the presence of the Director after the waterline has been pressure tested.

(b) All bedding, pipe zone backfill, compaction, polyethylene sheathing and other details of the water pipeline construction shall be returned to original condition after service connections are completed.

(c) Service connections to all ferrous mains shall be electrically insulated by means of a City approved insulating fitting.

(2) **Pipe Cutting:** Cutting shall be done neatly by methods that will not damage pipe.

(3) **Testing:** Testing of water service pipe shall be as specified in Section 9.13, “Testing of Water Pipes,” of these Standards.

(4) **Backfilling and Restoring Surface Conditions:** Backfilling and Restoring surface conditions shall be as specified in Section 9.02, “Excavation and Trenching,” of these Standards.

(5) **Disinfecting Potable Pipelines:** Water service pipe shall be disinfected as specified Section 9.12, "Disinfecting Waterlines," of these Standards.

9.06 Gate Valves

(A) General

(1) **Scope:** This section describes the furnishing and installation of gate valves and appurtenances for potable water service in the pipe diameter size range of 4 to 12 inches.

(2) **Quality Assurance**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) All valves shall be tested in accordance with AWWA C500 or C509. Certified copies of the results of all tests, together with an affidavit of compliance shall be provided to the City inspector prior to construction.

(B) Materials

(1) **Gate Valves**

(a) Gate valves are required for 4-inch through 12-inch valve sizes. The Director may approve a different valve type where practical installation of a gate valve is not feasible.

(b) Gate valves shall be iron body, resilient-seated gate valves with non-rising bronze stems with design, construction, and pressure ratings conforming to AWWA Specifications C-509-01, Resilient Seated Gate Valves, or C515-01, Reduced Wall Resilient Seated Gate Valves, and with modifications specified herein.

(c) Stem seals shall be triple "O" ring seals designed so that the seals above the stem collar can be replaced with the valve under pressure and in full open position.

(d) Gate valves shall be one of the following types:

(i) American Flow Control, Series 2500 (C515 only).

(ii) Mueller, Series 2360 (C509 only).

(iii) American AVK.

(iv) Series 45 CLOW Valves, Models 2639 and 2640.

(e) With the exception of tapping valves and valves in vaults, gate valves shall have mechanical joint ends.

(f) All ferrous internal and external surfaces of the valves shall be epoxy coated in conformance with AWWA C116-03, Protective Fusion Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron and Gray Iron Fittings, and C550-05, Protective Interior Coatings for Valves and Hydrants. The coating shall be a two-part thermosetting epoxy suitable for field over coating and for touch-up with the same coating material without special surface preparation. The supplier shall furnish detailed performance tests of adhesion, hardness, and abrasion resistance of the furnished coatings when requested by the City. The coating shall

have a successful record of performance in valves, pipe, or other fittings for a minimum of ten years.

(g) The resilient seat gate valve stem shall have external break-off capabilities for over-torquing and positive stop to prevent over compression.

(h) All external bolts, nuts, and washers used in conjunction with valves shall be stainless steel, and tee-bolts shall be "Cor-blu".

(i) Valves shall be delivered complete with bolts, glands, and rubber gaskets in conformance with AWWA C111-07, Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.

(2) **Valve Boxes**

(a) All buried valves shall be provided with valve boxes. Valve boxes shall be of cast iron, 3-piece screw type, suitable for the depth of cover required by the drawings. Valve boxes shall be 5 ½ inches in diameter, shall have a minimum thickness at any point of 1/16 inch, and shall be provided with suitable cast iron bases and stay-put covers. Covers shall have cast thereon “water” on the top. They shall be Tyler 6860 series or approved equal.

(b) The valve box shall have at least 6 inches adjustment above and below specified depth of cover over pipe.

(c) All parts of valve boxes, bases, and covers shall be coated by dipping in bituminous varnish.

(d) Valves and valve boxes shall be set plumb. Each valve box shall be placed directly over the valve it serves, with the top of the box brought flush with the finished grade. After being placed in proper position, earth shall be filled in around each valve box and thoroughly tamped on each side of the box.

(3) **Special Wrenches and Keys:** All tools needed to operate valve and to open valve box lid. At least one of each type as required for each style and size of box and lid shall be furnished by the contractor. Provide 1 key for each valve. Key lengths shall be as approved by the Director.

(C) Execution

(1) **Handling:** All valves and actuators shall be transported and stored in a manner that will protect them from damage.

(2) **Installation:** Install valves as indicated in Chapter 11, “Technical Drawings,” of these Standards, and set plumb on a firm base. All foreign matter shall be removed from the valve interior prior to installation.

(3) **Valve Boxes:** Install a valve box over the gate valve with the base section centered over the operating nut and resting on well-compacted backfill. The top section shall be so set as to allow equal movement above and below finished grade, with the final elevation to be 1/4 inch below finished grade in roadways and 1 to 2 inches above grade outside of roadways. The top of base section shall be placed approximately on line with the operating nut at the top of the valve stem, and the entire assembly shall be plumb.

(4) **Tests:** Gate valve tests shall be with and part of the general tests on the companion water lines.

(5) **Disinfection:** Gate valve disinfection shall be done with and as a part of the disinfection to the companion water lines.

9.07 Butterfly Valves

(A) General

(1) **Scope:** This section describes the furnishing and installation of butterfly valves and appurtenances for potable water service in the pipe diameter size range of 12 inches to 24 inches.

(2) **Quality Assurance:** Manufacturer's installation recommendations and certificates of compliance shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(3) **Testing:** All valves shall be tested in accordance with Section 3.8 of AWWA C504. Certified copies of the results of all tests, together with an affidavit of compliance shall be provided to the City inspector prior to construction.

(B) Materials

(1) **Butterfly Valves**

(a) Butterfly valves shall be rubber-seated conforming to the AWWA C504 and designed for buried service. The valves shall be designed to operate as open or closed with a design velocity of 8 feet per second. The valves shall have a cast-iron body with mechanical joint ends conforming to ANSI 21.11, AWWA C111 and shall be rated for a design working pressure of 150 psi. Butterfly valves shall be one of the following types: Mueller, Lineseal III and XPII (sizes up to 48 inches), Pratt, Triton XR-70 (sizes 24 inches to 72 inches), or K-Flo 500 Series (sizes up to 20 inches); unless a butterfly valve equivalent in design and composition to these types has been approved by the Director.

(b) Discs shall be cast or ductile iron with stainless steel, type 304, either stub or one-piece shafts. Discs shall be secured to shafts by means of solid, smooth sided, stainless steel or monel pins or dowel pins. Each taper pin or dowel pin shall extend through or shall wedge against the side of the shaft and shall be mechanically secured in place. The use of bolts, setscrews, knurled or fluted dowel pins, expansion pins, roll pins spring pins, or other devices in lieu of the pins specified herein will not be acceptable.

(c) Shaft bearings shall be the bushing type of nylon or Teflon. Thrust bearings that are directly exposed to line liquid and that consist of a metal bearing surface in rubbing contact with an opposing metal bearing surface will not be acceptable. Shaft seals may be rubber ring or chevron packing.

(d) Seats shall be rubber vulcanized to the body and designed to provide bubble tight shutoff with mating surface of Type 304 or 316 stainless steel or monel mounted on the discs. Valve seat configurations that rely on the mating pipe flange to hold the seat in position in the valve body will not be acceptable.

(e) The valve operator shall be the traveling-nut type designed for previous stated conditions, in an enclosed body, sealed to prevent the entrance of groundwater up to the depth of 5 feet above the valve. The operator shall have travel limiting

devices to prevent over closing or opening damage to the valve. Valves shall open counterclockwise with the use of a valve key on a 2-inch square operating nut. The housing of traveling-nut type actuators shall be fitted with a removable cover that shall permit inspection and maintenance of the operating mechanism without removing the actuator from the valve.

(C) Execution

(1) **Handling:** All valves and actuators shall be transported and stored in a manner that will protect them from damage.

(2) **Installation:** Install valves with the shaft horizontal according to the manufacturer's recommended installation procedures. Operate all valves from full open to full close before installation. Check all seats, seat rings, shaft sleeves, disc connections, etc. prior to installation.

(3) **Valve Boxes:** Install valve boxes over the valve operator with the base section centered over the operator nut and resting on well-compacted backfill. The top section shall be set to allow equal movement above and below finished grade, with final elevations to be 1/4 inch below finished grade in roadways and 1 inch to 2 inches above grade outside of roadways. The top of base sections shall be placed approximately on line with the operator nut at the top of the valve stem, and the entire assembly shall be plumb.

(4) **Tests:** Butterfly valve tests shall be done with and as a part of the general tests on the companion water lines.

(5) **Disinfection:** Butterfly valve disinfection shall be done with and as a part of the general disinfection to the companion water line.

9.08 Tapping Sleeves and Valves

(A) General

(1) **Scope:** This section describes the furnishing and installation of tapping sleeves and valves for potable water service in the pipe diameter size range of 4 inches to 12 inches.

(2) **Quality Assurance**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) The manufacturer of tapping sleeves and valves shall be experienced in their design and construction, shall be regularly engaged in their manufacture, and shall have produced tapping sleeves and valves of the sizes specified herein that have given successful service for a period of at least 5 years.

(B) Materials

(1) **General**

(a) All tapping sleeves shall be constructed of stainless steel that meets or exceeds the requirements of ASTM A240 Type 304 UNS designated S30400. Tapping sleeves shall be "Romac Industries" SST, "Mueller" H-

304L, “Ford” FTSS, “JCM” 432, or a tapping sleeve of equivalent design, material, and rating approved by the Director.

(b) Extension stems, valve boxes, and special wrenches and keys shall be as specified in Section 9.06(B), “Materials,” of these Standards.

(2) **Flanges:** Flanges shall be fabricated from steel plate, and all dimensions shall conform to AWWA Standard C207, Class D. Flanges shall be machined to a flat rate with finish of 250 micro inches or machined to a flat surface with a serrated finish in accordance with AWWA Standard C207. In addition, the machined face shall also be recessed for tapping valves in accordance with the MSS Standard SP-60.

(3) **Gaskets:** Gaskets shall be compounded from new materials, and the shape and cross-section of the gasket shall provide adequate seal for the design pressure. Gaskets shall be shop glued to the groove provided in the body section.

(4) **Fasteners:** Bolts and hex nuts shall be stainless steel or an approved equivalent for corrosion control.

(5) **Testing Outlet:** A 3/4-inch NPT by welded coupling shall be attached to the outlet nozzle of each tapping sleeve assembly, complete with a 3/4-inch square head pipe plug.

(6) **Tapping Valves:** With the exception of the valve ends and other modifications necessary for tapping service, tapping valves shall be as specified in Section 9.06(B), “Materials,” of these Standards. Each tapping valve shall be provided with a flanged inlet end designed, faced and drilled for attachment to the outlet flange of the tapping sleeve; an outlet end provided with a tapping flange for attachment of a standard drilling machine; and a mechanical joint bell end for connection of the branch main. The size of the waterway shall include the appropriate clearance for the diameter of the tapping machine cutter recommended by the valve manufacturer. Tapping valves shall be Mueller “No. H-667" or equal.

(7) **Painting:** All ferrous internal and external surfaces of the valves shall be epoxy coated in conformance with AWWA C116-03, Protective Fusion Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron and Gray Iron Fittings, and C550-05, Protective Interior Coatings for Valves and Hydrants. The coating shall be a two-part thermosetting epoxy suitable for field over coating and for touch-up with the same coating material without special surface preparation. The supplier shall furnish detailed performance tests of adhesion, hardness, and abrasion resistance of the furnished coatings when requested by the City. The coating shall have a successful record of performance in valves, pipe, or other fittings for a minimum of ten years.

(C) Execution

(1) **Tapping Valves:** Install tapping valves in the lines as indicated on the drawings and set plumb on a firm base. All foreign matter shall be removed from the valve interior prior to installation. Valves shall be securely bolted to the tapping sleeve in accordance with the manufacturer’s instructions using the fasteners specified in Subsection 9.08(B)(4) of these Standards.

(2) **Tests:** Valve tests shall be done with and as a part of the general tests on the companion waterlines.

(3) **Disinfection:** Valve disinfection shall be done with and as a part of the general disinfection to the companion waterline.

9.09 Fire Hydrants

(A) General

(1) **Scope:** This section describes the furnishing and installation of fire hydrants for potable water service.

(2) **Quality Assurance**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) All valves shall be tested in accordance with Section 5.1 of AWWA C502. Certified copies of the results of all tests, together with an affidavit of compliance shall be provided to the City inspector prior to construction.

(B) Materials

Fire hydrants shall be "Mueller" Super Centurion 250 A-423 or "CLOW" Medallion 395" (the "CLOW" Medallion shall be a higher-pressure rating with chain tagged "heavy duty"), with mechanical joint bottom connection and meet the following requirements:

(1) **Inlet Pipe:** 6-inch, mechanical joint inlet shoe and accessories.

(2) **Trench Depth:** 4-1/2 feet cover (Note: standard shipping depth is 5.0").

(3) **Operating Nut:** 1-1/2-inch Pentagon National Standard Threads.

(4) **Open:** Left (CCW).

(5) **Connection:** Two 2-1/2-inch hose nozzles and one 5-1/4-inch pumper nozzle.

(6) **Threads:** National Standard Hose Threads.

(7) **Pressure:** 150 psi working pressure, 300 psi pressure.

(8) **Break-Off Flange:** Hydrants shall be provided with traffic break-off flange.

(9) **Mechanical Joint Bolts and Nuts:** The mechanical joint bolts and nuts shall be anti-galling coated stainless steel, "NSS" Cor-Blue, or an equivalent in design, material, and specifications.

(10) **Shoe Nuts and Bolts:** Shoe nuts and bolts shall be corrosion resistant stainless steel, Grade 304.

(11) **Color:** Color shall be Rustoleum No. 831 "restful green" or KWAL "hydrant green" except for bonnet, weather caps and nozzle caps, which must be Rustoleum No. 2766 "reflectorized white."

(12) **Spares:** A set of spare break-off parts shall be furnished.

(C) Execution

(1) **Hydrants:** Where applicable, hydrants shall be installed with pumper outlet facing the adjacent roadway or parking area. Set hydrants at such elevations that the connecting pipe shall drain to the main with a grade of not less than 1 percent, and upon a concrete foundation not less than 6 inches thick and 18 inches square. The centerline of nozzles shall be at least 18 inches above finished grade. Firmly block the back of the hydrant

opposite the pipe connection with a concrete thrust block braced against the vertical face of the trench to prevent the hydrant from blowing off the line.

(2) **Drainage Aggregate and Backfill:** Place not less than 1/3 cubic-yard of approved clean gravel or crushed rock around the base of each hydrant and 12 inches over the top of the supply pipe to insure drainage. A layer of 30-pound asphalt-saturated felt paper or heavy vinyl sheet shall be placed over gravel to keep backfill material from sifting into gravel. Thoroughly compact the backfill around hydrants, to the grade line, in an approved manner.

(3) **Operations Check:** Clean hydrant interiors of all foreign matter before installation. Stuffing boxes shall be tightened and the hydrant inspected in opened and closed positions to see that all parts are in working condition.

(4) **General:** Hydrants shall be tagged "out-of-service" until the water system is operational. It is the responsibility of the contractor to notify Boulder Police Communications regarding the location of the tagged hydrants.

9.10 Combination Air Valve

(A) General

(1) **Scope:** This section describes the furnishing and installation of combination air valves for potable water service.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Manholes:** Refer to Section 9.16, "Manholes and Inlets," of these Standards.

(2) **Combination Air Valve:** The valve shall be a 2-inch combination air release vacuum valve, "Vent-O-Mat" Series 050 RB X 25 2 1, or approved equivalent in design, material, and specifications. The combination air valve shall be provided with a 2-inch diameter hand wheel operated gate valve.

(3) **Hose Gate Valve:** A 3/4-inch hose gate valve is to be installed in the air release valve manhole. The valve shall have a bronze body, threaded end, solid wedge, union bonnet, inside screw rising stem gate valve. These valves shall be "Powell" 375 HS. Each hose gate valve shall be equipped with a brass cap and chain.

(4) **Ball Valve:** Ball valves shall be of bronze or brass construction with two-piece end entry body, bronze or brass ball, Teflon or Viton stem seal, reinforced Teflon seats and thrust washer, a removable operating lever, and threaded ends. Valves shall be rated not less than 500 psi non-shock cold WOG and shall be drip-tight in both directions. Valves shall be "Conbraco Industries" Apollo 70-100 Series, "Powell" Fig 4210T, or "Stockham" S-216.

(5) **Corporation Stop:** A corporation stop shall be as referenced in Subsection 9.05(B)(3), of these Standards.

(6) **Insulators:** Insulators shall be as referenced in Subsection 9.05(B)(6), of these Standards.

(C) Execution

(1) **Installation:** Install valve, manhole, and appurtenances as indicated on Drawing No. 5.22, in Chapter 11, "Technical Drawings," of these Standards, and in accordance with applicable provisions of the related sections.

(2) **Tests:** Valve tests shall done be with and as a part of the general tests on the companion waterlines.

(3) **Disinfection:** Valve disinfection shall be done with and as a part of the general disinfection to the companion waterlines.

9.11 Pipeline Fittings

(A) General

(1) **Scope:** This section describes the furnishing and installation of pipeline fittings for potable water service.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Gray or Ductile Iron:** Fittings shall be made from gray iron or ductile iron and manufactured in accordance with AWWA C110-08, Ductile Iron and Gray Iron Fittings, or AWWA C153-06, Ductile Iron Compact Fittings.

(2) **Rubber Gasket Joints:** Fittings shall be furnished with rubber gasket joints in accordance with AWWA C111-07, Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.

(3) **Design:** Fittings shall be rated for a design working pressure of 350 psi pressure rating and shall conform to the dimensions and weights shown in the tables of the AWWA standards referenced in this Section 9.11(B) of these Standards.

(4) **Certification:** The manufacturer shall prepare a certified statement that the inspection and all specified tests have been performed and the results thereof comply with the requirements of the applicable AWWA standard(s) specified in Section 9.11(B) of these Standards. The contractor shall cause a copy of the certification to be sent to the City upon request.

(5) **Ductile Iron Flanged Fittings:** Ductile iron flanged fittings shall be manufactured in accordance with the following:

(a) Integrally cast flange fittings: AWWA C110-08, Ductile Iron and Gray Iron Fittings.

(b) Threated flange fittings: AWWA C115, Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges.

(c) Ductile iron flanged fittings shall be rated for 250 psi working pressure and shall be installed with special gaskets that achieve 350 psi working pressure.

(6) **4 Through 6 Inch Fittings:** 4 through 16-inch diameter fittings shall be furnished with a fusion bonded epoxy inside and out, with a standard thickness as defined in AWWA

C116-03, Protective Fusion Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron and Gray Iron Fittings. The Director may waive the requirement for fusion bonded epoxy on fittings if the Director finds that specific fittings are not available.

(7) **Bolts and Nuts:** Fittings shall be furnished with tee-head mechanical joint bolts and hexagon nuts, fabricated from corrosion resistant high strength, low alloy steel such as "Cor-Ten" or “Blue Bolts.”

(8) **Connection fitting:** Mechanical joint anchoring fittings (swivel) shall also be used. Infact Corporation’s “Foster Adaptor” may also be used to connect between mechanical joint fittings, valves and hydrant connections.

9.12 Disinfecting Waterlines

(A) Scope

This section describes the disinfecting of all portions of the potable water system, including buried piping, valves, hydrants, and any portion of the existing connecting system that might have become contaminated during construction activities, and also any temporary water service piping used during construction.

(B) Materials

(1) **Chlorinating Material:** The chlorinating material shall either be a hypochlorite solution, tablets or granules.

(2) **Tablet Attachment:** The hypochlorite tablets shall be fastened to the top of the pipe using Permatex No. 1.

(C) Execution

(1) **Disinfection**

(a) Care shall be taken to prevent contaminating materials from entering the water mains during construction or repair. Such materials that may accidentally enter the main shall be removed by flushing. This flushing shall be done prior to disinfection unless the tablet method of disinfection is used. If, in the opinion of the Director, the contaminated material that has entered cannot be removed by flushing, the interior of the pipe shall be cleaned by mechanical means and then swabbed with a 1 percent hypochlorite solution.

(b) Upon completion of the water pipelines, all new pipe, valves, hydrants, etc. shall be thoroughly flushed and disinfected, using a continuous-feed method of hypochlorite and water mixture or hypochlorite tablets or granules in accordance with AWWA Standard C-651, latest revision.

(c) The chlorinating material shall be introduced into the water lines and distribution systems in a manner approved by the Director. After a contact period of not less than 24 hours, the treated water in the lines shall contain not less than 10 mg per liter chlorine using the continuous-feed method or 25 mg per l chlorine using the tablet or granular method throughout the length of the line. The system shall be flushed after successful completion of disinfection with clean water until the residual chlorine content is no more than 1.0 mg per liter. All valves in lines

being disinfected, except those being used as bulkheads, shall be opened and closed several times during the contact period. During flushing and disinfection the contractor shall make sure that none of the disinfection solution enters any existing water main.

(d) Flushing shall be done with a flushing velocity of at least 2 ½ feet per second. The contractor shall provide all fittings required to flush the line. Flushing will be accomplished in such a manner that no erosion will occur and there will be no damage to street, fish, animals, plants or other property.

(2) **Bacteriological Examination:** After the system has been thoroughly flushed and before the new water line is connected to the distribution system, samples shall be taken from representative points in the system, at intervals of 1200 feet, in sterile bottles treated with sodium thiosulfate. Labeled samples shall be submitted to the City Drinking Water Program staff, or designated certified laboratory, for bacteriological examination. Submitted samples shall meet all City and State bacteriological standards, showing the absence of both coliform and heterotrophic bacterial growths. If the initial disinfection fails to produce satisfactory bacteriological results, the new main shall be reflushed and resampled. If check samples also fail to produce acceptable results, the main shall be rechlorinated by the continuous feed or slug method until satisfactory results are obtained.

(3) **Disposal of Solution:** Following testing, the solution and flushing water shall be disposed of by the contractor into the nearest sanitary sewer line. The solution and flushing water shall not be dumped into any lakes, streams, waterways, irrigation ditches or stormwater drainage systems. If wasted water cannot be safely discharged into a sanitary sewer system, and then a reducing agent shall be applied to the wasted water to thoroughly neutralize the chlorine residual remaining in the water.

9.13 Testing of Water Pipes

(A) General

This section describes the testing of all water pipe including water mains, fire lines and services.

(B) Materials

The contractor shall provide all necessary test equipment including test pumps, pipe, connectors, meters, gauges, instruments, and other equipment required. Pressure gauges used shall be graduated in increments no more than 5 psi and shall have a range of approximately twice the test pressure. Gauges meters and other instruments shall be calibrated prior to testing.

(C) Execution

(1) **Notification and Witness**

(a) The contractor shall notify the Director of all tests at least 48 hours prior to testing so that the Director can witness the tests.

(b) The pipe may be subjected to hydrostatic pressure and inspected and tested for leakage at any convenient time after the trench has been partially backfilled, except at the joints, or backfilled as permitted by the Director. Where any section is provided with concrete thrust blocks, the pressure test shall not be made until at least 2 days have elapsed after the concrete was installed.

(2) **Pressure Test**

(a) All new pipe shall be pressure tested prior to connection to the existing system. All pipe shall be tested at a pressure of 150 psi at the lowest point in each section or 1½ times the working pressure, whichever is greater.

(b) Prior to testing, all equipment that would be damaged by the test pressure shall be removed. This equipment shall be replaced in the system after testing is complete. All pipe and appurtenances shall be backfilled except for joints unless otherwise permitted by the Director.

(c) The contractor shall slowly fill the pipe with water prior to testing and remove all air from the piping system. Each valved section, unless otherwise directed by the Director, shall be tested prior to connection to the existing system. The duration of each pressure test shall be at least 2 continuous hours. Test time will be accrued only while full test pressure is on the system. All water used in testing the pipelines shall be provided by the contractor from a potable water source.

(d) The specified test pressure shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Director. The contractor shall furnish all necessary labor, equipment, and connection corporation stops to the pipeline to perform the test.

(e) No testing shall be permitted against valves or fittings that are part of the existing system unless specifically approved by the Director. All exposed pipes, fittings, valves, hydrants, and joints will be carefully examined during the test. Any cracked or defective pipe, fittings, valves, or hydrants discovered during the pressure test shall be removed and replaced by the contractor with sound material. The test shall be repeated until the test is satisfactory to the Director.

(3) **Leakage Test**

(a) A leakage test shall be conducted after the pressure test has been completed, unless the pressure test indicates that there are no leaks. The contractor shall furnish the pump, pipe, connections, meters and all other necessary apparatus, and shall furnish all necessary assistance to conduct the test. The duration of each leakage test shall be two hours, and, during the test, the main shall be subjected to a hydrostatic pressure specified.

(b) No pipeline installation will be accepted until the leakage is less than the amount computed by the following formula:

$$L = \frac{SD(P)^{0.5}}{133{,}200}$$

Where: L = Allowable Leakage (Gallons Per Hour)

S = Tested Length of Pipe (Feet)

D = Nominal Diameter of Pipe (Inches)

P = Average Test Pressure During the Test (psi)

(c) The contractor shall, at their own expense, locate and repair the points of leakage until the leakage is within the specified allowance.

9.14 Polyvinyl Chloride (PVC) Non-pressure Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of polyvinyl chloride (PVC) non-pressure pipe and appurtenances for storm sewer mains, sanitary sewer mains and sewer services in the pipe diameter size range of 4inches to 15inches.

(2) **Quality Assurance: Manufacturer's** certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **PVC Non-pressure Pipe**

(a) PVC non-pressure pipe shall be type PSM polyvinyl chloride (PVC) having a cell classification of 12454 or 12454 or 13364 (with a minimum tensile modules of 500,000 psi) as defined in ASTM D1784. All PVC pipe and fittings shall meet or exceed all of the material requirements of ASTM D3034 and thickness requirements of SDR 35.

(b) Provisions must be made for contraction and expansion at each joint with a rubber ring and integral thickened bell as part of each joint. Gaskets shall conform to ASTM F477. Pipe shall be supplied in laying lengths of 19-1/2 to 20 feet. All pipe and fittings shall be assembled with a non-toxic lubricant. Each length of pipe and all fittings shall have marked on the exterior the following:

(i) Manufacturer's Name or Trademark;

(ii) Nominal Pipe Size;

(iii) PVC Cell Classification (e.g. 12454-B);

(iv) Legend - Type PSM SDR-35 Sewer Pipe; and

(v) ASTM - D3034.

(c) All fittings and plugs to be used with the PVC pipe shall be those manufactured by the manufacturer of the pipe. Each special fitting shall be a completely manufactured unit with either bells or spigots on each connection that are an exact duplication of the bells and spigots on the pipeline. Fittings with any other type of connections will not be accepted.

(2) **Plugs:** Plugs shall be specifically manufactured for the pipelines where they are to be installed. The plug shall be constructed of a material approved by the Director and shall provide a permanent watertight installation.

(3) **Couplings**

(a) Couplings shall be used only where shown on the approved drawings or where approved in writing by the Director. The contractor shall provide a description of an exact location of any couplings used.

(b) Flexible couplings shall consist of a rubber gasket or boot with a stainless steel shield and tightening bands. Couplings shall be ASTM C1173 Type B couplings and shall be "Fernco Strong Back" or an approved equivalent.

(4) **Grout**

(a) Grout shall conform to the specifications defined in Section 9.16(B)(5). The contractor may substitute a two-component, 100 percent solids epoxy resin for the specified grout.

(b) Grout used for sealing service connections shall be a 2-component, waterproof epoxy grout specifically manufactured for this application. The grout shall adhere to any of the dissimilar materials.

(5) **Sealants:** Sealants used on manholes or pipe connections shall be equal to SIKAFLEX-la, a one component polyurethane base, elastomeric sealant. When required due to moisture or immersion, provide SIKAFLEX 429 or an equivalent primer for application onto the substrate according to manufacturer's recommendation.

(C) Execution

(1) **General**

(a) Each pipe length and fitting interior, interior surface of bells, and exterior surface of spigots shall be cleaned of all foreign material before placement in the trench and shall be kept clean at all times thereafter. Each item shall also be examined for cracks and other defects before installation.

(b) Pipe shall be cut, only whenever necessary, to conform to location of manholes or connections. All cuts shall be straight, true, and at right angles to the axis of the pipe. The cutting process shall leave a smooth end without damaging the pipe. All burrs shall be removed from the ends of cut pipe, and the end lightly rasped or filed. All tools used in cutting pipe will be subject to the Director's approval.

(c) Pipe laying shall proceed with the spigot ends of pipe pointing in the direction of the flow, unless otherwise approved by the Director. Each pipe length shall be laid true to line and grade in such manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets to the flow line. Pipe shall be laid in a dewatered trench and shall not be used for draining water from the trench. Do not lay pipe when trenches or weather conditions are unsuitable for such work.

(d) Whenever the pipe is left unattended or pipe laying is not in progress, temporary plugs shall be installed at all openings. Temporary plugs shall be watertight and of such design as to prevent debris and animals from entering the pipe. All temporary plugs will be subject to approval by the Director.

(e) The contractor shall install the materials in accordance with the manufacturer's recommendations. If there is a conflict between the methods prescribed in the approved plans and the manufacturer's instructions, the contractor shall obtain resolution from the Director, before proceeding with the work.

(2) **Pipe Installation**

(a) Pipe Laying: No deflection in the joints shall be allowed. All pipe shall be fully supported along the full length of pipe barrel without support by the bell mounding.

(b) Pipe Joints

(i) The outside of the spigot and the inside of the bell shall be thoroughly wiped clean. Set the rubber ring in the bell with the marked edge facing toward the end of the bell. Lubricate the spigot end using a thin film of the manufacturer-supplied lubricant. Push the pipe spigot into the bell. Position the completed joint so that the mark on the pipe end is in line with the end of the bell.

(ii) Bevel the end of cut pipe with a beveling tool after the pipe is field cut. Place a clearly visible position mark at the correct distance from the end of the field-cut pipe.

(3) **Connection of Pipe to Concrete Manhole Base**

(a) The pipe shall be encased in the concrete poured for the manhole base as detailed in Drawing No. 6.01, "Standard Sewer Manhole," in Chapter 11, "Technical Drawings," in these Standards. Special provisions shall be made for water tightness of the connection.

(b) The exterior circumference of the pipe where encased in concrete for water tightness shall be uniformly roughened or scarified by sanding with coarse sandpaper or emery cloth for at least 6 inches encased length.

(c) Additionally, gasket as specified elsewhere shall be stretched onto the pipe to form a weep ring where encased in concrete. Any alteration to the above specified methods for pipe connection to concrete shall be submitted to the Director for approval.

(4) **Grouting**

(a) Any opening between the manhole wall and pipe made during construction shall be closed and sealed with watertight grout. The opening shall be of sufficient size to accommodate the pipe, "O" rings, and grout. The grout shall extend no less than the full width of the manhole barrel.

(b) Channels that have been cut into concrete bases shall be smoothed to the specified contour with grout. The grout shall extend no less than the full width of the manhole barrel.

(5) **Temporary Plugs:** Where required on construction plans and at the end of each sewer service stub out, the pipe shall be sealed with a removable plug. Plugs shall be specifically manufactured for the pipelines where they are to be installed. The plug shall be constructed of a material approved by the Director and shall provide a permanent watertight installation without permanently sealing the joint.

(6) **Sewer Services:** The general location of the sewer service lines is detailed in Drawing No. 6.06, "Sewer Service Line," in Chapter 11, "Technical Drawings," in these Standards. Actual locations of the service lines shall be determined by the approved construction plans and in the field by the Director. The contractor shall notify the Director prior to constructing each sewer main so that the Director may have adequate time to determine the final location of each service tee or wye fitting to be installed in the sewer main. Failure of the contractor to properly notify the Director as noted above may result in the contractor's removal of any portion of the sewer main that is necessary to install the fittings in their proper location as determined by the Director.

(a) The contractor will be allowed to tap and install a service saddle to new sewer mains only at those locations approved by the Director. Connections onto sewer mains shall be made only by boring or drilling with equipment designed for this

purpose. Connections shall not be made by impact equipment. The contractor shall request, in writing, Director approval of methods and equipment proposed to be used for performing connections.

(b) The contractor shall remove from the sewer main all debris created by making connections before the service line is connected.

(c) Service line saddle connections shall be attached to the sewer main with an epoxy-bonding agent. Where the sewer main has been lined, the original sewer main shall be removed and the saddle shall be attached directly to the liner. The bonding agent shall be applied to a clean, dry surface. The connection shall remain dry until the bonding material has set, depending upon environmental conditions. Backfill around the connection shall not be attempted until the material has hardened and been accepted by the Director.

(d) At the end of all sewer services, the contractor shall provide plugs and furnish and set two marker posts. One marker post shall be buried at least 3 feet and shall extend at least 2 feet above the ground surface and shall have a piece of green flagging at the top or be painted green. The second marker shall extend from the end of the service to 18 inches below the existing surface. The marker posts shall be wood 2 x 4, 4 x 4 or #4 rebar.

(7) **Backfilling and Restoring Surface Conditions:** Shall be as specified in Section 9.02, "Excavation and Trenching," of these Standards.

(8) **Testing:** Testing of PVC non-pressure pipe shall be as specified in Section 9.17, "Testing of Gravity Sewer Pipelines and Manholes," of these Standards.

9.15 Reinforced Concrete Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of reinforced concrete pipe and appurtenances for culverts and storm drains in the pipe diameter size range of 12 inches to 144 inches. Reinforced concrete pipe shall not be used for sanitary sewer mains.

(2) **Quality Assurance:**

(a) Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(b) The pipe will be tested by the manufacturer based on the three-edge bearing test for both the 0.01-inch crack and the ultimate strength as set forth in ASTM C-497. The pipe shall be tested at the manufacturer's plant. Not more than 1 percent of the number of pipe lengths, but no fewer than two pipes, for each size of pipe, will be tested. The contractor shall provide copies of the test results to the Director for approval. The Director may select pieces to be tested.

(B) Materials

(1) **Reinforced Concrete Pipe**

(a) The reinforced concrete pipe shall comply with the requirements of ASTM C76. The pipe shall be Class III unless noted otherwise on the approved construction

plans. The cement for the pipe shall conform to the requirements set forth in ASTM 150 and shall be type II and shall have a minimum compressive strength of 4,000 psi. All wall thicknesses shall be those established in "Wall B" in table 3, of said C76 specification, and the reinforcement shall be shown in the same "Wall B." Each section, or "stick", of pipe shall be 7 feet-6 inches or greater in length.

(b) No elliptical reinforcement will be permitted except for any elliptical reinforced concrete pipe designated on the construction plans.

(c) Lifting holes will not be permitted in any of the pipe. The following shall be clearly marked on the exterior surface of the pipe:

(i) ASTM Specification;

(ii) Date of manufacture;

(iii) Class and size; and

(iv) Name or trademark of manufacturer.

(d) The joint design shall be tongue and groove, or bell and spigot. Joints for the circular reinforced concrete pipe shall be all rubber gasket conforming to ASTM C-443, latest revision. The gasket shall be attached to the spigot of the pipe and shall make the joint flexible and watertight. The contractor may use butyl mastic joint sealant in rope or trowel applied form in lieu of rubber gaskets for circular pipe if approved in writing by the Director. For all non-circular pipe and culverts, butyl mastic joint sealant may be used. The contractor shall submit test results and material specifications on the sealant to the Director before the Director gives written approval of its use. This sealant shall be made specifically for permanently sealing joints in tongue and groove concrete sewer pipe, must adhere tightly to the pipe surface, and form a tight flexible joint. The gaskets or sealants shall be installed as directed by the manufacturer of the pipe.

(e) Flared end sections, bends and tees shall comply with the requirements of ASTM C76 and shall be the same class and shall have the same joint design as the pipe described above.

(f) Visual inspections of all materials shall be made at the job site, and pipe will be rejected on account of any deficiencies covered by ASTM Specification Designation C76 or on account of the following:

(i) Porous spots, inside or outside, having a greater area than 10 square inches and a depth of more than 1/4 inch;

(ii) Patched or repair of porous spots or other defects that are not approved by the Director; or

(iii) Exposure of reinforcement that indicates the reinforcement has been replaced.

(C) Execution

(1) Laying Pipe

(a) All materials shall be carefully lowered into the trench piece-by-piece by means of a derrick, ropes or other suitable tools or equipment, in such a manner as to prevent damage. Under no circumstances shall materials be dropped or dumped

into the trench. All pipe shall be inspected for defects prior to installation. Any defective, damaged or unsound pipe shall be rejected.

(b) All foreign matter or dirt shall be removed from the inside of the pipe and fittings before the pipe is lowered into its position in the trench. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the trench. If the pipe-laying crew is unable to place the pipe into the trench without getting foreign matter or dirt into it, the Director may require that, before lowering the pipe into the trench, a heavy, tightly woven canvas bag of suitable size be placed over each end and left there until the connection is to be made to the adjacent pipes.

(c) An approved snug-fitting stopper or plug shall be installed in each pipe immediately after it is laid and prior to any further excavating, or backfilling. All openings along the line of the main shall be securely closed as directed and, in the suspension of work at any time, stoppers shall be placed to prevent dirt or other substances from entering the main. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe.

(d) Pipes shall be laid to a true line and at uniform rates of grade between manholes as shown on the approved construction plans. Fine grading to the bottom of the barrel shall proceed ahead of the pipe laying. The grade shall be accurately established for each joint by laser beam, or other means approved in writing by the Director. The laser beam shall be checked with a level each time it is moved and each day before construction proceeds, and thereafter as required to assure that it is set at the correct alignment. If any errors of grade are observed, pipe laying shall stop until the grade is corrected.

(e) Pipe laying shall proceed upgrade with the spigot ends pointed in the direction of flow. No pipe shall be laid in water or when the trench conditions are unsuitable for such work. The contractor shall make all connections of pipe to the manholes that have previously been constructed. When connecting to existing sewers, the contractor shall take every precaution necessary to prevent dirt or debris from entering the existing lines.

(f) Bedding shall be placed under and on both sides of the pipe as each length of sewer pipe is installed.

(2) **Joining Pipe**

(a) Use a method of joining pipe sections that ensures that ends are fully entered and inner surfaces are flush and even. The equipment used to force the joints together must be adequate enough to overcome the gasket pressure involved.

(b) Just prior to joining the pipes, the ends of the pipe shall be thoroughly cleaned to remove all foreign substances that may have adhered to the pipe surface. All dust and dirt shall be removed with a clean rag. A lubricating solution that is not injurious to the gasket or concrete, such as flax soap or water glass, shall be liberally applied to the gasket groove and to the entire surface of the bell ring. Following this operation, a thin film of lubricant shall be applied to the gasket that shall then be snapped into place in the groove, after which a small diameter smooth steel rod shall be inserted between the gasket and groove and run completely around the gasket to equalize the gasket tension.

(c) In the event that any foreign matter becomes imbedded in the lubricant, or the lubricant becomes contaminated by water or other substances before the joint is started, the area affected shall be re-cleaned and new lubricant shall be applied.

(d) The pipe being jointed shall be carefully moved into position, be line and grade checked, and as the spigot end is started into the bell of the section previously laid, the gasket position shall be checked to ensure uniform entry into the bell at all points.

(3) **Testing and Flushing Pipe**

(a) Prior to acceptance of each section of storm sewer line, the contractor shall jet clean all sewers up through 18 inches in diameter. Larger storm sewers shall be cleaned by other appropriate methods approved by the Director. All dirt and debris shall be prevented from entering the existing storm sewer system by means of watertight plugs or other suitable methods.

(b) If the Director finds it necessary to clean the mains immediately after construction by rodding, jetting, or both, the Director shall assess the contractor for the cleaning at a set per foot charge with a minimum dollar amount.

(c) The Director will televise all mains as part of public inspection, and will bill the contractor for the televising at a set per foot charge with a minimum dollar amount. Any defects found during the televising shall be repaired by the contractor, in a manner approved by the Director.

(d) Any visible infiltration, that the Director finds to be the result of poor installation of the specified materials, shall be repaired by the contractor in a manner approved by the Director before the work will be accepted.

(e) Before acceptance of the work, the Director will survey the manhole invert and surface elevations. Any inverts or surface elevations not meeting the approved design in the construction plans shall not be approved and shall be redone to the satisfaction of the Director.

(f) Upon completion of construction, the Director will carefully inspect all sewers and appurtenances. Any unsatisfactory work shall be removed and replaced by the contractor in a proper manner. The invert of sewer and manholes shall be left smooth, clean, and free from any obstructions throughout the entire line. Manhole rings and covers must be raised to finished grade before final acceptance of the sewer.

(g) For sanitary sewers, testing shall be as specified in Section 9.17, “Testing of Gravity Sewer Pipelines and Manholes,” of these Standards.

9.16 Manholes and Inlets

(A) General

(1) **Scope:** This section describes the furnishing and installation of precast concrete manholes, storm sewer inlets and appurtenances.

(2) **Quality Assurance:** Manufacturer’s certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **General**

(a) Manholes shall be constructed of precast concrete riser sections, in accordance with Drawing No. 6.01, "Standard Sewer Manhole," in Chapter 11, "Technical Drawings," of these Standards. The concrete sections shall conform to ASTM C478. The top section required for change of diameter shall be concentric cone or flat slab. Invert channel shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. The minimum internal diameter of the manhole barrel shall be in Table 9-6, "Required Manhole Diameters," for all manhole installations:

Table 9-6: Required Manhole Diameters

Pipe Size (Diameter)	Inner Manhole Section Diameter
18 Inches (and Smaller)	4 Feet
21 - 36 Inches	5 Feet
42 - 48 Inches	6 Feet
54 Inches (and Larger)	Special Detail

(b) The minimum internal diameter of the manhole barrel may also be determined by the number and size of pipes junctioning at a manhole. In such cases, the Director may modify the minimum internal diameter of the manhole barrel as required.

(c) To bring the manhole cover to the correct elevation, the adjustment section of each manhole shall be constructed of brick that is sound and true in shape and size and shall be Grade S-W from clay or shale. Precast concrete grade adjustment rings may be substituted for the brick. These rings shall be not less than 6 inches wide and furnished in heights to allow for 1-inch adjustment. Total adjustment height, with grade rings or bricks, shall not exceed 12 inches.

(2) **Joints:** Precast manhole and inlet joints shall be made watertight with RUB'R-NEK, Kent Seal No. 2, or LO-MOD GEL material, or approved equivalent. The diameter of gasket shall be as recommended by the manufacturer.

(3) **Frame and Cover:** Manhole frames and covers shall be of heavy duty traffic lids, Colorado Springs pattern, round base, 22-1/8 inch opening lids 1 inch thick, non-locking type with frame and cover weighing approximately 327 pounds. The cover and frame seat shall be machine finished to prevent any rocking of the cover in its associated frame. The cover shall have the word "SEWER" for sanitary sewer manholes, or "STORM SEWER" for storm sewer manholes clearly cast on the surface. Covers for other utility manholes shall also be marked with the appropriate utility designation. Frames and covers shall be CASTINGS, INC. MH 310 COVER B, or approved equivalent.

(4) **Manhole Steps:** Manhole steps shall be built into and thoroughly anchored to the manhole walls at time of fabrication and shall be positioned as shown on the approved construction plans, and in accordance with the technical drawings in Chapter 11, "Technical Drawings," of these Standards. The steps shall be made of polypropylene coated reinforcing steel.

(5) **Grout:** Grout shall be "non-shrink" type with aluminum filings; grout with iron filings is not acceptable. Grout shall be "Five Star Grout," "Embeco Grout" or equivalent.

(6) **Concrete:** Concrete for cast-in-place manhole bases shall have a 28-day compressive strength of not less than 3,000 psi. The maximum water content shall be 0.5 pounds of water per pound of cement. Entrained and entrapped air shall be between 4 and 9 percent. All reinforcement shall be standard deformed reinforcement conforming to the requirements set forth in ASTM, A615, Grade 60.

(7) **Inlets:** Inlets shall be constructed of reinforced concrete and shall conform to the dimensions and specifications as set forth for Type "R" Curb Inlets in Chapter 11, "Technical Drawings," of these Standards, and CDOT's M & S Standards. Inlet steps shall be built into and thoroughly anchored to the walls at the time of inlet construction. These steps shall conform to the requirements for manhole steps and shall be positioned as shown on the technical drawings.

(C) Execution

(1) **Construction of Manholes**

(a) Concrete bases shall be poured on undisturbed ground. Pipe sections shall be flush on the inside of the structural wall (except as noted below) and project outside sufficiently for proper connection to the next pipe section. All pipelines into a manhole shall have a joint located no more than 12 inches from the exterior wall. Where incoming pipes enter a storm drain manhole at an elevation 3 feet or greater above the base, the incoming pipe shall project 2 inches inside the manhole. All annular spaces around the pipe opening shall be grouted.

(b) For all precast manhole bases, the ground surface below precast concrete bases shall be excavated 6 inches below the elevation of the bottom of the base and backfilled with bedding material, meeting the requirements of Subsection 9.02(B) of these Standards. The bedding material shall be carefully leveled and smoothed as to give uniform support to the precast base over its entire area.

(c) The invert channels of manholes shall be constructed in accordance with the Drawing No. 6.03, "Manhole Invert," in Chapter 11, "Technical Drawings," of these Standards. They shall be smooth and semicircular in shape, conforming to the inside of the incoming and outgoing sewer pipelines. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Where differences of 24 inches or less in invert elevations are called for, sloped flow channels shall be formed so the water does not undergo a vertical drop. A drop manhole shall be installed where the specified distance in the manhole inverts exceeds 24 inches. The inlet channels may be formed directly in the concrete of the manhole base. The floor of the manhole outside of the channel shall be smooth and shall slope towards the channel not less than 1 inch per foot nor more than 2 inches per foot. The manhole covers shall be set with a final elevation of 1/4 inch below the finished grade in roadways and 1 to 2 inches above grade outside of roadways. When a manhole is located in the pavement area, it shall not be constructed to final grade until the pavement has been completed, unless directed otherwise by the Director.

(d) Install joint material per manufacturer's instructions so that no voids are present. Grout all joints inside and outside after manhole assembly is completed.

(e) Gaskets for connecting PVC pipe to manhole sections shall be specifically manufactured for that purpose. The gasket shall provide for at least five bearing points on the pipe surface. The interior circumference of the gasket shall be approximately 5 percent less than the exterior circumference of the pipe. The gasket shall be as manufactured by Hamilton Kent Mfg. Co. of Kent, Ohio, or approved equivalent. All annular spaces around pipe openings must be grouted.

(f) Stubs shall be provided at manholes when indicated on the construction plans. Such stubs shall be sealed with a removable plug. Plugs shall be specifically manufactured for the pipelines where they are to be installed. The plug shall be constructed of a material approved by the Director and shall provide a permanent watertight installation.

(2) **Adjusting Manhole Tops:** When grade adjustment of an existing structure is specified, remove frames and covers and reconstruct as required. Reset cleaned frames at the indicated elevation. Prior to final acceptance, clean structures of accumulations of silt, debris, or foreign matter.

(3) **Testing Manholes:** Refer to Section 9.17, "Testing of Gravity Sewer Pipelines and Manholes," of these Standards.

9.17 Testing of Gravity Sewer Pipelines and Manholes

(A) General

This section describes the testing of gravity sewer pipelines and manholes including sanitary sewers and storm drains.

(B) Materials

The contractor shall provide all equipment and material specifically designed for the testing specified in this section.

(C) Execution

(1) **Notification and Witness:** The contractor shall notify the Director of all tests at least 48 hours prior to testing so that the Director can witness the tests.

(2) **When to Test:** The pipe shall be tested for leakage after the pipe has been installed and the trench has been partially backfilled, except at the joints, or backfilled as permitted by the Director.

(3) **Testing Procedures**

(a) **General:** All sanitary sewer mains and appurtenances shall be cleaned, tested, and PACP TV inspected after backfill operations have been completed. The contractor shall furnish all labor, materials, tools, and equipment necessary to clean the pipe and appurtenances, perform the tests and all work incidental thereto. Any damages to the pipeline caused by cleaning or testing operations shall be repaired or replaced by the contractor

(b) **Alignment and Grade:** Gravity sewer pipelines will be checked by the Director to determine whether any displacement of the pipe has occurred after the trench has been bedded. The maximum vertical deflection allowed for PVC pipe is five percent. The city may require the contractor to perform deflection tests of the

pipe before acceptance. Optional devices for testing include calibrated television, photography, properly sized go-no-go mandrel, sewer ball, or deflectometer. The method used shall be approved by the City. To ensure accurate testing, the line shall be thoroughly cleaned prior to testing.

(4) **Air Tests**

(a) Air testing of sanitary sewer pipes shall be done on all sections of pipe between manholes. The pipe shall be cleaned and may be wetted before air testing. The section of pipeline being tested shall be plugged at each manhole with pneumatic balls.

(b) Low-pressure air shall be introduced into the plugged line until an internal pressure of 4 psig greater than the average backpressure of any ground water pressure that may submerge the pipe would cause. At least 2 minutes shall pass to allow air temperature to stabilize before the test time is started.

(c) No pipeline installation will be accepted if the pressure drops 0.5 psig or more during the time and for the length of pipe shown in Table 9-7, "Specifications for Air Testing of Sanitary Sewer Pipes," of these Standards:

(d) If the pipeline installation fails the air test, repairs shall be made and the pipe shall be retested until it passes the air test.

(5) **Deflection**

(a) All PVC non-pressure pipes shall be tested for vertical deflection after placement and compaction of backfill. The maximum deflection allowed is 5 percent.

(b) Method of testing shall be by calibrated television, photography, properly sized go-no-go mandrel, sewer ball, or deflectometer. The method used shall be approved by the Director. Any and all pipe with vertical defection greater than the allowable shall be excavated, and removed from the pipeline, replaced, backfilled and compacted as specified, and retested at the contractor's expense.

Table 9-7: Specifications for Air Testing of Sanitary Sewer Pipes

Pipe Diameter (Inches)	Minimum Test Time for Pipe Lengths up to Lengths in Column 3 (min:sec)	Maximum Pipe Length for Minimum Time Testing in Column 2 (Feet)	Minimum Test Time for Pipe Lengths Greater than Column 3 (Seconds)
4	1:53	597	0.190 x Pipe Length (Feet)
	2:50	398	0.427 x Pipe Length (Feet)
8	3:47	298	0.760 x Pipe Length (Feet)
10	4:43	239	1.187 x Pipe Length (Feet)
12	5:40	199	1.709 x Pipe Length (Feet)
15	7:05	159	2.671 x Pipe Length (Feet)

(6) **Television**

(a) Following completion of sewer line work, the contractor shall perform and supply the City with a PACP TV inspection report and digital video of the sewer. TV inspections shall be performed by a PACP certified inspector. Prior to performing the TV inspection, the sewer improvements must be complete,

accessible, and cleaned using pressurized water sufficient to allow for a detailed inspection. The city will not accept inspections for lines that have not been cleaned.

(b) Following TV inspections and any necessary repairs that the contractor may have identified, the city will review the inspection data. If the condition of the pipe is determined to be free of structural defects, deflections, debris, defects in pipe material, and other installation errors, the work will be eligible for acceptance.

(D) Sanitary Sewer Manholes

(1) **General**

(a) During the construction of the manholes, the contractor shall, in accordance with good construction practice, ensure that no earth, sand, rocks or other foreign material exists on the joint surfaces during assembly of the sections. The Director shall check each manhole to determine whether the manhole fulfills the requirements of the construction plans and these Standards.

(b) The Director shall visually check each manhole, both exterior and interior, for flaws, cracks, holes, or other inadequacies that might affect the operation or watertight integrity of the manhole. Should any inadequacies be found, any repairs deemed necessary by the Director shall be made by the contractor.

(c) Exfiltration tests as specified above shall be performed on all sanitary sewer manholes.

(2) **Vacuum Testing:** When required by the Director, sanitary sewer manholes shall be vacuum tested with the following procedure:

(a) Each manhole shall be tested immediately after assembly and prior to backfilling.

(b) All lift holes shall be plugged with an approved non-shrink grout.

(c) No grout will be placed in the horizontal joints before testing.

(d) All pipes entering the manhole shall be plugged, taking care to securely brace the plugs from being drawn into the manhole.

(e) The test head shall be placed at the inside of the top of the cone section and the seal inflated in accordance with the manufacturer's recommendation.

(f) A vacuum of 10 inches of mercury shall be drawn and the vacuum pump shut off. With the valves closed, the time shall be measured for the vacuum drop to 9 inches. The manhole shall pass if the time is greater than 60 seconds for one 48-inch diameter manhole, 75 seconds for 60 inches, and 90 seconds for 72 inches.

(g) If the manhole fails the initial test, necessary repairs shall be made with a non-shrink grout while the vacuum is still being drawn. Retesting shall proceed until a satisfactory test is obtained.

9.18 Corrugated Metal Pipe

(A) General

(1) **Scope:** This section describes the furnishing and installation of corrugated metal pipe and appurtenances for drainage culverts in the pipe diameter size range of 12 to 54 inches.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Corrugated Metal Pipe**

(a) Pipe shall be fabricated from zinc-coated (galvanized) iron or steel sheets conforming to AASHTO M-218 except as modified herein. The diameter or span by rise dimensions indicated on the drawings shall mean the nominal inside dimensions of the conduit. The widths of the laps and depths or corrugations shall be as specified in AASHTO M-36. The pipe shall have the following minimum gauge (specified thickness) for the sizes shown in Table 9-8, "Corrugated Base Metal Specifications," of these Standards:

Table 9-8: Corrugated Base Metal Specifications

Diameter (Inches)	Gauge Number	Specified Galvanized Thickness (Inches)	Specified Galvanized Thickness (Inches)
21 and Smaller	16	0.064	0.0598
24	14	0.079	0.0747
30 - 54	12	0.109	0.1046

(2) **Dimpled Coupling Bands:** The dimpled coupling bands shall be the same thickness as that used for the pipe and shall be at least 12 inches wide. The dimples shall conform substantially to the shape and depth of pipe corrugations and shall be in circumferential rows. Each row shall contain dimples so spaced as to effectively engage all corrugations of the pipe ends. All bands shall have at least two zinc coated bolts per connection, conforming to ASTM A 307, grade A, electroplated in accordance with ASTM A 164, Type RS, not less than ½ inch in diameter. The bands shall have end connection angles, conforming to ASTM A 36, zinc-coated in accordance to ASTM A 153, not less than 2 inches by 2 inches by 3/16 inch by 11 inches, adequately fastened to the band.

(3) **Fittings (Including Flared End Sections) and Specials:** Fittings and specials shall be of the same material, coating, and wall thickness, including the same structural qualities, as the adjoining pipe. Steel flared end sections shall be furnished complete with field-bolted toe plates.

(4) **Repair of Damaged Spelter Coatings:** Units such as tees, angles or bends on which the spelter coating has been burned by flame cutting and gas or arc welding, or otherwise damaged in fabrication or shipping, shall be wire-brushed and painted with two coats of Haltz-Rust HR-54-53 or equal conforming to Federal Specification and Standards, TT-P-

641, or as otherwise approved by the Director. Culverts, pipes, fittings, specials, etc., on which the spelter coating has been bruised or broken either in the shop or in shipping, or that shows defective workmanship, will be rejected.

(C) Execution

Installation of corrugated steel pipe is considered to be a flexible conduit and, therefore, special care must be taken during the bedding and backfilling operations. Installation and backfilling operations shall be in accordance with the recommended practices set forth in the "Handbook of Steel Drainage and Highway Construction Projects," published by the American Iron and Steel Institute.

(1) **Bedding**

(a) All pipe shall be bedded with an approved granular bedding material. The pipe shall be bedded true to line and grade with uniform and continuous support from a firm base. Blocking shall not be used to bring the pipe to grade.

(b) The bedding material shall be placed evenly on both sides of the pipe to a point 12 inches above the top of the pipe. Special care shall be taken to ensure that all voids are filled beneath the pipe haunch and that the bedding material is properly placed and compacted to provide lateral restraint. The trench sidewall shall be adequately braced, shored or sheeted as necessary to stabilize the trench walls. The trench shall not be any wider than necessary for proper installation, and pipe jointing. The bedding material shall be placed under haunches and around the pipe alternately in 6-inch layers on both sides of the pipe to permit thorough consolidation of the bedding material. This material is placed alternately to keep it at the same elevation on both sides of the pipe at all times.

(2) **Backfilling:** After the pipe has been properly installed and bedded, the remaining trench excavation shall be restored as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement or Sidewalks," B.R.C. 1981. Pipe installed outside of public rights-of-way where no pavement is impacted may be backfilled in the following manner. The backfill shall be placed in 8-inch loose lifts and compacted to 90 percent Standard Proctor density (AASHTO T-180) with mechanical hand tampers, for the first 2 feet. At least 4 feet of cover over the top of pipe shall be provided before the use of wheel-mounted mechanical tampers (free drop hammer), hydraulic tampers, (Hydraulic ram hammers) or other heavy tamping equipment will be permitted. Puddling or jetting will not be allowed.

(3) **Removal of Trench Protection:** Extreme care shall be taken in the removal of cribbing, shoring, sheeting, etc., so as not to disturb previously constructed foundation, bedding and initial backfill. If it was necessary to place or drive sheeting or other trench protection below the top of the pipe, the sheeting, shoring, etc., shall be cut off at a point 1 foot above the pipe and the remaining material shall be left in place. Removal of this portion could seriously jeopardize the side support necessary for "flexible conduits" and create excessive lateral soils pressures and pipe deflections.

(4) **Protection of Conduit During Construction:** Maximum supporting strength in flexible conduits does not develop until the fill consolidates. Therefore, excessive concentrated loads or heavy equipment on top of or alongside if the pipe shall be avoided.

9.19 Cured-in-Place Pipe (CIPP)

(A) General

(1) **Scope:** This section describes the reconstruction of pipelines and conduits by the installation of a resin-impregnated flexible tube that is inserted into the original non-pressure conduit.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Resin-Impregnated Tube**

(a) The tube shall meet the requirements of ASTM F1216 and shall have a uniform thickness that, when compressed at installation pressures, will equal the specified nominal tube thickness, with a -5 percent manufacturing tolerance. The tube shall be fabricated to a size that when installed will tightly fit the internal circumference and length of the original pipe. Allowance should be made for circumferential stretching during insertion. The minimum length shall be that deemed necessary by the contractor to effectively span the distance between respective access points unless otherwise specified. The contractor shall verify the lengths and diameters in the field before fabricating the tube. Individual insertion runs can be made over one or more manhole sections as determined in the field by the contractor. The maximum allowed insertion run is 1,200 feet. Intermediate manholes will be reopened as directed by the Director.

(b) The outside layer of the tube (before insertion) shall be translucent plastic coated with a flexible material that clearly allows inspection of the resin impregnation (wet-out) procedure. The translucent plastic coating on the tube will allow visual proof that the resin has wet-out the entire tube and that there are no dry areas. A vacuum shall be used to ensure the resin fills all dry areas. The plastic coating shall not be subject to delamination after curing of the CIPP.

(c) The tube shall be homogenous across the entire wall thickness containing no intermediate or encapsulated elastomeric layers. No materials will be allowed in the tube that is subject to delamination of the cured CIPP.

(2) **Resin:** The resin system shall meet the requirements of ASTM F1216.

(3) **Structural Requirements**

(a) The CIPP wall thickness will be measured in accordance with the applicable sections of ASTM Test Method D2122. Sufficient readings, at least eight, will be made to ensure that the minimum thickness has been determined. A cylindrical anvil tubing micrometer accurate to +0.02mm (+0.001 in) will be used. The minimum wall thickness at any cross section shall meet or exceed those shown on the proposal forms and the approved plans, with the allowable minus five (-5) percent tolerance. The wall thickness tests will be performed by a Certified Independent Laboratory, approved by the Director. All costs, for testing, shall be borne by the contractor.

(b) The layers of the CIPP shall be uniformly bonded. It shall not be possible to separate any two layers with a probe or point of a knife blade so that the layers separate cleanly of the probe or knife blade moves freely between the layers, nor shall separation of any layers occur during testing performed under the requirements of this specification.

(c) The cured pipe material (CIPP) shall conform to the minimum structural standards, as follows:

(i)	Flexural Stress (ASTM D-790)	4,500 psi
(ii)	Modulus of Elasticity (ASTM D-790)	250,000 psi

(d) The liner shall be designed assuming a fully deteriorated host pipe.

(C) Execution

(1) **Cleaning**

(a) The contractor shall be required to remove all internal debris from the line by use of water jet equipment prior to inserting the CIPP tube. The cleaning operation shall remove any and all debris so that each joint of pipe can be thoroughly inspected and successfully reconstructed.

(b) All sludge, dirt, sand, rocks, grease and other solid or semi-solid material resulting from the cleaning operation shall be removed at the downstream manhole of the section being cleaned. Passing material from one manhole to another will not be permitted.

(c) All such debris resulting from the cleaning operations shall be removed from the site and disposed of in the proper manner. The contractor shall bear all costs associated with testing of debris and proper dumping. Dumping of the debris shall be in accordance with all local, state, and federal regulations.

(d) All debris shall be removed from the downstream manhole and the site no less often than at the end of each workday. The contractor shall leave no debris unattended at the site. Under no circumstances will the contractor be allowed to accumulate debris beyond the stated time. In the event the contractor has not removed the debris generated by the cleaning operation, the contractor will not be allowed to proceed with the work until the debris is properly removed.

(e) During all sewer cleaning operations, satisfactory precautions shall be taken to protect the sewer lines from damage that might occur by improper use of cleaning equipment. Precautions shall be taken to ensure that the cleaning operation will not cause any damage or flooding to public or private property being served by the section of sewer line being cleaned. The contractor shall bear all costs associated with any flooding or damage to basements or structures.

(2) **Bypassing Flows:** The contractor shall provide for flows around the section(s) of pipe designated for rehabilitation. The bypass shall be made by plugging the line at an existing upstream manhole or adjacent system. The pump and bypass lines shall be of adequate capacity and size to handle the flow. Bypassing includes any main lines and service lines, street gutters or open excavations. Any spills that occur must be immediately cleaned and the affected area disinfected.

(3) **Inspection of Pipelines:** Inspections of pipelines shall be performed by trained personnel experienced in locating breaks, obstacles and service connections by closed circuit

television. The inspection of pipelines is also to determine active service connections and the addresses that they serve. The interior of the pipe shall be carefully inspected to determine the location of any conditions that may prevent proper installation of the CIPP into the pipeline and it shall be noted so these conditions can be corrected. The contractor shall perform and supply the City with a PACP TV inspection report and digital video of the sewer prior to and after installation of the CIPP lining.

(4) **Line Obstructions:** It shall be the responsibility of the contractor to clear the line of obstructions such as solids and roots that will prevent the insertion of the CIPP. If pre-installation inspection reveals an obstruction such as a protruding service connection, dropped joint, or a collapse that will prevent the inversion process, and it cannot be removed by conventional cleaning equipment, then the contractor shall repair the excavation to uncover and remove or repair the obstruction. Such excavation shall be approved in writing by the Director prior to the commencement of the work.

(5) **CIPP Installation**

(a) CIPP installation shall be in accordance with ASTM F1216, Section 7, with the additional following requirements. The resin shall be cured by circulating hot water within the tube. After curing, the finished pipe (CIPP) shall be continuous and tight fitting.

(b) The contractor, and the Director, shall designate a location where the tube will be impregnated with resin prior to installation, in order that an inspection can be made to determine proper materials and procedures. A resin and catalyst system compatible with the requirements of this method shall be used.

(c) The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing heat supply. Another such gauge shall be placed at the remote manhole to determine the temperature at that location during the cure. If air pressure and steam are used with styrene-based resins, the compressed atmosphere shall be monitored with a safety gas detector to ensure that it does not reach the explosive limit.

(d) The finished CIPP shall be continuous over the entire length of an insertion run between two manholes and be free, as commercially practicable, from visual defects such as foreign inclusions, dry spots, pinholes, and delamination. It shall also meet the leakage/pressure test requirements specified below (water tightness).

(e) Before the insertion process begins, the minimum pressure required to hold the tube tight against the existing conduit and the maximum allowable pressure so as not to damage the tube shall be provided by the tube manufacturer, and it will be the contractor's responsibility to obtain and submit this information to the Director. Once the insertion has started, the pressure shall be maintained between the minimum and maximum pressures until the operation has been completed. If air pressure is used for inversion, the equipment shall be fitted with a pressure gauge accurate to 0.01 psi. Should the pressure deviate from within the range of minimum and maximum pressures, the installed tube will be rejected, and the contractor will remove and dispose of the tube, at their expense.

(f) Before the curing process begins, the pressure required to hold the flexible tube tight against the host pipe shall be provided by the tube manufacturer and submitted to the Director prior to any inversion process. Once the cure has started and dimpling for laterals is completed, the required pressure shall be

maintained until the cure is complete. Should the pressure deviate more than 1 psi (2.3 feet of water) from the required pressure during the critical curing period, the tube will be rejected, and the contractor will be responsible for its removal and disposal and replacement with new CIPP at, at their expense. A complete log of the pressures shall be maintained on site and shall be offered to the Director after each inversion.

(6) **Sealing at Manholes:** A hydrophilic end seal shall be installed at the upstream and downstream manholes prior to installation of the CIPP liner. The end seals shall be LMK Insignia End Seals or equivalent.

(7) **Service Connections**

(a) After the curing of the CIPP is completed, the contractor shall restore the existing active service connections and branch connections. The connections shall be reopened without excavation, and in the case of non-man entry pipes, from the interior of the pipeline utilizing a remotely controlled cutting device, monitored by a closed-circuit television camera, that re-establishes them to not less than 95 percent capacity, while conforming to the shape of the existing opening. All reinstated openings shall be smoothed by brushing with a wire brush.

(b) The contractor shall verify the possession of at least two complete cutting devices in good working order before each insertion.

(c) If excavations for the purpose of re-opening connections are required, the contractor will be responsible for all costs and liability associated with such excavation and restoration work.

(d) No service connection shall remain out of service for more than 24 hours at a time unless the contractor has provided temporary facilities or other appropriate accommodations for the affected service.

(8) **Testing:** CIPP samples shall be prepared and tested in accordance with ASTM F1216, Section 8.1, using both methods 8.1.1 and 8.1.2 if so required by the Director. The test will be performed by a Certified Independent Laboratory, approved by the city. Tests results shall be submitted to the Director. Costs of the tests are considered to be incidental to the project.

(9) **Visual Inspection:** Visual inspection of the CIPP shall be in accordance with ASTM F1216, Section 8.4. The contractor shall perform and supply the City with a PACP TV inspection report and digital video of the sewer prior to and after installation of the CIPP lining.

9.20 Pipe Bursting Non-Pressure Pipe

(A) General

(1) **Scope:** This section describes the reconstruction of pipelines and conduits by which a bursting unit splits the existing pipe while simultaneously installing a new polyethylene pipe of the same size or larger where the old pipe existed.

(2) **Quality Assurance:** Manufacturer's certificates of compliance and installation recommendations shall be provided to the City inspector prior to construction. Installation recommendations shall be followed during construction.

(B) Materials

(1) **Polyethylene Plastic Pipe:** The pipe shall be high density polyethylene pipe and meet the applicable requirements of ASTM F714 Polyethylene (PE) Plastic Pipe (SDR-PR). Sizes of the insertions to be used shall be such to renew the pipe to its original or greater flow capacity. The pipe shall be homogenous throughout and shall be free of visible cracks, holes, foreign material, blisters, or other deleterious faults.

(2) **Dimension Ratios:** The polyethylene pipe shall meet or exceed the thickness requirement of SDR 17.

(C) Execution

(1) **Bypassing Flows:** The contractor shall provide for flow around the section(s) of pipe designated for reconstruction. The bypass shall be made by plugging the line at an existing upstream manhole or adjacent system. The pump and bypass lines shall be of adequate capacity and size to handle the flow. Bypassing includes any main lines and service lines, street gutters or open excavations. Any spills that occur must be immediately cleaned and the affected area disinfected.

(2) **Inspection:** Inspection of work shall be in accordance with Section 9.17, "Testing of Gravity Sewer Pipelines and Manholes," of these Standards.

(3) **Equipment:** The pipe bursting tool shall be designed and manufactured to force its way through existing pipe material by fragmenting the pipe and compressing the old pipe sections into the surrounding soil as it progresses. The bursting unit shall be pneumatic and shall generate sufficient force to burst and compact the existing pipeline. The bursting tool shall be selected in accordance with the manufacturer's recommendations to meet the project specific requirements for the type and size of pipe being burst and upsized if specified. The pipe bursting tool shall be pulled through the sewer by a winch located at the receiver pit. The bursting unit shall pull the polyethylene pipe with it as it moves forward.

9.21 Telecommunication or Cable System Standards

The installation and construction of telecommunication or cable systems shall comply with the requirements as set forth in Chapter 11-6, "Boulder Cable Code," B.R.C. 1981, and these Standards.

(A) General

(1) **Applicable National Standards:** All telecommunications and cable system construction shall conform to the requirements of the following standards:

(a) American National Standards Institute, Inc. (ANSI), Electronic Industries Association (EIA), and Telecommunications Institute of America (TIA) Standards: EIA/TIA Standards Proposal No. 2840-A, Proposed Revision of EIA/TIA-568 (if approved to be published as EIA/TIA-568-A), EIA/TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces, and TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications.

(b) National Electrical Safety Code (NESC) C2-1993, published by the Institute of Electrical and Electronics Engineers (IEEE), Inc.

(c) National Electrical Code (NEC), published by the National Fire Protection Association (NFPA).

(d) Federal Communications Commission.

(e) Colorado Public Utilities Commission.

(f) Williams-Steiger Occupational Safety and Health Act (OSHA).

(2) **Construction Plans Required:** Detailed construction plans, as outlined in Chapter 1, "General Requirements," of these Standards, showing the specific underground and/or aerial cable routing and associated conduit, manhole and/or pole locations and specifications, shall be submitted to the Director's office for review and approval.

(a) Construction plans for Directional Boring or Narrow Trenching operations shall meet design standards of Subsurface Engineering (SUE) Level B or above. At the City's request, the applicant shall provide full engineered plan & profile drawings.

(3) **Protection of Systems:** All systems shall be protected from washouts, floods, unstable soil, landslides, or other hazards that may cause the facility to move or fail.

(B) Underground Facilities

(1) **Cable Protection**

(a) All buried telecommunications cable shall be installed in conduit, SDR 9 or 11 HDPE pipe, or equivalent. Cable placement by means of direct plow-in will not be allowed within the City's rights-of-way.

(b) Major conduit duct banks (more than 4 conduits) and those comprising a portion of the City's telecommunications conduit backbone infrastructure shall be encased in concrete with a minimum strength of 2000 psi. When encased in concrete, conduit may be PVC Type EB, DB, or equivalent. The concrete encasement shall have a minimum thickness of 4 inches around the entire conduit or duct bank.

(c) Multiple duct systems shall have spacers installed at intervals to allow the concrete mix encasement throughout the entire duct structure.

(d) Conduit placed by directional bore method will be allowed subject to approval by the Director.

(2) **Depth of Cover:** The minimum depth of cover over the conduit shall be 30 inches.

(a) Narrow Trenching Exception: For existing pavements 6 inches or less, distance from top of pavement to top of conduit is 10 inch minimum, 24 inch maximum. For Existing pavements greater than 6 inches thick, distance from top of pavement to top of conduit equals the pavement thickness plus 4 inches minimum, 24 inch maximum.

(i) If Narrow Trench abuts lip of curb & gutter, minimum depth of conduit is 12".

(3) **Trench Specifications - Roadway and Other Paved Surfaces**

(a) All trenches shall be open cut unless otherwise permitted by the city.

(b) Trenches shall have a minimum width of 10 inches unless Narrow Trenching is proposed where minimum trench width is 1 inch and maximum is 3 inch, but no greater than 1 inch maximum of conduit size.

(c) Trench backfill and surface restoration shall comply with the standards as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement and Sidewalks," B.R.C. 1981.

(d) Narrow Trenching can about the concrete lip line of curb gutter with 12-inch minimum conduit depth.

(e) Narrow Trench cannot be placed within 2 feet of vehicle wheel paths. If street is signed, labeled or striped as a shared roadway for both bicycle and vehicular traffic, narrow trench cannot be within 2 feet of the common wheel paths.

(f) Narrow Trench alignment on roadways must be marked out and follow the designated path so that the finished product has straight lines. Trenches that deviate from a straight path will be subject to mill and overlay, at the city's discretion upon inspection.

(4) **Trench Specifications - Landscaped Areas**

(a) All trenches shall be open cut unless otherwise permitted by the City.

(b) Trenches shall have a minimum width of 10 inches, with exception to narrow trenching where minimum width is 1 inch and max is 3 inches.

(c) Trenches shall be backfilled and compacted to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698.

(d) The City shall be contacted if there is any question whether or not the proposed work will cause any damage to trees shrubs or other landscaping or if construction is within 5 feet of a tree. All utility construction near existing trees shall abide by the tree protection requirements specified in Chapter 3, "Streetscape Design," of these Standards.

(5) **Alternative Installation Methods:** Boring or Narrow Trenching methods may be allowed by the Director if the Director finds that these methods are advantageous to the city or if industry standard open trench methods are impractical.

(a) Missile method for tunneling under curb/gutter and sidewalks can be used as an Alternative for lateral installation associated with Narrow Trenching. Any voids must be between tunnel walls and conduit placed must be filled with flowable fill and use of a concrete vibrator is required.

(6) **Joint Use Trench Requirements**

(a) Joint trenching operations require advanced planning and coordination with the utilities involved.

(b) Vertical and horizontal separations between telecommunications or cable systems and other facilities shall be maintained as required by NESC Section 32, Underground Conduit Systems. Conduit systems for telecommunications and cable systems shall be separated from conduit systems for power supply systems by:

(i) 3 inches of concrete,

(ii) 4 inches of masonry, or

(iii) 12 inches of well-tamped earth.

(7) **Warning Tape:** A cable warning tape shall be placed 12 to 18 inches above the conduit in the trench.

(a) For Narrow Trenching, warning tape is recommended but not required.

(8) **Manholes**

(a) All cavities required for cable pulling purposes shall be constructed as load bearing manholes or handholes. Handholes shall not be placed in any traveled lane, road shoulders, sidewalk, multi-use path, or bike lane.

(b) Manholes or handholes shall be placed at maximum 1,200 feet intervals. In no case shall conduit bend radius exceed 180 degrees between manholes. Manholes shall be installed at each street intersection at a minimum. Manholes shall be rectangular: 6 feet wide by 7 feet long by 4 feet deep; or circular 4 feet diameter with a nominal depth of 4 feet minimum.

(c) Manholes or handholes shall be installed flush or ¼" below the surrounding grade.

(C) Aboveground Facilities

(1) **Facility Protection:** All aboveground facilities shall be protected from accidental damage by vehicular traffic impacts or similar causes either by being located a safe distance away from traffic or by structural barricades.

(2) **Obstruction to Traffic Prohibited:** All aboveground facilities shall be located so as not to cause unnecessary obstruction to pedestrian and vehicular traffic.

(3) **Clearances:** All aboveground telecommunications facility construction shall conform with the minimum clearances as specified in Section 23 of the NESC.

(a) Cables shall maintain the following minimum clearances between any adjacent or crossing power cables under all conditions of cable loading:

(i) Horizontal clearances shall be at least 5 feet from power cables at a potential of up to 129 kV, and at least 5 feet plus 0.4 inches per kV over 129 kV from power cables exceeding a potential of 129 kV.

(ii) Vertical clearances shall be at least 4 feet from power cables at a potential of up to 750 V, at least 6 feet from power cables at a potential of 750 V to 22 kV, at least 6 feet plus 0.4 inches per kV over 22 kV from power cables at a potential between 22 kV and 470 kV. Vertical clearances shall comply with NESC Rule 233C3 for minimum clearance from cables at a potential greater than 470 kV.

(b) Cables, poles, and stubs shall maintain the following minimum clearances from power conductors, power poles and other objects:

(i) Poles shall have a minimum clearance of 4 feet from fire hydrants, signal pedestals, and call boxes.

(ii) Cables shall have a minimum horizontal clearance from power poles in no wind conditions.

(iii) Poles and stubs shall have a minimum horizontal clearance of 5 feet in no wind condition from power wires up to 50 kV.

(c) Poles shall have a minimum separation of at least 2 feet from the street side of the curb to the nearest part of the pole and shall be located a sufficient distance from the street side of the curb to avoid contact with ordinary vehicles using the road.

(d) Poles shall have at least 12 feet horizontal clearance from the nearest rail to the nearest part of the pole.

(e) Cables shall have at least 2 feet vertical clearance from Police and Fire Alarm facilities.

(f) Cables shall have at least 3 feet clearance in all directions from signs, chimneys, tanks, and other installations.

(g) Cables shall maintain the following minimum vertical clearances as measured from the lowest point of the cable when crossing the following objects:

(i) Roads, Streets, and all areas subject to truck traffic: 18 feet.

(ii) Alleys, Driveways, and Parking Lots: 18 feet.

(iii) Railroad tracks: 28 feet.

(iv) Roofs, not accessible: 4 feet.

(v) Spaces and Ways, accessible to pedestrians only: 12 feet.

(vi) Roofs, accessible to vehicular traffic, but not trucks: 12 feet.

(h) Cables shall maintain a minimum vertical clearances of 16 feet as measured from the lowest point of the cable when running alongside but not overhanging roads, streets, or alleys.

(i) A minimum vertical clearance of 40 inches shall be maintained between telecommunications cables and power cables at the attachment points on joint use poles.

9.22 Electric Power Facility Standards

The following standards shall apply to all electric power related facilities constructed within the City's public rights-of-way or easements.

(A) General

(1) **Undergrounding Required:** All electric power facilities constructed in the City's public rights-of-way or easements shall be underground unless otherwise permitted by franchise or the Director.

(2) **National Standards:** All electric power facility construction shall conform to the requirements of the following standards:

(a) 1993 National Electrical Safety Code (NESC) C2-1993, published by the Institute of Electrical and Electronics Engineers (IEEE), Inc.

(b) National Electrical Code (NEC), published by the National Fire Protection Association (NFPA).

(c) Colorado Public Utilities Commission.

(d) Williams-Steiger Occupational Safety and Health Act (OSHA).

(3) **Construction Plans Required:** Detailed construction plans, as outlined in Chapter 1, "General Requirements," of these Standards, showing the specific underground and/or aerial cable routing and associated conduit, manhole and/or pole locations and specifications, shall be submitted to the Director for review and approval.

(4) **Protection of Facilities:** All facilities must be protected from washouts, floods, unstable soil, landslides, or other hazards that may cause the facility to move or fail.

(B) Underground Facilities

(1) **Underground Cable Protection**

(a) All primary circuits (greater than 600 volts) located under concrete road surfaces, where circuit density is high, and in all arterial roads shall be installed in conduit, 4-inch minimum diameter, PVC Type EB, DB or equivalent. All conduit joints shall be solvent welded. The conduit shall be encased in concrete with a minimum strength of 2000 psi and have a minimum thickness of 4 inches around the entire conduit or duct bank.

(b) All secondary circuits (600 volts or less) supplying services larger than 800 amperes shall be installed in conduit, 2-inch minimum diameter, PVC Type EB, DB or equivalent. All conduit joints shall be solvent welded. The conduit shall be encased in concrete with a minimum strength of 2000 psi and have a minimum thickness of 4 inches around the entire conduit or duct bank.

(c) Multiple duct bank systems shall have spacers installed at intervals to allow the concrete mix encasement throughout the entire duct structure.

(2) **Depth of Cover**

(a) The minimum depth of cover over primary circuits (greater than 600 volts) shall be 42 inches.

(b) The minimum depth of cover over secondary circuits shall be 30 inches (600 volts or less).

(c) The minimum depth of cover over circuits for street lighting and signals shall be 18 inches.

(3) **Trench Specifications - Roadways and Other Paved Surfaces**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall have a minimum width of 10 inches.

(c) Trench backfill and surface restoration shall comply with the standards as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement and Sidewalks," B.R.C. 1981.

(4) **Trench Specifications - Landscaped Areas**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall have a minimum width of 10 inches.

(c) Trenches shall be backfilled and compacted to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698.

(d) The City shall be contacted if there is any question whether or not the proposed work will cause any damage to trees, shrubs or other landscaping or if construction is within 5 feet of a tree.

(5) **Alternative Installation Methods:** Boring methods may be allowed by the Director if the Director finds that these methods are advantageous to the city or if open trench methods are impractical.

(6) **Joint Use Trench Requirements**

(a) Joint trenching operations require advanced planning and coordination with the utilities involved.

(b) Vertical and horizontal separations between electric power facilities and other facilities shall be maintained as required by the NESC section 32 Underground Conduit Systems.

(7) **Warning Tape:** A cable warning tape shall be placed 12 to 18 inches above the conduit or cable in the trench.

(8) **Manholes:** All cavities required for cable pulling purposes shall be constructed as load bearing manholes or handholes. Handholes shall not be placed in any traveled lane including road shoulders, sidewalks, multi-use paths, or bike lanes.

(C) Aboveground Facilities

(1) **General**

(a) All aboveground facilities shall be protected from accidental damage by vehicular traffic impacts or similar causes either by being located a safe distance away from traffic or by structural barricades.

(b) All aboveground facilities shall be located so as not to cause unnecessary obstruction to pedestrian and vehicular traffic.

(2) **Clearances:** The minimum overhead transverse clearance shall conform to National Electrical Safety Code Standards but shall not be less than 18 feet measured from the highest point of the road prism to the bottom of the cable.

9.23 Gas Distribution Facility Standards

The following standards shall apply to all gas distribution related facilities constructed within the City's public rights-of-way or easements.

(A) General

(1) **Undergrounding Required:** All gas distribution facilities constructed in the City's public rights-of-way or easements shall be underground unless otherwise permitted by franchise or the Director.

(2) **National Standards:** All gas distribution facility construction shall conform to the requirements of the following standards:

(a) Minimum Federal Safety Standards for Natural Gas Pipelines in the Code of Federal regulations 49 Part 192.

(b) Colorado Public Utilities Commission.

(c) Williams-Steiger Occupational Safety and Health Act (OSHA).

(3) **Construction Plans Required:** Detailed construction plans, as outlined in Chapter 1, "General Requirements," of these Standards, showing the specific gas distribution line and appurtenances locations and specifications, shall be submitted to the Director for review and approval.

(4) **Protection of Facilities:** All facilities must be protected from washouts, floods, unstable soil, landslides, or other hazards that may cause the facility to move or fail.

(B) Underground Facilities

(1) **Materials**

(a) Steel or plastic material shall be used for the gas distribution pipe.

(b) All plastic pipe must be installed below ground level.

(2) **Depth of Cover**

(a) Depth of cover shall be measured from the final grade to the top of the pipe.

(b) Minimum depth of cover for shall be 36 inches for transmission lines and 30 inches for distribution lines.

(c) Minimum depth of cover for service lines shall be 24 inches.

(d) Transmission and distribution lines installed under streams and ditches must have minimum cover of 48 inches.

(3) **Trench Specifications - Roadways and Other Paved Surfaces**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall have a minimum width of 10 inches.

(c) Trench backfill and surface restoration shall comply with the standards as set forth in Section 8-5-12, "Standards for Repairs and Restoration of Pavement and Sidewalks," B.R.C. 1981.

(4) **Trench Specifications - Landscaped Areas**

(a) All trenches shall be open cut unless otherwise permitted by the Director.

(b) Trenches shall have a minimum width of 10 inches.

(c) Trenches shall be backfilled and compacted to at least 90 percent of maximum density at optimum moisture content as determined by ASTM D698.

(d) The City shall be contacted if there is any question whether or not the proposed work will cause any damage to trees, shrubs or other landscaping or if construction is within 5 feet of a tree.

(5) **Alternative Installation Methods:** Boring methods may be allowed by the Director if the Director finds that these methods are advantageous to the city or if open trench methods are impractical.

(6) **Joint Use Trench Requirements**

(a) Joint trenching operations require advanced planning and coordination with the utilities involved.

(b) Vertical and horizontal separations between gas distribution facilities and other facilities shall be 6 inches minimum.

(7) **Warning Tape:** A cable warning tape shall be placed 12 to 18 inches above the conduit in the trench.

(8) **Components**

(a) Transmission line valves shall be installed in boxes or be otherwise readily accessible.

(b) Transmission line pressure relief and pressure limiting devices shall be installed in underground vaults, unless aboveground installation is permitted by the Director.

(c) All service lines shall be equipped with shutoff valves.

(d) An electrically conductive tracer wire shall be installed with all plastic and non-conductive pipes.

(9) **Casing Pipe:** Gas pipe shall be installed in casings under all highways. Casing pipe shall be steel pipe with a wall thickness of 1/4 inch minimum extending at least 5 feet beyond the limits of any highway improvements.

(10) **Corrosion Protection**

(a) All pipes susceptible to corrosion shall be cathodically protected and have a protective coating.

(b) All corrosion susceptible pipes must also be electrically isolated from other metallic structures.

(C) Testing Requirements

All newly constructed pipes shall be tested prior to placing the line in service. No pipe shall be placed in service, or returned to service, with leaks or without adequate corrosion protection.

(1) **Pressure Testing:** All pipes shall be pressure tested for leakage as described in CFR 49 part 192. In order to establish the maximum allowable operating pressure (MAOP), pipes shall be tested at 1-1/2 times the MAOP.

(2) **Corrosion Control Testing:** Corrosion control devices shall be tested whenever the pipe is exposed for maintenance or repair. Additionally, all corrosion control devices must be tested at least once each calendar year.

(3) **Records Retention:** Records of the testing shall be maintained for the life of the pipe.

(D) Aboveground Facilities

(1) **Facility Protection:** All aboveground facilities shall be protected from accidental damage by vehicular traffic impacts or similar causes either by being located a safe distance away from traffic or by structural barricades.

(2) **Traffic Obstruction Prohibited:** All aboveground facilities shall be located so as not to cause unnecessary obstruction to pedestrian and vehicular traffic.

CHAPTER 10
STREETSCAPE & LANDSCAPE STANDARDS

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10.01 General

(A) Intent

The Streetscape and Landscape Standards are intended to supplement the design standards specified in Chapter 3, "Streetscape Design and Tree Protection," of these Standards, and provide minimum standards for the construction and planting of streetscapes in public rights-of-way.

(B) Scope

These Standards apply to streetscapes and public landscapes located, standing, or growing within or upon any City of Boulder public right-of-way or park. The streetscape requirements of this chapter are in addition to those set forth in Chapter 3, "Streetscape Design and Tree Protection," and applicable streetscape drawings in Chapter 11, "Technical Drawings," of these Standards and the B.R.C. 1981.

(C) Reference Standards

Where not specified in these Standards or the B.R.C. 1981, in order to protect the public health, safety, and welfare, the Director of Public Works in consultation with the Director of Parks and Recreation will specify the standards to be applied to the design and construction of streetscapes and public landscapes and the planting of trees, and may refer to one or more of the references listed in the References Section of these Standards.

(D) City Approval Required

All work associated with the planting, maintenance, and removal of trees and landscaping materials located, standing, or growing within or upon any City of Boulder public right of way is subject to City of Boulder approval or permit issuance as set forth in Chapter 8-5, "Work in the Public Right of Way and Public Easements," and Chapter 6--6, "Protection of Trees and Plants," B.R.C. 1981.

(E) Water Conservation

All landscaping shall be designed for maximum water efficiency, as specified in Section 9-9-12-9-12 "Landscaping and Screening Standards," B.R.C. 1981.

(F) Public Lands Other Than Public Rights-of-Way

Unless otherwise required by the Director in consultation with the Director of Parks and Recreation, all landscaping construction activities on public lands other than public rights-of-way, such as parks, open space and greenway corridors, are exempt from the construction and planting requirements of these Standards. However, these Standards may be used as a basis for construction and planting activities on all public lands.

10.02 Site Preparation

(A) Description

Site preparation includes, without limitation, layout, tree protection, demolition, clearing, excavation, fill and backfill, addition of topsoil, and finish-grading.

(B) Materials

Planting soil nutrient and mechanical compositions are unique to individual sites, species, and

project conditions such as geotechnical recommendations and green infrastructure requirements. One soil type may not be viable across an entire project. The following requirements shall be satisfied to ensure proper soil nutrients and mechanical composition are provided.

(1) **Imported Fill:** Imported fill for landscaping shall be clean, fertile, sandy loam soil that is free from turf, lime, ashes, debris, noxious weeds, roots, stones over 4 inches in diameter, harmful chemicals, or other materials that are detrimental to plant growth. Fill shall have a pH of 6.0 to 8.0, salt of less than 2 mmhos/cm, sodium absorption ratio of less than eight, and at least an 85 percent germination rate for narrow and broadleaf plants. Fill shall not be hauled in a frozen, wet, or muddy condition. An agricultural suitability analysis of the proposed topsoil from an accepted, accredited testing agency at contractor's cost shall be provided to the City to confirm nutrient and mechanical requirements are met.

(2) **Native Soil:** Surface soil in the areas designated on the soils plan as existing soil shall not be altered, compacted to root limiting density, graded or contaminated before or during the construction process and shall be considered acceptable for planting and longterm health of the plants specified either as it exists or with only minor modification. An agricultural suitability analysis of the proposed topsoil from an accepted, accredited testing agency at contractor's cost shall be provided to the City to confirm nutrient and mechanical requirements are met.

(3) **Soil Requirements for Imported and Native Soil:**

(a) Topsoil shall be fertile, friable, sandy loam topsoil. Topsoil shall be free of stones over 1 inch in diameter, lumps, refuse, plants or their roots, sticks, noxious weeds, salts, soil sterilant or other material that is detrimental to plant growth. Topsoil shall not be delivered or used while in a frozen or muddy condition.

(b) Topsoil shall have an acidity range of pH 6.0 to 8.0 and contain not less than 5 percent organic matter as determined by loss on ignition of moisture-free samples dried at 100 degrees Centigrade. Topsoil shall have salt of less than 2 mmhos/cm and a sodium absorption ratio of less than eight.

(c) Topsoil shall meet the mechanical analysis outlined in Table 10-1, "Topsoil Mechanical Analysis," of these Standards:

Table 10-1: Topsoil Mechanical Analysis

	Passing percent	Retained percent
1-inch screen	100%	0 - 0%
½-inch screen	97 - 100%	0 - 3%
No. 100 mesh sieve	60 - 40%	40 - 60%

(C) Construction Requirements

(1) **Layout:**

(a) The contractor is responsible for:

(i) Establishing and recording all necessary boundary points, lines,

elevations, grades, access points, and benchmarks onsite for proper control, landscape protection, coordination with subcontractors, and execution of the work.

(ii) Verifying all furnished survey and topographic data, all points, lines, and elevations.

(iii) Notifying the Director of any discrepancies between information on approved construction plans and actual site or field conditions or measurements and receive approval for required modification prior to continuing work.

(iv) Staking all cuts and fills on the sites as shown on the grading plan.

(b) Shoulders and toes of slopes shall be smoothly blended to the flat areas.

(c) No cut or fill is allowed within the dripline of existing trees without the prior approval of the Director pursuant to Section 3.05(B)(5) of these Standards.

(2) **Clearing of Project Site:** The contractor is responsible for:

(a) Removing from the site all trees and shrubs, brush and weed growth, stumps, and root systems designated on the approved construction plans for removal.

(i) All trees to be removed shall be marked with an "X" in blue permanent marking and approved by the Director prior to removal.

(ii) All other plant material not designated for removal shall be protected and maintained consistent with Chapter 3.05(B) of these Standards.

(iii) Stripped-off brush and weed growth shall be hauled offsite. No burning or nesting of materials shall be permitted onsite.

(b) Maintaining adequate fire protection while clearing operations are underway.

(c) Replacing any existing sod damaged by construction operations. Replacement sod shall meet the standards of Section 10.04, "Seeding/Sodding," of these Standards.

(d) If specifically required on the approved construction plans, scalping the top of soil, including grasses and roots, to a depth specified in the plans and stockpile onsite or remove as indicated.

(3) **Excavation:** The contractor is responsible for:

(a) Stripping, stockpiling, and replacing existing topsoil in areas of fill on the finished grade to at least 4 inches deep.

(b) Excavating so as to provide adequate drainage of the site at all times.

(c) Using hand methods of excavation within the dripline of trees pursuant to root protection requirements in Section 3.05(B)(3) of these Standards.

(4) **Fill and Backfill Operations:** The contractor is responsible for the following:

(a) Obtaining the Director's approval of the subgrade before commencing soil preparation, adding of topsoil, finish grading or planting, and obtaining the Director's approval of the finish grade before commencing planting, mulching or other subsequent operations. The following grading tolerances shall be applied:

(i) Tolerances shall not exceed 0.1 feet above or below desired subgrade elevations in planted areas, and no tolerance will be allowed on subgrades prepared for paving or site improvements, or subgrades immediately adjacent to curbs or island pavements.

(ii) Settling of finish grade shall not exceed 0.1 feet.

(b) Completing clearing operations before beginning any filling or backfilling.

(c) If sufficient suitable fill or backfill material is not available on the project site, furnishing additional materials according to standards for hauled-in fill or topsoil, as required in these Standards.

(d) Placing fill and backfill in layers not to exceed 6 inches in compacted depth with the following compaction standards:

(i) Each layer shall be compacted to the specified density. Landscaping fill and backfill shall be compacted to no less than 80 percent and no more than 85 percent density in areas to be planted.

(ii) Compaction shall not occur when soil is wet.

(e) Ensuring that filling and backfilling shall provide adequate site drainage at all times. Fill or backfill shall not be placed on wet ground.

(5) **Finish Grading:**

(a) Work in this section shall consist of cutting, filling, shaping, and grading according to the lines, grades, elevations and cross sections on the approved landscaping or engineering plans.

(b) The contractor is responsible for the following:

(i) Completing all finish grading onsite. The top of the subgrade shall be the depth below the finish grade as required for pavements, sod, walks, mulches and other site improvements.

(ii) Protecting the finish grade areas and regrading to correct any irregularities caused by hauling materials or by other operations over the finish grade.

(iii) Repairing any erosion or other damage resulting from weathering action before final acceptance.

(c) Excavated and filled sections and adjacent transition areas shall be smooth, properly compacted and free from irregular surface changes. The degree of finish grading shall be that ordinarily obtained from either blade, grader, or scraper operations. Where finishing cannot be satisfactorily completed with power equipment, hand methods shall be used.

(d) Unless otherwise indicated, the subgrade shall be evenly sloped to provide drainage away from site improvements or the centerline of medians. Swales shall be cut as shown on the plans but shall not reduce the thickness of the topsoil specified.

(e) Finish grading shall conform to the grade elevations shown on an approved landscaping plan and shall be free from debris and other materials that would be detrimental to the subgrade. Settling of any finish grade shall not be more than 0.1 feet, and if settling is greater, the contractor shall bring the grade to specified elevations.

10.03 Planting

(A) Description

Planting includes, without limitation, the placement of live trees and shrubs, the placement of materials to protect and enhance plant growth, and the methods applied in planting and maintaining landscape plants.

(B) Materials

(1) **Edger:** Ryerson or approved equivalent steel edger, 1/8-inch by 4- inch steel with steel stakes, painted with rust-inhibiting black paint. The edger shall have a rolled or folded edge or be capped with plastic safety-edged material.

(2) **Filter Fabric:** Fabric shall not be used with any planting unless specifically approved as part of a detailed Landscaping Plan. Fabric shall not be used within the driplines of any existing trees or within 10 feet of any newly planted trees. If approved, fabric shall be 30.1-mil DeWitt Weed Barrier or approved equivalent.

(3) **Pesticides:** Comply with the specifications of Chapter 6-10, “Pesticide Use,” B.R.C. 1981.

(4) **Tree Wrapping Material:** New, 4-inch wide, bituminous impregnated tape, corrugated or crepe paper, brown in color, specifically manufactured for tree wrapping. Tree wrapping shall be fixed with pliable or nonbinding tape. No wire shall be used. If tree wrapping is used, the tree wrap shall be removed by April 1 of the following growing season.

(5) **Compost:** Well-weathered and weed-free cow or sheep manure or other composted

materials. No mountain peat shall be used.

(6) **Stakes:** Green 8-foot steel tee posts with blade.

(a) Trees shall be secured to stakes using minimum 2-inch-wide nylon and cotton blend webbing with heat sealed ends, a tensile strength of 1000 pounds and brass grommets for attachment of wire between strap and stake.

(b) Grommets shall be 1 ¼ - inch in diameter with a ½ -inch diameter eye that is set at least ½ -inch from end of strap.

(c) Wire shall be 12-gauge galvanized steel covered with a PVC sleeve.

(d) Straps shall be of sufficient length in relation to tree caliper so that grommets do not touch trunk.

(e) A protective cap shall be secured to the top of all stakes.

(7) **Mulch:**

(a) Wood chip mulch shall be clean wood chips or fiber, free of soil or man-made debris, shredded into coarse pieces ranging in size from 1 inch to 3 inches. All landscape plantings shall be mulched with 3 to 4 inches of wood chips. “

(b) Rock, gravel, cobblestone, or other inorganic material shall not be used in planting beds as a temporary or permanent mulch. unless specifically approved as part of a detailed Landscaping Plan.

(8) **Plant Materials:**

(a) All plants shall be “ “Northern Grown” unless otherwise specified in these Standards, except for plants of the genus *Juniperus*.

(i) Northern Grown means plants grown in nurseries for at least two full growing seasons located in hardiness Zones 1 through 5, as shown on a United States Department of Agriculture map.

(b) All plants shall be appropriate for the local climate and site-specific growing conditions. All plants shall be of species identified under and allowed by these Standards and shall conform to the following:

(i) Selected to meet the goal of maximum water efficiency and zoned or grouped according to their water requirements in accordance with Section 9-9-12,”Landscaping and Screening Standards,” B.R.C. 1981.

(ii) Individually identified on legible, weatherproof labels securely attached to the plants. Labels shall be durable and shall remain legible for at least 60 days from site delivery.

(iii) Labels shall include the correct genus, species, variety name, accepted

common name of the plant, size or grade of stock, and source nursery of the plant.

(iv) Labels shall remain until after City inspection and then shall be removed by the contractor.

(c) Tree selection and placement shall be in accordance with Section 3.03, "Tree Selection and Placement," of these Standards.

(d) Trees shall conform to and have the following characteristics:

(i) A well-developed branch structure typical of the size and species with no "V" crotches, codominate stems, or included bark. The height of branching should bear a relationship typical of size and species so that the crown of the tree will be in balance as the tree grows.

(ii) Healthy buds, stems, and bark that are without mechanical, injury, insect, or disease signs or symptoms.

(iii) Healthy, vigorous, and free from visual defects, mechanical injuries, plant diseases, and all forms of insect infestation until final acceptance.

(iv) A well-branched and vigorous root system typical of size and species and free from bent or kinked roots, roots girdling the trunk, and other defects.

(v) All trees shall be balled and burlapped. Root balls shall have a sufficient diameter for the fibrous and feeding root system necessary to provide for full recovery of the tree following planting. Minimum root ball sizes shall meet the following specifications outlined in Table 10-2,

Table 10-2: Minimum Root Ball Sizes

Caliper	Minimum Root Ball Diameter
1 ½"	20"
1 ¾"	22"
2"	24"
2 ½"	28"
3"	32"

(vi) Shrubs may be either balled and burlapped or container grown.

(e) All trees and shrubs shall be freshly dug at time of delivery, unless they are container-grown.

(C) Construction Requirements

(1) **Layout and Identification:** The contractor shall use stakes, flags, or containerized plants to locate all trees and shrubs according to an approved landscaping plan.

(2) **Schedule:**

(a) Nothing shall be planted between October 15 and March 1 without prior written approval of the Director. Stock, other than container-grown stock, shall not be planted between June 1 and September 1 without prior written approval of the Director.

(b) Nothing shall be planted during freezing or excessively windy, hot, or wet weather or when the ground conditions cannot be properly worked for digging, mixing, raking, or grading.

(c) Nothing shall be planted until the adjacent site improvements, pavements, irrigation installation and finish grading is completed. The irrigation system shall be in approved, operating condition prior to any planting.

(3) **Plant Protection and Delivery:**

(a) The contractor shall protect all installed plant material from injury, excessive drying or winds, improper ventilation, over watering, freezing, high temperatures, or any other condition damaging to the plant until final acceptance. Any plants showing evidence of poor care or that are molded, mildewed, wilted, or dried-out shall be rejected. Colored waxes or other materials that coat the aerial parts of plants, or the removal of primary buds and/or shoots, including terminal buds and first order leaders, of plants are not acceptable.

(b) Plant materials shall be planted on the day of delivery if possible. All plants not planted on day of delivery shall be placed in a temporary nursery, kept moist, shaded and protected from sun and wind. If balled and burlapped plants are not planted on the day of delivery, they shall be heeled-in immediately in the temporary nursery, kept moist and protected with damp soil, mulch, or other acceptable material. All plants shall be planted within 48 hours after delivery. Plants shall not be bound with wire or rope that may damage the bark or break branches. Plants shall be lifted and handled from bottom of ball or container and shall not be dropped or lifted by the trunk, stem or foliage. Plants with balls that are loose, cracked, broken, man-made or completely dry or plants with trunks loose in the ball before or during planting operations shall not be accepted and shall be removed from the site at contractor's expense.

(c) The contractor shall deliver all packaged landscape materials to the site in original unopened containers bearing name, trade name, manufacturer, trademark, and conformance to State Law.

(d) Existing trees shall be protected per Section 3.05, “Tree Protection for Construction Sites,” of these Standards.

(4) **Excavation of Planting Pit:**

(a) All plant pits shall be centered on the plant location and excavated in a cylindrical shape with vertical sides and flat bottom. The depth of the plant pit shall be measured from adjacent finish grade of the soil, not from the mulch. The base of all soil balls shall be placed on undisturbed soil.

(b) Trees: The diameter of all tree pits shall be at least two times the diameter of the

ball or spread of the roots. Tree pits shall be excavated so that the top of the ball will be 2 inches above finish grade.

(c) Shrubs: The diameter of all shrub pits shall be at least two times diameter of the ball or spread of roots. Shrub pits shall be excavated so that the top of the ball will be 1 inch above finish grade.

(d) Vines and Ground Covers: The diameter of all vine and ground cover pits shall be two times the spread of roots. The planting pit shall be excavated so that the top of the ball is 1 inch above finish grade.

(e) All holes and pits shall be protected as specified in the General Conditions at all times when work is not being carried on at the site of excavation.

(5) **Planting and Staking for Plant Installation:**

(a) For all trees, the contractor shall drive stakes 3 feet vertically into firm soil outside the planting pit with blade on tree side. The contractor shall run a double strand of wire through one grommet in the strap, wrap the strap around the trunk at no more than one-third the height of tree, and run wire through other grommet and back to stake. Strap and wire attachment between the stake and tree shall be adjusted so that straps are under just enough tension to avoid visible sag in lines. Rigid guying shall not be accepted. Straps and wires shall be placed so as to be perpendicular to the trunk. Stakes shall be parallel or slightly angled away from the trunk.

(b) The contractor shall place stakes according to tree height or caliper as follows: deciduous trees under 2 inches in width - one stake oriented northwest; deciduous trees between 2 and 3 inches in width, and evergreen trees less than 5 feet in height - two stakes oriented northwest and southeast; deciduous trees 3 inches in width and larger and evergreen trees 5 feet in height and larger - three stakes with one oriented northwest and the other two oriented 120 degrees in either direction from northwest.

(c) All deciduous trees shall have a sod-free base at least 3 feet in diameter. All evergreen trees shall have a sod free base extending to the dripline. This sod free area shall be extended where necessary to include all stakes.

(d) The contractor shall return to the site and remove all stakes and guy wires between May 21 and June 7 after one full growing season.

(e)Unless otherwise specified, all areas designated for mass planting such as for ground covers or vines shall be amended with 5 cubic yards per 1,000 square feet of manure compost. The contractor shall first prepare the subgrade by discing or rototilling the subgrade to a depth of 8 inches. No ripping or chiseling shall be allowed. After preparing the subgrade, the amendments shall be thoroughly rototilled into the soil to a depth of 8 inches. The contractor shall remove any rocks, debris or foreign matter in excess of 1 inch in length or diameter encountered to an 8-inch depth or in a manner adequate to accommodate typical

root depth of the specified plant material.

(6) **Spraying, Pruning, Watering and Mulching for Plant Installation:**

(a) After watering on the day of planting, and throughout the maintenance period, the contractor shall ensure that all plants are sufficiently, but not over, watered. The contractor shall water each plant with a minimum of 10 gallons of water per diameter inch trunk width per week unless otherwise specified in an approved Tree Protection Plan.

(b) Wood chip mulch shall be placed in all planting beds, shrub areas and the sod-free area of a 3-foot radius at the base of each tree. The mulch shall be spread carefully and evenly to a depth of 3-4 inches. Mulch shall be removed 2 inches back from the trunk. Shredded wood chip mulch shall be watered thoroughly two times to aid in matting the mulch in place. The mulched areas shall be graded so that the top of the mulch will be flush with the top of the curb, sidewalk, edging or sod.

(c) The contractor shall be responsible for damage to any underground utility, irrigation line, paving, adjacent structures or other improvements. In the event a pipe, line, rock formation, or other obstruction interferes with a plant location, the contractor shall notify the Director to receive approval for a new plant location.

10.04 Seeding/Sodding

(A) Description

(1) Seeding/sodding includes, without limitation, the planting and installation of grasses (native or otherwise), preparation of soils and grading, and the methods to be applied in planting and maintaining of grasses until full establishment is achieved.

(B) Materials

(1) **Fertilizer:** Specified fertilizer shall be supplied in the original supplier's containers with label and order form showing composition and quantity. Fertilizer shall be intact, free-flowing, dry and in quantity, as specified for sodded or seeded areas, as shown on the plans. Fertilizer for sod and seeding soil preparation shall be a compound equivalent to 18-46-0 applied at the rate of 10 pounds per 1,000 square feet.

(2) **Bluegrass:** Bluegrass shall be Colorado-grown, 100 percent certified Kentucky Bluegrass, of three improved bluegrass varieties complying with applicable Colorado and Federal regulations. Newport, Park, Delta and Common Kentucky Bluegrass are not acceptable varieties for the sod mixture. The sod shall have a vigorous and healthy root system and top growth and shall have been regularly fertilized, watered, mowed, sprayed and shall be free from objectionable weeds and/or grasses. Sod strip shall have from 5/8 inch minimum to 1-inch maximum thickness of soil adhering to root system, cut into strips 18-inch maximum width by 4 feet minimum length. Sod that has dried out, or sod

with adhering soil that breaks, tears or crumbles away will not be accepted. Sod cut for more than 24 hours shall not be accepted. Sod rolls shall be kept moist, protected from sun, heat or wind in transport and after delivery. Prior to cutting, the sod shall be evenly mowed for a blade length of at least 1 inch but not more than 2 inches.

(3) **Turf-type Tall Fescue:** Turf-type tall fescue seed or sod shall be purchased from a reputable seed dealer, complying with requirements specified. Seed mixture shall be of at least three varieties (a maximum of five) of dwarf type tall fescue (i.e., Monarch, El Dorado, Rebel Jr., Crew Cut, SR 8200, or other approved varieties).

(a) PLS shall not be less than 88 percent.

(b) Specified PLS shall be calculated as shown in Section (5)

(4) **Buffalo Grass:** Buffalo grass shall be either seed, plugs, or sod.

(a) Buffalo grass seed shall be purchased from a reputable seed dealer, complying with the requirements specified. Seed mixture shall be “Texoka” or “Sharp's Improved” or approved equivalent.

(i) PLS shall not be less than 75 percent.

(ii) Specified PLS shall be calculated as shown in Subsection (B)(5).

(b) Buffalo grass plugs or sod shall be 100 percent certified turf-forming variety 609, or approved equivalent. Buffalo grass imported from states south of Colorado may be approved due to the difficulty in establishing sod in the front range climate.

(i) All sod shall be healthy, in vigorous condition, of natural green color, free of disease and harmful insects. The sod shall be laid within 48 hours of harvest.

(ii) Plugs shall be cut from sod as described in this Section. Nursery grown plugs are acceptable with prior approval by the Director.

(c) If sod is to be used for medians larger than 12 feet wide, Buffalo grass is preferred.

Table 10-4: Soil Amendment Mix Mechanical Analysis

	Percent (%) Passing	Percent (%) Retained
2" Screen	100	0
1" Screen	90-100	0-10
½ " Screen	50-80	20-50
#100 Mesh Sieve	0-15	85-100

(5) **Soil Amendment:** Soil amendment for sod and seed areas, shall be manure compost, and shall contain at least 50 percent organic matter. The mixture shall be free from clay subsoil, sawdust, commercial wood products, stones, lumps, plants, roots, sticks, weed stolons and seeds, high salt content, and other materials harmful to plant life. The materials shall be coarsely ground and thoroughly mixed together to ensure an even composition. Cow manure or mushroom compost shall be free from lumps, debris or chemicals harmful to landscape plantings. The soil amendment mix shall have an acidity from pH 5.5 to 8.0, and meet the mechanical analysis outlined in Table 10-4, "Soil Amendment Mix Mechanical Analysis," of these Standards.

(6) **Erosion Control Netting:** Jute mesh erosion control netting or approved equivalent shall be used.

(C) Construction Requirements

(1) Subgrade and Soil Preparation:

(a) The contractor shall lay out and stake the boundary of all areas to be sodded, seeded, or plugged prior to commencing any work. The contractor shall prepare the subgrade of all seeded or sodded areas by discing or rototilling the soil to a depth of 6 inches. No ripping or chiseling shall be allowed. No rototilling or discing is to be done within the protection area of existing trees. After the subgrade has been completed, soil preparation shall begin by spreading the soil amendment evenly within the seeding or sodding limits at the rate of (6) cubic yards per 1,000 square feet.

(b) For sod, -18-46-0 fertilizer shall then be spread uniformly over the entire area at the rates as specified for soil preparation. The area shall again be disced or rototilled at right angles to the first tillage, then formed by rolling to provide a proper seed bed or sodding surface. The sod or seed bed shall be totally free from rock, debris, vegetable matter, weeds or clay clods over ½ inch diameter, prior to any sodding or seeding operations.

(2) Finish and Fine Grading:

(a) Positive Surface Drainage: The contractor shall finish and fine grade the project area to establish an even and well-matched grade over the entire surface.

Positive surface drainage shall be assured, and there shall be no depressions, subsequent settling or irregularities in the finished grade.

(b) Transitional Areas: At any transitional point or line where one plane intersects another, such as from a sloping area or berm to a level area, a smooth and gentle transition shall be made. There shall be no abrupt changes in grade. There shall also be a smooth transition between existing turf and the new sod. The grade elevations of the two areas shall be matching.

(3) **Schedule:** All seeding shall be scheduled between March 1 and October 15 unless prior written approval from the Director has been obtained.

(a) No sodding and seeding shall take place during inclement weather.

(b) No sodding and seeding work shall commence until the adjacent site improvements, pavements, irrigation installation and finish grading is completed. The irrigation system shall have been tested and be in operating order prior to any seeding or sodding.

(c) The contractor shall barricade sodded area immediately after sod installation as specified on the approved construction plans or in these Standards. The barricade shall include the following:

(i) Standard construction lath at 5-foot intervals connected with three tiers of colored plastic flagging.

(ii) "KEEP OFF THE SOD" signs attached to the barricading every 25 feet.

(4) **Seeding:**

(a) Seeding shall be done with a Brillion drill or approved mechanical seeder. Seed shall be evenly distributed on a still day into a slightly moist seed bed. Seed shall be drilled 1/8 inch into the prepared seed bed. If the slope is too steep to drill, seed shall be broadcast at double the application rate and covered with 1/8 inch of soil with a harrow or hand rake for small areas. The seeding shall be done in two separate applications crossing the area at right angles to guarantee proper coverage. Drill seed across slopes rather than up and down, following the contour to reduce erosion.

(i) Native grasses shall be seeded at a rate of 20 pounds PLS/acre when drilled and 35 pounds PLS/acre when broadcast.

(ii) Buffalo grass shall be seeded at a rate of 3 pounds PLS/1000 square feet when drilled and 5 pounds PLS/1000 square feet. when broadcast.

(iii) Turf type tall fescue shall be seeded at a rate of 6 pounds/1000 square feet when drilled and 9 pounds/1000 square feet when broadcast.

(b) After seeding operations have been completed, the entire seeded area shall be

hydromulched with “Conwed 2000" or approved equal hydro mulch material. The hydro mulch shall be applied by using mechanical hydromulcher, evenly distributed on a still day. The hydro mulch material shall be applied at the rates recommended by the manufacturer. Within 12 hours after seeding, the sprinkler system shall be activated to moisten seeded areas to a depth of 1 inch. All seeded areas shall be kept so moistened by frequent light watering until final acceptance of the project or as required by City Land Use Regulations, and such watering shall be the responsibility of the contractor.

(c) Protect seeded slopes (greater than 2.5 horizontal to one vertical) with erosion control netting or other methods acceptable to the Director. Cover netting with straw or other acceptable mulch.

(d) Seeding is not complete and will not be accepted until 70% coverage is achieved with the intended species.

(5) **Bluegrass Sodding:**

(a) Sod shall be laid on a firm, premoistened bed with tight joints so that no voids occur under or between strips. All end joints shall be staggered, and the sod roll length shall run perpendicular to all slope fall lines. Sod shall be tamped, rolled, and watered immediately after sodding operations are completed.

(b) No sod shall be installed within a radius of 3 feet around any tree within the project limits. Shredded wood chips shall be installed to a 3-inch depth in this 3 foot area. All rolls terminating at the project limits shall be cut in a straight line unless otherwise specified and the exposed edge covered with topsoil. All sod installed around planting beds shall be cut to conform to the shape of the bed as shown on plan or laid out onsite. Sod shall be laid flush with paving, curbs and irrigation heads and 1 inch below the top edge of steel edging.

(c) In the event that sod dries or shrinks, a mixture of screened topsoil and specified bluegrass seed shall be brushed into the cracks and tamped flush. Excessively shrunk sod (over 3/4-inch shrinkage) shall be replaced with new sod. Any sod laid on slopes steeper than 3:1 (33 percent) shall be laid at a 90-degree angle to the slope and held in place with two wooden dowels per sod piece.

(d) The contractor shall activate the sprinkler system to water sod immediately after each section of sod is laid. The contractor shall operate the sprinkler to soak all sod and the underlying soil to a depth of 2 inches and maintain this moisture level until final acceptance. The contractor shall water the sod in the early morning and late afternoon for the duration of this period.

(6) **Buffalo Grass Sod:**

(a) Prior to sodding, the site should be lightly irrigated to alleviate “sod-wicking” and desiccation. The sod shall be laid by staggering joints with all edges touching. Installation shall be performed between April 1 to August 31. Immediately following the laying of the sod, the sod should be rolled with a

roller, weighing at least 150 pounds, heavy enough to imprint the sod into the soil.

(b) The contractor shall irrigate immediately after any sod installation, so that the sod and underlying soil is completely wetted to a depth of 4 to 6 inches (saturated). Subsequent irrigation shall be applied as necessary as determined by daily inspection of the sod panels. Daily inspection should consist of manually raising several sod panels and testing the level of moistness in the soil by pinching the soil together. If the soil remains 'pinched' together, and is moist, and the panel's sod pad is also moist, then the sod does not require watering that day. If the soil, after being pinched, falls apart, the sod shall be irrigated to retain the required moisture level. The sod soil pad and underlying soil should be moist at all times.

(c) Rainfall received during the establishment period may reduce the irrigation required. If temperatures exceed 95 degrees for periods of several days, the sod may have to be inspected more frequently and additional daily irrigation cycles may be required. If the soil that has been sodded is extremely hard, or compacted, and not easily saturated, or dries out quickly, the sod and soil shall be kept consistently moist the first ten days.

(d) Normal establishment should display the following characteristics. Within 48 hours of installation the sod should turn a straw color, which is called a dormant stage, although the roots would continue to grow while the top growth is dormant. Within 5 to 7 days feeder roots should begin appearing. Within 14 to 21 days new green top growth should be seen and the sod should be firmly rooted. Once this occurs, daily manual inspections would no longer be required. Sod should then be watered 1½ inches per week for 2 to three months, to prevent drought stress, until deeper rooting takes place.

(e) The contractor is to thoroughly discuss required installation, establishment and post-establishment methods, irrigation, and maintenance requirements with the sod supplier (specifically for sod maintenance - weed control/removal, i.e., what chemical can safely be used, etc.).

(7) **Buffalo Grass Plugs:**

(a) Plugs shall be planted on 12-inch centers with a requirement of at least nine (9) plugs per square yard of ground. Plugging machinery must convert 16 x 24-inch sod panels into plugs and plant in one operation. Each 16 x 24-inch sod panel yields 24 4-inch square plugs, with a total of 81 plugs cut from a yard of sod. At least 80 percent of the plugs shall be a 4-inch square plug (4 x 4 inches); minimum acceptable size for the remainder of the plugs is 2 x 4 inches, nor maximum size any larger than 4-inch x 4 inch. Coordinate equipment passes to maintain parallel, evenly spaced rows. Immediately following plugging, the plugs should be rolled with a roller, weighing at least 150 pounds, heavy enough to imprint the plugs into the soil.

(b) All plugs shall be planted within 48 hours of harvest of the sod. All plugs shall be healthy, in vigorous condition, of natural green color, free of disease and

harmful insects. Water after any portion of the plugging is complete, within 4 hours of planting, so that the plugs are completely wetted and the underlying soil is wetted to a depth of 4 to 6 inches.

(c) All buffalo grass sod establishment, irrigation, and maintenance requirements shall apply to plugs. Plugs will require more frequent manual inspection and more frequent watering. After the initial establishment period, plugs should be watered 1 inches per week until desired coverage is achieved.

10.05 Permanent Underground Irrigation System

(A) Description

Underground irrigation includes, without limitation, installing a complete and permanent underground irrigation system consisting of irrigation pipelines, sprinklers, valves, and controllers as part of any landscaping project.

(B) Materials

(1) **Sprinkler System Components:** All sprinkler system components shall be those of the manufacturers specified in these Standards, or be an approved equivalent, and shall be installed in accordance with these Standards.

(2) **Sprinkler Heads:** Pop-up rotary impact or stream spray sprinklers shall be used to water sod , using full and part circle heads as specified on any approved landscape plans. Requirements for the sprinklers include the following:

(a) Sprinklers shall provide coverage as specified on any approved landscape plans, plus or minus 5 percent of the flow rate and 2 ½ feet within the design radius during a low wind situation.

(b) Sprinkler heads shall meet the following specifications:

(i) Minimum pop-up height of 6 inches forpop ups and MP rotators or 5 inches for larger rotors with heavy retract spring;

(ii) Part circle sprinklers shall be adjustable for any arc between 20 and 340 degrees;

(iii) Have built-in check valves in the head to control low head drainage and reduce air compression in lines. The check valve shall be serviceable from the top of the head without requiring excavation and removal of the head from the riser.

(c) Sprinklers shall be vandal resistant and shall have vandal-resistant cover screws or no exposed screws in the cover.

(d) Sprinklers shall be tamper resistant to prevent changing the direction of throws by means of locking friction collars, gear drives, and limited access features.

(e) Sprinklers shall have a drive mechanism that will ensure proper and even rotation and coverage on 4:1 slopes.

(f) Sprinklers shall have rubber covers or similar protective devices.

(3) **Bubblers:** Requirements for bubbler heads shall include the following items:

(a) Heads shall operate properly between 10 psi and 80 psi;

(b) Heads shall have a molded plastic body with a ½ inch female pipe thread;

(c) Heads shall have a nozzle flow adjusting screw, providing fully open to completely closed positions;

(d) Heads shall have a plastic basket screen to protect nozzles from clogging.

(4) **Automatic Control Valves:**

(a) Automatic electric remote-control valves shall be slow acting diaphragm-type electric solenoid valves. Solenoids shall be two-watt running, current 24-volt AC, 50/60 cycle operation. The valve shall be slow opening and closing by means of a "shunt" resistor to avoid damage from surge pressures. Valve flow range shall be 1 to 200 gallons per minute depending on size with a pressure range of 10 to 200 PSI.

(b) All valve bodies and bonnets shall be constructed of heavy case bronze with accurately machined valve seat surfaces and internal parts. Inlet part of diaphragm chamber shall have a removable screen for easy cleaning, accessible without removing bonnet from valve body. Valve bonnets shall be equipped with a slotted plug or bleed screw for manual operation of valves at any time without energizing the solenoid, and a manual flow control stem.

(5) **Isolation Gate Valves:** Isolation gate valves for installation on main lines shall be of brass construction, designed for 200 psi working pressures, and have solid disc, non-rising stems with a heel and screwed ends. Gate valves 3 inches or larger shall be brass or iron AWWA gate valves with rubber gaskets or mechanical joints.

(6) **Quick-Coupling Valves:** Anti-rotation quick-coupling valves installed in main lines shall be of a cast brass body construction and have a self-closing and locking protective cover. The throat shall incorporate a single keyway with positions for regulation of water flow, with a flow range of 10 to 70 gallons per minute and a pressure range of 5 to 125 psi. Replaceable seals shall be provided at the valve seat and throat, and the internal parts shall be removable for service. Installation on a main line in shall include a 10-inch circular locking valve box over the coupler body. Size shall be 1 inch. Quick-coupling valve keys shall have 1-inch male top pipe threads. Swivel hose ells shall be 1-inch N.P.T. x 3/4-inch hose thread.

(7) **Manual Drain Valves:** The system shall be equipped with 3/4-inch curb stop manual globe drain valves at all low points on main lines. Valves shall be of bronze construction

with threaded connections, cross handles, and operating keys. Install valves in a locking valve box. Angle valves will not be accepted.

(8) **Y-Strainers:** Y-Strainers for installation on main line shall be bronze "Y" type strainers with a screen mesh.

(9) **Wire Connectors:** All wire connections at electric control valves and all splices of wire in the field shall be made using "snap-tits," or an approved equivalent, wire connectors. Significant requirements for connectors include the following items:

(a) Connectors shall be rated at 600 volts for PVC insulated copper wire, Underwriters Laboratory listed, and water-resistant.

(b) Connectors shall consist of a PVC base socket, sealing plug, and wire crimping sleeve and shall provide a permanent waterproof joint by using a silicone sealer for joint makeup.

(10) **Controllers:**

(a) Automatic sprinkler controllers shall be completely automatic in operation and shall electrically start all sprinkler cycles and time the individual stations. Controllers shall have standard 117-volt power inputs, 24.0 volt, 60 cycle outputs with separate independent timing stations, 14-day programming, and be capable of automatically starting a watering cycle at the beginning of any hour for 23 hours per day. Each station shall have an "OFF" switch for "0" time and individual incremental timing control for 0-to-60-minute station timing. Each station shall have an "ON-Repeat" switch for eliminating one or more stations from initiating a repeat cycle on any or all stations after the normal watering cycle has been completed. A 14-day clock shall be provided for maximum programming versatility and any timer pins shall be of the captive type to prevent loss. It shall be possible to operate controller manually and to select and operate manually any station. All controls shall be capable of being manipulated at any time in any sequence without damage to controller. The controller shall have the ability for dual programming and shall have soil moisture sensing equipment.

(b) Soil moisture sensing equipment shall have an adjustable control module with an override function, and at least two in-ground sensors/tensiometers. Sensors must buffer salinity and have the ability to withstand winter conditions without removal.

(c) A reset circuit breaker shall protect each controller from damage due to excessive current. A master "ON-OFF" switch shall provide for turning controller "OFF" during rainy weather, while allowing day and hour clocks to continue in operation. The controller shall have as standard built-in features an electrical circuit to operate a master valve and moisture sensor circuit to allow operation of controllers in conjunction with a moisture sensing device. Install valve output surge protection arresters for control wiring and common.

(d) All wiring to and from controllers shall be through color-coded plugs and sockets. Controller cabinets shall be locking, weatherproof type, constructed of

heavy gauge steel with corrosion resistant enamel finish inside and out.

(e) Controllers shall conform to NEC Class 2 requirements of 24-volt valves. Controllers shall be for wall or pedestal mounting.

(11) **Valve Boxes:** Lockable valve boxes shall be sized to provide maintenance access to all valve and controller component. The underside of all control valve boxes shall be clearly marked to indicate controller numbers and valve numbers.

(12) **Pipe:**

(a) Main Line Pipes:

(i) Main pressure line pipe shall be NSF approved virgin polyvinyl chloride pipe or HDPE. Pipe shall be suitable for use at maximum hydrostatic working pressures of 200 PSI. Pipe shall be made from clean, virgin, NSF approved, type 1, grade 1 PVC, conforming to Astin Resin specification D1784-60 and project standard D2241 for PVC 1120 SDR 26 or SDR 21. PVC pipe is to be belled end and solvent weld. Solvent cement and primer shall be of the type prescribed by the manufacturer.

(ii) Gasket pipe and fittings shall be used for main lines 3 inches or larger. Gasketed pipe shall be of the type prescribed by the manufacturer. No insert gaskets or insert gasket fittings shall be accepted. Thrust blocks shall be provided in accordance with pipe manufacturer's recommendations.

(b) Marking and Declaration of Compliance: Pipe marking shall show the size, series, identification, and manufacturer's trade name at intervals of not more than 20 feet. Pipe shall include the seal of approval of the National Sanitation Foundation spaced at intervals required by NSF regulations.

(c) PVC Fittings: All pipe fittings shall be schedule 40 PVC (ASTM D2466 and D1784). Solvent cement shall conform to ASTM D2564.

(d) Brass Pipe and Fittings:

(i) Brass pipe shall be 85 percent red brass, (ANSI) Schedule 40.

(ii) Fittings shall be medium brass, 125-pound class, screwed type.

(iii) Dielectric unions shall be used wherever a copper-based metal (copper, brass, bronze) is connected to an iron based metal (iron, galvanized and stainless steel).

(e) Copper Pipe: Copper pipe shall meet the requirements of Type K, ASTM B88. Fittings shall be copper or cast bronze. Silver solder shall be used for joints.

(f) Lateral Line Pipes: Pipe for rotary sprinkler laterals shall be NSF approved HDPE polyethylene, rated at 80 PSI, using sch 40 insert fittings and adjustable

stainless-steel clamps with stainless steel screws. All piping shall be CS-256-63 ASTM D2239, PE 2306-100. 2 inch or larger class 200 -1" sch 40 lateral piping shall meet the standards for main line pipes.

(g) Static Pressure Reduction: Static pressure on the main line shall be relieved by the installation of a "master" automatic control valve.

(13) **Risers:** Rotary pop-up sprinklers shall have an adjustable swing joint riser assembly consisting of Schedule 80 PVC nipples, and marlex and Schedule 40 PVC ells.

(14) **Irrigation Sleeves:** All horizontal sleeves under paved areas and vertical sleeves shall be PVC Class 200 pipe, or SDR 35 glue joint and glued 4-inch diameter for lines 2 inches and smaller, and 6-inch diameter for lines 2 ½ inches to 3 inches. A separate 2-inch diameter sleeve for control valve wires shall be laid under any new pavements. This sleeve shall be placed next to the main line sleeve.

(15) **Backflow Prevention Device:** Backflow prevention devices shall be installed in accordance with these Standards and B.R.C. 1981.

(16) **Electrical Copper Wires:** Electrical copper wires from valves to controller shall be 14 gauge or larger PVC-insulated copper and UNDERWRITERS LABORATORY approved for direct burial. Use 10-inch valve boxes for all wire splice locations. Control wires shall be red and common wires shall be white.

(17) **Drip Valve Assemblies:** Drip valve assemblies shall have strainers with a 120-mesh nylon screen and ½ inch blow-out. Pressure reducing valves shall have manual adjusting nuts.

(18) **Drip Emitters and Tubing:** Drip emitters shall use drip tubing conforming to ASTM D1248 and ASTM D3350. Capillary tubing shall have 1/8-inch i.d.

(19) **Drip Line Blow Out Stubs:** Drip line blow out stubs shall be installed at all ends of drip tubing.

(C) Construction Requirements

(1) Applicable Standards:

(a) All work involving standard plumbing systems shall be executed by a licensed and bonded plumber. Electrical services to controllers shall be installed by a licensed electrician. All work shall be executed according to the B.R.C. 1981, and these Standards. The contractor shall schedule inspection of electrical services to controllers with the City and allow at least 7 working days for subsequent approval and connection to the power source by the Public Service Company. The contractor shall furnish any additional material and labor when required to comply with the B.R.C. 1981, and these Standards.

(b) The contractor shall perform a leakage test on all systems on the site at normal working pressures.

(c) The contractor shall guarantee irrigation application in accordance with any approved landscape plan; any unwatered areas due to poor layout, placement of or insufficient sprinklers shall be corrected by the contractor at their expense.

(d) Work shall be in accordance with good practices prevailing in the piping trades.

(e) All work shall be protected from vandals or flooding during construction.

(2) **Layout of Work:** Before any installation operations are started, the contractor shall completely stake out the irrigation system on the site. Any discrepancies in irrigation water coverage shall be reported and corrected at this time.

(3) **Schedule:**

(a) No sprinkler system construction shall take place during wet weather or when temperatures are less than 30 degrees Fahrenheit.

(b) All required sleeving shall be performed prior to any paving operations. All procedures necessary for the insertion and installation of irrigation pipe and wires into sleeves shall be performed after paving operations have been completed.

(c) Installation of the system shall not take place until all earthwork has been substantially completed and compacted and all other site improvements, pavements, etc. have been completed.

(4) **Trenching and Piping:**

(a) The contractor shall perform all necessary excavation for installation of their work. Over-excavations shall be backfilled, and hand tamped prior to installing pipe. Any pumping, shoring, or bracing shall be provided by contractor.

(b) Manufacturer's specifications covering installation of their material shall be followed. Underground lines up to 2 inches shall have minimum horizontal clearance of 2 inches of each other, and larger lines shall have a clearance of 4 inches. No sprinkler lines shall be stacked vertically in a common trench. Lines shall have minimum horizontal clearance of 12 inches from the lines of other trades. There shall be a minimum 2-inch vertical clearance between any lines crossing 45 degrees - 90 degrees. Minimum cover over lateral piping shall be 12 inches, or to a depth to accommodate valves and other equipment, whichever is greater. All PVC main line shall be at 18-inch minimum depth of bury. PVC main line is to be encased in sand 4 inches on all sides.

(c) Where trenches and lines run adjacent to existing irrigation lines and properties, damage to these shall be avoided and shall be restored to their original condition

(d) When pipe laying is not in progress, or at end of each day, pipe ends shall be closed with tight plug, or cap, or taped with PVC pipe wrap. All work shall be performed in accordance with good practices prevailing in the piping trades.

(e) Tunneling will be permitted where the pipe must pass under any obstruction that cannot be removed. In backfilling the tunnel, the final density of the backfill must match that of the surrounding soil. It shall be acceptable to use a casing of suitable diameter that shall be installed first by tunneling or jacking, and the pipe shall then be laid through the casing, observing the same precautions as though it were installed in open trench.

(f) Trenches shall be cut to true line and grade and shall be excavated so that the pipe shall be supported uniformly. The contractor shall be responsible for staking the trench lines. Minimum grade of piping to drain shall be 3 inches/100 feet.

(g) If ground water is encountered during trench excavation above the elevation of the bottom of the pipe grade, such water shall be drained until the pipe has been installed. Pipe joints and open ends shall be plugged to prevent ground water from entering the pipe.

(h) Thrust blocks shall be installed behind all gasketed fittings, in line valves, and caps. Gasket pipe fittings shall be installed according to manufacturer's recommendations. Concrete for thrust blocks shall cure for 72 hours before pressure is applied to the system.

(5) **Threaded Joints:**

(a) Field-threading of plastic pipe or fittings shall not be permitted. Only factory-formed threads shall be used.

(b) Factory-made nipples shall be used wherever possible. Field-cut threads in metallic pipe will be permitted only where absolutely necessary. When field threading, cut threads accurately on axis with sharp dies.

(c) All threaded joints shall be assembled with pipe joint compound consisting of liquid Teflon. The compound is to be applied to male threads only.

(d) Where assembling soft metal (brass or copper) or plastic pipe, strap type friction wrenches shall be used; metal-jawed wrenches shall not be used.

(6) **Sleeves:**

(a) The contractor shall furnish and install sleeves of appropriate size, depth, and location to accommodate all irrigation pipe beneath any paved surfaces prior to pipe installation as specified herein, unless they have been previously installed. Where irrigation lines run under proposed paved surfaces, the contractor shall sleeve the lines a distance 2 feet beyond the edge of the surface. Sleeves shall be PVC Class 200 pipe/SDR 35 glue joint glued.

(b) Installation of sleeves shall precede construction paving. Sleeves shall be encased in sand 4 inches on all sides, with backfill compacted to 95 percent of standard Proctor density. Sleeves shall be buried at a depth of 18 inches. Separate sleeves placed at the 18 -inch bury depth shall be provided for wires

passing under paved sections. All sleeves installed under a parking lot or street shall be flow-filled

(c) All sleeves shall be marked by the placement of nylon rope, or an approved equivalent marking material.

(7) **Backfilling:**

(a) Trenches shall not be backfilled until all required tests on the system have been completed and until the line has been inspected and approved by the Director. Trenches shall be carefully backfilled with suitable materials, free from stones larger than 2 inches in maximum dimension, by depositing the material in 6-inch layers and thoroughly compacting the backfill to 95 percent of standard Proctor density.

(b) Ponding and/or jetting may be used only if prior approval is obtained and only when the backfill material is sandy or gravelly. An excess of water shall be avoided in order to prevent disturbance of the earth under and around the pipe. Likewise, the amount of water used shall be controlled so as not to risk "floating" the pipe out of position. Adequate dikes shall be constructed along the trench to retain and guide the water. When jetting is used, jets shall be of an approved design and of sufficient length to reach the bottom of each layer and the water supply shall be continuous.

(c) Site excavation material will generally be considered satisfactory for backfill purposes provided that backfill materials are free from rubbish, vegetable matter, frozen materials, or stones larger than 2 inches in maximum dimension. Any material not meeting these specifications for backfill shall be removed from site.

(d) Backfilling shall not be performed in freezing weather. All trenches shall be left slightly mounded to allow for settlement after the backfilling is completed. If sinking of the trenches occurs, it is the responsibility of the contractor to correct such conditions.

(8) **Manual Drain Valves:** Manual drain valves shall be located, furnished, and installed by the contractor at all low points on sprinkler lines. A drain sump of not less than 6 cubic feet of 1/2 inch washed gravel shall be installed surrounding each drain valve. All manual drain valves are to be installed with drain valve sleeves.

(9) **Electric Control Valves:**

(a) Electric control valves shall be automatic and purchased from the manufacturer specified, or be an approved equivalent, matching size, model and quantity as listed on an approved landscape plan. All control valves shall be installed at the locations shown on the approved landscape plan.

(b) Electric control valves shall be installed in accordance with the manufacturer's recommendations. All valves shall have sufficient clearance from adjacent obstructions to provide accessibility for maintenance. All valves shall be

installed at sufficient depth to provide at least 6 inches cover to finished grade. Only one control valve per valve box shall be installed.

(c) Control wire shall have an 18-inch expansion loop at each valve and elsewhere as necessary to prevent possible wire breaks. Where more than one control wire is located in the trench, the wires shall be taped together at 20-foot intervals to maintain orderly and efficient installation. All control wires shall be placed carefully alongside and slightly below the main line for protection. Control wires not protected by the irrigation main shall be laid in a 2-inch PVC class 200 sleeve. Electrical control wires shall be extended along the irrigation main and connected to the controller.

(d) Electrical control wires shall be connected with snap-tite connectors. Splicing will be permitted only on runs exceeding 500 feet in length and shall be located at valve locations. Wires shall be bundled and taped at 20-foot intervals. A minimum wire loop of 24 inches shall be provided at each control valve, splice, and every 100 feet of wiring. Two spare #14-1 wires, blue in color, shall be installed along the entire length of the main line from the controller to farthest control valve on each and every branch of the main line.

(10) **Pressure Reducing Valves:** Pressure reducing valves (PRV) shall be installed to ensure proper operating pressures at sprinkler locations.

(11) **Valve Boxes:** All automatic control valves, pressure reducing valves, backflow prevention devices, isolation gate valves, manual drain valves, and quick-coupling valves are to be installed in valve boxes. The valve box and cover shall be flush with the final grade and level. The valve box shall be installed with a 4inch layer of 1 ½ inch washed gravel on the sides and below the box. If the box encloses a double check valve assembly, the gravel layer below the box shall be equal in volume to the volume of the box.

(12) **Quick-Coupling Valves:** Quick-coupling valves shall be installed in conformance with these Standards. Additional quick-coupling valves shall be located every 200 feet along the main line. All valves shall be installed in separate 10-inch circular valve boxes placed flush with the final grade and level.

(13) **Isolation Gate Valves:** Isolation gate valves on the main line shall be plumb with finished grade and installed in a valve box placed flush with the final grade and level. Extensions may be added onto the valve box as necessary to level box with finish grade.

(14) **Sprinklers:**

(a) Installation of sprinklers includes furnishing, installing, and testing, risers, fittings, sprinkler heads, bubblers, and other sprinkler system components in accordance with an approved Landscaping Plan. Sprinkler piping shall be thoroughly flushed before the installation of the sprinkler heads and bubblers.

(b) Sprinkler heads shall be set plumb and level with finished grade at locations shown on an approved Landscaping Plan. Sprinklers shall be set 12 inches

behind concrete improvements such as curb and gutter or sidewalks. Sprinklers installed where grass has not been sodded shall be installed on temporary risers extending minimum 3 inches above grade. After finished grades are established and the ground has settled, the contractor shall lower sprinklers to finished grade.

(c) Bubblers shall be set plumb and level before mulch is installed.

(d) Rotary pop-up sprinklers on swing joint risers shall be installed as shown in these Standards and may be adjusted in the field as necessary.

(15) **Drip Valve Assemblies:** Installation of drip valve assemblies shall in conformance with these Standards.

(16) **Drip Emitters and Tubing:** Installation of drip emitters and tubing shall be installed in conformance with these Standards at a depth of 4 inches below top of grade. For this purpose, top of grade does not include mulch or rock layers. Drip line blow-out stubs are to be installed at all ends of drip tubing. Drip tubing may be installed in turf areas as lateral piping.

(17) **Controllers and Related Work:** The controller shall be mounted on three wolmanized CCA 6-inch x 6-inch ties, set at least 24 inches below grade and a maximum of 18 inches above grade. The controller shall be located as shown on an approved landscape plan, and be mounted inside a locking, weather-proof metal cabinet. The contractor shall provide and install a 15-amp electrical circuit breaker in a locking, weatherproof box. The contractor shall wire the circuit breaker and controller and run wire to the Public Service Company pull box, leaving an 18-inch tail of wire in the pull box or sleeve. After connection, the contractor shall notify the City's Inspection Services to inspect controller and circuit breaker wiring prior to notifying Public Service Company to connect power to the wiring. The contractor shall be responsible for manual operation of the sprinkler system until power is connected. All wiring shall be performed by a licensed electrician.

(18) **Testing and Adjusting:**

(a) All main lines having continuous pressure shall be tested at a minimum pressure of 120 psi. Visual inspection shall be performed, and any leak shall be repaired. Repaired lines shall be retested until no leakage is occurring.

(i) Zone lateral lines shall be tested at the design operating pressure of the zone. Any leaks found shall be repaired and the zone retested. All sprinklers shall be operating at the same pressure plus or minus 7 percent.

(ii) The entire irrigation system shall be tested at normal working pressure for leaks in the system and retested until no leakage is occurring. The pressure test shall be performed under the observation of the Director for final approval.

(iii) After testing, the entire irrigation system shall be thoroughly flushed

with at least 100 percent of operating flow passing through each pipe, beginning with larger mains and continuing through smaller lines in sequence.

(b) The entire system shall be "fine-tuned" by regulating valves, adjusting patterns and breakup arms, setting pressure reducing valves at proper pressure and similar, to provide optimum and efficient coverage.

(c) Final inspection shall include observation and approval by the Director of the performance, method of operation, and coverage of the irrigation system.

(d) The contractor shall furnish two sets of keys for all quick-couplers, manual drain valves, gate valves, and controllers as well as padlocks and keys for controller circuit breaker boxes, two sprinklers and nozzles of each type, hose ells for all quick couplers, and all related loose parts necessary to operate the system, as part of the final acceptance by the Director.

(19) **Record Drawings (As-Builts):** Upon completion of improvements and prior to final acceptance, the contractor shall submit as-built drawings of the irrigation system to the Director. The as-built drawings shall comply with the requirements of Subsection 1.03(G), "As-Built Drawings," of these Standards, and shall include the location of following items:

(a) Connection to existing water lines.

(b) Routing of sprinkler pressure lines (maximum 100 feet along routing).

(c) Sprinkler control valves.

(d) Quick coupling valves.

(e) Drain valves.

(f) Drip line blow-out stubs.

(g) Control wire routing if not with pressure main line.

(h) All gate valves.

(i) Other related equipment as directed by the City Manager.

(20) **Operation Instruction:** Prior to final acceptance of improvements, the contractor shall submit three written sets of operating instructions, with cut sheets of all products, and a guideline summer watering program.

(21) **Controller Charts:**

(a) Controller charts shall be prepared for the Director once record (as-built) drawings have been accepted.

(b) A controller chart shall be provided for each automatic controller installed.

(c) The controller chart may be a reproduction of the record drawing if scale permits fitting of the chart to the controller door. If photo reduction prints are required, the reductions shall be sized to ensure full legibility.

(d) The controller chart shall represent the actual “as-built” system, showing the specific area covered by that controller.

(e) The controller chart shall identify the area of coverage of each remote-control valve, using a distinctly different pastel color on drawing over the entire area of coverage.

GLOSSARY

SECTION 1: ABBREVIATIONS

Wherever the following abbreviations are used in these Design and Construction Standards (Standards), or in association with these Standards, the intent and meaning shall be as follows:

AAN	American Association of Nursery-men
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ABC	Aggregate Base Course
AC	Asphaltic Cement
ACI	American Concrete Institute
ADT	Average Daily Trips
AGCA	Associated General Contractors of America
AI	Asphalt Institute
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute, Inc.
APWA	American Public Works Association
ARA	American Railway Association
AREA	American Railway Engineering Association
ARTBA	American Road and Transportation Builders Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATSSA	American Traffic Safety Services Association
AWG	American Wire Gauge
AWPA	American Wood Preservers Association
AWS	American Welding Society
AWWA	American Water Works Association
BFD	Boulder Fire Department
BMP	Best Management Practices
BRC	Boulder Revised Code, 1981
CCA	Colorado Contractors Association
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CLOMA	Conditional Letter of Map Amendment
CLOMR	Conditional Letter of Map Revision
CMP	Corrugated Metal Pipe

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CP	Colorado Procedure
CPUC	Colorado Public Utilities Commission
CRS	Colorado Revised Statutes, 1973, as amended
CRSI	Concrete Reinforcing Steel Institute
CUHP	Colorado Urban Hydrograph Procedure
DHV	Design Hour Volume
DIP	Ductile Iron Pipe
DRCOG	Denver Regional Council of Governments
DWG	Drawing
EDLA	Equivalent Daily Load Applications
EIA	Electronic Industries Association
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FL	Flowline
FPS	Feet Per Second
FSS	Federal Specifications and Standards
GIDM	Gallons Per Inch Diameter Per Mile
GPAD	Gallons Per Acre Per Day
GPCD	Gallons Per Capita Per Day
GPM	Gallons Per Minute
HCM	Highway Capacity Manual
HBP	Hot Bituminous Pavement
HGL	Hydraulic Grade Line
HSG	Hydrologic Soil Group
ICBO	International Conference of Building Officials
IFC	International Fire Code
IPC	International Plumbing Code
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IMSA	International Municipal Signal Association
IPCEA	Insulated Power Cable Engineers Association
ISO	Insurance Service Office
ITE	Institute of Transportation Engineers
LID	Low-Impact Development
LLD PE	Linear low-density polyethylene
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
LOS	Level of Service
MDCIA	Minimizing Directly-Connected Impervious Areas
MIL	Military Specifications
MPH	Miles Per Hour
MUP	Master Utility Plan
MUTCD	Manual on Uniform Traffic Control Devices
NACTO	National Association for Transportation Officials
NCAR	National Center for Atmospheric Research
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPK	Nitrogen-Phosphorus-Potassium
NSF	National Sanitation Foundation
OSHA	Occupational Safety and Health Administration
PC	Point of Curve
PCC	Portland Cement Concrete or

PLS	Point of Compound Curve Pure Live Seed
PMR	Physical Map Revision
POTW	Publicly Owned Treatment Works
PRC	Point of Reverse Curve
PRV	Pressure Reducing Valve
PT	Point of Tangent
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
ROW	Right of Way
RPA	Receiving Previous Area
RTD	Regional Transportation District
SAE	Society of Automotive Engineers
SCM	Stormwater Control Measure or Control Measure for Post-Construction Stormwater Quality
SDR	Standard Dimensional Ratio
SEO	State Engineer's Office
SHAC	State Highway Access Code
SWMP	Stormwater Management Plan
TC	Top of Curb
TIA	Telecommunications Institute of America
TMDL	Total Maximum Daily Load
TMP	Transportation Master Plan, City of Boulder
UBC	Uniform Building Code
UDFCD	Urban Drainage and Flood Control District
UIA	Unconnected Impervious Area
UL	Underwriters Laboratories, Inc.
UMC	Uniform Mechanical Code
USDCM	Urban Storm Drainage Criteria Manual
USGS	United States Geological Survey
VPC	Vertical Point of Curve
VPI	Vertical Point of Intersection
VPT	Vertical Point of Tangent
WQCV	Water Quality Capture Volume

SECTION 2: DEFINITIONS

Words and phrases contained in these Standards shall be read in context and construed according to the rules of grammar and common usage. Words and phrases that have acquired a technical or particular meaning, whether by definition, adoption herein, or otherwise, are intended to be construed accordingly.

Wherever the phrases **"as directed"**, **"as required"**, **"as permitted"**, or phrases of like meaning are used, it shall be understood that the direction, requirements or permission of the Director of Public Works (Director) is intended. Similarly, use of the words **"approved"**, **"acceptable"**, and **"satisfactory"** shall refer to approval of the Director.

The definitions in this Glossary apply throughout these Standards. The words or phrases presented have the following meaning unless the context clearly indicates otherwise:

"Alteration" means a request to use a substitute or alternative material, method, or process which will perform the same function as that provided in a particular standard.

"Approach" means the portion of an intersection leg which is used by traffic approaching the intersection.

"Approved plan" means the engineering design and construction drawings for public improvements, prepared by an engineer, which has been granted final approval by the Director of Public Works in accordance with these standards.

"Approved Tree List" means a list of trees published annually by the Director, in consultation with the Director of Parks and Recreation, that are suitable to the local environment and provides for a wide range of varieties and cultivars which fit into local landscapes.

"As-built" means an engineering drawing of record, prepared under the direction of a licensed Colorado registered professional engineer, reflecting the actual construction of public improvements in the service area, including, but not limited to, final grading, alignments, dimensioning, elevations, locations and materials sizing andtype.

"Average Daily Trips (ADT)" means the volume of traffic passing through a given point during a given time period, divided by the number of days in that time period.

"Backflow" means the reversal of the direction of flow of water or mixtures of water and other liquid, gases, or other substances into the distribution pipes of a potable water supply from any source or sources caused by backpressure and/or back-siphonage.

"Backflow prevention assembly" means any approved assembly, method, or type of construction designed to prevent backflow or back-siphonage into a public water supply by isolating the owner's water system from the public water system. In addition, see Section I. of these rules.

"Caliper" means a diameter measurement of a tree's trunk, and is measured around the trunk of the tree, six inches above tree base grade for one to four inch caliper trees and 12 inches above tree base grade for five to eight inch caliper trees. Trees measuring between four and five inch caliper shall be rounded off to the nearest inch.

“Capacity” means the maximum number of vehicles that have a reasonable expectation of passing over a given roadway or section of roadway in one direction during a given time period.

“Certified Backflow Prevention Device Tester” means any person who has passed a State of Colorado approved or sponsored certification examination, and who is listed as a certified backflow prevention device tester with the Colorado Department of Public Health and Environment.

"City" means the City of Boulder, a Colorado home rule city in Boulder County, Colorado.

"City water system" means the source and distribution facilities of the water system to the point of delivery to the owner water system. The source includes all components of the facilities utilized in the production, treatment, storage, and delivery of water to the distribution system. The distribution system includes the network of conduits used for the delivery of water from the source to the owner water system.

"Contractor" means a person, firm, partnership, subcontractor or corporation, licensed by the City that is responsible for the construction of approved public improvements associated with a specific project, or projects, within the City of Boulder service area. This term also includes the contractor’s superintendent and on-site manager.

"Colorado Cross Connection Control Manual" means a manual published by the Colorado Department of Public Health and the Environment addressing cross connection control practices, Fourth Edition - Revised.

"Cross connection" means any physical arrangement whereby the city’s water supply system is connected, directly or indirectly, with any other water supply system, sewer, drain, conduit, pool, storage reservoir, plumbing fixture, or other device which contains, or may contain, contaminated water, sewage, or other waste or liquid of unknown or unsafe quality which may be capable of imparting contamination to the public water supply as a result of backflow. Bypass arrangements, jumper connections, removable sections, swivel or changeover assemblies, and other temporary or permanent assemblies through which, or because of which, backflow could occur are considered to be cross connections.

“Delay” means the stopped time per approach vehicle, in seconds per vehicle.

“Design Hour Volume” means the hourly traffic volume used for street design and capacity analysis, usually one (1) or more peak hours during a 24 hour period.

“Design Speed” means five (5) to 10 miles per hour above the proposed or desired speed limit of the facility under design.

“Design Vehicle” means that all public and private streets must be designed to accommodate an SU-30 vehicle. The definition of this vehicle type is found in AASHTO’s Geometric Highway Design Standards.

"Developer" means the person, owner, firm, or corporation responsible for the development and completion of all public improvements associated with a proposed project in accordance with these standards.

“Diameter” means the diameter size measurement of a tree's trunk, and is measured around the trunk at 4.5 feet above the tree base grade for trees greater than eight (8) inch caliper.

“Director” or "Director of Public Works" means the city manager of the City of Boulder, Colorado or the manager’s authorized representative responsible for the enforcement of these standards and approval of the design and construction of public improvements within the City of Boulder service area, and the overall management and direction of the Public Works Department.

“Dripline” means the outermost edge of a tree's canopy, projected on the ground.

"Engineer" means the Colorado registered professional engineer responsible for the design of all public improvements submitted to the City for a proposed project in accordance with these standards, including all plans, calculations, specifications, and coordination of field surveys.

"Construction plan" means the engineering design and construction drawings for public improvements, prepared by an Engineer which has been submitted for final approval by the Director of Public Works in accordance with these standards.

“Hourly Volume” means the number of vehicles that pass over a given section of a lane or roadway during one hour.

"Inspector" means the Director of Public Works, or his/her designee, responsible for the inspection of public improvements construction.

“Level of Service (LOS)” refers to the definitions of LOS provided in the Highway Capacity Manual, “Definitions and Concepts.”

"May" means is authorized to, or a permissive condition which indicates a choice between two (2) or more alternatives.

“Modification” means a request to change or modify a standard or the parameters of a standard because the particular application may not require the degree of rigor which the standard requires.

“Peak Hour” means the concept referring to the hour of a day when the highest volume of traffic occurs on a transportation facility.

“Planting Strip” means the landscape area within a street median, the landscape planting strip between the curb and detached sidewalk, or the landscape area between the back edge of a public sidewalk (attached or detached) and the right-of-way/property line.

"Public improvements" means any public facility, system or infrastructure in the City of Boulder service area including, but not limited to: earthwork or landscaping, streets, sidewalks, bike paths, trails, parking and traffic control devices; water supply, treatment, storage and distribution systems; wastewater collection and treatment systems; and stormwater and flood control collection and conveyance systems in public easements or right-of-way.

“Public Sign” means any sign that is posted by a governmental entity within the right-of-way for the

purpose of directing traffic or parking.

"Record Set" means the engineering design and construction drawings for public improvements, sealed and signed by an engineer, approved by the Director of Public Works in accordance with these standards, and maintained on file in public records as the final approved construction document.

“Root Protection Zone” means the ground area surrounding the entire tree that extends from trunk to dripline, or a minimum of fifteen feet for column-shaped trees, whichever is greater.

"Shall" means a mandatory duty to conform to the specified standard. Where certain requirements in these standards are described with the "shall" stipulation, it is mandatory that these requirements be met or exceeded.

"Should" means an advisory condition. Where "should" is used, it is considered to be recommended or advisory, but not mandatory.

“Sidewalk, Attached” means a sidewalk and curb that are attached as one (1) continuous element.

“Sidewalk, Detached” means a sidewalk that is separated from the curb by a landscape planting strip.

“Sight Distance” means the length of roadway ahead visible to the driver. The minimum sight distance available must be long enough to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path.

“Speed Change Lane” means a separate lane for the purpose of enabling a vehicle entering or leaving a roadway to increase (acceleration lane) or decrease (deceleration lane) its speed to a rate at which it can more safely merge or diverge with through traffic. Includes tapered areas.

"Standards" means the "Design and Construction Standards" manual for the City of Boulder.

“Storage Lane” means additional length added to a deceleration lane, to store the maximum number of vehicles likely to accumulate during a critical period without interfering with the through lanes.

“Street Tree” means any tree in the public right-of-way.

“Streetscape” means landscaping design for any streetside area, generally including but not limited to

planting strips and medians.

“Transportation Demand Management” means any action or set of actions aimed at reducing the impact of traffic by influencing people’s travel behavior.

“Trips” means a vehicle moving from an origin point to a destination point. Trips are one-way.

“Waiver” means a request to delete or omit the application of a particular standard.

"Work" means any activity involved in the performance of constructing, installing, repairing or

maintaining public improvements.

REFERENCES

Where not specified in these Standards or the Boulder Revised Code (B.R.C.) 1981, to protect the public health, safety, and welfare, the Director of Public Works will specify the standards to be applied to the design and construction of public improvements and may refer to one or more of the following references:

GENERAL REFERENCES

Code of Federal Regulations (CFR)

Colorado Revised Statutes (CRS)

TRANSPORTATION REFERENCES

Guide for the Development of Bicycle Facilities, American Association of State Highway and Transportation Officials

Public Rights-of-Way Accessibility Guidelines, United States Access Board

Urban Bikeway Design Guide, National Association of City Transportation Officials

Urban Street Design Guide, National Association of City Transportation Officials

Bicycle Parking Guidelines, Association of Pedestrian and Bicycle Professionals

Institute of Transportation Engineers (ITE) *Guidelines for Major Urban Street Design*

ITE *Trip Generation Manual*

Manual on Uniform Traffic Control Devices (MUTCD)

STREETSCAPE AND TREE PROTECTION REFERENCES

American Standard for Nursery Stock, American Association of Nurserymen.

Guide for Plant Appraisal, International Society of Arboriculture.

Species Ratings and Appraisal Factors Guide, Rocky Mountain Chapter, I.S.A.

Standard Practices for Trees, Shrubs, and Other Woody Plant Maintenance (ANSI. A300), American National Standard Institute.

Streetscape Standards for the Boulder Valley Regional Center.

Himelick's Tree and Shrub Transplanting Manual, International Society of Arboriculture.

Valuation of Landscape Trees, Shrubs, and Other Plants, International Society of Arboriculture.

UTILITIES REFERENCES

Manual of Water Supply Practices, American Water Works Association (AWWA)

Insurance Services Office (ISO)

Denver, Colorado, Board of Water Commissioners, Engineering Standards

Colorado Cross Connection Control Manual

American Society of Civil Engineers (ASCE) *Manuals and Reports on Engineering Practice - Gravity Sanitary Sewer Design and Construction*

Colorado Department of Health *Design Criteria for Wastewater Treatment Works*

International Plumbing Code (IPC)

International Fire Code (IFC)

CDOT Standard Specifications for Road and Bridge Construction. 2017

Installation Guide for Ductile-Iron Pipe, Ductile Iron Pipe Research Association

Handbook of Steel Drainage and Highway Construction Projects, American Iron and Steel Institute

STORM WATER REFERENCES

Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual, Volumes 1, 2, and 3.*

US Army Corps of Engineers *Users and Programmers Manuals for HEC-1 (Flood Hydrograph Package), HEC-2 (Water Surface Profiles), and HEC-RAS.*

State of Colorado Department of Public Health and Environment §303(d) List of Water-Quality-Limited Segments Requiring TMDLs or for which a Total Maximum Daily Load (TMDL) (Note: with this list, adopted in 5 CCR 1002-93, the State of Colorado implements the requirements of §303(d) of the federal Clean Water Act.)