

OCTOBER 2024

BOZEMAN MT

City of Bozeman Design and Construction
Standards

AMENDMENT SUMMARY

Revision No.	Date	Section	Description
1	10/2024	-	Comprehensive update

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Appendix A - City of Bozeman Fire Line Standard

Fire Line Standard

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Attachment B – Contractor’s Material and Test Certificate for Underground Piping

Appendix B – Random Sampling Example

Random Sampling Example

Appendix C – Bozeman Lighting and Electrical Specification

Chapter 1 - General Requirements

Chapter 1 General Requirements

1.1. PURPOSE

This document has been prepared to assist design engineers, architects, developers, contractors, or other interested individuals with the preparation of plans and specifications for public infrastructure improvements so that they will meet the requirements of the City of Bozeman (COB). The requirements specified herein have been established through the subdivision regulations, municipal code, or City policies. The goal of standardizing design and construction within COB is to protect public health and safety and promote operational efficiency while minimizing life-cycle costs of public infrastructure.

It is the intent of the COB to revise this document on an as-needed basis as regulations and policies are modified. Written comments on the COB Design and Construction Standards are encouraged and may be submitted to the City Engineer.

If any portion of this document is found to conflict with the Bozeman Municipal Code (BMC), the provisions of the BMC shall supersede the standards contained herein.

1.2. ACRONYMS, ABBREVIATIONS AND TERMS

Acronyms, abbreviations, and terms used in this document are found in the Glossary.

1.3. APPLICABLE LAWS, REGULATIONS AND STUDIES

Engineers, developers and contractors are strongly encouraged to become knowledgeable about the latest editions of all applicable laws and regulations, City of Bozeman ordinances, design standards, and reports having jurisdiction over infrastructure design and construction within the City of Bozeman. These requirements include, but may not be limited to, those identified below.

1.3.1 State and Federal

- A. CFRs including, but not limited to, the Environmental Protection Agency Regulations
- B. Administrative Rules of Montana (ARM)
- C. Montana Code Annotated (MCA)
- D. Montana Department of Environmental Quality (MDEQ) Circulars 1, 2, 4, and 8
- E. International Fire Code with local amendments

1.3.2 City of Bozeman

All infrastructure projects shall comply with the most current version of the following documents which are listed in descending order of precedence:

- A. Bozeman Municipal Code (BMC)
- B. COB Design and Construction Standards (DCS)
- C. COB Modifications to Montana Public Works Standard Specifications (COB Modifications)
- D. Montana Public Works Standard Specifications (MPWSS)

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The COB Design and Construction Standards and COB Modifications to MPWSS are collectively referred to as COB Engineering Standards.

1.3.3 Facility Plans

The most recently adopted versions of the City Water and Wastewater Facilities Plans shall govern sewer and water trunk main design and sizing. The Storm Water Master Plan and Transportation Plan shall govern their respective service area issues.

- A. Water Facility Plan Update
- B. Wastewater Collection Facilities Plan Update
- C. Transportation Master Plan
- D. Storm Water Facilities Plan

1.4. APPROVALS AND PERMITS

1.4.1 COB Engineering Division

Public infrastructure improvements such as sanitary sewer and water mains, fire water service lines to buildings, storm sewer mains, street and transportation improvements, and streetlights must be approved by the COB Engineering Division prior to construction. Refer to Chapter 2 and the City of Bozeman website for additional details. ([COB Engineering Guide and Checklists – bozeman.net](#))

1.4.2 COB Planning Division

Projects such as subdivisions and site plans must go through the Development Review process with the COB Planning Division of Community Development. Refer to Chapter 2 and the City of Bozeman website for additional details. ([Planning Checklists, Guides, and Brochures – bozeman.net](#))

1.4.3 COB Encroachment Permit

A commercial or residential encroachment permit must be obtained from the City Engineering Division prior to placing any permanent structures within any public utility easements or public right-of-way or performing any construction, excavation, or other work within any public utility easements or public right-of-way. The permittee shall adhere to all terms of the permit including, but not limited to, providing notice to the City Engineering Division prior to commencement of work, obtaining insurance as required by the permit, and restoring right-of-way to its original condition.

1.4.4 COB Sidewalk/Driveway and Curb Cut Permit

A sidewalk/driveway and curb cut permit must be obtained from the City Engineering Division prior to constructing or replacing sidewalks or drive approaches in the public right-of-way. All construction work and materials shall adhere to the City of Bozeman Sidewalk and Driveway Specifications as outlined in the permit application and shall conform to all applicable City of Bozeman codes and regulations.

1.4.5 COB Street Cut Permit

A street cut permit must be obtained from the City Engineering Division prior to cutting any city street. The permittee shall adhere to all terms of the permit including, but not

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limited to, providing notice to the Street Superintendent prior to commencement of work, paying applicable fees, obtaining insurance/bonds as required by the permit, protecting traffic, and restoring the street surface. All construction work and materials shall adhere to the restoration requirements as outlined in the permit application and shall conform to all applicable City of Bozeman codes and regulations.

1.4.6 COB Floodplain Permit

A floodplain permit is required for all actives and/or development occurring within the Special Flood Hazard Area (SFHA) unless specifically exempted in BMC 38.600.240.

1.4.7 Montana Department of Transportation

Additional permits may be required for the Montana Department of Transportation (MDT) approaches and work occurring within right-of-way under the jurisdiction of MDT.

1.4.8 Montana Department of Environmental Quality

Approval from DEQ is required to construct, alter, or extend COB public water and sewer systems. DEQ has delegated certifying authority to COB for certifying adequacy of storm water drainage and municipal facilities in subdivisions as set forth in MCA 76-4-127.

MDEQ application include, but may not be limited to, the following:

- A. Subdivision Review Joint Application
- B. Municipal Facilities Exclusion Checklist (MFE)
- C. Construction Stormwater Permit (See Chapter 6 - Storm Drainage Design)

1.4.9 Construction Adjacent to Waterways

In addition to City of Bozeman and Montana DEQ Construction Stormwater permit applications, if construction activities will impact a waterway, one or more additional permits may be required. For the purpose of this manual, a waterway is defined as a ditch, drain, creek, stream, river or wetland. Conservation districts, along with participating resource agencies, developed a joint application form that includes the requirements of the following agencies and their required permits:

1. Conservation Districts (local government) - [310 permits](#)
2. MT Fish, Wildlife and Parks (state government) - SP 124 permits
3. Floodplain Administrators (Building Department) - floodplain permits
4. US Army Corps of Engineers (federal government) - Section 404/Section 10 permits
5. MT Department of Environmental Quality (state government) - 318 (turbidity) Authorizations
6. MT Department of Natural Resource and Conservation (state government) - Navigable river land use licenses and easements.

The joint application can be found on the Montana DNRC website (<http://dnrc.mt.gov/licenses-and-permits/stream-permitting>).

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1.5. EASEMENTS

1.5.1 Utility Easements

A. A "utility easement" granted to the public is required for all public utility mains not located within public street right-of-way. An easement shall be a minimum of twenty (20) feet wide for one utility main if the main is seven (7) feet from the edge of the easement and additional utility mains will not occupy the easement. An easement shall be a minimum of thirty (30) feet wide for two utility mains. An additional ten (10) feet is required for each additional main that occupies the easement.

Wider easements may be required at the discretion of the City of Bozeman for large or deep utility lines or where permanent structures are located adjacent to the easement. Easements not established by plat will be executed on standard forms available from the City Engineering Division.

B. It is preferred that utility mains are no less than nine (9) feet from the edge of the easement. At no time will the utility main be less than seven (7) feet from the edge of the easement.

C. Utility easements will also be required for all meter pits and fire hydrants maintained by the City of Bozeman. Easements for meter pits and fire hydrants shall be a minimum of twenty (20) feet wide.

D. No permanent structures shall be placed within a utility easement unless an encroachment permit has been obtained. Trees and other significant landscaping features shall not be placed within ten (10) feet of any utility main. Significant landscaping features include, but are not limited to, items such as retaining walls, large boulders, raised garden beds, and other similar items that would be disrupted by maintenance or replacement of the utility.

E. All easement documents must conform to City of Bozeman requirements and must meet the formatting requirements of the Gallatin County Clerk and Recorder's office.

1.6. ENGINEER'S RESPONSIBILITY

1.6.1 Design

Engineering documents (plans, specifications, and design reports) shall be stamped and signed by a registered Professional Engineer (Engineer, Design Engineer) licensed to practice in the State of Montana with responsible charge of the project. Documents to be stamped and signed shall be in accordance with these standards and in laws of the State of Montana governing such practice.

1.6.2 Construction

A. Duties of Engineer

The following duties shall be the responsibility of a registered Professional Engineer licensed to practice in the State of Montana with responsible charge of the project:

- I. Issue written clarifications or interpretations of the requirements of the Contract Documents (i.e. plans and specifications).

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- II. Disapprove or reject work which Engineer believes to be defective and require special inspection or testing of the work whether or not the work is fabricated, installed, or completed.
- III. Review Shop Drawings and samples for compliance with the Contract Documents.
- IV. Review proposed changes in work and submit such changes to the City of Bozeman or other public agencies having jurisdiction for review.
- V. Issue Certificate of Substantial Completion and Certificate of Completion and Acceptance.
- VI. Provide all testing and inspection items specified in Section 1.10.

B. Duties of RPR

The Engineer will furnish a qualified Resident Project Representative (RPR) and other field staff to assist the Engineer in observing the performance of the work. The RPR will act as directed by, and under the supervision of the Engineer, and will confer with the Engineer regarding the RPR's actions. The RPR shall not authorize any deviation from the approved plans and specifications or substitution of materials or equipment, unless authorized by the Engineer.

The RPR and/or other field staff of the Engineer will:

- I. Conduct extensive on-site observations of the work in progress and field checks of materials and equipment to provide protection against defects and deficiencies in the work of the Contractor.
- II. Perform construction observation, documentation, and required testing of all critical construction work including, but not limited to: all underground or buried work including placement and connection of utility lines and appurtenances, trench backfill and compaction, placement of geotextile fabric membranes, placement of fill or embankments; placement of curb and gutter and other surface drainage improvements; placement of pavement base and surface courses; and placement of sidewalks.
- III. Advise the Engineer and Contractor of the commencement of any work requiring Shop Drawings or sample if the submittal has not been approved by the Engineer.
- IV. Report to the Engineer whenever RPR believes that any work is unsatisfactory, faulty, defective, does not conform to the approved plans and specifications, has been damaged, or does not meet the requirements of any inspection, test or approval required to be made.
- V. Advise the Engineer of work that the RPR believes should be corrected, rejected, should be uncovered for observation, or requires special testing, inspection, or approval.
- VI. Verify that all tests are conducted in the presence of appropriate personnel, and observe, record and report to the Engineer appropriate details relative to testing procedures.

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- VII. Accompany visiting inspectors representing the City of Bozeman or other public agencies having jurisdiction over the project.
- VIII. Maintain at the job site orderly files for correspondence, reports of job conferences, Shop Drawings and samples, reproductions of original Contract Documents including all Work Directive Changes, Addenda, Change Orders, Field Orders, additional Drawings issued subsequent to the execution of the contract or beginning of work, Engineer's clarifications and interpretations of the Contract Documents, and other Project related documents.
- IX. Keep a detailed and accurate diary or log book, recording Contractor hours on the job site, weather conditions, prime and subcontractor daily work force, daily log of equipment onsite or standby, data relative to questions of Work Directive Changes, Change Orders, or changed conditions, list of job site visitors, daily activities, decisions, observations in general, and specific observations in more detail as in the case of observing test procedures.
- X. Furnish Engineer with periodic reports of progress of the work.
- XI. Furnish Engineer and Contractor a list of observed items requiring completion or correction before Engineer may issue a Certificate of Substantial Completion, assess completion or correction of said items, advising Engineer on their status, and make recommendation to Engineer regarding issuance of a Certificate of Substantial Completion.
- XII. Conduct final inspection of the project in the company of Engineer, Owner, Contractor, and City of Bozeman, and prepare final list of items to be completed or corrected.
- XIII. Verify that all items on final list have been completed or corrected and make recommendations to Engineer concerning final acceptance.

1.7. CONTRACTOR'S RESPONSIBILITY

Contractor's responsibilities shall be in accordance with MPWSS, COB Modifications to MPWSS, and as specified herein.

1.7.1 Submittals

All required shop/fabrication drawings shall be submitted by the Contractor to the Engineer. The Engineer will submit the submittals to the City through the City's electronic plan review system.

1.7.2 Warranty

The Contractor shall guarantee all work for a period of two years from the date of acceptance by the City of Bozeman on the Certificate of Completion and Acceptance. The Warranty shall remain in full force for the two-year period following this date, however if the expiration date of the Warranty falls between November 16 and May 15, the expiration date of the Warranty shall be the following June 30.

Refer to the City of Bozeman Fire Service Line Standard for fire service warranty requirements.

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1.7.3 Bonding

Prior to acceptance of the publicly maintained infrastructure, the Contractor shall post a Maintenance Bond with the Owner equal to 20% of the actual cost of the improvements to correct any deficiencies in workmanship and/or materials which are found within the warranty period. The City of Bozeman shall be named as a dual obligee on the bond. The City of Bozeman expressly reserves the right to draft the Maintenance Bond for repairs not completed by the Property Owner, Developer, or Contractor within 30 calendar days of being advised that repairs are required.

The Commencement Date for the Maintenance Bond shall be the date of acceptance by the City of Bozeman on the Certificate of Completion and Acceptance. The Maintenance Bond shall remain in full force for the two-year period following this date, however if the expiration date of the Maintenance Bond falls between November 16 and May 15, the expiration date of the Maintenance Bond shall be the following June 30. Maintenance Bonds may be in the form of a Surety Bond or a Certified Check.

Refer to the City of Bozeman Fire Service Line Standard for fire service bonding requirements.

1.8. **DEVELOPER'S RESPONSIBILITY**

The Developer shall be responsible for locating underground infrastructure until record drawings have been submitted and the public infrastructure is accepted by the City. Developer is responsible to ensure Engineer, Resident Project Representative, and Contractor meet all duties and responsibilities for each category for all developer led projects. Unmet duties or responsibilities will result in denial of project acceptance by the City until all duties and responsibilities of project have been met.

1.9. **DEVIATIONS FROM STANDARDS – ADMINISTRATIVE WAIVER**

All deviations from standards set forth in The Design and Construction Standards and COB Modifications to MPWSS must be approved by the COB Engineering Division. The request for a deviation must be submitted in writing to the City Review Engineer using the Engineering Standards Administrative Waiver Request form posted on the City website. An Administrative Waiver Request be submitted through the City's electronic plan review system with the Preliminary Infrastructure Review submittal (Stage 2, Planning Division) or Final Infrastructure Review (Stage 3, Engineering Division). If a waiver request is approved during Stage 2, the Applicant shall include the approval with the Stage 3 submittal.

1.9.1 Administrative Waiver Review Process

- A. Applicant submits Engineering Standards Administrative Waiver Request form through the City's electronic plan review system.
- B. City Review Engineer will determine if the request should be considered for approval and will consult with the City Engineer if needed.
- C. If the request is denied, the Applicant will be notified in writing through the City's electronic plan review system that it is denied by the City Review Engineer.
- D. If the request will be considered, affected City staff and/or qualified experts regarding potential operational, financial, and legal impacts may be consulted.
- E. If the request is approved, the Applicant will be notified in writing through the City's electronic plan review system that it is approved by the City Review Engineer.

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1.9.2 Administrative Waiver Review Criteria

Adequate justification for the waiver request must be provided. Cost of meeting the Standards generally is not a valid justification for an Administrative Waiver request. The following criteria will be used to evaluate a waiver request:

- A. The deviation from standards is not in conflict with applicable state and federal codes and requirements.
- B. The deviation from standards will not harm, or will be beneficial to, the public in general.
- C. The deviation from standards is consistent with the general purpose of standards to protect public health and safety and promote operational efficiency while minimizing life-cycle costs of public infrastructure.

Administrative Waiver approval applies only to the project seeking the waiver and does not apply to future phases of the project or other projects. Administrative Waiver approval does not constitute a change in the City of Bozeman Design and Construction Standards and is not considered a precedence or policy for future projects.

COB does not have the authority to grant a waiver from the requirements of applicable DEQ standards or waivers from requirements of other jurisdictions.

1.10. CONSTRUCTION INSPECTION, TESTING, AND QUALITY CONTROL

A Professional Engineer, or the Professional Engineer's designated representative, shall provide all required construction inspection and testing. Inspection and testing shall be in accordance with the current adopted edition of the MPWSS and these Standards. Full-time, on-site observation shall be conducted during active installation of underground City utilities (e.g. sewer and water mains and services, storm drainage mains and laterals, etc.).

The Engineer or its representative shall make on-site observations of Contractor's work while it is in progress at intervals appropriate to the various stages of construction as necessary to assess the progress of Contractor's executed work. Such visits and observations include spot checking, selective sampling, and similar methods of general observation of the work to determine if the work is proceeding in accordance with the approved construction contract documents. The Engineer or its representative shall be present for all field testing.

The City reserves the right to halt construction on a project if inspection and testing are not occurring in accordance with these requirements.

Construction documentation and certification shall be submitted to the City in accordance with Section 3.5. Inspection and testing items to be documented during construction are summarized as follows:

- A. Water Systems
 - I. Hydrostatic and leakage testing in accordance with Section 02660 of MPWSS and COB Mods.
 - II. Flushing of main in accordance with Section 02660 of MPWSS and COB Mods. City staff will operate valves and test chlorine concentration.
 - III. Bacteriological testing accordance with Section 02660 of MPWSS and COB Mods.

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- IV. Continuity testing for ductile iron water mains when required by Engineer or City.
 - V. Record elevations of water main at 50' intervals.
 - VI. Record horizontal locations (station and offset) and elevations of all valves, fittings, pipe deflections, and fire hydrants.
 - VII. Record horizontal locations (station and offset) and elevations of water services at connection to main and curb box.
 - VIII. Verification of required thrust block locations and dimensions. Verification of mechanical joint restraints to assure proper restraint lengths.
 - IX. Record elevations for water systems shall be at 0.1' accuracy.
- B. Gravity Sanitary Sewer Systems
- I. Visual light testing in accordance with Section 02730 of MPWSS.
 - II. Leakage testing (water or air) in accordance with Section 02730 of MPWSS and COB Mods.
 - III. Cleaning/flushing of main.
 - IV. TV Inspection by City of Bozeman.
 - V. Record elevations for all sanitary sewer manhole inverts and slope of all sewer mains.
 - VI. Record length and slope of all sanitary sewer service connections. Elevations at the end of dry service line stubs. Sanitary sewer service connection locations shall be relative to manholes (station and offset).
 - VII. Record elevations for sanitary sewer manholes shall be at 0.01' accuracy.
- C. Sanitary Sewer Force Mains
- I. Hydrostatic and leakage testing in accordance with Section 02730 of MPWSS.
 - II. Record horizontal locations and elevations of sanitary sewer force main at 50' intervals.
 - III. Record horizontal locations and elevations of all valves, fittings, and pipe deflections.
 - IV. Record elevations for force mains shall be at 0.1' accuracy.
- D. Storm Drainage Systems
- I. Record elevations for all storm drain manhole inverts and slope of all storm drain mains.
 - II. TV Inspection by City of Bozeman
 - III. Visual inspection of line, grade, and roundness of culverts
 - IV. Record elevations for storm drain manholes shall be at 0.01' accuracy.

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E. Fill and Backfill

All trench backfill material in improved areas and all embankments shall be compacted for the full depth and shall be compacted to 95% of the theoretical maximum proctor density as determined by AASHTO-T-99.

- I. Documentation for theoretical maximum density and optimum moisture content as determined by AASHTO-T-99 for all native backfill, subgrade, pit run, sub-base course, and crushed base course materials within the right-of-way and utility easements. Tests shall be no older than one year.
- II. Documentation of sieve analysis for all native backfill, subgrade, pit run, sub-base course, and crushed base course materials within the right-of-way and utility easements. Tests shall be no older than one year.

City Engineering Division may require testing of materials delivered to project site to verify consistency with approved sieve analysis documentation.

- III. In-place density tests for utility main and utility service lateral trenches in accordance with Section 02221 of COB Modifications.

In-place density tests for subgrade and embankment within the right-of-way and utility easements in accordance with Section 02230 of COB Modifications.

In-place density tests for sub-base course within the right-of-way and utility easements in accordance with Section 02234 of COB Modifications.

In-place density tests for crushed base course within the right-of-way and utility easements in accordance with Section 02235 of COB Modifications.

F. Lighting

- I. Record locations of poles, conduit, splice boxes, meters, and lighting control centers.
- II. Record electrical one-line diagrams/wiring schematics.

G. Bituminous Pavement

- I. Documentation for dated job-mix formula for hot plant mix bituminous pavement which conforms to the procedures of the Asphalt Institute's MS-2 manual. The job mix formula shall be no older than one year and shall have the same aggregate and asphalt sources and grades as the mix used for the public improvements. In addition, test results of ASTM D 1075 for the effect of water on cohesion of compacted bituminous material shall be provided by the Engineer.
- II. Certified results of a Marshall Test showing the bulk specific gravity determination, stability and flow data, and density and void analysis.
- III. Minimum of one "field Marshall Test" per 2,000 tons of mixture placed to check for variations from the job-mix formula.
- IV. Four core samples shall be required for every 1,000 tons of mixture placed, with a minimum of three samples for projects that use less than 1,000 tons.

Chapter 1 - General Requirements

The location of the core samples shall be determined on a random basis using a system of random numbers, so that each ton of material has the same probability of being selected. For random locations falling near the pavement joints, obtain the core as close to the location as possible without having any part of the core circumference coming closer than 12 inches to the pavement edge or joint.

The Engineer may take additional core samples at locations, where based on observations of the paving process and/or the results of nuclear density tests, there is reasonable belief that the in-place material is unsatisfactory.

The Engineer shall submit the sampling plan to the City Engineering Division upon completion of the paving, prior to taking cores. (An example for one method of determining random sample locations is included in the appendix of these Design and Construction Standards).

The Engineer shall provide a certified laboratory report from the samples taken as to thickness and actual density. Testing laboratories shall meet the requirements of ASTM D3666 (Evaluating and Qualifying Agencies Testing and Inspecting Bituminous Paving Materials). The Engineer shall certify that the core holes have been patched with hot plant mix asphalt.

- V. The City Engineering Division may require pavement cores to be taken after construction but prior to City acceptance of the improvements in any areas of concern, to determine in-place density of asphalt, thickness of aggregates and asphalt layers, etc.

H. Concrete

- I. One set of concrete tests shall be required for every 50 cubic yards of concrete placed within the public right-of-way and concrete incorporated into public infrastructure improvements. Concrete to be tested includes, but is not limited to, surface concrete placed for streets, approaches, sidewalks, curb, and gutter, and structural concrete for retaining walls, pedestals, poles, luminaires, and signals. For projects using less than 50 cubic yards of concrete, a minimum of one set of concrete tests is required.

Sampling and testing shall be done by persons that are currently certified as ACI Concrete Field Testing Technicians, Grade 1. The concrete shall be sampled, specimens made, and compliance determined in accordance with the following:

Sampling Fresh Concrete	ASTM C-172
Slump	ASTM C-143 or AASHTO T119
Air Content	ASTM C-231 or C-173 or C-138 or AASHTO T152
Compressive Strength	ASTM C-39 or AASHTO T22
Making and Curing Test Specimens in the Field	ASTM C-31 or AASHTO T23

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1.11. CONSTRUCTION DEFICIENCIES

1.11.1 Acceptance/Correction of Deficient Pavement Improvements

Acceptance tests shall be evaluated by the Engineer for conformance with the specifications. Any results that indicate the in-place material does not conform with the specifications shall be immediately reported to the City Engineering Division, along with a recommendation of corrective action to bring the material into compliance with the specifications. The City Engineering Division shall determine what corrective action is necessary in order for the improvements to be accepted by the City of Bozeman. Corrective action may include total removal and replacement of the deficient material, partial removal and replacement, placing additional material, or in lieu of corrective action, payment of a penalty to the City of Bozeman in certain instances.

A. Portland Cement Concrete

If an individual strength test (average of two cylinders tested at 28 days) falls below the specified strength, the in-place material represented by the failed test shall immediately be randomly cored for acceptance testing. A minimum of three and maximum of six cores shall be taken. If the average strength tests of the acceptance cores are deficient in strength by less than 500 psi, the Contractor shall remove and replace the deficient concrete or pay the City of Bozeman 0.50 times the unit price bid times the area determined to be deficient in strength. If the average strength tests are deficient by more than 500 psi, the area of the concrete determined to be deficient shall be removed and replaced.

B. Asphaltic Concrete Pavement

The asphaltic concrete pavement shall be tested and evaluated for acceptance on a lot basis, with one lot being 1,000 tons of material.

- I. Thickness. If the average thickness of the pavement cores is more than $\frac{1}{4}$ " below the plan thickness, or if any one individual core is more than $\frac{1}{2}$ " below the plan thickness, corrective action or payment of a penalty will be required.
 - a. Average Thickness Deficiencies. If the average thickness deficiency is between $\frac{1}{4}$ " and $\frac{1}{2}$ ", corrective action such as placement of additional material (i.e. overlay or chip seal), as determined by the City Engineering Division, will be required. In lieu of placing additional material, the City Engineering Division may allow the payment of a penalty to the City of Bozeman in the amount of 0.25 times the unit price bid of the asphalt pavement times the amount of pavement determined to be deficient. If the average thickness deficiency is more than $\frac{1}{2}$ ", an overlay will be required, along with cold milling of the existing pavement to provide for a minimum overlay thickness of 1.5".

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b. Individual Core Thickness Deficiency. If any one core thickness is determined to be more than $\frac{1}{2}$ " below plan thickness, additional cores shall be taken at 10 foot intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is found which is not deficient by more than $\frac{1}{4}$ ", in order to determine the extent of the deficient pavement. If the thickness deficiency is more than $\frac{3}{4}$ ", the area that is deficient shall be removed from pavement edge to pavement edge and replaced to bring the non-complying areas to planned thickness. If the thickness deficiency is not more than $\frac{3}{4}$ ", the deficient area will either be removed and replaced to the planned thickness, or a penalty will be paid to the City of Bozeman in the amount of 1.5 times the unit price bid times the amount of pavement that is deficient in thickness.

II. Density. The average density of the pavement cores shall equal or exceed 93% of the maximum density as determined by ASTM D2041 (Rice's density). If the average density is less than 93% but more than 90.9%, the pavement that has deficient compaction shall be milled and overlaid (1.5" minimum depth), or a penalty in the amount of 0.10 times the unit price bid for the pavement material times the amount of pavement that has deficient compaction shall be paid to the City of Bozeman. If the average density is 90.9% or less, the pavement area affected will be removed and replaced or overlaid as determined by the City Engineering Division. If any one core is determined to have a density of less than 86%, additional cores shall be taken at 10-foot intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is found which has a density of at least 91%. The area that is determined to have deficient compaction shall be removed from pavement edge to pavement edge and replaced, or a penalty will be paid to the City of Bozeman in the amount of 1.5 times the unit price bid times the amount of pavement that is deficient in density.

C. Unit Prices

If unit prices for the project are unavailable, unit prices shall be as determined by the City Engineering Division for the various items of work.

Chapter 2 - Review Process

Chapter 2 Review Process

2.1. GENERAL

2.1.1 Submittal Format

Submittal of plans, specifications, design reports, and all subsequent correspondence and submittals for public infrastructure improvements including, but not limited to, sanitary sewer and water mains, fire service lines, storm sewer mains, street, transportation improvements, and street lighting must be made through the City's electronic plan review system (i.e. application portal).

All Engineering documents (plans, specifications, and design reports) shall be stamped and signed by a registered Professional Engineer licensed to practice in the State of Montana with responsible charge of the project.

The Engineering Division electronic plan review system and Engineering Guides and Checklists can be accessed via the Development Center in the [City's Engineering Division webpage](#).

File naming protocol shall follow the conventions set forth by the City's Submittal Guidelines which can be accessed via the [City's Engineering Infrastructure and Permits webpage](#).

2.1.2 Hardcopies

Hardcopies of public infrastructure submittals will not be required except for those specified below.

2.2. REVIEW STAGES

The public infrastructure review process is generally summarized below. Specific requirements may be subject to change periodically. Refer to the City's Engineering Division webpage for current checklists, Applicant tasks, and additional requirements for each review stage.

2.2.1 Stage 1 – Concept Infrastructure Review (Planning Division)

The Concept Infrastructure Review will occur during the planning pre-application review such as a Subdivision Pre-Application, Concept Review, or Informal Review. Stage 1 is submitted through the [Planning Division application portal](#).

Planning/BMC related application waivers shall be submitted at Stage 1.

2.2.2 Stage 2 – Preliminary Infrastructure Review (Planning Division)

The Preliminary Infrastructure Review will occur during the planning application review such as a Subdivision Preliminary Plat, Site Plan, or Master Site Plan. Stage 2 is submitted through the [Planning Division application portal](#).

Water, sewer, storm drainage, traffic, lighting, and other required design reports shall be submitted at Stage 2.

Landscaping and Irrigation Plans shall be submitted at Stage 2. Refer to the City of Bozeman Landscape and Irrigation Performance and Design Standards Manual for Landscape and Irrigation Design Plan submittal requirements.

Chapter 2 - Review Process

Engineering Standards Administrative Waiver Requests shall be submitted at Stage 2 or Stage 3.

2.2.3 Stage 3 – Final Infrastructure Review

The Final Infrastructure Review will take place after the Planning application (Stage 2) has been deemed adequate by the City Review Engineer. Stage 3 is submitted through the [Engineering Division application portal](#).

Engineering Standards Administrative Waiver Requests shall be submitted at Stage 2 or Stage 3. Provide any waivers approved in Stage 2 with this submittal.

The Final Infrastructure Review process will occur as follows:

A. Pre-Screen

The City will pre-screen the Applicant's infrastructure submittal package to ensure the Applicant has provided a complete package and has uploaded the files correctly. The pre-screen review includes proper naming, filing, and sizing conventions. Once deemed adequate in pre-screen, a City Review Engineer will be assigned to the project and the review process will begin.

B. Initial Review

The COB will attempt to complete the initial review and provide written comments to the Applicant within thirty (30) calendar days of receiving a submittal that is deemed complete. A review meeting may be scheduled with the Design Engineer and City representatives to discuss review comments if the Design Engineer desires. Pre-design and interim meetings with the Design Engineer and City Engineering staff are encouraged. Review comments will be provided to the Applicant through the application portal.

C. Comment Response

To expedite the review process, each submittal of revised plans and specifications should be accompanied by a written response from the Design Engineer which addresses each comment.

D. Revision Review

The COB will attempt to complete each review of revised plans and specifications within fourteen (14) calendar days of receiving the revisions. Review comments will be provided to the Applicant through the application portal.

E. Comment Resolution

All COB review comments must be adequately addressed and resolved before the final plans and specifications are approved by the City Engineering Division for construction.

F. Final Plans and Specifications

Upon final City approval, all plan sheets will be stamped with a City of Bozeman Approval Stamp in the perimeter border area. Approved plan sheets along with an official City of Bozeman approval letter will be placed in the application portal.

Chapter 2 - Review Process

G. Approval

Final Plans and Specifications approval is valid for one year. The Applicant may request an extension if construction is not complete within one year of approval. The extension request shall be submitted to the City Review Engineer for the project. If the extension is denied, the Applicant shall resubmit the project for review and approval. The resubmittal will be subject to the latest standards that have been adopted at the time of resubmittal.

2.2.4 Stage 4 – Engineering Permit Submittal

The Engineering Permit Submittal can take place at the same time as Stage 3. Typically, this occurs once a contractor has been selected. If permits are not required for the project, the Applicant may proceed directly to Stage 5.

The following permits may be necessary for the proposed development and, if applicable, shall be submitted with associated forms and exhibits as indicated in individual permit guidance documents:

- A. Public ROW Utility Occupancy Permit
- B. Residential Encroachment Permit
- C. Contractor Encroachment Permit
- D. Sidewalk/Driveway and Curb Cut Permit
- E. Street Cut Permit

2.2.5 Stage 5 – Pre-Construction Submittal Review and Meeting

The Pre-Construction (Pre-Con) Submittal Review and Meeting will take place after an infrastructure approval letter has been issued for Stage 3 and Stage 4 permits (if applicable) have been approved and issued.

For projects subject to Department of Environmental Quality (DEQ) review and approval, a copy of the project approval letter from DEQ and approved plans and specifications must be submitted to the City Engineering Division prior to the preconstruction meeting.

The Applicant shall submit their Pre-Con submittal package through the **Engineering Division application portal**. Once the Pre-Con submittals have met all City requirements the City Review Engineer will reach out to the Applicant to schedule the Pre-Con meeting.

A Preconstruction Meeting Criteria Checklist shall be submitted which lists items that must be received by the City of Bozeman prior to scheduling a preconstruction meeting. The Engineer responsible for construction oversight and project certification must conduct the Pre-Con meeting and discuss all required items.

The Preconstruction Meeting Criteria checklist and required items for the Pre-Con agenda can be found on the [Engineering Division application portal](#).

Chapter 2 - Review Process

2.2.6 Stage 6 – Construction Changes/Revisions (if applicable)

Construction Changes or Revisions are only applicable to review and document significant field changes. Stage 6 is submitted through the **Engineering Division application portal**.

The EOR (Engineer of Record) shall contact the City Review Engineer when a significant change is discovered to determine if the change requires Stage 6 review. If Stage 6 review is required City staff will create a new ProjectDox workflow for the EOR to upload applicable drawings and documents. City approval of the construction revision shall be obtained before the changes are implemented on-site.

Any changes implemented onsite before change or revision approval is received are at the risk of being rejected and not formally accepted by the City.

2.2.7 Stage 7 – Pre-Pavement Walk-through (if applicable)

The Pre-Pavement (Pre-Pave) Walk-through is only applicable for paving that will be publicly maintained. The walk through will occur after curb and gutter have been installed and soil compaction test results have been submitted to the City. **Stage 7 is coordinated directly with the city assigned Review Engineer.**

The Engineer shall conduct the pre-paving inspection. The Contractor and a representative from the City shall attend the inspection.

2.2.8 Stage 8 – Final Inspection

The Final Inspection takes place after all public infrastructure has been completely installed in accordance with approved plans and specifications. **Stage 8 is coordinated directly with the City assigned Review Engineer.**

The Engineer should reach out directly to the City Review Engineer and request a final walk-through one (1) week before the desired walk-through date. The Applicant should ensure all work on public infrastructure is complete and all public infrastructure is completely visible with no storage of materials or snow affecting the ability to inspect the infrastructure.

Once the Applicant has resolved all punch list items and the City Review Engineer has approved the final inspection, the Applicant can submit their final acceptance and closeout package through the Engineering Division Application portal.

2.2.9 Stage 9 – Final Acceptance

Final Acceptance takes place after a complete closeout procedure. Stage 9 is submitted in the **Engineering Division application portal**.

Project close-out and acceptance must occur within 90 days of project completion.

Submit stamped and signed final record drawings to the City Review Engineer, including one set on mylar and one full-size set on paper. An electronic version of the record drawings shall also be submitted to the Engineering Division application portal. Record drawings must be certified by a Professional Engineer licensed in the State of Montana.

Once the City Review Engineer deems the closeout package approved, the Certificate of Completion and Acceptance will be signed by the City and uploaded to the Engineering Division application portal.

Chapter 2 - Review Process

Failure to provide all of the necessary close-out documentation within the 90-day period may result in delaying approval for future projects submitted by the Engineer until such time as the necessary documents are provided.

2.2.10 Stage 10 – Two-Year Warranty Inspection

A two-year warranty inspection walk-through will take place not less than 75 days, or more than 120 days prior to the expiration of the maintenance bond. See Section 1.7.2 for additional information regarding the two-year warranty and maintenance bond.

The two-year warranty inspection protects the City of Bozeman against deficient materials or workmanship on public infrastructure projects. The inspection is attended by the Engineer, civil contractor representative, City Engineering staff, and applicable division superintendents.

During the inspection, any inadequate items will be identified at the discretion of City staff. The Engineer is responsible for creating a “punch list” of all deficient items and restoring the work to meet the requirements of the approved construction documents prior to release of the maintenance bond.

The City of Bozeman reserves the right to draft the maintenance bond for any repairs not completed within 30 days of the warranty inspection.

The two-year warranty inspection and subsequent repairs are the final stage of the development review process.

Chapter 3 - Submittal Requirements

Chapter 3 Submittal Requirements

3.1. GENERAL

3.2. DESIGN REPORTS

Design reports shall be prepared by a Professional Engineer licensed in the State of Montana demonstrating compliance with these requirements shall be submitted to and approved by the City of Bozeman.

The following reports shall be submitted and approved during Stage 2 – Preliminary Infrastructure Review such as Subdivision Preliminary Plat, Site Plan, or Master Site Plan.

3.2.1 Water Design Report

The water distribution system design report should include the applicable information required by Section 1.1 of Circular DEQ-1 in addition to the following items:

- A. A design report prepared by a Professional Engineer licensed in the State of Montana which addresses fire and domestic flow requirements shall be submitted to and approved by the City.
- B. The report shall include flow test results or modeled flow results, as approved by the City, which show the static pressure and available flow from the hydrant at 20-psi residual pressure.
 - I. If a hydrant flow test is required, the City must perform the hydrant flow test (Fire Flow/Model Flow Request Link)
 - II. If modeled flow data can be utilized, the City can provide the modeled data. if available through the City (Fire Flow/Model Flow Request Link)
- C. An overall plan of the development, including all areas outside of the study area which would naturally be served through the study area shall be provided.
- D. The Design Engineer shall calculate and provide the average day demand, the max day demand, and the required fire flow.
 - I. Refer to the current Water Facility Plan for design data, including:
 - a. Average Day Demand
 - b. Peaking Factor
 - c. Max Day Demand
 - d. Peak Hour Demand
- E. Provide demand calculations in units of gpd or EDUs.
- F. Provide velocity calculations in units of feet per second.

3.2.2 Sewer Design Report

The sewer design report should include the applicable information required by Section 11.1 of Circular DEQ-2 in addition to the following items:

Chapter 3 - Submittal Requirements

- A. A design report prepared by a Professional Engineer in the State of Montana which addresses sewer flows at full build-out of the development shall be submitted to and approved by the City. An overall plan of the development, including all areas outside of the study area which would naturally be served through the study area shall be included.
- B. Average daily flows, peak hour flow criteria, wastewater flow rates by zoning areas, peaking factors, and other applicable design criteria shall be used as defined in the current Sanitary Sewer Facility Plan.
- C. List all improvements or proposed additions to the sanitary sewer system.
- D. For existing or proposed lift stations, provide the following:
 - I. A description of the existing and/or proposed wet well, pumping system, and force main.
 - II. The capacity of the existing and/or proposed pumps and potential for upgrading.
 - III. A map showing the existing and/or proposed lift station service area.
 - IV. A list of the existing users and their average design flows.
 - V. The existing and/or proposed peak design flow and reserve capacity.
 - VI. The pump run and cycle times for the existing and/or proposed average and peak design flows.
 - VII. The hydraulic capacity of the existing and/or proposed force main(s).
 - VIII. A list of the proposed users and their average design flows.
 - IX. The proposed average and peak design flows to the lift station.
 - X. The reserve capacity of the lift station with the proposed project at full capacity.
 - XI. The pump run and cycle times for the proposed average and peak design flows.
 - XII. Recommendations for improvements to an existing lift station, if necessary, to enable the lift station to serve the proposed project.
 - XIII. The City Engineer may require a sulfide generation analysis. Corrosion resistant linings and special lift station design are required when dissolved sulfide is likely to exceed 0.2 mg/l.

3.2.3 Stormwater Drainage Plan Report

The purpose of the Stormwater Drainage Plan report is to describe existing drainage conditions and the plan for control of stormwater runoff from the proposed project. The plan should provide a detailed description of the stormwater management strategy along with a grading and drainage Plan, details, calculations, sizing, and locations for all proposed drainage facilities. The plan shall include a narrative describing in detail how the drainage features will function for the Water Quality Storm, the Minor storm, and the Major storm events. The written narrative shall provide sufficient information and details such that the reader has a clear understanding of how the project's stormwater system will function for each storm event. The level of detail presented in the report shall be commensurate with the level of complexity of the stormwater drainage plan. Insufficient

Chapter 3 - Submittal Requirements

report content will be grounds for rejection of the submittal. Additional details of the required Stormwater Drainage Plan are provided in Chapter 6 of these Design Standards.

3.2.4 Traffic Impact Study (TIS)

Demonstrate that adequate transportation capacity exists or will be provided to serve the proposed development consistent with the city's adopted design standards and long-range plans.

- A. A Transportation Impact Study (TIS) is required if the proposed development meets any of the following criteria:
- I. The proposed development exceeds the following thresholds. For uses not included below refer to Table 2 from Chapter 2 of the ITE Recommended Practice: Multimodal Transportation Impact Analysis for Site Development;

Use	Threshold
Single detached dwellings	50 dwellings
Single attached dwellings	90 dwellings
Multi-dwelling structures	130 dwellings
Retail	5,300 sq. ft. gross floor area

- II. The development proposes access spacing that do not meet the requirements on any collector or arterial streets;
 - III. The development intensifies use and is not adjacent to a collector or arterial street;
 - IV. The proposed development is in an area that was included in a previous TIS and the trip generation for the proposed development exceeds the values assumed for the area in the previous TIS or if the previous TIS is more than 5 years old;
 - V. Other special circumstances as determined by the Director of Transportation and Engineering.
- B. When required above, the study area for the Transportation Impact Study (TIS) shall include:
- I. Nearest collector-collector, arterial-arterial, or arterial-collector intersections that serves the proposed development.
 - II. Intersections of existing local streets with arterial and collector streets within 1,000 feet of the proposed development.
 - III. Local streets that connect to existing local streets.
 - IV. Additional locations as identified by the Director of Transportation and Engineering.

Chapter 3 - Submittal Requirements

C. When required, the Transportation Impact Study must include the following information:

I. Project description.

Identify location of project and describe the existing transportation network and facilities that serve the development. This should include all classifications of streets, active transportation facilities and transit service. Describe how the proposed development will connect to the existing system including the use of local streets that connect the proposed development to arterial or collector streets. Identify the timeline for build out of the development including any anticipated phases.

II. Existing traffic volumes.

Provide information on existing traffic volumes collected within two years of the study, including bicycle and pedestrian volumes and existing transit routes and stops. Identify locations, dates, and times of data collection. Identify the peak hours of the existing transportation system. Locations near schools or special generators may need to include counts to help identify the peak periods. Data collection should cover 3 days, typically Tuesday, Wednesday and Thursday. Provide information on seasonal adjustment factors used and the basis of the factors.

III. Site trip generation.

Identify number of weekday trips that will be generated by the proposed development using the most recent version of the Institute of Transportation Engineers Trip Generation Manual or approved alternative methodology. For mixed use sites, include trip generation in the form of a table of each type of land use, the independent variable, as appropriate, the trip rates used (daily and peak) and resulting trip generation. Include identification of the peak hours for the site as well as for the adjacent transportation system. Include adjustments, when appropriate, for pass by trips, internal trip capture, and any reductions based on mode split. Any adjustments must be detailed in the report and must be based on identified and accepted methods. For phased projects the trip generation for each phase should be identified. For redevelopment sites, include a comparison of existing trips with trips generated by the proposed development.

IV. Adjacent trip generation.

Identify current or proposed developments and the associated trip generation from those developments that will be added to the existing volumes to make up the total background volumes. Identify anticipated additional traffic growth.

V. Trip distribution.

Identify how the trips generated by the site will be distributed to the transportation system. Include any assumptions made and identify the methodology utilized to develop the trip distribution.

Chapter 3 - Submittal Requirements

VI. Traffic assignment.

Utilizing the developed trip distribution, show how the existing and future trips are assigned to the streets serving the proposed development. Include figures that show traffic volumes on the transportation system. Include all streets, including local streets, which will distribute trips to transportation system. Include graphics, which show:

- a. A.M. and P.M. peak hour existing volumes;
- b. A.M. and P.M. peak hour site generated volumes;
- c. A.M. and P.M. peak hour current year total traffic;
- d. A.M. and P.M. peak hour total traffic at year of build out; and
- e. Total daily traffic (with site-generated traffic shown separately).

VII. Capacity analysis.

Provide level of service analysis for existing and proposed arterial-arterial, collector- collector, and arterial-collector intersections. Provide level of service for the existing conditions and at the year of anticipated full build out. If full build out will exceed 5 years from the study date, analysis at 5 years and at full build out is required. Analysis must include evaluation of signalization warrants. Where appropriate, intersection capacity should be analyzed for both signalization and roundabout operation. Capacity analysis will utilize the methods identified in the most recent version of the Highway Capacity Manual.

VIII. Crash Study.

Summarize crash history, including bicycle and pedestrian involved crashes, for the study area over the most recent 5 years of available data. Crash history should provide aggregate number of crashes as well as crash rates and a comparison to statewide averages for facility type.

IX. Site operational analysis.

Identify any proposed modification to access spacing and demonstrate turning movements for fire apparatus and/or other applicable design vehicles.

X. Recommended mitigations.

Identify mitigation strategies to address areas that do not meet City design standards. Mitigations should be identified to address:

- a. Intersection capacity that does not meet the level of service standard identified in Section 7.1.16;
- b. Vehicular volumes requiring traffic calming for local streets in the study area that exceed the volume threshold per Section 7.1.16;
- c. Crash clusters exceeding statewide average per Section 7.1.16; and
- d. Barriers to safe bicycle and pedestrian movement as identified by the Director of Transportation and Engineering.

Chapter 3 - Submittal Requirements

If the project is phased, include identification of when the mitigations are required. Describe any anticipated increased maintenance that will be necessary due to increased traffic.

- XI. The information needed to demonstrate proposed compliance with [Section 38.270](#), Bozeman Unified Development Code.

Special care is needed when concurrent construction is proposed.

3.2.5 Pavement Design Report

A Pavement Design Report, based upon specific site soil data and design-year traffic loading conditions, prepared by a Professional Engineer, or other qualified professional approved by the City Engineering Division.

The design shall be based on at least a 20-year performance period traffic volume. However, the minimum design lane Equivalent 18,000-lb Single Axle Load (ESAL) used in the pavement design shall not be less than 75,000-ESAL. The minimum asphalt pavement thickness for any new local roadway shall be three (3) inches. The minimum asphalt pavement thickness for any new collector or arterial roadway shall be four (4) inches. A minimum of six (6) inches of high quality untreated aggregate base shall be provided for designs utilizing asphalt pavement over untreated aggregate base.

3.2.6 Lighting Design Report

Provide lighting calculations showing roadway luminance, intersection illuminance, sidewalk illuminance, and light trespass. Provide luminaire submittal form, cutsheets, and other applicable items in accordance with the City of Bozeman Lighting and Electrical Specification.

3.3. LANDSCAPE DOCUMENTATION PACKAGE

Landscape and irrigation system submittals shall meet the requirements of the [City of Bozeman Landscape and Irrigation Performance and Design Standards Manual](#) for landscaping within COB right-of-way.

3.4. CONSTRUCTION PLANS AND SPECIFICATIONS REQUIREMENTS

3.4.1 General Requirements

- A. Review of project plans and specifications take place after the planning application (Stage 2) has been deemed adequate by the City Review Engineer.
- B. All project infrastructure plans must be submitted at the same time. Separate approval of infrastructure elements is not allowed unless approved by the City Engineer.
- C. Where existing infrastructure is being extended The Engineer of Record must confirm to their satisfaction the existing material, size, elevation, horizontal alignment, grade, and all critical utility crossings, prior to plan and specification submittal.
- D. All plans must be either 24-inch by 36-inch or 22-inch by 34-inch in size and in PDF format. All plans submitted for review and approval shall be stamped, signed, and dated by a Professional Engineer licensed in the State of Montana.

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- E. Separate plans shall be submitted for water facilities and sanitary sewer facilities. Plans for storm sewer facilities may be included with plans for street facilities if all information can be clearly shown. Plans for publicly maintained storm sewer facilities shall be on separate plan sheets.
- F. All plans will have both plan and profile views of the proposed improvements. A general location map shall be provided showing the relationship of each page to the overall development. Water mains, sanitary sewer mains, storm water mains, and fire services must have both plan and profile views of the proposed improvements. Plan and profiles shall be on the same page, and wherever possible, each should be aligned vertically on the page.
- G. Project datum and benchmarks shall be clearly identified on the plans. The datum shall be NAVD88/State Plane.
- H. English units are required.

3.4.2 Specifications Requirements

- A. The City of Bozeman has adopted “Montana Public Works Standard Specifications” (MPWSS) as the standard specifications for new construction. A separate document, “City of Bozeman Modifications to MPWSS” has been adopted which supplements and modifies certain sections of MPWSS. All project manuals must incorporate, preferably by reference, MPWSS (latest adopted edition) and the “City of Bozeman Modifications to MPWSS”, including any addenda.
- B. Additions or changes to the above standard specifications must be done through Special Provisions or similar supplemental sections in the project manual.
- C. Projects that are fully or partially funded by the COB shall incorporate Instructions to Bidders and Special Provisions that are approved by the COB.

3.4.3 Drawing Scales

Plan and Profiles views must have a clearly labeled scale, the City reserves the right to reject plans that are difficult to read.

- A. Plan View: appropriate scale to clearly convey all information
- B. Profile View, Horizontal: match plan view scale
- C. Profile View, Vertical: appropriate scale to clearly convey all information
- D. Stationing interval: 100 feet or 50 feet

3.4.4 Plan Requirements

The following items will be required on all plans. Existing features should be shown dashed or with a lighter shading than proposed new features. All construction will be tied to the centerline of a City right-of-way, to the centerline of a City easement, to a platted property line, or to section lines.

- A. Title Sheet
- B. Table of Contents / Notes Sheet
- C. Plan View

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- I. North Arrow
- II. Legend of Symbols
- III. Property lines and ownership or subdivision information
- IV. Street names and easements with width dimensions
- V. Project Stationing
- VI. Limits of existing paved or graveled surfaces
- VII. Monument boxes
- VIII. Culverts
- IX. Existing and proposed utilities and structures, including:
 - a. Line size and material where appropriate;
 - b. Water lines (main lines and service lines), valves, and hydrants;
 - c. Sanitary sewer lines (main lines and service lines) and manholes;
 - d. Storm sewer lines, manholes, and inlets;
 - e. Gas lines;
 - f. Electric lines, poles, transformers;
 - g. Telephone lines, manholes, junction boxes;
 - h. Cable T.V. lines, junction boxes;
 - i. Irrigation ditches and structures;
 - j. Irrigation system connection to City main, meter pit, and B.F.P. locations;
 - k. Fiber optic lines, manholes, junction boxes;
 - l. Streetlights;
 - m. Proposed method of restoration of all areas disturbed during construction.

D. Profile View

- I. Vertical and horizontal grids to scales.
- II. Final grade (solid).
- III. Existing grade (dashed).
- IV. Existing utility lines where crossed.
- V. Project Stationing
- VI. Utility crossings

3.4.5 Utility Plan Requirements

- A. The following general notes must appear on all plan sets:
 - I. All construction will conform to MPWSS, (Latest) Edition, and City of Bozeman Modifications to MPWSS.

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- II. Any existing or new valves which control the City of Bozeman's water supply must be operated by City of Bozeman personnel only.
 - III. The Contractor must notify the City of Bozeman Water Department a minimum of 24- hours prior to beginning any work.
 - IV. Contractor must field-verify line and grade of existing connections.
- B. Plans for water facilities shall show the following:
- I. Size, type, and structural class of proposed new water line(s), including AWWA specifications.
 - II. Bedding class.
 - III. Type of excavation and backfill.
 - IV. Existing water lines including size and material.
 - V. Proposed valves, fittings, fire hydrants, and service lines, with stationing.
 - VI. Depth of cover from finish grade to proposed water line(s).
 - VII. Requirements for pipe deflection, if necessary.
 - VIII. Type of joint restraint, if required.
 - IX. Size of gravity thrust blocks based on calculated design.
 - X. Existing or proposed pressure reducing valves.
- C. Plans for sanitary sewer facilities shall show the following:
- I. Size, type, and structural class of proposed new sewer line(s), including American Society for Testing and Materials (ASTM) specifications.
 - II. Slope of each proposed pipeline segment.
 - III. Bedding class.
 - IV. Type of excavation and backfill.
 - V. Existing sewer lines and manholes including size, material, field-verified invert elevations and field-verified slopes.
 - VI. Proposed manhole with stationing and rim and invert elevations.
 - VII. Existing and proposed sewer service lines with size and stationing.
 - VIII. Existing and proposed cleanouts.
- D. Plans for storm drainage facilities shall show the following:
- I. Size, type, and structural class of proposed new storm drain line(s), including ASTM specifications.
 - II. Slope and invert elevations for each proposed storm drain segment.
 - III. Bedding class.
 - IV. Type of excavation and backfill.

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- V. Proposed manholes with stationing and rim and invert elevations.
- VI. Proposed storm drain inlets and inlet laterals with stationing and grate flowline and inlet and lateral invert elevations.
- VII. Proposed stormwater retention or detention ponds with construction staking coordinates and elevations for grading, construction details and elevations of flow control and spillway structures, and coordinates and elevations of permanent benchmarks for monitoring of sediment accumulation and associated maintenance cleaning needs.
- VIII. Stormwater outfall discharge points with stationing and invert elevations.

3.4.6 Roadway Plan Requirements

- A. Plans for streets or roadways shall show the following:
 - I. Limits of cuts and/or fills. Extents shall show where finished grade contours meet existing grade.
 - II. Existing and proposed utilities, including manholes and valves.
 - III. Proposed new construction, including paving width and limits, curb and gutter, crosspans, sidewalks, and pedestrian ramps.
 - IV. Existing and finished grades, with finished grade slopes.
 - V. Vertical and horizontal curves, with curve data:
 - a. Horizontal curves - R, Δ , L, PC and PT Stationing
 - b. Vertical curves - K, L, VPC, VPI, and VPT Stationing and elevations
 - VI. Profile of centerline.
 - VII. Profiles of left and right curb lines, if they are not the same.
 - VIII. Any required utility adjustments.
 - IX. Existing and proposed signs and pavement markings.
 - X. Existing and proposed storm drainage facilities, including culverts, pipes, inlets, sidewalk chases, ditches and detention/retention ponds, with invert and/or spot elevations.
 - XI. Top of curb elevations at P.C.s, P.T.s, and inlets.
 - XII. For curb returns, show and label high point location, elevation and intersection of flow line in plan view if applicable.
 - XIII. Existing and proposed street monuments.
 - XIV. Typical roadway section(s), dimensioned and drawn to scale, showing:
 - a. Right-of-way
 - b. Backslopes
 - c. Sidewalks/shared use paths
 - d. Curb and gutter

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- e. Pavement thickness
- f. Base and sub-base thickness
- g. Cross-slopes

3.4.7 Lighting and Electrical Plan Requirements

- A. Plans for lighting and electrical shall show the following:
 - I. Pole locations, conduit locations, pull/splice box locations, and meter locations.
 - II. Details of point of service, lighting control center, electrical on-line diagrams, conduits and cables, pole foundations, poles, and luminaires.

3.5. POST CONSTRUCTION DOCUMENTATION

The following documentation shall be required prior to final acceptance of sanitary sewer, water main, storm drain, Portland cement concrete, and bituminous pavement improvements within City right-of-way or easements.

3.5.1 Construction Certification

- A. The Engineer shall submit a letter to the City certifying that the public improvements (i.e. sanitary sewers, water mains, storm drainage facilities, and streets) were installed in accordance with the approved plans and specifications and shall be accompanied by Record Drawings for the project.

The Engineer shall submit verification that all thrust blocking was installed in accordance with the approved plans and specifications shall be included in the certification letter. If mechanical restraints are used in lieu of thrust blocks, verification that the restrained length as installed meets or exceeds the manufacturers recommendations shall be included.

- B. The Engineer shall submit the Certified Checklist for Testing & Documentation Requirements for Infrastructure Improvements.

3.5.2 Testing Documentation

The Engineer shall conduct testing at the frequencies specified in Section 1.10 and submit all testing documentation with the construction certification.

A. Water Systems

- I. The Engineer shall furnish documentation and dates for acceptable water system tests as specified in Section 1.10. This information shall be required for all public water main extensions.

B. Gravity Sanitary Sewer Systems

- I. The Engineer shall furnish documentation and dates for acceptable sewer system tests as specified in Section 1.10. This information shall be required for all public sewer main extensions.

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C. Sanitary Sewer Force Mains

- I. The Engineer shall furnish documentation and dates for acceptable sanitary sewer force main tests as specified in Section 1.10. This information shall be required for all public sewer main extensions.

D. Storm Drain Systems

- I. The Engineer shall furnish documentation and dates for acceptable storm drainage system tests as specified in Section 1.10. This information shall be required for all storm drainage systems within the Public right-of-way.

E. Fill and Backfill

- I. The Engineer shall furnish documentation as specified in Section 1.10. This information shall be required for all public sewer main, water main, storm drain and street extensions.
- II. The Engineer shall furnish documentation of in-place field density tests as specified in Section 1.10. This information shall be required for all public sewer main, water main, storm drain, and street extensions.

F. Bituminous Pavement

- I. The Engineer shall furnish all documentation and test results as specified in Section 1.10. This information shall be required for all public street extensions.

G. Concrete

- I. The Engineer shall furnish Portland cement concrete tests as specified in Section 1.10. This information shall be required for all public street extensions.

3.5.3 Record Drawings

Submit stamped and signed final record drawings to the City Review Engineer, including one set on mylar and one full-size set on paper. An electronic version of the record drawings shall also be submitted to the Engineering Division application portal.

- A. The datum used as the basis for the elevations in record drawings shall be clearly identified.
- B. Record elevations shall be provided for the top of the water main at 50' intervals to the nearest 0.1'.
- C. Record elevations shall be provided for all sanitary sewer manhole inverts to the nearest 0.01'.
- D. An accurate record of the location, length, slope, and size of all sanitary sewer service connections, as installed, must be provided by the Engineer. Elevations at the end of dry service line stub-ins are required. The locations where sanitary sewer services connect to mains shall be identified by sewer alignment stationing or distance from nearest upstream manhole. This information shall be required for all public sewer main extensions and service connections to existing mains.

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- E. An accurate record of the locations, elevations, and slopes of the storm drainage facilities including, but not limited to surveyed invert elevations and slopes of storm drain pipe segments, invert and manhole lid elevations, invert and grate elevations for inlets, bottom and top of bank elevation for retention or detention ponds, invert and spill elevations of flow control structures of detention ponds, and crest elevation of emergency spillways of detention ponds. Engineer shall also provide a comparison of the record vs. Design flow capacities of the storm drain pipe segments and record vs. Design storage volumes for retention and detention ponds and sediment forebays. TV Inspection reports shall be provided for storm drain connections in public right of way. Benchmark elevations shall be established for all new stormwater ponds for monitoring of sediment accumulation and associated maintenance cleaning needs. Benchmarks shall be established on concrete water control structures or other permanent and immovable structures at the immediate location. The benchmark elevation shall be certified by either a P.E. or L.S. registered in the state of Montana. The datum used as the basis for the elevation shall be clearly identified.
- F. An accurate record of the locations of the lighting and signal poles, conduit, splice boxes, meters, and lighting control centers must be provided by the Engineer. Provide electrical one-line diagrams/wiring schematics that represent what was constructed.

Special Improvement Lighting District (SILD) approval and cut sheets of all equipment shall be provided with the record drawings in accordance with the City of Bozeman Lighting and Electrical Specification.

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4.1. LOCATION

4.1.1 Water Mains

- A. Water mains located in public street right-of-way shall be placed nineteen (19) feet off the north or west right-of-way lines for streets 35 feet in width or greater (back of curb to back of curb). For streets less than 35 feet in width, water mains shall be placed 5.5 feet west and north of the street centerline. On curvilinear street alignments, water mains shall be a minimum of two (2) feet from the edge of the concrete gutters at all locations.
- B. Water mains within a proposed development shall be arranged to allow the suitable development of any adjoining un-developed land and shall be constructed to the boundary lines of the tract being developed. An Administrative Waiver may be considered by the City if this requirement cannot be met due to topography or other physical conditions.
- C. A minimum depth of cover of six and one-half (6 ½) feet below final grade shall be maintained over all water mains. Where the minimum depth of cover is not maintained, insulation shall be provided in accordance with City of Bozeman Modifications to MPWSS. Where there is less than three (3) feet separation between water mains and storm drains, four (4) inches of insulation shall be installed between the lines.
- D. Trees and other significant landscaping features shall not be placed within ten (10) feet of any utility main. Significant landscaping features include, but are not limited to, items such as retaining walls, large boulders, raised garden beds, and other similar items that would be disrupted by maintenance or replacement of the utility.
- E. Clearance from Other Utilities

The following utility clearances shall be maintained unless otherwise approved by the City Engineering Division. All clearances are based on the outside edge of the water line to the outside edge of the other utilities.

- Horizontal clearances from water mains and services:

<u>Utility</u>	<u>Water Main Clearance⁽¹⁾</u>	<u>Water Service Clearance⁽²⁾</u>
Cable TV, Gas, Power	10 feet	5 feet
Telephone, Fiber Optics	10 feet	5 feet
Storm Drain	10 feet	5 feet
Sewer Main	10 feet	5 feet
Sewer Service	5 feet	2 feet

⁽¹⁾ The City Engineering Division may require additional horizontal clearance between deep water mains and other utilities or structures to allow for future maintenance and replacement.

⁽²⁾ The City Engineering Division may require additional horizontal clearance between water services and large or deep utility lines to allow for future maintenance and replacement.

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- Vertical clearances from water mains and services:

<u>Utility</u>	<u>Water Main Clearance</u>	<u>Water Service Clearance</u>
Cable TV, Gas, Power	1 foot	0.5 feet
Telephone, Fiber	1 foot	0.5 feet
Misc. Private Utilities	1 foot	0.5 feet
Storm Drain	1.5 feet	0.5 feet
Sewer Main	1.5 feet	0.5 feet
Sewer Service	0.5 feet	0.5 feet

When water mains cross sanitary sewer or storm drain mains, the crossing must be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support must be provided for the sewer to maintain line and grade and to prevent damage to the water main.

4.1.2 Valves

- A. Valves shall not be located underneath curb and gutters, sidewalks, or shared use paths. Valves within vehicle wheel paths should be avoided wherever possible.

4.1.3 Water Services

- A. If typical curb box locations cannot be met (i.e. 8-feet setback behind property line to accommodate dry utilities), alternate criteria may be applied upon approval of the City Engineering Division. The following conditions should be met:
- Curb boxes are preferably located on or near the property or easement line.
 - Suitable locations are provided for dry utilities that do not conflict with curb boxes or ability to connect to service stubs in the future.
 - Curb boxes must be a minimum of 3 feet from all foundations and structures.
 - Curb boxes are accessible to be turned on and off at all times and must not be located in parking areas.
 - Service stubs for future connection must not be located in paved areas.
- B. Multiple fire or domestic water services serving the same building or multiple buildings of common ownership may be placed in a common trench with 1 foot of clearance between pipes.
- C. A minimum depth of cover of six and one-half (6 ½) feet below final grade shall be maintained over all water services. Where the minimum depth of cover is not maintained, insulation shall be provided in accordance with City of Bozeman Modifications to MPWSS. Where there is less than three (3) feet separation between water services and storm drains, four (4) inches of insulation shall be installed between the lines.
- D. All curb stops located in pavement shall have a valve box riser around the top of the curb stop.

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4.2. DESIGN CRITERIA

4.2.1 Additions

All additions or modifications to the COB water system shall be designed in accordance with the criteria set forth in these Standards, MDEQ Circular DEQ-1, MPWSS, COB Modifications to MPWSS, the City's latest adopted Water Facility Plan Update, and COB Fire Service Line Standard as approved by the City Engineering Division.

Ductile Iron Pipe (DIP) shall be used exclusively for water mains unless an Administrative Waiver is approved by the City Engineering Division. DIP and fittings shall be provided with a metallic zinc coating in accordance with ISO 8179 and enhanced polyethylene encasement unless a soils corrosivity analysis indicates that these corrosion mitigation measures are not required. The Ductile Iron Pipe Research Association (DIPRA) Design Decision Model (DDM) shall be used to determine the appropriate corrosion mitigation measures when a corrosivity analysis is performed.

4.2.2 Main Size

The water distribution system shall be designed to meet the Maximum Day Demand (MDD) plus Fire Flow and the Peak Hour Demand (PHD).

The working residual water pressure shall not be less than 20 psi at any point in the water distribution system under MDD plus Fire Flow.

The working pressure shall not be less than 50 psi at any point in the water distribution system under PHD. Areas near reservoirs and on the edge of pressure zones may have a minimum pressure of 35 psi under peak hour demand where approved by the City Engineering Division.

The velocity of the water in the system shall not exceed the values specified in Table 4.2.1 under PHD conditions.

Table 4.2.1 – Water Main Velocity Requirements	
Water Main Type	Maximum Velocity (fps) ⁽¹⁾
Transmission Main (12-inch and larger)	3
Distribution Main (10-inch and smaller)	5
⁽¹⁾ Maximum velocity under PHD Conditions	

The minimum diameter for any new main is 8-inch, unless an Administrative Waiver is obtained from the City of Bozeman for smaller diameters.

If a new development is connecting to an existing 6-inch water main, the Engineering Division may require the project to upsize the existing main to a minimum of 8-inch to meet hydraulic requirements or if the existing pipe is nearing the end of its useful life. Generally, pipe will be upsized along the frontage of the property between existing valves. For frontages less than one block width, a minimum of one block of increased main size is required.

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4.2.3 Roughness Coefficient

A "C" Factor of 130 shall be used in modeling system designs.

4.2.4 Average Daily Demand

A. Planning Values

When development plans are not fully known (e.g. Concept Infrastructure Review Stage), Average Daily Demand (ADD) shall be estimated on a per acre basis using the duty factors in Table 4.2.2. Planning level duty factors include estimated irrigation.

B. Final Values

When development plans are known (e.g. Site Plan Review Stage), per capita and per unit values must be used to determine average daily demand.

Design of new water distribution infrastructure to serve residential areas shall be based on an average daily usage of 135 gallons per capita per day at 2.17 people per dwelling unit.

Design of new water distribution infrastructure to serve non-residential areas shall be based on an average daily flow rate for the development being constructed. Typical flow values per unit from Circular DEQ-4 shall be used.

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4.2.5 Planning Demand

Table 4.2.2 shows the design average daily water demand on a per acre basis for zoned areas.

Table 4.2.2 – Water Duty Factors By Zoning Designation		
Zoning Designation	Zoning Description	Average Day Demand ^{(1),(2)} (gpad)
R-S	Residential Suburban District	107
R-1	Residential Single-Household Low Density District	533
R-2	Residential Two-Household Medium Density District	700
R-3	Residential Medium Density District	2,380
R-4	Residential High Density District	3,180
R-5 ⁽³⁾	Residential Mixed-Use High Density District	4,560
R-O	Residential-Office District	496
RMH	Residential Manufactured Home Community District	718
B-1	Neighborhood Business District	1,277
B-2	Community Business District	614
B-2M ⁽³⁾	Community Business District - Mixed	4,560
B-3	Central Business Park District	1,262
M-1	Light Manufacturing District	134
M-2	Manufacturing and Industrial District	879
B-P	Business Park District	179
NEHMu	Northeast Historic Mixed-Use District	583
UMU	Urban Mixed Use	2,109
REMu ⁽³⁾	Residential Emphasis Mixed Use	4,560
PLI	Public Lands and Institutions District	98
MSU	Montana State University	1,086
⁽¹⁾ The flow allocation in this table is based on gross area.		
⁽²⁾ Average Day Demand includes irrigation.		
⁽³⁾ R-5, B-2M, and REMU allow a broad range of use and intensity of development and must be verified by the Design Engineer.		

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4.2.6 Peaking Factors

Peaking factors shall be used to determine MDD and PHD values per Table 4.2.3.

Table 4.2.3 – Water Demand Peaking Factors	
Item	Peaking Factor ⁽¹⁾
Maximum Day Demand (MDD)	2.3
Peak Hour Demand (PHD)	3.0
⁽¹⁾ MDD and PHD shall be calculated by multiplying ADD by the appropriate peaking factor.	

4.2.7 Fire Flow Demand

Fire flow demand shall be in accordance with the latest version of the International Fire Code (IFC) adopted by COB and as approved by the COB Fire Chief. For facility planning purposes, COB uses the fire flow guidelines based on land use in Table 4.2.4.

Table 4.2.4 – Fire Flow General Guidelines By Land Use	
Land Use Description	Fire Flow ⁽¹⁾ (gpm)
Manufacturing and Industrial	5,000
Light Manufacturing and Central Business	4,000
Community and Neighborhood Business; Public Lands; Medium and High Density Residential	3,000
Single Family Low and Medium Density	1,500
⁽¹⁾ The fire flow values in this table are guidelines only and may not be indicative of the requirements for specific developments or buildings. Fire demand for specific developments shall be in accordance with International Fire Code (IFC) and as approved by the COB Fire Chief.	

4.2.8 Dead Ends

All main extensions shall be looped, where possible. All dead-end 8" mains shall end with a fire hydrant or 2" blowoff capable of producing adequate flushing velocities. Larger diameter, 10" or greater, dead-end mains shall end with a fire hydrant.

Permanent dead-end mains shall not exceed 500-feet long. Temporary dead-end mains scheduled for future extension may end with a blow-off in lieu of a fire hydrant.

4.2.9 Services

A. General

- I. A water line is designated as either a service line or water main based on its use, not its size. Generally, a line serving a single building or property is considered a service line; a line serving more than one building or intended to serve more than one building or facility is generally designated a water main.

Chapter 4 - Water System

- II. Each building shall be supplied by a separate service line and meter, with the exception of Accessory Dwelling Units (ADUs), which should be supplied by the primary residence service and meter provided the following conditions are met:
 - a. The primary residence service is adequately sized according to the fixture unit method.
 - b. The ADU is on the same lot and under the same ownership as the primary residence.
- III. The service stubs shall be installed in accordance with the COB Standard Drawings for service lines unless otherwise approved pursuant to Section 4.1.2.
- IV. No service line shall be extended into a building until an "Application for Service" has been completed and a Plumbing Permit has been obtained from the Building Department. An Administrative Waiver may be granted to extend a service to a future building area in certain circumstances (e.g. service needs to be extended to future building area so a parking lot can be paved).
- V. Backflow prevention devices shall be installed on each fire and domestic service line in accordance with COB Modifications to MPWSS. The backflow prevention device shall be installed directly to the meter for domestic services. The backflow prevention device shall be installed directly to the OS&Y valve for fire services.
- VI. Meters will be installed inside the building by the Water Department on all service lines except for fire service lines. Meter pits shall not be used unless specifically approved by the Water Superintendent. Water meters are ordered based on what is originally applied for with the building permit application when the application is paid. If there are deviations from what is on the original application, the Applicant shall correct the application and payment, so the correct meter is ordered for the building.
- VII. The termination of any existing service stubs (either for domestic, irrigation or fire service) that are not utilized for service upon the development of the lot will be required unless the Water Superintendent grants a waiver. Lines terminated shall be capped or plugged at the main as determined by the Water Superintendent and any curb boxes and valve boxes on the line shall be removed.
- VIII. For single-household lots where demand is known, service stubs shall be installed with infrastructure construction.
- IX. For large commercial or multi-household lots where demand is not reasonably known, the Water Department may allow for omission of service stubs with infrastructure construction to prevent installation of improperly sized service stubs. The Streets Division may require the project to mill and overlay a portion of the street if an excessive amount of street cuts are proposed during site development.
- X. Service pipe shall be type "K" copper for sizes less than 4-inch, and ductile iron for services 4-inch and larger. Plans and specifications prepared by a Professional Engineer licensed in the State of Montana shall be submitted for 4-inch and larger service lines.

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B. Service Size

- I. All service line stubs shall be sized to adequately serve the maximum anticipated demand for the property being served.
- II. All service connections shall be uniform size from the service line tap to the building structure or structures unless otherwise approved or required by the Water Superintendent. The Water Department shall reserve the right to require a larger service connection to any building, structure or development if the water requirements when calculated by the fixture unit method, as specified in the Uniform Plumbing Code, cause the service line velocity to exceed eight (8) feet per second.
- III. The standard sizes of service lines are $\frac{3}{4}$ ", 1", 1½", 2", 4", 6", and 8". The minimum size of a fire service line is 1-inch. The minimum size of a service line stub is 1", to allow for the potential use of the domestic supply for a fire sprinkler system.

C. Service Length

- I. The length of service lines from the main to the structure may not exceed 150 feet in length, unless approved in writing by the city.

4.2.10 Valves

Valves shall be installed in accordance with the following unless otherwise approved or required by the Water Superintendent:

- A. All connections to an existing water main will begin with a new valve unless there is an existing valve of suitable condition at the point of connection. Installing a new valve near an existing valve to avoid testing against an existing valve is not allowed.
- B. Valves shall be located at not more than 500-foot intervals in commercial districts and at not more than one block or 800-foot intervals in other districts.
- C. Every leg of a main intersection shall have a valve.
- D. Valves shall be placed so that main shutdowns can be accomplished with only one fire hydrant being out of service at a time, unless it can be shown that the requirements of Appendix C of International Fire Code can be met with more than one fire hydrant out of service. This exception is intended to apply to areas where numerous fire hydrants are in close proximity to each other due to FDC requirements.
- E. All valves located within streets shall be constructed with a concrete collar in accordance with the COB Standard Drawings.

4.2.11 Hydrants

Hydrants shall be provided at each street intersection and at intermediate points so that hydrants are spaced from 350 feet to 500 feet depending on the area being served. Mid-block hydrants shall be installed in line with lot lines.

A minimum of 60 inches clear space shall be maintained around the circumference of all fire hydrants. With the exception of hydrant barrier posts, trees, structures, and other above ground obstructions are not allowed within this clear space.

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Final hydrant locations are subject to approval by the City of Bozeman Fire Chief.

4.2.12 Air Relief

Air relief shall be provided at all high points in the line where air can accumulate by means of hydrants, services, or air relief valves.

4.2.13 Pressure Reducing Valves

Pressure reducing valves shall be installed when the anticipated average-day line pressure exceeds the maximum pressure specified for the applicable pressure zone as outlined in the latest Water Facility Plan Update.

4.2.14 Thrust Restraint

All thrust restraint shall be designed to withstand the test pressure or the working pressure plus surge allowance, whichever is larger. Adequate factors of safety shall be employed in the design.

4.2.15 Booster Pump Stations

RESERVED

4.2.16 Water Storage Reservoirs

RESERVED

Chapter 5 - Sanitary Sewer System

Chapter 5 Sanitary Sewer System

5.1. LOCATION

5.1.1 Sanitary Sewer Mains:

- A. Sanitary sewer mains located in public street right-of-way shall be placed along the centerline of the street for streets 35 feet in width or greater (back of curb to back of curb). For streets less than 35 feet in width, sewer mains shall be located 5.5 feet east and south of the street centerline.
- B. Where streets are curvilinear, manholes should be located in the center of the street wherever possible, however non-centerline locations that are not in vehicle wheel paths are acceptable if it will reduce the total number of manholes required. On curvilinear street alignments, sewer mains shall be a minimum of two (2) feet from the edge of the concrete gutters at all locations.
- C. Sewer mains within a proposed development shall be arranged to allow the suitable development of any adjoining un-developed land and shall be constructed to the boundary lines of the tract being developed. An Administrative Waiver may be considered by the City if this requirement cannot be met due to topography or other physical conditions.
- D. Gravity sewer mains shall have a minimum depth of cover of four (4) feet below final grade. All sewer mains with less than five (5) feet of cover shall be adequately insulated in accordance with City of Bozeman Modifications to MPWSS. Where there is less than three (3) feet separation between sewer mains and storm drains, four (4) inches of insulation shall be installed between the lines.

Sewer force mains shall have a minimum depth of cover of (6) feet unless adequately insulated.
- E. Trees and other significant landscaping features shall not be placed within ten (10) feet of any utility main. Significant landscaping features include, but are not limited to, items such as retaining walls, large boulders, raised garden beds, and other similar items that would be disrupted by maintenance or replacement of the utility.
- F. Clearance from Other Utilities

The following utility clearances shall be maintained unless otherwise approved by the City Engineering Division. All clearances are based on the outside edge of the sewer line to the outside edge of the other utilities.

- Horizontal clearances from sewer mains and services:

<u>Utility</u>	<u>Sewer Main Clearance⁽¹⁾</u>	<u>Sewer Service Clearance⁽²⁾</u>
Cable TV, Gas, Power	10 feet	5 feet
Telephone, Fiber Optics	10 feet	5 feet
Storm Drain	5 feet	5 feet
Water Main	10 feet	5 feet
Water Service	5 feet	2 feet

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⁽¹⁾ The City Engineering Division may require additional horizontal clearance between deep sewer mains and other utilities or structures to allow for future maintenance and replacement.

⁽²⁾ The City Engineering Division may require additional horizontal clearance between sewer services and large or deep utility lines to allow for future maintenance and replacement.

- Vertical clearances from sewer mains and services:

<u>Utility</u>	<u>Sewer Main Clearance</u>	<u>Sewer Service Clearance</u>
Cable TV, Gas, Power	1 foot	0.5 feet
Telephone, Fiber	1 foot	0.5 feet
Misc. Private Utilities	1 foot	0.5 feet
Storm Drain	1 foot	0.5 feet
Water Main	1.5 feet	0.5 feet
Water Service	0.5 feet	0.5 feet

When sanitary sewer mains cross water mains, the crossing must be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support must be provided for the sewer to maintain line and grade and to prevent damage to the water main.

5.1.2 Sanitary Sewer Services

- A. Multiple sewer services serving buildings of common ownership may be placed in a common trench with 1 foot of clearance between pipes.
- B. Gravity sewer services shall have a minimum depth of cover of four (4) feet below final grade. All sewer services with less than five (5) feet of cover shall be adequately insulated in accordance with City of Bozeman Modifications to MPWSS. Where there is less than three (3) feet separation between sewer mains and storm drains, four (4) inches of insulation shall be installed between the lines.

5.2. DESIGN CRITERIA

5.2.1 Additions

All additions or modifications to the COB sanitary sewer system shall be designed in accordance with the criteria set forth in these Standards, Circular DEQ- 2, MPWSS, COB Modifications to MPWSS, the Uniform Plumbing Code, and the City's latest adopted Wastewater Facility Plan as approved by the City Engineering Division.

5.2.2 Main Size

- A. New sanitary sewer mains shall be sized to flow at no more than 75-percent of full capacity at peak hour conditions upon the full build-out of the development. The effects of the proposed development's sewer loading on existing downstream sewer lines shall be analyzed. The minimum diameter of a sewer main is 8-inches.
- B. Main lines shall be sized for design flow, not available slope. Oversizing main lines to justify using flatter slopes is not allowed. Minimum main line slopes shall comply with Circular DEQ-2.

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- C. If a new development is connecting to an existing 6-inch sewer main, the City Engineering Division may require the project to upsize the existing main to a minimum of 8-inch along the frontage of the property to the nearest downstream main of equal or greater size as the replaced main. The extent and size of the sewer main replacement will be determined based on the peak-hour sanitary sewer demand on anticipated build-out, tie-in location, and existing upstream and downstream sewer slopes.

5.2.3 Friction Factor

A Manning's friction factor of 0.013 shall be used in designing new sewers.

5.2.4 Design Average Flow

A. Planning Values

When development plans are not fully known (e.g. Concept Infrastructure Review Stage), design average flow shall be estimated on a per acre basis using the values Table 5.2.1.

B. Final Values

When development plans are known (e.g. Site Plan Review Stage), per capita and per unit values must be used to determine design average flow.

New sanitary sewer infrastructure to serve residential areas should be designed for an average daily domestic flow rate of 64.4 gallons per capita per day at 2.17 people per dwelling unit.

New sanitary sewer infrastructure to serve non-residential areas shall be designed to accommodate an average daily flow rate for the development being constructed. Typical wastewater flow values per unit from Circular DEQ-4 shall be used.

C. Base Infiltration Rate

A base infiltration rate of 150 gallons/acre/day shall be added to domestic flow calculations when designing all new sewers. The base infiltration rate shall be applied to the gross area of the development.

5.2.5 Peaking Factor

A peak hour factor shall be calculated for each pipe segment based on the following formula:

$$\frac{Q_{max}}{Q_{ave}} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}} \quad (P = \text{Population/thousands})$$

For non-residential flows an equivalent population shall be calculated for use in the peaking factor formula. Equivalent population is calculated by dividing the total design average flow by domestic per capita flow.

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5.2.6 Planning Flow Values

Table 5.2.1 shows the design average wastewater flow rates on a per acre basis for zoned areas.

Table 5.2.1 – Wastewater Flow By Zoning Designation			
Zoning Designation	Zoning Description	Domestic Flow ⁽²⁾ (gpad)	Domestic Flow + Base Infiltration ^{(1), (3)} (gpad)
R-S	Residential Suburban District	60	210
R-1	Residential Single-Household Low Density District	280	430
R-2	Residential Two-Household Medium Density District	490	640
R-3	Residential Medium Density District	2,100	2,250
R-4	Residential High Density District	2,800	2,950
R-5 ⁽⁴⁾	Residential Mixed-Use High Density District ₂	2,800	2,950
R-O	Residential-Office District	400	550
RMH	Residential Mfg Home Community District	660	810
B-1	Neighborhood Business District	1,100	1,250
B-2	Community Business District	480	630
B-2M ⁽⁴⁾	Community Business District - Mixed	2,800	2,950
B-3	Central Business Park District	1,040	1,190
M-1	Light Manufacturing District	100	250
M-2	Manufacturing and Industrial District	420	570
B-P	Business Park District	130	280
NEHMU	Northeast Historic Mixed-Use District	470	620
UMU	Urban Mixed Use	1,000	1,150
REMU ⁽⁴⁾	Residential Emphasis Mixed Use	2,800	2,950
PLI	Public Lands and Institutions District	50	200
MSU	Montana State University	1,140	1,290
⁽¹⁾ The flow allocation in this table is based on gross area. ⁽²⁾ Domestic Flow is the portion of flow that originates from indoor plumbing and water use including residential, commercial and industrial activities. ⁽³⁾ Includes a base infiltration rate of 150 gpad. ⁽⁴⁾ R-5, B-2M, and REMU allow a broad range of use and intensity of development and must be verified by the Design Engineer.			

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5.2.7 Manholes

A. Manhole Spacing

The maximum distance between manholes shall be as follows:

Sanitary Sewer Pipe Size	Maximum Distance
8" – 15"	400'
18" – 30 "	500'
Larger than 30"	600'

B. Barrel Size

The alignment and number of pipes into the manhole will determine the barrel size for the size of pipe used. All 48-inch manholes will have eccentric cone top sections if total manhole height is greater than six feet. All other manholes will have flat tops. All drop manholes shall be "inside drop" with a minimum barrel diameter of 60-inch. The internal diameter of the manhole barrel shall be typically as follows:

Sanitary Sewer Pipe Size	Barrel Diameter
12" or less	48"
15" to 27"	60"
30" to 48"	72"

Manholes larger than seventy-two (72) inches may be allowed with specific approval by the City Engineering Division.

C. Manhole Channels

All manholes shall have full-depth channels. When a smaller main is being connected to a larger main at a manhole, the manhole inverts shall be set so that the 8/10 depth of flow of each main is equal in elevation. The minimum drop across a manhole (invert in to invert out) is 0.2' (cut-in manholes excepted).

D. All manholes located within streets shall be constructed with a concrete collar in accordance with the COB Standard Drawings.

5.2.8 Sanitary Sewer Mains

PVC pipe shall be used for all gravity flow main lines unless other materials are specifically approved by the City Engineering Division.

5.2.9 Sanitary Sewer Services

The minimum diameter of a service is 4-inch.

Services shall connect to the main with in-line gasketed wyes. A waiver to use an alternative connection method may be granted in circumstances where there would be numerous consecutive wyes to accommodate more than two services in close proximity to one another. Approved alternative connections shall be made by a core and tap with approved fitting. The minimum clearance between outside of service pipes shall be no more than the diameter of the adjacent service pipes or 6", whichever is greater.

The service line stub, from the main to the property line or easement line, shall be installed with a maximum slope of 1/2-inch per foot. The minimum slope of a 4-inch service line stub is 1/4-inch per foot. The minimum slope of a 6-inch service line stub is

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1/8-inch per foot. Sewer service line stubs will typically be installed 15-feet from the downstream lot line. Services are to be installed perpendicular to the main.

Each building shall have a separate service line from the building to the sewer main, with the following exception: Accessory Dwelling Units (ADUs) may share sewer service with the service from the primary dwelling unit on the lot, provided that the service is television inspected at the owner's expense, and the Water/Sewer Superintendent determines that the service is in an acceptable condition for shared use.

5.2.10 Access Roads

A 12'-wide all-weather gravel access road, with turnarounds if needed, shall be constructed to provide access to all sanitary sewer manholes not located within a paved public or private street or parking lot.

5.2.11 Cut-in Manholes

Pre-cast manhole bases are preferred for cut-in manholes. Poured-in-place cut-in manholes may only be used if approved by the Sewer Superintendent.

5.2.12 Temporary Sanitary Sewer Bypass

Existing flows for active sanitary sewer facilities must be maintained at all times. Temporary wastewater bypass systems shall be provided for projects affecting active sanitary sewer systems in accordance with COB Modifications to MPWSS.

5.2.13 Sanitary Sewer Lift Stations

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6.1. REGULATORY THRESHOLD

6.1.1 Applicability

These Storm Drainage Design Standards shall apply to Subdivision, Site Plan, Site Plan Modification, Master Site Plan development or redevelopment, and Infrastructure projects within the City of Bozeman, that exceeds the regulatory threshold. The regulatory threshold is defined as 5,000 square feet or more of developed area. If a new connection to the City's storm drainage system from an existing development exceeding this threshold is installed, the development's storm drainage system shall be brought into compliance with these Storm Drainage Design Standards.

6.1.2 Development

Development is construction on previously undeveloped land or construction expansion on partially developed land. The total developed area is used to determine if the threshold will be exceeded.

- I. For example, an existing site has a 10,000 sf lot, consisting of a 3,000 sf building, 500 sf of landscaped area, 1,000 sf of parking and hardscape (4,500 sf of developed area), and 5,500 sf of undeveloped area. The proposed project, through the ultimate phase of development, will add 3,000 sf to the building, 1,500 sf to the parking lot, and 500 sf of new landscaping (9,500 sf of developed area). Therefore, the regulatory threshold would be exceeded, and the project would need to comply with these Storm Drainage Design Standards.

6.1.3 Redevelopment

Redevelopment is the reconstruction of a previously developed site. Redevelopment occurs when existing facilities are demolished and rebuilt or substantially improved through reconstruction. For redevelopment, the regulatory threshold applies to the total area proposed for reconstruction.

- I. For example, an existing site has a 10,000 sf lot, consisting of a 6,000 sf building, 1,000 sf of landscaped area, and 2,500 sf of parking and hardscape (9,500 sf of developed area). Through redevelopment, 4,000 sf of the 6,000 sf building and 1,500 sf of the 2,500 sf of parking and hardscape will be reconstructed, for a total reconstructed area of 5,500 sf. The redevelopment would exceed the regulatory threshold and the site would need to be brought into compliance with these Storm Drainage Design Standards.

6.1.4 Compliance

The City Engineer reserves the right to require compliance with any or all of these Design Standards regardless of the size of the developed area or the amount of reconstruction.

6.1.5 Exemptions

- A. The following project categories are exempt from these Storm Drainage Design Standards:

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- I. Actions by a public utility or any other government agency to remove or alleviate an emergency condition, restore utility service, or reopen a public road to traffic.
- II. Projects that, when completed, will not have physically disturbed the land.
- III. Replacement of individual utilities.
- IV. Mill and Overlay, Chip seal, or fog seal projects.

6.2. REFERENCE DOCUMENTS

These standards are written for use by Engineers who are familiar with generally accepted hydrologic, hydraulic, water quality treatment, and hydrogeologic design principles. A detailed presentation of design methods and procedures is not included, as this information is readily available through industry-accepted publications. In particular, the Storm Drainage Design standards rely on the following key documents:

- a. Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 22 (HEC-22), "Urban Drainage Design", Publication No. FHWA-HIF-24-006, revised February 2024. References to specific sections of HEC-22 to be used for the design of storm drainage systems in the City of Bozeman are included throughout this document. HEC-22 is available on the FHWA Website ([Urban Drainage Design Manual - fhwa.dot.gov](https://www.fhwa.dot.gov/urban_drainage_design_manual/)).
- b. The current version of the *Montana Post-Construction Storm Water BMP Design Guidance Manual* shall be used for design of post-construction (permanent) stormwater management controls. This document is available on the City of Bozeman website ([Montana Post-Construction Storm Water BMP Design Guidance Manual - bozeman.net](https://www.bozeman.net/montana-post-construction-storm-water-bmp-design-guidance-manual)).
- c. The current version of the City of Bozeman *Best Management Practice (BMP) Manual for Construction Sites* ([Bozeman BMP Manual for Construction Sites - bozeman.net](https://www.bozeman.net/bozeman-bmp-manual-for-construction-sites)) shall be used as a guide for the proper application, materials, installation, and maintenance of temporary erosion and sediment control BMPs during construction activities.

References to additional documents for specific design elements are provided as appropriate.

Construction of storm drainage facilities shall be in accordance with the current edition of the Montana Public Works Standard Specifications (MPWSS) and the City of Bozeman Standard Modifications ([COB Mods to MPWSS](#)).

6.3. GENERAL REQUIREMENTS

The rate, volume and patterns of stormwater runoff from proposed projects shall be determined in accordance with these Storm Drainage Design standards and shall be the foundation of the Stormwater Drainage Plan.

General stormwater management requirements are as follows:

- a. The storm drainage system for a proposed development shall be arranged to allow for suitable development of adjoining un-developed land.
- b. Where a planned development will be crossed by or adjacent to a watercourse, such as a stream, swale, ditch, drain, channel, etc., the watercourse shall be preserved to the maximum extent possible. If preservation of the existing watercourse is not possible, Developer shall provide adequate accommodations to ensure that the function and integrity of the watercourse are properly maintained. Mitigation and setbacks from watercourses shall be as

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directed in [Section 38.410.100](#) of BMC. Applicable regulations from State and Federal agencies will also need to be met in the event existing watercourses are not preserved.

- c. Non-stormwater discharge (illicit discharge) is prohibited from entering the storm drain system as detailed in [BMC Chapter 40, Article 4, Division 4 – Regulations and Requirements](#).
- d. There exists the potential for ditches/drains to overtop during rain events, resulting in the potential for flooding of adjacent properties. Engineer shall account for this potential and provide appropriate mitigation measures through the planning, design, and construction of homes or businesses. This includes, but is not limited to, flood proofing or establishing appropriate building floor elevations and grading plans.
- e. There exists the potential for adjacent ditches/drains to leak, contributing to seasonally high groundwater conditions within the development, which will need to be accommodated in the design of stormwater management facilities, grading, and in establishing minimum building foundation elevations.
- f. Off-site runoff from the developed property shall perpetuate pre-development drainage patterns. Engineer shall verify that off-site discharge can be safely conveyed through the downstream neighboring properties to the point at which the runoff is collected in a viable drainage system.
- g. The minimum elevation of residential dwellings, commercial buildings, or other permanent facilities must be established in recognition of the City's design standard allowing for an 18-inch depth of flow in the gutter flowline of adjacent streets during the Major Storm.
- h. Post-project changes in flood hazards during the Major Storm due to changes to runoff volumes, rates, or patterns shall be identified, along with recommended mitigation measures.
- i. Due to the potential for increased pollutant runoff, some sites may be subject to additional regulatory and design requirements. Refer to Attachment A for the following facilities: Fueling station, facility storing/transporting more than 1,500 gallons of petroleum products, hydraulic equipment storage, property zoned controlled or heavy industrial, vehicle maintenance/repair, nurseries, lawn care/fertilizer facility, agricultural or animal care facility, or other similar facilities.
- j. Stormwater facilities in subdivisions or on private properties shall be owned, operated, and maintained by the subdivision Property Owner's Association (POA) or private property owner in accordance with [BMC Sec.40.04.720](#). No private facilities may be located in the public right-of-way unless approved by the City Engineering Division. The Acknowledgement of Stormwater Facility Maintenance Requirements, Operation, Inspection and Maintenance Plan, and the Stormwater Facility Inspection Form shall be included with the Stormwater Drainage Plan associated with these facilities.
- k. Stormwater management shall be implemented in accordance with [BMC Chapter 38, Article 4, Sec. 38.410.080 – Grading and Drainage](#) and the criteria provided herein.

6.4. STORMWATER DRAINAGE PLAN REQUIREMENTS

The Stormwater Drainage Plan shall provide a comprehensive presentation of the stormwater management strategy including geotechnical/hydrogeological considerations where appropriate, operation, inspection and maintenance plans, as well as the Acknowledgement of Stormwater Facility Maintenance Requirements.

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6.4.1 Stormwater Drainage Report

The Stormwater Drainage report shall include background information and supporting data, calculations, and map exhibits of the existing and proposed topography, contributing drainage basins and sub-basins, and drainage features. Both off-site and on-site contributing drainage areas shall be included. The report shall include a narrative describing in detail how the grading and drainage features (grading, storm drains, inlets, swales, permanent erosion protection, detention/retention ponds, water quality treatment features, outlet structures, etc.) will function for the Water Quality storm, the Minor storm, and the Major storm events. The report shall also describe how the proposed drainage plan integrates with previously approved drainage plans for the development as well as subsequent phases of the development. The standardized outline for the Stormwater Drainage report includes the following elements:

- a. Title Page
- b. Introduction
- c. Hydrology and Hydrogeology
- d. Existing Stormwater Drainage Conditions
- e. Proposed Stormwater Drainage System
- f. Evaluation of Major Storm Flood Risks
- g. Operation, Inspection, and Maintenance Considerations
- h. References
- i. Appendices

Additional details of the standardized outline are provided in Attachment B.

6.4.2 Geotechnical/ Hydrogeological Report

The purpose of the Geotechnical/Hydrogeological Report is to provide sufficient information such that the reviewer has a clear understanding of underlying soils and water table conditions and how those will interact with and be impacted by the proposed stormwater facilities. The report shall describe the potential impacts that stormwater runoff will have on groundwater levels, structures, and facilities both within and adjacent to the development as well as proposed mitigation solutions as needed. The geotechnical/hydrogeological report shall be signed by a Professional Engineer licensed in the State of Montana. Guidance for a typical Geotechnical/Hydrogeological evaluation to support design of stormwater infiltration facilities is provided in Attachment C.

6.4.3 Operation, Inspection, and Maintenance Plan

The purpose of the Operation, Inspection, and Maintenance (OI&M) Plan is to identify the party responsible for operations, inspection, and maintenance of the stormwater facility, detail inspection and maintenance schedules/activities, provide estimated costs and a financial plan for operation, inspection, and maintenance as well as facility replacement, to ensure the sustainability of the approved design operating conditions. Approval of the OI&M Plan must be received prior to approval of the development project. The OI&M Plan shall include a signed Waiver of Protest to the Formation and Participation in a Special Improvement District to fund operation, inspection, and maintenance activities.

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An Acknowledgement of Stormwater Facility Maintenance Requirements will also be required as a condition of approval. The OI&M Plan shall include the following:

- a. A description of the responsible party or entity for operation, inspection, and maintenance as well as replacement of storm drainage facilities and the legal mechanism for succession/assignment.
- b. A list of contact names and contact information (phone number, e-mail address, mailing address)
- c. Site plan illustrating the storm drainage facilities and system components.
- d. A detailed list of required maintenance and inspection activities, schedule, and frequency for the various system components.
- e. Stormwater Facility Inspection Form with exhibit illustrating maintenance inspection requirements (see Attachment E).
- f. Expected design life and replacement schedule for each component of the facility.
- g. Itemized cost estimates for recurring operation, inspection, and maintenance activities and planned facility replacement.
- h. A financial plan and funding mechanism for funding the recurring operation, inspection, and maintenance activities and planned facility replacement. The plan shall include sinking fund calculations considering estimated inflation over the life of the system components and a determination of the annual funding to be set-aside for operation, inspection, maintenance, and replacement needs.

The responsibility for proper maintenance of stormwater facilities is governed by [Chapter 40, Article 4, Division 5, Section 40.04.720 - Maintenance of Stormwater Facilities](#) of the BMC. Failure to provide proper maintenance or to correct deficiencies may result in civil or criminal penalties. The City of Bozeman may perform corrective, or maintenance work if the owner or responsible party fails to perform in a timely manner, at the expense of the owner or responsible party. A stormwater maintenance district may be formed in accordance with Montana Code Annotated (MCA) 7-12-4102 ([Authorization for creation of special improvement districts -- petition for creation, MCA \(mt.gov\)](#)) including all lots within the development.

6.4.4 Acknowledgement of Stormwater Facility Maintenance Requirements

An Acknowledgement of Stormwater Facility Maintenance Requirements shall be submitted to ensure sustained functionality of the stormwater facilities. A sample acknowledgement form is provided in Attachment D.

6.5. RAINFALL

6.5.1 Application

This section provides design storm frequency criteria and associated precipitation data to be used in the design of stormwater facilities within the City of Bozeman. The information provided for the Water Quality Storm is intended for use in the design of post-construction (permanent) stormwater management controls.

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6.5.2 Minor and Major Drainage Systems

Every community has two distinct drainage systems, whether or not they are actually planned or designed: 1) the Minor Drainage System and; 2) the Major Drainage System. In combination, the two form the Total Drainage System.

The Minor Drainage System is designed to transport the runoff from more frequent storm events with a minimum of disruption to the urban environment. For the City of Bozeman, the Minor Storm has a 10-year recurrence interval and shall be used for the design of stormwater interception and conveyance facilities.

Drainage systems shall also be evaluated for the Major (100-year) storm to minimize public health and life hazards, damage to structures, and interruption to traffic and services. Drainage interception and conveyance systems may need to be designed to convey a portion, or all, of the Major storm runoff if Major storm runoff cannot be safely conveyed to a suitable receiving system through natural or constructed drainageways, or if allowable flow depths in streets cannot be achieved (see Section 6.7.2).

Stormwater drainage planning and design shall address both the Minor and Major Drainage Systems.

Detention storage to control the rate of runoff to pre-developed levels shall be designed for the full range of storm events (2-year through 100-year).

6.5.3 Design Storm Depth and Intensity

Rainfall depths and intensities for durations from 5 minutes to 24 hours and recurrence intervals from 2 year to 100 years are provided in Table 6.5.1 and Table 6.5.2 respectively.

Table 6.5.1 – Precipitation Depth – Duration (Depth In Inches)						
Duration	2-year	5-year	10-year	25-year	50-year	100-year
5-min	0.17	0.26	0.32	0.40	0.45	0.51
10-min	0.25	0.38	0.47	0.58	0.66	0.74
15-min	0.31	0.47	0.57	0.71	0.81	0.90
20-min	0.33	0.50	0.61	0.75	0.86	0.96
25-min	0.35	0.53	0.65	0.80	0.92	1.03
30-min	0.37	0.56	0.69	0.85	0.97	1.09
35-min	0.38	0.58	0.71	0.87	1.00	1.12
40-min	0.39	0.59	0.73	0.90	1.02	1.15
45-min	0.40	0.61	0.75	0.92	1.05	1.18
50-min	0.41	0.62	0.76	0.94	1.07	1.20
55-min	0.42	0.63	0.77	0.95	1.08	1.22
1-hr	0.42	0.64	0.79	0.97	1.10	1.24
2-hr	0.49	0.68	0.81	0.98	1.10	1.22
3-hr	0.56	0.74	0.86	1.01	1.12	1.23
6-hr	0.71	0.88	0.99	1.14	1.24	1.35
12-hr	0.91	1.12	1.26	1.43	1.56	1.69
24-hr	1.18	1.49	1.70	1.96	2.15	2.34

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Based on DOWL Precipitation Analysis (2016)

Table 6.5.2 – Precipitation Intensity - Duration (Intensity In Inches per Hour)						
Duration	2-year	5-year	10-year	25-year	50-year	100-year
5-min	2.08	3.16	3.87	4.76	5.43	6.09
10-min	1.53	2.31	2.83	3.48	3.97	4.45
15-min	1.24	1.87	2.29	2.83	3.22	3.61
20-min	0.99	1.50	1.84	2.26	2.58	2.89
25-min	0.84	1.28	1.56	1.93	2.20	2.46
30-min	0.75	1.13	1.38	1.70	1.94	2.18
35-min	0.66	0.99	1.22	1.50	1.71	1.92
40-min	0.59	0.89	1.09	1.35	1.53	1.72
45-min	0.54	0.81	1.00	1.23	1.40	1.57
50-min	0.49	0.74	0.91	1.12	1.28	1.44
55-min	0.45	0.69	0.84	1.04	1.18	1.33
1-hr	0.42	0.64	0.79	0.97	1.10	1.24
2-hr	0.24	0.34	0.41	0.49	0.55	0.61
3-hr	0.19	0.25	0.29	0.34	0.37	0.41
6-hr	0.12	0.15	0.17	0.19	0.21	0.22
12-hr	0.08	0.09	0.10	0.12	0.13	0.14
24-hr	0.049	0.062	0.071	0.082	0.090	0.098

Based on DOWL Precipitation Analysis (2016)

The depth versus duration information in Table 6.5.1 shall be used together with the NRCS Type II rainfall distribution to develop a 24-hour storm hyetograph (precipitation depth versus time) to generate the runoff hydrograph (stormwater runoff versus time) for the contributing drainage area as described in Section 6.6. The rainfall intensities listed in Table 6.5.2 for the corresponding durations (times of concentration) shall be used in the Rational Method to determine peak runoff rates. For times of concentration other than those listed in Table 6.5.2, do not interpolate within Table 6.5.2 directly; rather, the corresponding intensity shall be determined using a linear interpolation of precipitation depths. (i.e., the 5-year, 22-minute rainfall depth interpolated from the 5-year, 20-minute and 25-minute depths is 0.51 inches, which translates to an intensity of 1.40 inches per hour).

6.6. RUNOFF

6.6.1 Application

This section discusses criteria for delineation of the contributing drainage basin and for selection of acceptable stormwater runoff calculation methods to be used for drainage design.

6.6.2 Drainage Basin Area

Developer is responsible for defining the drainage plan in areas where master drainage plans do not yet exist. The total drainage area, including upstream offsite areas, contributing stormwater runoff to the point of interest shall be included in the

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delineation of drainage basins. Runoff from upstream undeveloped land, not part of the proposed project, shall be included in the design calculations. Runoff from upstream developed property must be determined based on existing conditions or approved storm drainage improvement plans. A detailed contour map based on the most accurate topographic information available shall be used to define the limits of off-site contributing areas.

There are many irrigation ditches traversing the City of Bozeman. Irrigation ditches should generally, not be considered to be a basin boundary since storm runoff from up-basin may overtop the ditch and flow into the area of development.

Large drainage basins will typically need to be divided into sub-basins to effectively evaluate the pre-development and post-development stormwater runoff conditions.

6.6.3 Selection of Runoff Calculation Methods

Acceptable runoff calculation methods and their applications are summarized in Table 6.6.1.

Table 6.6.1 – Acceptable Runoff Calculation Methods		
Runoff Calculation Method	Applications	Limitations/Notes
NRCS Method	- Used for determining peak runoff rates and runoff hydrographs for larger drainage basins - Used for determining storage requirements for detention or retention facilities	- Appropriate for use on developments and basins larger than 5 acres
Rational Method	- Used for determining peak runoff rates for sizing conveyance systems - Should not be used when routing of runoff hydrographs is required	- Should only be used for developments and contributing drainage basins of 5 acres or less - Should only be used for basins with homogeneous land use
EPA SWMM	- Used for complex drainage systems requiring modeling of a network of system components	- Can be used for the full range of drainage design challenges.
Modified Rational Method	- A simplified method used for preliminary estimates of storage requirements for small drainages	- required detention volume is estimated by subtracting the total outflow volume from the Rational-based inflow volume (flow rate over the duration/time of concentration of interest) for each respective duration through the storm. - Should only be used for developments with homogenous land use and basins of 5 acres or less

Stormwater modeling software (e.g. Autodesk Storm and Sanitary Analysis, InfoSWMM, etc.) is appropriate for the full range of project types including large, complex Subdivisions or Master Site Plan developments. However, the hydrologic methods employed by the modeling software must be consistent with the approved methods outlined in this section and shall be pre-approved for use by the City Engineering Division.

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6.6.4 NRCS (SCS) Hydrograph Method

The NRCS Hydrograph Method shall be employed using the procedures detailed in Section 4.3.1.1 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)). The resulting peak flows should be verified against the results from other methods and, where practicable, against observed runoff during historic rainfall events in Bozeman to ensure reasonableness.

A. Soil Types

Use site-specific soils information to define runoff and infiltration characteristic of the development when available. Where site-specific soils information is not available, the Natural Resources Conservation Service (NRCS) Soil Survey of Gallatin County can be used to provide a preliminary determination of the soils and corresponding hydrologic soil groups for each drainage sub-basin ([Gallatin County Web Soil Survey \(usda.gov\)](http://www.usda.gov/gallatin-county-web-soil-survey/)).

B. Time of Concentration

The time of concentration shall be calculated using the procedures detailed in the TR-55 Method ([NRCS TR-55 - Urban Hydrology for Small Watersheds](http://www.nrcs.gov/tr-55-urban-hydrology-for-small-watersheds/)). Time of concentration (T_c) should range from five minute to 20 minutes for most basins. The final build-out of the development shall be considered in determining appropriate T_c flow paths. Sheet flow lengths shall be limited to no more than 150' and, unless approved by the City Engineering Division, flow paths from backyards shall not be considered in the determination of T_c . Multiple flow path scenarios shall be evaluated in selecting the flow path which results in the shortest time of concentration, which will govern determination of the peak flow rate.

C. Curve Numbers

Curve numbers (CNs) to be used shall be as set forth in Table 6.6.2. Depending on basin size, multiple CNs with associated runoff properties, representing multiple sub-basins may be required. Conservative estimates shall be used when selecting representative CN values.

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Table 6.6.2 – Runoff Curve Numbers for Urban Areas (Average Watershed Condition, $I_a = 0.2 S_R$)				
Land Use Description	Curve Numbers for Hydrologic Soil Group			
	A	B	C	D
Fully Developed Urban Areas (Vegetation Established)				
Lawns, open spaces, parks, golf courses, cemeteries, etc.				
Good condition; grass cover on 75% or more of the area	39	61	74	80
Fair condition; grass cover on 50 to 75% of the area	49	69	79	84
Paved parking lots, roofs, driveways, etc.	98	98	98	98
Streets and roads				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Paved with open ditches	83	89	92	93
Average % impervious*				
Commercial and business areas 85	89	92	94	95
Industrial districts 72	81	88	91	93
Residential Lots: Average % impervious*				
65	77	85	90	92
38	61	75	83	87
30	57	72	81	86
25	54	70	80	85
*Interpolate as necessary				
Developing Urban Areas (No Vegetation Established)				
Newly graded area	77	86	91	94
Native Ground Cover				
Herbaceous – mixture of grass, weeds and low growing brush, with brush the minor element (30%-70% ground cover)		71	81	89
Herbaceous – mixture of grass, weeds and low growing brush, with brush the minor element (>70% ground cover)		62	74	85
Sagebrush with grass understory		35	47	55
Pasture, grassland or range – continuous forage for grazing	39	61	74	80
Meadow – continuous grass, protected from grazing, mowed for hay	30	58	71	78
Cultivated Agricultural Lands				
Row crops	67	78	85	89
Close-seeded or broadcast legumes or rotation meadow	58	72	81	85
Small grain crops	63	75	83	87

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6.6.5 Rational Method

One of the simplest and most widely used equations for the calculation of peak runoff from small basins is the Rational formula, as follows:

$$Q = C_f CIA$$

Where: Q = Flow in cfs,

C_f = correction factor for infrequent storms,

C = a dimensionless runoff coefficient,

I = rainfall intensity in inches per hour, and

A = drainage area in acres

The Rational Method shall be applied using the procedures detailed in Section 4.2.2 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)) except as modified herein. The resulting peak flows should be verified against the results from other methods and, where possible, against observed runoff during historic rainfall events in Bozeman to ensure reasonableness.

A. Frequency Correction Factors

Table 6.6.3 lists the correction factor to be used for infrequent (severe) storm events.

Table 6.6.3 – Frequency Correction Factors for Rational Method	
Recurrence Interval (years)	Adjustment Factor C_f
2 through 10-year	1.00
25-Year	1.10
50-Year	1.20
100-Year	1.25
NOTE: $C \cdot C_f$ should not exceed 1.00	

B. Time of Concentration

The time of concentration shall be calculated using the procedures detailed in Section 4.2.2.3 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)). Time of concentration (T_c) should range from five minute to 20 minutes for most basins. The final build-out of the development shall be considered in determining appropriate T_c flow paths. Sheet flow lengths shall be limited to no more than 150' and, unless approved by the City Engineering Division, flow paths from backyards shall not be considered in the determination of T_c . Multiple flow path scenarios shall be evaluated in selecting the flow path which results in the shortest time of concentration, which will govern determination of the peak flow rate.

C. Runoff Coefficients

Runoff Coefficients to be used shall be as set forth in Table 6.6.4. Depending on the land use within the basin area, multiple runoff coefficients may be required. Sub-basins for use with the Rational Method shall be delineated to represent generally homogenous land uses. Where basins include a mix of highly variable land uses, the Rational Method can generate unrealistically low peak flow rates due to use of

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unrealistically low weighted-average runoff coefficients. Conservative estimates shall be used when selecting representative runoff coefficients.

Table 6.6.4 – Runoff Coefficients ("C") for the Rational Method	
Type of Drainage Area	Runoff Coefficient, C*
Residential:	
Neighborhood areas	0.70
Single-family areas	0.50
Multi-units, detached	0.60
Multi-units, attached	0.75
Apartment dwelling areas	0.70
Industrial:	
Light use areas	0.80
Heavy use areas	0.90
Parks, cemeteries	0.10 – 0.25
Playgrounds	0.20 – 0.40
Railroad yard areas	0.20 – 0.40
Unimproved areas (forest)	0.10 – 0.30
Lawns:	
Sandy soil, flat, 2%	0.10
Sandy soil, average, 2-7%	0.15
Sandy soil, steep, 7%	0.20
Heavy soil, flat, 2%	0.17
Heavy soil, average 2-7%	0.22
Heavy soil, steep, 7%	0.35
Streets, parking lots and other paved areas:	
Asphaltic and concrete	0.95
Brick	0.85
Drives, walks and roofs	0.95
Gravel Areas	0.70-.85

*Higher values are usually appropriate for steeply sloped areas and longer return periods (severe storms) as infiltration and other losses have a proportionally smaller effect on runoff in these cases.

6.6.6 EPA SWMM Runoff Method

The EPA SWMM runoff method is widely accepted and can be used for the full range of project types including large complex drainage basins, Subdivisions, or Master Site Plans. The resulting peak flows should be compared to the results from other methods and, where possible, against observed runoff during historic rainfall events in Bozeman to ensure reasonableness.

6.6.7 Modified Rational Method

The Modified Rational Method (also known as the Rational Method Triangular Hydrograph Method) was developed prior to the availability of computer aided software, with the intent of using the simplistic rational method for volumetric sizing of storage facilities (Poertner, 1974). The Modified Rational Method approximates the volume of runoff for each duration through a storm event (5 minutes through the full storm duration) with peak flows based on the time of concentration for each respective duration and a triangular approximation of the runoff hydrograph for each. The difference between the volume of runoff into the facility and the outflow from the facility during

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each respective duration through the storm is used to estimate the maximum accumulated detention storage requirement. See Chapter 10 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)).

This simplified approach is more valid for small homogenous basins such as rooftop drainage, parking lots, or other small components of a development, with contributing areas less than 5 acres.

6.7. HYDRAULIC ANALYSIS AND DESIGN

6.7.1 Application

This section provides criteria to be used in the design of public storm drainage infrastructure including gutters, inlets, manholes, storm drains, open channels, culverts, and bridges to safely convey storm runoff.

6.7.2 Gutter Flow

The primary purpose of streets is to convey traffic and the use of streets for stormwater runoff conveyance must therefore be restricted. However, streets are an integral part of both the Minor and Major drainage systems and may be used for transporting a controlled amount of storm runoff. The City of Bozeman allows the use of streets for drainage within the limitations specified in Table 6.7.1 and Table 6.7.2. The functional classification of streets within the City of Bozeman are defined in the most recent version of the Bozeman Transportation Master Plan ([2017 Bozeman TMP](#)).

Table 6.7.1 – Allowable Use of Streets for Minor Storm Runoff	
Street Classification	Maximum Street Encroachment
Local	No curb overtopping. Flow may spread to crown of street. ¹
Collectors	No curb overtopping. Flow spread must leave at least one, 11' lane free of water. ¹
Arterials	No curb overtopping. Flow spread must leave at least two, 11' lanes free of water. ¹
Arterials (more than 6 lanes)	No curb overtopping. Flow spread must leave at least four, 11' lanes free of water. ¹

¹Where no curbing exists, encroachment shall not extend beyond property lines, except at drainage easements.

Table 6.7.2 – Allowable Use of Streets for Major Storm Runoff	
Street Classification	Maximum Depth
Local and Collectors	The depth of water at the gutter flowline shall not exceed 18 inches. Residential dwellings and public, commercial, and industrial buildings shall not be inundated at the ground line unless flood-proofed.
Arterials	To allow for emergency vehicles, the depth of flow at the street crown shall be no more than six inches. Residential dwellings and public, commercial, and industrial buildings shall not be inundated at the ground line unless flood-proofed.

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A. Hydraulics

Gutter flow encroachment and hydraulics shall be evaluated using the methods presented in Section 5.3 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)).

B. Minimum Gutter Slope

Gutters shall be constructed at slopes no flatter than 0.4 percent for retrofit conditions and 0.6 percent for new construction. Proper drainage shall also be considered in the design of roadway vertical curves. The gutter slopes at the locations 50 feet either side of high points or low points shall be at least 0.3 percent to achieve proper drainage. The length of the vertical curve shall correspondingly be based upon a K-value of 167 or less. Where this K-value is exceeded, separate gutter profiles from the centerline profile may be required, resulting in varying cross slopes to ensure adequate drainage. Flanking inlets or slotted drain may also be required on either side of sags for proper gutter flow interception.

C. Inlets

I. General

The interception capacity and required spacing of inlets shall be determined in accordance with the procedures described in Chapter 7 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)).

Recommended Locations for inlets:

- a. Upstream of pedestrian crossings
- b. At low points in the gutter grade
- c. Where significant inflows from off the right-of-way are expected
- d. On horizontal curves where a change from normal crown to super-elevation may cause water to sheet-flow across the road
- e. Where lay-down curb (e.g., at approaches) may allow the flow to escape and cause flooding
- f. Where necessary to maintain gutter flow spread widths and depths within the allowable limits set forth in Table 6.7.1 and Table 6.7.2
- g. Mid-block inlets within subdivisions, shall be located along property lines to minimize impacts to future driveways and other development features
- h. Where a curbed roadway crosses a bridge, the gutter flow should be intercepted and not permitted to flow onto the bridge

II. Inlet Types

Allowable storm drain inlets are detailed in the City of Bozeman Standard Modifications to the Montana Public Works Standard Specifications (MPWSS) on Standard Drawings 02720-1 through 02720-11 ([COB Mods to MPWSS](#)). Other inlets may be allowed with approval of the City Engineering Division.

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- a. Inlets in sag locations – inlet capacity in sump locations shall reflect 50 percent plugging by debris (design capacity equals 50 percent of the theoretical capacity).
- b. Inlets at on-grade locations – inlet capacity on-grade shall reflect 25 percent plugging by debris, (design capacity equals 75 percent of the theoretical capacity).
- c. Inlets installed within the right-of-way, or adjacent to trails, sidewalks, and bike lanes must have grates that are designated for use with pedestrian and bicycle traffic. Approval from the City Engineering Division is required for inlets within the right-of-way that are not designated for pedestrian and bicycle traffic.
- d. The capacity of inlet grates shall be checked against the capacity of the inlet lateral pipe to ensure that the lateral pipe has adequate capacity to convey intercepted runoff from the inlet(s).

D. Sidewalk Chases:

- I. The use of sidewalk chases is discouraged, and their use is limited to situations where it is not possible to use standard storm inlets and piping. Stormwater from concentrated points of discharge shall not be allowed to flow over sidewalks but shall drain to the roadway by the use of chase sections, where necessary.
- II. Chase sections shall not be located within a curb cut of driveways. Chase sections shall be identified by station and elevation.
- III. Sidewalk chase sections are to be constructed in accordance with the City of Bozeman Standard Drawings.

6.7.3 Storm Drains

A. Hydraulics

Use the methods set forth in Chapter 9 of the HEC-22 Manual for the hydraulic design of storm drains ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage/)), except as modified herein.

I. Freeboard Requirements

Storm drains shall be designed to operate in an open channel (non-pressurized) flow condition during the Minor storm. Storm drains may be designed to pressurize (surcharge) during Major storm events; however, surcharging shall not result in a hydraulic grade line (HGL) elevation higher than the criteria listed in Table 6.7.2.

II. Diameter, Slope, and Velocity Limits

Minimum slopes for storm drains shall be as required to maintain a full-flow velocity of at least 2.5 feet per second during the Minor Storm. Maximum full-flow velocity shall be limited to 12 feet per second in storm drain mains during the Minor Storm.

Minimum diameter for storm drain main lines, which will be part of the public storm drainage system, shall be 15 inches. Minimum diameter for storm drain

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laterals shall be 12 inches. Minimum diameter for private connections into the public storm drainage system shall be 6 inches as discussed in Section 6.7.3E. Pipe sizes shall increase in the downstream direction and transitions from smaller pipes to larger pipes shall occur by matching the inside top (crown) of the pipes where practicable. Where it is not possible to match crowns, the 80-percent diameter points of the pipes shall be matched, where necessary and with approval from the City Engineering Division, inverts may be matched if the HGL during the Minor Storm does not exceed the gutter flowline elevation.

III. Manning “n” Values

The Manning’s “n” value used for the design of storm drains shall be as shown in Table 6.7.3.

Table 6.7.3 – Manning’s Coefficients (n) for Storm Drain Conduits		
Pipe Material	Roughness or Corrugation	Manning’s n
Concrete Pipe	Smooth	0.013
Concrete Boxes	Smooth	0.015
Spiral Rib Metal Pipe	Smooth	0.013
Corrugated Metal Pipe, Pipe-Arch and Box	2-2/3 by 1/2 in Annular	0.027
	2-2/3 by 1/2 in Helical	0.023
	6 by 1 in Helical	0.025
	5 by 1 in	0.026
	3 by 1 in	0.028
	6 by 2 in Structural Plate	0.035
	9 by 2-1/2 in Structural Plate	0.037
Poly Based Thermoplastic	Smooth	0.015
	Corrugated	0.025
PVC Based Thermoplastic	Smooth	0.011

*Published values may differ. Values presented in this table assume long term use of pipe which leads to increased roughness. Manufacturer recommendations shall be used if values are higher than presented above.

B. Materials

Storm drain materials and installation shall be in accordance with the City of Bozeman Standard Modifications to the Montana Public Works Standard Specifications ([COB Mods to MPWSS](#)). Minimum cover and structural design of storm drains shall be based on the material type, bedding, and backfill specified. HS-20 live loading shall be assumed unless unique conditions of the crossing warrant a higher load capacity (i.e., HS-25 or E-80). Seasonal high water table shall also be considered in determining buoyancy forces and to preclude submergence of the storm drain system.

C. Access Manholes

I. General

Access manholes are required when joining pipes of different type or sizes, at horizontal or vertical bends in the alignment, at lateral connections, and at the upstream terminus of storm drain mains.

II. Required Size

The required minimum manhole size shall be as shown in Table 6.7.4.

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Table 6.7.4 – Minimum Allowable Manhole Size

Storm Drain Diameter	Manhole Diameter
12" to 24"	4'
27" to 36"	5'
42"	6'
48" and larger	Junction box or Tee Manhole

Larger manhole diameters or junction vaults may be required when storm drain alignments are not straight through or where lateral pipes enter the manhole. The number and size of pipes that may be connected to any single manhole is limited in order to maintain the integrity of the structure. For angled connections or those with several pipes on the same plane, a larger manhole than set forth in the Table 6.7.4 may be required. For structural integrity, minimum undisturbed wall (edge of pipe opening to edge of pipe opening through the manhole wall) shall be 8 inches and for 72-inch and larger diameter structures, the minimum undisturbed wall between openings shall be 12 inches, unless otherwise allowed by the manufacturer's engineer.

III. Required Spacing

The maximum manhole spacing along storm drains is as set forth in Table 6.7.5.

Table 6.7.5 – Maximum Allowable Manhole Spacing

Storm Drain Diameter	Maximum Spacing
12" to 36"	400'
42" to 60"	500'
66" and Larger	600'

IV. Maximum Manhole Depth

Manhole depths shall not exceed 20 feet without special safety provisions such as intermediate platforms and minimum diameter risers of 48 inches.

V. Drop Manholes

The difference between the highest trunk line pipe invert entering a standard manhole and the invert leaving shall not exceed 24 inches. Manholes exceeding 24 inches of fall shall be designed as drop manholes. Drop manholes with drop heights exceeding six feet shall be designed with high strength (6,000 psi) concrete.

D. Clearance from Other Utilities

The following utility clearances shall be maintained where possible. Exceptions shall be approved by the City Engineering Division. All clearances are based on the outside edge of the storm drain to the outside edge of the other utilities.

a. Horizontal clearances from storm main:

Cable TV, Gas, Power	5 feet
Telephone, Fiber Optics	5 feet
Sewer	5 feet
Water	10 feet

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b. Vertical clearances from storm main:

Cable TV, Gas, Power	1 foot
Telephone, Fiber Optics	1 foot
Misc. Private Utilities	1 foot
Sewer	1 foot
Water	1.5 feet

c. Water main crossings shall be designed to prevent freezing due to minimal clearance from storm drains.

d. Avoid crossing other utilities at highly acute angles. The angle measured between utilities shall be between 45 and 90 degrees.

E. Private Drainage System Connections

Private drainage system connections to the public storm drain system shall be approved by the City Engineering Division and shall comply with the following criteria. Such connections shall be owned and maintained to the property line or edge of easement by the property owner's association or private property owner.

- a. Private stormwater connections shall include backflow prevention where necessary to prevent stormwater from the City's storm drain system from surcharging onto private property. Backflow preventer must be installed on-site and not within the public right-of-way.
- b. The minimum pipe diameter for connections to the City's storm drain system shall be 6 inches, with a minimum slope of 1 percent to provide adequate scour velocity. The maximum pipe diameter allowed will depend on an evaluation of the capacity of the City's storm drain system and approval from the City Engineering Division.
- c. Direct connections of pumped discharge to the City's storm drain system are not allowed. Pumped discharge to control stormwater runoff per the requirements of this manual are allowed; however, pumped discharge shall be connected to a manhole or other access structure and the connection to the City's storm drain shall be made through a gravity connection.
- d. Private connections to the City's storm drain shall be made at right angles.
- e. Private connections to the City storm drain shall be made by the following (in order of preference):
 - o Core-drill and install appropriate fitting connection to the main line; or
 - o Connect to an adjacent catch basin or manhole. Such connection shall only be made with approval from the City Engineering Division if it is deemed to be in the best interest of the City.

F. Outfalls

I. General

- a. Use the guidance set forth in Section 9.1.5 of the HEC-22 Manual (Urban Drainage Design Manual - fhwa.dot.gov) as modified herein.

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- b. Invert elevations of outfalls shall be no lower than the bank-full water surface elevation (estimated as the 2-yr flood) in open channels or streams, where practicable.
- c. Outfalls downstream of detention facilities shall be designed to prevent backwater into those facilities.
- d. Outfalls into ditches/drains shall be constructed of material that will not be damaged by fire.

II. Erosion Protection and Energy Dissipation

- a. Erosion protection is required at the outfall to prevent erosion of the outfall channel bed and banks.
- b. Where flow velocities exceed 10 feet-per-second at the outfall during the Minor Storm (when the outfall conduit is running at design capacity), energy dissipation in addition to erosion protection shall be required to prevent erosion. Design energy dissipation measures in accordance with FHWA Hydraulic Engineering Circular (HEC) No. 14 ([Hydraulic Design of Energy Dissipators for Culverts and Channels - fhwa.dot.gov](https://www.fhwa.dot.gov/publications/hydraulic_engineering_circulars/hec14/)).
- c. The size classification of riprap used for erosion protection or energy dissipation shall be in accordance with the Montana Department of Transportation's Standard Specifications for Construction, Division 700 ([MDT Standard Specifications - mdt.mt.gov](https://www.mdt.mt.gov/standard-specifications/)).

G. Maintenance Access

All storm drain components (storm drain main, manholes, inlets, laterals, and outfalls) shall be accessible for operation and maintenance by the City of Bozeman, the property owners' association, or the private property owner.

When vehicle access is necessary, for maintenance of facilities constructed outside of the street section, access roads shall be provided in dedicated access easements. The minimum clear driving lane width of access roads is 12 feet. Access roads shall have a maximum grade of nine percent and shall be constructed with gravel, asphalt, concrete or other appropriate all-season surfacing.

Gates and/or bollards are required when necessary to restrict access to stormwater facilities.

6.7.4 Open Channel Conveyances

A. General

Design open channels that convey collected stormwater in accordance with the methods provided in Chapter 6 of HEC-22 ([Urban Drainage Design Manual - fhwa.dot.gov](https://www.fhwa.dot.gov/publications/hydraulic_engineering_circulars/hec22/)) except as modified herein. Boulevard swales that convey significant stormwater flows are considered a category of Open Channel Conveyance. Boulevard swales used for stormwater runoff control are discussed in Section 6.8.4.

Constructed drainage channels shall be lined with native vegetation, riprap or other erosion resistant materials. Concrete or asphalt shall not be used unless approved by the City Engineering Division.

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B. Clearance

Constructed drainage channels shall be located no closer than ten feet from any structure foundation as measured horizontally from the edge of the swale at the top of freeboard elevation.

C. Erosion Control

Channel segments shall be designed based on the permissible tractive force (shear stress) methodology set forth in Section 6.3 of HEC-22 ([Urban Drainage Design Manual - fhwa.dot.gov](https://www.fhwa.dot.gov/urban_drainage_design_manual/)) and HEC-15 ([Design of Roadside Channels with Flexible Linings - fhwa.dot.gov](https://www.fhwa.dot.gov/design_of_roadside_channels_with_flexible_linings/)).

Both the bare soil condition immediately following construction, and the anticipated vegetated conditions of the channel shall be evaluated. If the channel is determined to be unstable during the Minor Storm for either of these conditions, the appropriate long-term and transitional temporary linings shall be installed.

Erosion control structures, such as check drops or check dams, may be required to control flow velocities.

Soil preparation and planting of approved grass seed mixes shall conform to the City of Bozeman Landscape and Irrigation Performance and Design Standards Manual.

D. Freeboard Requirements

The maximum water surface elevation during the Major Storm shall be no less than one foot below the adjacent ground, window well, finished floor, top of foundation or any other entry point vulnerable to flooding for residential dwellings and public, commercial, and industrial buildings.

E. Roughness Coefficient (n)

Use Manning's roughness coefficients (n) for lined channels as set forth in Table 6.1 of HEC-22 ([Urban Drainage Design Manual - fhwa.dot.gov](https://www.fhwa.dot.gov/urban_drainage_design_manual/)). The design shall consider the channel roughness both immediately after construction and when vegetation is fully established. Conservatively high roughness coefficients, representative of unmaintained channel conditions, shall be used for the analysis of water surface profiles. Conservatively low roughness coefficients, representative of channel conditions prior to full vegetation establishment shall be used to determine maximum flow velocity in assessing appropriate erosion protection.

F. Side Slopes

Side slopes shall be no steeper than 4H:1V for grass-lined channels which need to be mowed, 3H:1V for unmaintained slopes of native vegetation, and 2H:1V for riprap-lined channels.

G. Maintenance Access

Provide maintenance access for inspection, mowing operations, and debris removal by conventional equipment along the full length of the conveyance channel. The type of equipment needing access is dependent on the size of the channel. Large channels will need access for dump trucks and loaders. For small ditches, pedestrian or pick-up

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truck access may be adequate. Channels may need to be offset within the easement to facilitate maintenance.

H. Operation & Maintenance of Open Channels

Maintenance of open channels is required to insure the conveyance capacity of the facility is maintained and that channel erosion does not occur. The condition of open channels should be checked periodically, especially after large storms or extended periods of high flow or immediately following periods of high intensity winds. Debris should be removed to prevent channel plugging, channel scour, and loss of channel conveyance. Erosion shall be repaired or stabilized.

Vegetated channels shall be maintained to ensure that vegetation does not limit the conveyance capacity of the facility. If conveyance restrictions are apparent, the vegetation should be trimmed to restore capacity. Vegetation above the ordinary high-water mark shall also be monitored primarily for its ability to retain bank stability without reducing channel capacity during high runoff from the Major Storm.

Maintenance of private conveyance channels shall be the responsibility of the facility owner as governed by [Section 40.04.720 - Maintenance of Stormwater Facilities](#) of the BMC.

6.7.5 Culverts

Culverts are used to convey water in irrigation ditches and natural drainage-ways under City Streets and trails. Culverts shall be designed using the methods set forth in the Federal Highway Administration (FHWA) Hydraulic Design Series No. 5 ([Hydraulic Design of Highway Culverts - fhwa.dot.gov](#)), except as modified herein.

A. Minimum Diameter

Culverts crossing streets and roadways shall not be smaller than a 24-inch equivalent diameter. Culverts crossing driveways shall not be smaller than a 15-inch equivalent diameter.

B. Street Overtopping

Culverts shall be sized such that the depth of street overtopping is limited as set forth in Table 6.7.6.

Table 6.7.6 – Allowable Street Overtopping Depths at Culvert Crossings		
Street Classification	Minor Storm	Major Storm
Local and Collector	None	Six inches at the street crown. Residential dwellings and public, commercial, and industrial buildings shall not be inundated at the ground line unless flood proofed.
Arterial	None	No overtopping allowed. Provide a minimum of 1-ft of clearance between the crown of the culvert and the water surface elevation where practicable, for drainage basins greater than one square miles.

C. Headwater Depth

The headwater (HW) depth shall be limited according to the following ratios to diameter (D):

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- a. For culverts with a cross-sectional area less than or equal to 30 square feet: $HW/D \leq 1.5$
- b. For culverts with a cross-sectional area greater than 30 square feet: $HW/D \leq 1.2$

Culverts must also be sized to minimize upstream backwater, such that the channel upstream is not overtopped during the Minor Storm event and flood hazards to upstream structures are not increased during the Major Storm.

D. Allowable Velocities

Culverts shall be designed to maintain a minimum velocity of 2.5 feet-per-second during the Minor Storm to prevent sediment accumulation and shall be designed with a minimum slope of 0.5 percent, where practicable.

Culverts shall be sized to limit velocities in order to minimize erosion potential during the Major Storm. For exit velocities in excess of 10 feet-per-second during the Major Storm, energy dissipation in addition to erosion protection shall be required to minimize erosion. Design energy dissipation features in accordance with FHWA Hydraulic Engineering Circular (HEC) No. 14 ([Hydraulic Design of Energy Dissipators for Culverts and Channels - .fhwa.dot.gov](https://www.fhwa.dot.gov/publications/hydraulic_engineering_circulars/hec14/hec14.pdf)).

E. Culvert Materials

Culverts shall be constructed of materials specified in the City of Bozeman Standard Modifications to the Montana Public Work Standard Specifications ([COB Mods to MPWSS](#)).

Culvert wall strengths and coatings shall be suitable for the soil conditions, design depths, bedding, backfill, and trench details. Culvert strength shall be designed assuming HS-20 live load capacity unless unique conditions of the crossing warrant a higher load capacity (i.e., HS-25 or E-80).

When an abrasive bed load is anticipated or when velocities exceed 10 feet per second, protective measures shall be implemented to limit pipe damage. Corrosion potential and groundwater levels shall also be considered in determining appropriate culvert materials and joint types. Corrosion potential shall be evaluated based on Resistivity, pH, Marble pH, and Sulfate content of the soil and groundwater.

F. End Treatments

Culverts shall be designed with appropriate end treatments at inlets and outlets to provide smooth hydraulic transitions and to conform to embankment slopes. Flared end sections shall generally be used per the City of Bozeman Standard Modifications to the MPWSS ([COB Mods to MPWSS](#)). Headwalls or wingwalls may also be appropriate where flared end sections will not provide adequate support for taller embankments. Materials used for end treatments at ditches/drains shall be able to withstand fire. Erosion protection and/or energy dissipators shall be provided as necessary to limit erosion. Depending on the culvert location, a safety grate or trash rack may be needed.

G. Maintenance Access

Provide maintenance access to the upstream and downstream ends of culverts for inspection and debris removal.

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6.7.6 Bridges

Hydraulic sizing for bridges across major drainages shall conform to the requirements of the Montana Department of Transportation (MDT).

6.8. RUNOFF CONTROL FACILITIES

6.8.1 Application

This section provides criteria for design of runoff control facilities including detention basins, retention/infiltration basins, and boulevard swales. These facilities are used to control the quantity of runoff discharged from the project site by storing runoff and releasing flow at a controlled rate through an outlet structure or through evaporation and infiltration. These runoff control facilities may also be used in conjunction with water quality treatment facilities discussed in Section 6.9. Runoff control facilities shall be sized with adequate volume to limit post-development runoff rates for the full range of potential storms (2-year through 100-year) to pre-development levels. Full retention of post-development runoff from the Major Storm (100-year, 24-hour) shall be required where no viable receiving conveyance channel or drainage system is available.

6.8.2 Detention Basins

Detention basins can be designed as a standalone facility, also known as a Dry Pond, where inflow runoff is routed through the basin and released at a controlled rate until the basin is completely drained out (see Extended Detention Basin in [Montana Post-Construction Storm Water BMP Design Guidance Manual - bozeman.net](https://www.bozeman.net/files/2018/05/Montana-Post-Construction-Storm-Water-BMP-Design-Guidance-Manual.pdf)). They can also be designed to “stack” on top of Wet Ponds in elevated water tables (see Wet Detention Basin in [Montana Post-Construction Storm Water BMP Design Guidance Manual - bozeman.net](https://www.bozeman.net/files/2018/05/Montana-Post-Construction-Storm-Water-BMP-Design-Guidance-Manual.pdf)) where temporarily stored runoff will drain down to the original wet pond water surface elevation at a controlled outflow rate, after the storm passes. Further details of permanent water quality BMPs are provided in Section 6.9

Parking lots can be used for on-site detention storage to control runoff from the Major Storm. Detention storage for the Minor Storm shall, however, be provided through a dedicated storage facility. Above ground storage in parking lots may not pond to a depth greater than 12 inches during the Major Storm.

Design of detention basins shall follow the procedures presented in Chapter 10 of the HEC-22 Manual, as modified herein ([Urban Drainage Design Manual - fhwa.dot.gov](https://www.fhwa.dot.gov/urban_drainage/)).

A. Groundwater

Where shallow groundwater is possible, the seasonal-high groundwater elevation must be determined in the design of detention basins to ensure that sufficient capacity will be available in the basin, above the historic, seasonal-high water table, for storage of stormwater runoff. For standalone dry detention basins, the historic, seasonal-high water table level shall be a minimum of two feet below the bottom of basin to avoid saturated conditions which interfere with performance of the facility. The seasonal-high water table level must be defined through at least one season of water table monitoring at the location of the proposed facility. Other means of establishing the site-specific seasonal-high water table may be accepted if approved by the City Engineering Division.

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B. Basin Geometry

- a. The maximum water level at any time shall not exceed a total depth of 6 feet (Dry Ponds alone or Dry Ponds “stacked” on top of Wet Ponds).
- b. Side slopes shall be no steeper than 4H:1V for slopes which need to be mowed, 3H:1V for unmaintained slopes of native vegetation, and 2H:1V for riprap-lined slopes.
- c. Embankment fill slopes for detention basins shall be no steeper than 3H:1V and preferably 4H:1V or flatter.
- d. The maximum water surface elevation during the Major (100-year) Storm shall be no less than one foot below the adjacent ground, window well, finished floor, top of foundation or any other entry point vulnerable to flooding for residential dwellings and public, commercial, and industrial buildings.
- e. Safety benches of 4 feet minimum width shall be included around the perimeter of wet ponds at the normal water level in those instances where the pond water depth exceeds 2.5 feet to provide a shallow area for people and animals that inadvertently enter the open water, to exit. Side slopes above the safety bench shall be no steeper than 4H:1V.

C. Maximum Drain-Down Time

Detention basins are used to limit discharge from the site to pre-development runoff rates. The water surface in the facility shall return to the pre-storm level within 72-hours after cessation of the storm.

D. Multi-Purpose Use

Detention facilities designed for multi-purpose use (sport courts, neighborhood parks, play areas, picnic areas, parking lots, etc.) are allowed. Multi-use amenities shall be anchored as needed to prevent floatation.

Runoff from, at a minimum, the Water Quality Storm event (see Section 6.9) shall be stored separately from the multiple use areas, in an area with the sole purpose of stormwater runoff storage.

Developer shall make arrangement for maintenance of such amenities unless such responsibility is accepted in advance by the City of Bozeman.

E. Setbacks

Setbacks for detention basins shall be established in accordance with the following:

- a. The minimum clearance to adjacent structure foundations or other facilities shall be at least ten (10) feet as measured horizontally from the top of freeboard elevation at the detention pond bank,
- b. adequate access shall be provided for operation and maintenance, and
- c. the relevant provisions of ARM 17.36.323 and Circular DEQ-8 shall be met.

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F. Water Quality Treatment

If the Dry Pond is being designed as a standalone facility, stormwater runoff from the water quality event shall be routed through a separate water quality treatment device, sediment forebay, or other appropriate water quality BMP, detailed in Section 6.9, prior to discharging to the detention basin, to facilitate removal of transported sediments and debris. If other pollutants such as oils, grease, or fuel (gasoline and diesel) could be present in the site runoff, the development may be subject to additional regulatory and design requirements (see Attachment A).

G. Outlet Control Structures

Outlet control structures shall be designed using the criteria and methods set forth in Chapter 10 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)), as modified herein.

- a. The outlet structure shall be designed to control outflows to pre-development runoff rates for the full range of storm events (2-year through 100-year).
- b. Minimum orifice diameter without screening is six inches. Screening shall be provided to prevent blockage for orifices of smaller diameter. Consider using perforated pipes with gravels as a filter media to prevent clogging for low-flow applications where appropriate.
- c. The minimum diameter for outlet conduits shall be 12 inches to facilitate maintenance. Anti-seep collars shall be placed around outlet conduits through embankments.

H. Emergency Overflow & Spillways

Use the criteria and methods set forth in Chapter 10 of the HEC-22 Manual ([Urban Drainage Design Manual - fhwa.dot.gov](http://www.fhwa.dot.gov/urban_drainage_design_manual/)), as modified herein. Overflow spillways shall include erosion protection capable of withstanding flows from extreme storm events. Overflows shall be directed along a safe discharge path to protect adjacent and downstream properties from damage. Runoff leaving the site shall be at the same location as pre-development runoff and shall be no greater than pre-developed flow rates.

I. Vegetation & Landscaping

Detention basins shall be landscaped to provide for slope stability, erosion control, and low maintenance. Landscape and irrigation plans shall be developed in accordance with the City of Bozeman Landscape and Irrigation Performance and Design Standards Manual. Floatable or erodible material (i.e., wood chips, straw mulch, etc.) shall not be allowed within the basin.

J. Maintenance and Maintenance Access

- Maintenance shall be performed by the property owners' association or commercial site owner, unless this responsibility is accepted by the City of Bozeman. An example Acknowledgement of Stormwater Facility Maintenance Requirements is provided in Attachment D.
- Regular inspection and maintenance will be required to remove invasive plants and accumulated sediment and debris. The responsibility for proper maintenance of

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stormwater facilities is governed by [Chapter 40, Article 4, Division 5, Section 40.04.720 - Maintenance of Stormwater Facilities](#) of the BMC.

- Approval of detention basins shall obligate the owner to repair, replace, or reconstruct the system if it fails to operate as designed and this shall be included as a provision of the Operation, Inspection, and Maintenance plan. Developer may be required to mitigate system deficiencies beyond the required warranty period, if the deficiencies were found to be the result of improper design, construction, or maintenance. Further, if the system fails to function properly, during Minor and Major storm events, Developer may be required to mitigate deficiencies beyond the warranty period.
- Stormwater detention basins shall be accessible for maintenance and operation and dedicated access easements or right-of-way of at least 20 feet wide shall be provided. Gates and/or bollards are required when necessary to restrict access to stormwater facilities.

6.8.3 Retention/Infiltration Basins

Retention and Infiltration basins are used to control runoff from the design storm event but can also be used to provide water quality treatment through storage and subsequent infiltration of runoff from the water quality event. This section discusses the design criteria for retention/infiltration basins for runoff control and/or water quality treatment of the runoff treatment volume (RTV). Further details of the water quality treatment design are discussed in Section 6.9.

Retention/infiltration basins can either be constructed as open systems or subsurface systems. Open systems typically include excavation of a basin designed to slowly infiltrate the collected runoff into the underlying soil. Subsurface retention/infiltration basins commonly take the form of boulder pits, vault systems, and injection wells which are typically used on sites with limited available space.

A. Geotechnical/Hydrogeological Evaluation

A geotechnical/hydrogeological evaluation completed by an Engineer licensed in the State of Montana is required to support the design of retention/infiltration basins for runoff control and/or water quality treatment. The evaluation shall include documentation of:

1. native soil conditions,
2. seasonal high groundwater level and how it is determined,
3. infiltration rates and controlling conditions,
4. groundwater mounding calculation, and
5. potential for impact to adjacent facilities and structures.

The level of analysis and required data will be dependent on the amount of stormwater to be managed, the type of infiltration facility proposed, and the soil conditions of the site. Guidance for a typical Geotechnical/Hydrogeological evaluation to support design of stormwater infiltration facilities is provided in Attachment C.

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- a. The infiltration rate shall be based on the Design Infiltration Rate or the Encased Falling Head Test procedure as specified in [Appendix C – Infiltration Testing Procedures of Circular DEQ-8](#).
 - b. Given the uncertainty of the estimated infiltration rate, infiltration over the duration of the storm event shall not be considered in calculating the required retention storage volume.
 - c. The Geotechnical/Hydrogeological evaluation shall identify the appropriate proximity of infiltration system in relation to adjacent facilities and structures. Where hydrogeological conditions exist that indicate potential impacts to facilities or structures by infiltrated stormwater, infiltration systems may not be considered appropriate for stormwater management.
 - d. Where shallow groundwater is possible, the seasonal-high water table level must be defined through at least one season of water table monitoring at the location of the proposed facility. Other means of establishing the site-specific seasonal-high water table may be accepted if approved by the City Engineering Division. The depth to the historic, seasonal-high water table, bedrock, hardpan or other impermeable layer shall be no less than two feet below the bottom of basin to allow for infiltration of stormwater runoff.
 - e. Where impermeable soils are near the bottom of the retention/infiltration basin, it may be possible to use a permitted stormwater injection well to augment infiltration (see Section F – Injection Wells). In some instances, it may be appropriate to extend the bottom of the infiltration system into underlying sand or gravel lens where groundwater is present, in order to achieve adequate infiltration rates. In these instances, runoff from the water quality event shall be routed through a water quality treatment device prior to discharge into the underlying groundwater.
- B. Basin Geometry
- a. The maximum water depth shall not exceed 6 feet for open retention/infiltration basins.
 - b. Safety benches of 4 feet minimum width shall be included around the perimeter of open retention/infiltration basins where the retained water depth can exceed 2.5 feet, to provide a shallow area for people and animals that inadvertently enter the open water, to exit. Side slopes above the safety bench shall be no steeper than 4H:1V.
 - c. Open retention/infiltration basin side slopes shall be 4H:1V or flatter for maintained grass-lined sections, 3H:1V for unmaintained native grass-lined sections and 2H:1V for riprap-lined sections.
 - d. Embankment fill slopes of open basins shall be no steeper than 3H:1V and preferably 4H:1V or flatter.
 - e. Subsurface retention/infiltration basins using aggregate for the infiltration media shall be sized based on the test value of porosity for the proposed fill material, not on the void ratio.

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- f. The maximum water surface elevation during the Major Storm shall be no less than one foot below the adjacent ground, window well, finished floor, top of foundation or any other entry point vulnerable to flooding for residential dwellings and public, commercial, and industrial buildings.

C. Maximum Drain-Down Time

Retention/Infiltration basins shall be capable of completely draining the design stormwater runoff volume, plus the runoff treatment volume (RTV) for combination facilities, within 72-hours after cessation of the storm.

D. Multi-Purpose Use

- a. Retention/infiltration facilities designed for multi-purpose use (sport courts, neighborhood parks, play areas, picnic areas, etc.) may be allowed where the hydrogeological conditions are appropriate. Multi-use amenities shall be anchored to prevent floatation.
- b. Runoff from, at a minimum, the Minor (10-Yr) storm event shall be stored separately from the multiple use areas, in an area with the sole purpose of stormwater runoff storage.
- c. The developer shall make arrangement for maintenance of such amenities unless such responsibility is accepted in advance by the City of Bozeman.

E. Set Backs

Retention/Infiltration basins shall be located such that:

- a. the facility does not interfere with underground utilities, utility easements, floodplains, etc.
- b. adequate access is provided for maintenance and operations (including construction considerations for full replacement of underground facilities).
- c. adjacent facilities are not impacted. The geotechnical/hydrogeological evaluation shall identify subsurface impacts to groundwater levels and adjacent facilities or structures.
- d. the relevant provisions of ARM 17.36.323 and Circular DEQ-8 are met.

The geotechnical and hydrogeological evaluation, detailed in Attachment C, shall identify potential subsurface and groundwater impacts to adjacent facilities or structures. Setbacks may need to be adjusted accordingly, beyond the minimums established above.

F. Injection Wells

- a. Stormwater injection wells (as classified by EPA) may be considered for use in conjunction with retention/infiltration systems to improve the overall infiltration rate. These wells can be used where shallow, low permeability soils overlay more permeable soils capable of accepting the volume and rate of stormwater infiltration necessary to meet the discharge requirements.

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- b. Depending on design of the subsurface retention/infiltration system, the system may be classified as a Class V EPA injection well. Developer shall obtain and submit appropriate permit as necessary prior to approval from the City.

G. Water Quality Treatment

Storage of stormwater runoff from the water quality event can be incorporated into the design of the retention/infiltration basin. A water quality treatment device or sediment forebay shall be included in the design to facilitate the capture and periodic removal of sediment.

If other pollutants such as oils, grease, or fuel (gasoline and diesel) could be present in the site runoff, the development may be subject to additional regulatory and design requirements (see Attachment A).

H. Maintenance & Maintenance Access

- a. Maintenance shall be performed by the property owners' association or commercial site owner, unless this responsibility is accepted by the City. An example Acknowledgement of Stormwater Facility Maintenance Requirements is provided in Attachment D.
- b. Retention/Infiltration facilities shall be accessible for operation and maintenance. When vehicle access is necessary, for facilities constructed outside of the street section, dedicated access easements of 20-foot minimum width shall be provided.
- c. Approval of retention/infiltration systems shall obligate the owner to repair, replace, or reconstruct the system if it fails to operate as designed and this shall be included as a provision of the Operation, Inspection, and Maintenance plan. Developer may be required to mitigate system deficiencies beyond the required warranty period, if the deficiencies were found to be the result of improper design, construction, or maintenance. Further, if the system fails to function properly, during Minor and Major storm events, Developer may be required to mitigate deficiencies beyond the warranty period.
- d. Regular maintenance shall be required such that the facility continues to operate as designed. The responsibility for proper maintenance of stormwater facilities is governed by [Chapter 40, Article 4, Division 5, Section 40.04.720 - Maintenance of Stormwater Facilities](#) of the BMC.

6.8.4 Boulevard Swales

Boulevard swales are designed to control runoff from the street section and/or adjacent areas, temporarily storing the runoff, and then discharging into an approved storm drain or infiltrating into the underlying soils. Given their limited size, boulevard swales typically have contributing drainage areas of less than 1 acre. Boulevard swales should not be confused with biofiltration swales discussed in the [Montana Post-Construction Storm Water BMP Design Guidance Manual - bozeman.net](#), which are used for water quality treatment designed for the runoff treatment flow (RTF).

A. Locations

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- a. Boulevard swales are commonly placed along roadways or property lines in a manner that integrates the swale with adjacent infrastructure, and landscaping features.
- b. Boulevard swales shall be located within the right-of-way or in a dedicated storm drainage easement.

B. Geotechnical/Hydrogeological Evaluation

Geotechnical/Hydrogeological investigations for boulevard swales, relying on infiltration for stormwater discharge, shall follow the same criteria as for retention/infiltration basins.

C. Basin Geometry

- a. The boulevard swale shall use a trapezoidal cross section with side slopes no steeper than 4H:1V for mowable grass-lined sections, 3H:1V for unmaintained native grass-lined sections, and 2H:1V for riprap-lined sections.
- b. The minimum bottom width shall be 1-ft.

D. Maximum Drain-Down Time

Boulevard swales used for stormwater retention shall be designed to fully drain the design volume within 72-hours after cessation of the storm.

E. Culverts

Culverts installed within boulevard swales shall be designed in accordance with the requirements of Section 6.7.5 and the City of Bozeman standard drawing for drive approaches.

F. Maintenance & Maintenance Access

- a. Boulevard swales shall be protected from high sediment loads during construction and until vegetation is established in the swale and on adjacent areas contributing runoff. This may require periodic cleaning of the boulevard swale until vegetation is fully established.
- b. Maintenance of swales and associated culverts shall be performed by the property owners' association or by the adjacent property owner. An example Acknowledgement of Stormwater Facility Maintenance Requirements is provided in Attachment D. Maintenance requirements shall address maximum vegetation heights, mowing, watering, fertilizing and frequency for sediment removal and erosion repairs.
- c. If direct access from the adjacent public right-of-way is not available, an access easement to the swale shall be provided to facilitate inspection, monitoring, and maintenance. Appropriate access shall also be provided for maintenance of culverts within the swale.
- d. Regular maintenance shall be required such that the facility continues to operate as designed. The responsibility for proper maintenance of stormwater facilities is governed by [Chapter 40, Article 4, Division 5, Section 40.04.720 - Maintenance of Stormwater Facilities](#) of the BMC.

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6.9. PERMANENT WATER QUALITY TREATMENT

6.9.1 Application

The City of Bozeman operates under a Municipal Separate Storm Sewer System (MS4) General Permit from the Montana Department of Environmental Quality (MTDEQ). Projects must implement post-construction stormwater management controls that are designed to infiltrate, evapotranspire, and/or capture for reuse the water quality storm event (first 0.5 inch of rainfall). For projects that cannot fully meet the requirement, the remainder of the runoff from the first 0.5 inches of rainfall must be treated onsite using stormwater management controls expected to remove 80 percent of total suspended solids (TSS). This section presents the requirements for implementation of post-construction (permanent) Best Management Practices to ensure compliance with the City's General Permit requirements.

The *Montana Post-Construction Storm Water BMP Design Guidance Manual* is available on the City of Bozeman website ([Montana Post-Construction Storm Water BMP Design Guidance Manual - bozeman.net](https://www.bozeman.net/DocumentCenter/View/10000/Montana-Post-Construction-Storm-Water-BMP-Design-Guidance-Manual)).

6.9.2 Water Quality Design Storm

The water quality design storm shall be used to size post-construction (permanent) stormwater runoff water quality treatment BMPs. Runoff treatment BMPs shall be sized based on the water quality volume and flow rate in order to achieve the required treatment efficiencies. The design storm for post-development water quality treatment shall be the 0.5-inch rainfall event.

The Runoff Treatment Volume (RTV) and Runoff Treatment Flow Rate (RTF) shall be determined in accordance with Chapter 3 of the *Guidance Manual*.

6.9.3 Selection of Permanent Water Quality BMPs

The BMP's listed in Chapter 5 of the *Guidance Manual* were developed to specifically meet the requirements of the General Permit. Permanent water quality treatment facilities in the City of Bozeman shall be designed in accordance with the most recent version of the [Montana Post-Construction Storm Water BMP Design Guidance Manual - bozeman.net](https://www.bozeman.net/DocumentCenter/View/10000/Montana-Post-Construction-Storm-Water-BMP-Design-Guidance-Manual).

6.10. EROSION AND SEDIMENT CONTROL

6.10.1 Application

This section provides criteria for selection, design, installation, and maintenance of temporary sediment and erosion control Best Management Practices (BMPs) to reduce impacts to surface waters, public rights-of way and adjacent properties during construction activities.

6.10.2 Permitting and Design Guidance

The required permits and design guidance for temporary sediment control associated with construction activities is detailed on the City of Bozeman website ([Sediment Control during Construction - bozeman.net](https://www.bozeman.net/DocumentCenter/View/10000/Sediment-Control-during-Construction)).

In accordance with [Chapter 40, Article 4, Division 3 – Construction Activity](#) of the Bozeman Municipal Code (BMC), a SWPPP (Stormwater Pollution Prevention Plan) and

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NOI (Notice of Intent) shall be submitted to both the City of Bozeman and Montana Department of Environmental Quality (MTDEQ) for acceptance. The SWPPP and NOI shall be submitted to the City prior to any grading on the site and prior to submittal to MTDEQ. The SWPPP and NOI submittal to MTDEQ shall be the same as prepared for the City of Bozeman.

6.10.3 Best Management Practices (BMP)

Temporary erosion and sediment control best management practices (BMPs) for construction sites in the City of Bozeman shall be designed and implemented in accordance with the current version of the [City of Bozeman Best Management Practice \(BMP\) Manual for Construction Sites](#).

Attachment A

Additional Water Quality Treatment Requirements for Select Sites

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Some commercial sites require additional stormwater runoff treatment. The table and text below identifies such facilities and the pollutant removal criteria.

Oil Treatment Required if:	Nutrient Treatment Required if:	Metals Treatment Required if:
1. Fueling Stations and similar type facilities 2. Commercial or industrial properties storing or transferring 1,500 gallons or more of petroleum chemicals 3. Vehicle maintenance/ equipment repair facilities 4. Hydraulic equipment storage areas 5. City determined necessary	1. Nurseries 2. Lawn care/ fertilizer facilities 3. Agricultural facilities 4. Animal Care facilities 5. City determined necessary	1. Fueling Stations and similar type facilities 2. Properties zoned control heavy industrial 3. Vehicle maintenance/ equipment repair facilities 4. Hydraulic equipment storage areas 5. City determined necessary

Oil Treatment* Oil treatment is required for all high use and high traffic areas regardless of the impervious area. Oil treatment facilities need only be located to treat stormwater which may contain oil and grease. Oil treatment facilities are not required to treat runoff from clean roofs, landscaped areas, or other areas which are separated from or not subject to surfaces which may contain oil or grease. Some high traffic areas may generate sufficient quantities of oil to threaten water quality, but the quantities may be insufficient for many oil control BMPs to be effective; therefore, these properties may employ different BMPs than are recommended for high-use areas.

The oil control facilities are intended to achieve the goals of no ongoing or recurring visible sheen, and to have a Total Petroleum Hydrocarbon (TPH) concentration no greater than 10 mg/l.

Nutrient Treatment* Nutrient, typically nitrogen and phosphorus, treatment is required at all nurseries, lawn care/fertilizer, agriculture, and animal care facilities over 1 acre in size. Nutrient treatment BMP facilities shall be sized to treat all stormwater discharging to the BMP. Nutrient treatment is not required for runoff which does not come in contact with chemical storage and application areas or areas inaccessible to animals. Treatment should achieve 50% reduction of total phosphorus and 35% reduction of total nitrogen, depending on influent concentrations and design.

Metals Treatment* Metals are typically in the form of particles and are generally removed with basic treatment requirements which remove total suspended solids. Therefore, properties requiring metals treatment should already be treated through TSS treatment. In the event that dissolved metals are reaching water bodies through stormwater runoff, additional control measures, such as filters may be required at such facilities. Metals removal should be from 20 to 85% depending on design, metal state (i.e., dissolved), influent concentration, etc.

* It is the responsibility of the developer to ensure site complies with DEQ, EPA or other agencies which may have additional regulations.

Attachment B

Stormwater Drainage Report Outline

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The Stormwater Drainage report shall be based on the following standardized outline.

TITLE PAGE

1. "Stormwater Drainage Report"
2. Project Name
3. Planning Application Number
4. Date
5. Signature and Seal of licensed Engineer

INTRODUCTION

1. Description of Property
 - a. Location including map exhibit
 - b. Area in acres
 - c. Ground cover (type of ground cover and vegetation)
 - d. Existing land uses and known and foreseeable future land uses
 - e. Topographic features and characterization
 - f. Geologic features and characterization
 - g. Existing drainage conditions and facilities
 - h. Natural Watercourses (when present)
 - i. Wetlands (when present)
 - j. Flood Hazard Zones (if applicable)
2. Previous drainage studies for the property (if any)
3. State or Federal Regulations (if applicable)

HYDROLOGY AND HYDROGEOLOGY

1. Design Storm Rainfall including summary table or chart
2. Summary of Geotechnical/Hydrogeological evaluation (attach report)

EXISTING STORMWATER DRAINAGE CONDITIONS

1. Description and map exhibit to illustrate existing drainage conditions.
 - a. Discussion of existing drainage basin runoff characteristics including summary table of subbasins
 - b. discussion and map exhibit of existing drainage patterns including off-site contributing areas and outfall
2. Hydrologic and Hydraulic Calculations or Modeling
 - a. Discussion and justification of hydraulic methods and computer models used
 - b. hydraulic capacity of existing drainage features
 - c. hydraulic capacity of existing outfall

PROPOSED STORMWATER DRAINAGE SYSTEM

1. Applicable Design Standards
2. Drainage System Design

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- a. Discussion of post-project drainage basin runoff characteristics including summary table of subbasins
- b. Discussion and map exhibit of post-project drainage patterns including off-site contributing areas and outfall
- c. Discussion and map exhibit of planned drainage features (channels, inlets, storm drains, treatment devices, ponds, outfalls, etc.)
3. Hydrologic and Hydraulic Calculations or Modeling
 - a. Discussion and justification of hydrologic and hydraulic methods and computer models used, basis for input parameters, a presentation of the results, comparisons to results from other accepted methods and, where possible, observations from actual storm events to validate the results.
 - b. Comparison of post-project runoff rates and volumes to existing runoff rates and volumes, including summary tables and charts
 - c. Discussion of hydraulic design of stormwater drainage system elements. Hydraulic calculations shall be presented for drainage system components including but not limited to the following:
 1. Culvert Capacities and inlet and outlet protection.
 2. Storm drain hydraulics including hydraulic grade line (HGL) elevations and roughness coefficients used
 3. Gutter flow spread as compared to allowable flow spread width
 4. Storm inlet interception and bypass
 5. Storm drain channel hydraulics including freeboard, HGL elevations, and erosion protection
 6. Detention or retention pond sizing, configuration, depth, and outlet structure hydraulics.
 7. Outfall drainage path to a public drainage system with adequate capacity
 8. Design of permanent erosion protection measures
 - d. Comparison of design hydraulics to design criteria to verify compliance.
 - e. Water Quality Treatment Design

EVALUATION OF MAJOR STORM FLOOD RISKS

1. Comparison of post-project flood hazards during the Major Storm to existing conditions
2. Discussion of potential flood hazards and mitigation measures
3. Discussion of impacts to FEMA regulated floodplains, where applicable

OPERATION, INSPECTION, AND MAINTENANCE CONSIDERATIONS

Attach a copy of the Operation, Inspection, and Maintenance (OI&M) Plan, Acknowledgement of Stormwater Facility Maintenance Requirements, and Stormwater Facility Inspection Form.

REFERENCES

Reference all documents and materials relied upon

APPENDICES

Provide supporting documents, structure details, hydrologic and hydraulic calculations, maps, schematic diagrams of computer models along with model input and output, previously approved drainage plans for the development, and any other supporting materials.

Attachment C
Geotechnical/Hydrogeological Evaluation

Chapter 6 - Storm Drainage Design

1. The geotechnical/hydrogeological evaluation shall include at a minimum:
 - a. A review of available geologic, hydrogeological, and topographic conditions to identify any site conditions that could impact the use of the storm drainage systems or the construction of sub-level structures. This review shall include all available previous geotechnical engineering reports for the development. Citations to possibly useful references are provided at the end of this appendix.
 - b. Where access to adjacent properties is unavailable, the project owner shall rely upon the best known information for the area, supplemented with available information, including any existing engineering reports or studies for sites in the vicinity.
 - c. A surface and subsurface reconnaissance of the site and an inspection of adjacent properties to assess potential impacts from the proposed stormwater system and to verify that the conditions are consistent with the mapped information.
 - d. The level of data for the hydrogeological assessment required will be dependent on the amount of stormwater to be managed, the type of infiltration system proposed, and the surface and subsurface soil conditions at the site. The assessment will be conducted by a professional with experience collecting and analyzing hydrogeological data.
 - e. An assessment of hydrogeological conditions that indicate the potential for infiltrated stormwater to impact on- or off-site, facilities or structures. The assessment will also demonstrate that impacts to groundwater elevation or flow, resulting from the proposed infiltration system will be confined to the property. **A groundwater mounding calculation shall be provided to identify the impacts of infiltrated stormwater runoff.** An example calculation method and spreadsheet is made available from the United States Geological Survey (USGS); however, other approved, similar calculation methods may be accepted. This information can be found at the following link: <https://pubs.usgs.gov/sir/2010/5102/>
2. Test Method Documentation shall include:
 - a. A map with the location of all subsurface field explorations, sampling locations and any in- place field tests;
 - b. A description of the field test and any difficulties encountered during excavation and testing;
 - c. A description of the equipment used to perform the field explorations or tests. When applicable, describe the type of fabric lining and gravel backfill used;
 - d. Logs of subsurface borings shall identify the depth to groundwater, the presence of any limiting layers and the target soil layer; include test pit or excavation dimensions. Borings intended to characterize hydrogeologic conditions for infiltrations systems should extend a minimum of 5-feet below the base of the proposed infiltration system, or a minimum of 15-feet below the ground surface, whichever is deeper;
 - e. Report test data documenting any infiltration testing, calculations, results problems encountered; and,
 - f. A description of the condition of any existing facilities being tested, noting any silt build-up, water level, connections to other structures (including distance to inverts of any interconnecting pipes), measured depths and dimensions, etc.
3. Results of field and laboratory testing conducted, including the grain size analysis represented both graphically and in tabular format;

Chapter 6 - Storm Drainage Design

4. A summary of field testing conducted and the measured and proposed design infiltration rates for infiltration systems.
5. Results of the sub-level structure feasibility study and a summary of the property boundary and down-gradient analysis as applicable; and,
6. A geologic cross-section of stormwater disposal areas drawn to scale, with the proposed stormwater disposal facilities superimposed on the cross-section. All relevant geologic units shall be clearly identified including the target disposal layer and limiting layers.
7. The Report Narrative shall include:
 - a. A Title Page with the following information:
 - i. "Geotechnical/Hydrogeological Evaluation Report"
 - ii. Project Name
 - iii. Planning Application Number
 - iv. Date
 - v. Signature and Seal of licensed Engineer
 - b. A brief project description including size, number of lots proposed, project location (section, township and range), and background information relevant to the drainage design;
 - c. A discussion of the study investigations including methods and results of field assessments, testing and analyses performed;
 - d. A description of the soil units and subsurface geologic conditions on the site and in the vicinity of the site;
 - e. A description of the site including surface, soil, and groundwater conditions, etc.
 - f. A Site Plan including:
 - i. Project boundaries (including all existing and proposed property lines);
 - ii. Labeled topographic contours (no greater than 2-foot contour interval), extending beyond the project boundaries;
 - iii. Location of the soil and geologic units identified;
 - iv. Location of significant structures, properties or geologic features on site and in the project vicinity;
 - v. Location of existing natural or constructed drainage features on site and in the project vicinity; and,
 - vi. Location of proposed site infrastructure including roadways and drainage features such as ponds, drywells, etc.
 - g. Conclusions and recommendations to support the Stormwater Drainage Plan
 - h. **The Geotechnical/Hydrogeological report shall be signed and stamped by a Professional Engineer licensed in the State of Montana.**

Attachment D

Acknowledgement of Stormwater Facility Maintenance Requirements

The acknowledgement form shall be submitted under a Cover Page with the following information:

- i. “Acknowledgement of Stormwater Facility Maintenance Requirements”
- ii. Project Name
- iii. Planning Application Number
- iv. Date
- v. Signature and Seal of licensed Engineer

Chapter 6 - Storm Drainage Design

The following acknowledgment form is provided as an example.

Acknowledgement of Stormwater Facilities Maintenance Requirements

PROPERTY OWNER:

NAME OF PLAN/DEVELOPMENT:

LOT/BLOCK/SUBDIVISION:

Property Owner hereby acknowledges that they are required to maintain all stormwater facilities on the Property pursuant to Bozeman Municipal Code sec. 40.04.720. This requirement is binding on any successor or assign of the Property Owner listed above.

The City requires stormwater facilities be constructed and adequately maintained on the Property in order to maintain the health, safety and welfare of City residents. Adequate maintenance is defined as keeping the stormwater facilities and all components thereof in good working condition so that these stormwater facilities continue to perform in accordance with the design intent.

Should the Property Owner fail to adequately maintain stormwater facilities, the City may enter upon the Property and take such steps as are necessary to correct deficiencies. The City may assess against the Property Owner for the cost of any repairs or necessary maintenance by any means provided for in the Bozeman Municipal Code.

By signing below Property Owner acknowledges they have read this document and the applicable provisions of the Bozeman Municipal Code, and they agree to the maintenance requirements for all stormwater facilities on their Property.

BY: _____

(Property Owner)

DATE: _____

Attachment E

Stormwater Facility Inspection Form

The Stormwater Facility Inspection Form shall be submitted under a Cover Page with the following information:

- i. “Stormwater Facility Inspection Form”
- ii. Project Name
- iii. Planning Application Number
- iv. Date
- v. Signature and Seal of licensed Engineer

Chapter 6 - Storm Drainage Design

Stormwater Facility Inspection Form

Section 1: General Information	
Facility ID:	Facility Type: Choose an item.
Date/Time: Click or tap to enter a date.	
Owner:	Contact:
Inspector's Name, contact info: Choose an item.	
Location/Access info:	
Type of Inspection: ☐ Routine, Dry Weather ☐ Routine, Wet Weather ☐ Complaint Driven ☐ Other: _____	
Section 2: Weather and Discharge Information	
Most recent precipitation or melt: Temperature:	
Is a stormwater discharge occurring? ☐ Yes ☐ No If yes, what is the source and quality of discharge?	
Is an illegal discharge occurring? ☐ Yes ☐ No If yes, what is the source and quality of discharge?	
Section 3: Facility Maintenance Priority	
☐ Low: Stormwater facility appears to be functioning as designed. Continue scheduled maintenance.	
☐ Medium: Stormwater facility requires minor to moderate sediment and vegetation maintenance to mitigate the risk of flooding, waterway pollution, and infrastructure failure.	
☐ High: Stormwater facility requires significant sediment dredging, vegetation removal, and/or infrastructure repairs to restore function.	
<u>Notes, Findings & Recommendations:</u> 	
Inspector's Signature: _____ Date: _____	

Chapter 6 - Storm Drainage Design

Section 4: Qualitative Analysis					
Components	#	Items	Conditions	Results	Notes and Required Actions
General	1.1	Accessibility	Degraded, missing, or inadequate maintenance access?	☐ Yes ☐ No	
	1.2	Debris	Trash, sediment, and waste within and around the facility?	☐ Yes ☐ No	
	1.3	Vegetation	Overgrown or dead cattails, woody shrubs, weeds, grass, and trees?	☐ Yes ☐ No	
	1.4	Infrastructure Condition	Damaged inlet pipe, outlet pipe, outfall structure, or fencing?	☐ Yes ☐ No	
Facility	2.1	Pretreatment Bay or Facility	Clogged, obstructed, or filled pretreatment forebay or facility?	☐ Yes ☐ No	
	2.2	Storage Bay	Clogged or filled storage bay?	☐ Yes ☐ No	
	2.3	Groundwater or Standing Water	Stagnant water with infiltration greater than 48 hours post-rain event?	☐ Yes ☐ No	
	2.4	Flow Path	Clogged or obstructed flow path?	☐ Yes ☐ No	
	2.5	Side Slopes	Barren or exposed surfaces on Facility's side slopes and bottom?	☐ Yes ☐ No	
Maintenance	3.1	Maintenance Plan or Agreement	Is there a written plan specific to this facility?	☐ Yes ☐ No	
	3.2	Implementation	Is there evidence of maintenance?	☐ Yes ☐ No	

Chapter 6 - Storm Drainage Design

Section 5: Quantitative Analysis				
Vegetation	Cover type	% Within facility	Notes	
	Bare ground			
	Aquatics			
	Grasses/Herbaceous			
	Trees >3" DBH			
	Shrubs			
	Total	100		
Elevation Analysis	Location	Reading (ft)	Elevation (ft)	Notes
	SRV#CP Control Point			
	SRV#1 Inlet			
	SRV#2 Outlet			
	SRV#3 Center			
	SRV#4 North of Center			
	SRV#5 East of Center			
	SRV#6 South of Center			
	SRV#7 West of center			
	SRV#8 Berm or overflow			
	SRV#9			
	Summary			

Chapter 6 - Storm Drainage Design

Section 6: Facility Maintenance Inspection Exhibit

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Chapter 6 - Storm Drainage Design

Section 7: Photo Log

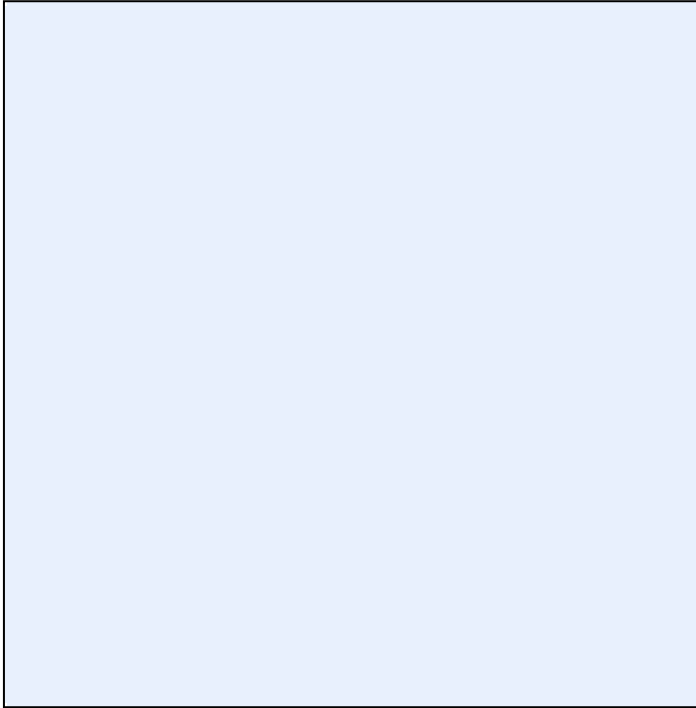


Photo 1
description

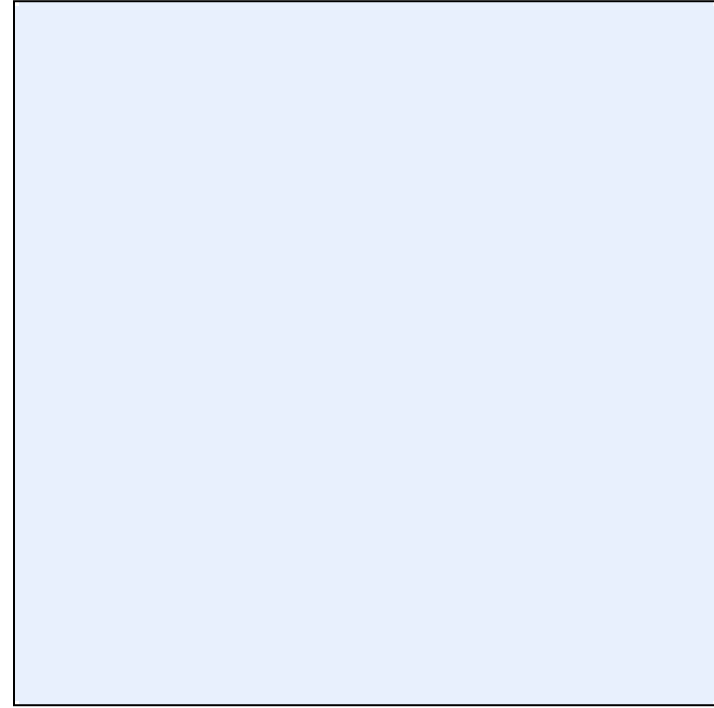


Photo 2
description

Chapter 7 - Transportation System

Chapter 7 Transportation System

7.1. ROADWAY DESIGN AND TECHNICAL CRITERIA

7.1.1 General

This chapter sets forth the minimum design and technical criteria and specifications to be used in the preparation of all roadway plans. All roadway plans should also be designed in conformance with Bozeman Unified Development Code, MPWSS; City of Bozeman Modifications to MPWSS; Americans With Disabilities Act; Public Right-of-Way Accessibility Guidelines (PROWAG); and City of Bozeman Transportation Master Plan.

The NACTO Urban Street Design Guide and the NACTO Urban Bikeway Design Guide should be the primary design guidance used by City transportation officials, planners, and engineers when designing streets and bikeways within the City of Bozeman.

7.1.2 Complete Streets

All new and reconstructed roadways shall be designed to accommodate and coordinate all modes of transportation, both motorized and non-motorized, and people of all ages and abilities. Complete street features include, but are not limited to, sidewalks, motor vehicle lanes, shared-use lanes and path, paved shoulders, street trees, landscaping, vegetative planting strips, curb and gutter, ADA curb ramps, crosswalks, refuge islands, pedestrian and traffic signals, directional signs, street furniture, bicycle parking facilities, public transportation stops and facilities, transit priority signalization, traffic calming devices such as rotary circles and curb bulb-outs, and surface treatments such as paving blocks, textured asphalt, and concrete, narrow vehicle lanes, raised medians, and dedicated transit lanes. All designs must be in compliance with City of Bozeman Resolution No. 4244 or most current Complete Streets Policy if applicable.

The NACTO Urban Streets Design Guide and the NACTO Urban Bikeway Design Guide should serve as primary guidance for the inclusion of these design features.

7.1.3 Traffic Calming

Traffic calming measures are integral components of street design aimed at enhancing safety, promoting sustainable transportation, and creating a more livable environment for communities. This section provides guidelines for the implementation of various traffic calming measures within the design of local streets. Designers shall utilize approved traffic calming features to reduce the probability of local street speeding by targeting through-streets of two or more blocks of uncontrolled traffic. Review and additional directives for local street traffic calming shall occur at the Engineering Infrastructure Review stage of development proposals. Refer to Federal Highway Administration/Institute of Transportation Engineers Traffic Calming ePrimer guidance for additional design parameters.

Arterial and Collector traffic calming shall follow similar principles of speed management, but specific treatments must be approved by the Director of Transportation and Engineering with consultation from the Fire Marshall before implementation.

All local streets shall consider incorporating the following types of approved traffic calming features into subdivision design:

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A. Horizontal Deflections:

I. Neighborhood Traffic Circles

- a. Circular intersection of two local streets. Design controls shall be approved by the City Transportation Engineer prior to implementation.

II. Curb Extensions

- a. Locate on through-streets with curb parking such that curb extension of sidewalk narrows the exposed crossing distance.

B. Vertical Deflections:

I. Speed Tables

- a. Appropriate for targeted speed reductions adjacent to land uses of high pedestrian and bicycle demand.
- b. May not be designed with a height of greater than 4 inches, ramps less than 6 feet, or top length of less than 10 feet.
- c. Taper edges of speed table to align with gutter pan such that drainage paths are not impeded.
- d. May be constructed of asphalt or concrete.

II. Raised Crosswalks

- a. All mid-block crosswalks shall be designed as raised crosswalks unless otherwise directed by the Director of Transportation and Engineering.
- b. Raised crosswalks shall follow the same design parameters as Speed Tables with appropriate accommodations for accessible path of travel including ramp grades, detectable warning surfaces, signing, and pavement markings.

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Table 7.1.1 – Minimum Design Standards for City Streets

Street Classification	Principal Arterial	Minor Arterial	Collector	Local ⁽⁴⁾	Rural ⁽⁵⁾
Right-of-way width ⁽¹⁾	110' - 120'	100'	90'	60'	90' – 110'
Design Speed (MPH)	35	30	30	25	30
Centerline radius on curves	(2)	(2)	300'	150'	300'
Tangent length between reverse curves	(2)	(2)	100'	50'	100'
Stopping sight distance	(2)	(2)	200'	155'	200'
Angle at intersection centerline	(2)	(2)	≥75°	≥75°	≥75°
Curb radius at intersections	(3)	(3)	(3)	(3)	N/A
Length of tangent at intersection	(2)	(2)	150'	100'	150'
Lane Width	10'	10' ⁽⁶⁾	10' ⁽⁶⁾	9'	12'
Bike Lane Width	5' ⁽⁷⁾	5' ⁽⁷⁾	5' ⁽⁷⁾	5'	5'
Parking Lane Width	8'	8'	8'	7'	N/A
Shoulder Width	N/A	N/A	N/A	N/A	4' ⁽⁸⁾
Boulevard Width	7'	6'	6'	5'	N/A
Sidewalk Width	6'	5'	5'	5'	N/A
Shared Use Path Width	10'	10'	10'	10'	8'
Maximum length of street with cul-de-sac ⁽⁹⁾	N/A	N/A	N/A	500'	N/A
Outside radius on cul-de-sac right-of-way ⁽⁹⁾	N/A	N/A	N/A	50'	N/A
Grade – maximum	(2)	(2)	7%	10%	10%
Grade – minimum	0.5%	0.5%	0.5%	0.5%	0.5%

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Table 7.1.1 – Minimum Design Standards for City Streets

Street Classification	Principal Arterial	Minor Arterial	Collector	Local ⁽⁴⁾	Rural ⁽⁵⁾
Grade within 150 feet of intersecting centerlines	(2)	(2)	3%	3%	3%
K Factor (minimum)					
Crest	40	25	25	15	25
Sag	60	45	45	30	45
Minimum VCL					
Crest	105	90	90	50	90
Sag	N/A	N/A	N/A	N/A	90

All street element widths adjacent to curb and gutter are measured from lip of gutter. Gutter pan shall not be included in element width. Face-of-curb is considered to be 0.5' from top-back-curb.

(1) The specific right-of-way and face-of-curb to face-of-curb street width will be determined on a case-by-case basis through the subdivision review process, and will be based on the specific needs, impacts and context of the development proposal.

(2) All design criteria shall meet approved FHWA guidance.

(3) See Section 7.1.7A.

(4) Local streets shall have a minimum face-of-curb to face-of-curb width of 35' where on-street parking is allowed and where off-street parking is reduced.

(5) The rural street standard does not include curb and gutter. The street width is measured from the edge of pavement to the edge of pavement.

(6) 11' minimum shall be used in single-lane sections bounded by curb and gutter (14' min. clear width from face of curb to face of curb).

(7) 2' minimum striped buffer (3' preferred) shall be included between outside travel lane and bike lane.

(8) 4' minimum paved. Provided additional 4' graded shoulder where right of way and topography allows.

(9) Cul-de-sacs are generally not allowed. The City Engineering Division may consider and approve the installation of a cul-de-sac only when necessary due to topography, the presence of critical lands, access control, adjacency to parks or open space, or similar site constraints.

7.1.4 Sidewalks, Curbs and Gutters and Driveways

- A. Typical roadway sections are shown in the Standard Drawings of Bozeman Modifications to MPWSS. Roadway typical sections shall conform to conditions of approval for the project.
- B. Concrete sidewalks shall be constructed on both sides of all roadways unless otherwise approved by action of City Commission. Sidewalks shall be 6-inches thick across driveways, and 4-inches thick elsewhere.

Chapter 7 - Transportation System

- C. All sidewalks shall have a minimum width of five (5) feet, except the minimum width shall be ten (10) feet in the B-3 Downtown Business District. All sidewalks that are to be publicly maintained and all sidewalks along arterial streets shall have a minimum width of six (6) feet and shall be 6-inches thick, fibermesh-reinforced concrete. Publicly maintained sidewalks are sidewalks along all parks, and any public facilities or City-owned structures which are anticipated to be maintained by the City of Bozeman.
- D. Integral curb and gutter shall be used on all roadways.
- E. Pedestrian ramps with detectable warnings shall be installed at all intersections and at mid-block street crossings for all new construction or reconstruction of curb and sidewalk. Pedestrian ramps shall be constructed in accordance with COB Modifications to MPWSS, Section 608 of Montana Department of Transportation Detailed Drawings, PROWAG, and Americans with Disabilities Act (ADA) requirements. Pedestrian ramps details shall be shown at all curb returns on the roadway plans.
- F. Guardrails may be required in certain situations. Guardrails shall be designed and constructed in accordance with AASHTO Standards or as directed by the City Engineering Division.
- G. Drop-curbs for driveways may only be installed with the initial curb construction when the final building locations have been determined. Driveway locations and designs shall conform to [Section 38.400.090](#), Bozeman Unified Development Code.
- H. Curb transitions for curb bulbs shall be accomplished using 35' minimum radius curves to achieve the desired pavement narrowing. All curb bulbs shall be adequately marked with flexible roadway delineators and yellow curb paint as necessary. The minimum curb bulb throat width is 14 feet (face-of-curb to face-of-curb).

7.1.5 Street Vision Triangles

A. Vision Triangle.

The vision triangle for any access onto any street or alley shall be determined based on the most recent version of AASHTO's A Policy on Geometric Design of Highways and Streets. On corner lots in all districts, no fence, wall or planting in excess of 30 inches above the street centerline grade is permitted within the vision triangle. Nothing in this section prohibits portions of buildings 12 feet or more above grade from encroaching into a required vision triangle.

B. Provision for trees in street vision triangle.

- I. Single-stem canopy trees are discouraged but may be permitted in street vision triangles as described in this section, provided that mature trees do not significantly affect safe driving conditions and are maintained such that no canopy foliage exists below a height of ten feet above centerline of intersecting streets.
- II. Trees which are located in the street vision triangle, and which preexisted the adoption of the ordinance from which this chapter is derived may be allowed to remain, provided the trees are trimmed such that no limbs or foliage exist below a height of ten feet above centerline grades of intersecting streets.

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C. Departures.

The review authority may grant a departure from these street vision triangle standards for intersections with traffic signals, intersections on one-way streets, or intersections on streets classified as an urban route by the Montana Department of Transportation. Departure criteria are: a revision can be accomplished without jeopardizing the public's health, safety and welfare, the intent of this chapter, or the intent of the city's land use plan.

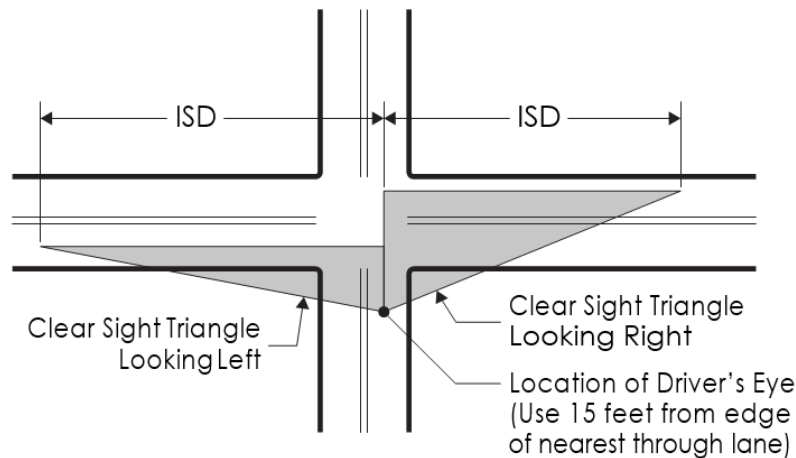


Figure 7-1 ISD - Intersection Sight Distance

7.1.6 Drainage

Drainage systems shall be designed in accordance with Chapter 6 of these Design and Construction Standards. Design plans, including a drainage report, for the drainage system are required for concurrent review with, and shall be considered part of, the roadway design.

A. Cross Slope

Except at intersections, or where super-elevation is required, roadways shall be level from top of curb to top of curb and shall have a two (2) percent crown as measured from centerline to lip of curb, or lip of median curb to lip of outside curb on roadways with raised center islands. Parabolic or curve crowns are not allowed. Maximum pavement cross slope allowed is five (5) percent at warped intersections, as measured above. In no case shall the pavement cross slope at warped intersections exceed the grade of the through street.

When warping side streets at intersections, the crown transition should be completed within 75-feet horizontally for local streets, 100-feet horizontally for collector streets, and 150-feet horizontally for arterial streets. The crown of the through street shall be decreased to 1.5% through intersections, with the crown transitions being accomplished within 100 feet on either side of the intersections. Quarter crowning may be accepted on a case-by-case basis with prior approval from the City Engineering Division.

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Warping at intersections must meet the requirements of PROWAG for crosswalk and ramp locations.

B. Temporary Erosion Control

Temporary erosion control is required at the ends of all roadways that are not completed due to project phasing, subdivision boundaries, etc. Prevention of erosion at the roadway terminus shall be by methods approved by the City Engineering Division.

7.1.7 Horizontal Alignment

A. Curb Return Radius

For purposes of identifying the nature of an intersection, the functional classification of each roadway is as delineated in the current version of the Bozeman Transportation Master Plan.

Local streets intersecting local or private streets will typically use a 10' curb return radius to control turning speeds.

Where local streets intersect collector streets, a 15' curb return radius is typically used. The swept path of a Conventional School Bus (S-BUS-36) shall be evaluated by the Design Engineer at all intersections on a collector street. Vehicles turning off or onto the collector will not encroach on other lanes but may use additional width on the intersecting street. If the swept path passes over the proposed curb return, all improvements within the swept path must be constructed to withstand vehicle loads without damage, e.g., thickened and reinforced concrete sidewalk and pedestrian ramps, traffic-rated utility boxes, etc. Traffic control devices must be placed outside the swept path while maintaining conformance with MUTCD guidelines.

At all arterial street intersections with arterial streets, the swept path of a WB-67 shall be evaluated by the Design Engineer. The swept path must be contained entirely within the roadway section, i.e., provide a 2-foot shy distance from the face of curb. Multi-centered curves for curb returns are encouraged to minimize the distance that pedestrians must cross at these intersections.

B. Design Speed

Design speed shall be as shown in Table 7.1.1 of these specifications.

C. Horizontal Curves

The minimum centerline radius for horizontal curves shall be as shown in Table 7.1.1 of these specifications. Variances from the requirements of Table 7.1.1 for local streets only may be considered on a case-by-case basis.

D. Intersections

The following requirements apply to street intersections:

- I. All roadways shall intersect at right angles as nearly as possible. In no case shall the angle of intersection be less than seventy-five degrees (75°);

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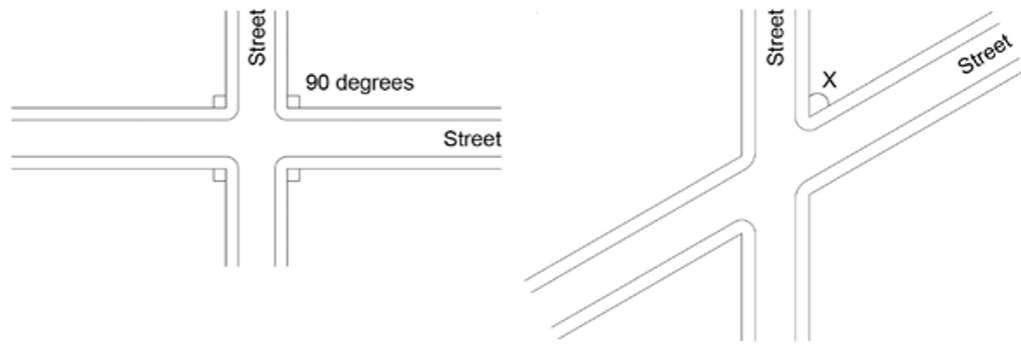


Figure 7-2 Intersections

- II. Two local streets intersecting a third street from opposite sides shall meet at the same point, or their centerlines shall be offset at least 125 feet;
 - III. Two streets intersecting a collector or arterial through street must be evaluated for conflicts between overlapping left-turn movements from the through street. Provide sufficient offset distance to prevent conflict at peak hour traffic volumes;
 - IV. No more than two streets may intersect at one point;
 - V. Intersections of streets are subject to the spacing requirements of [Table 38.400.090-1](#), Bozeman Unified Development Code; Intersections must be designed to provide adequate visibility for traffic safety based on the designated operating speeds of the intersecting roadways;
 - VI. Hilltop intersections are prohibited, unless no alternatives exist. Intersections on local streets within 100 feet of a hilltop are prohibited. Intersections on arterial and collector streets within 200 feet of a hilltop are prohibited. If no alternatives to a hilltop intersection exist, additional traffic control devices are required;
 - VII. The grade of approaches to major highways may not exceed five percent; and
 - VIII. Any street which intersects a paved minor collector or greater street must be paved for at least 75 feet from the existing edge of pavement.
- E. Super-elevation
- Super-elevation ($e_{\max} = 4\%$) may be required for arterial roadways and selected collector roadways. Horizontal curve radius and super-elevation shall be in accordance with AASHTO recommendations.
- Super-elevation shall not be used on local roadways.
- F. Spiral Curves
- Spiral curves shall not be used on roadways within City of Bozeman jurisdiction (State highways excluded) except by written approval of the City Engineering Division.
- G. Barricades
- Whenever roadways terminate due to project phasing, subdivision boundaries, etc., barricades are required in accordance with the Manual of Uniform Traffic Control Devices (MUTCD) and City standards.

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H. Dead-End Streets and Alleys

- I. Dead-end streets must comply with any City-adopted International Fire Code, Appendix D. No dead-end streets longer than 150 feet are permitted without an approved turn-around. Where streets terminate, the developer must provide a cul-de-sac at the terminus. All approved turnarounds must be signed as Fire Lane.
- II. "T" turnarounds, in-lieu of temporary cul-de-sac, must comply with city design specifications and standards, and with any city-adopted International Fire Code, Appendix D. All other design requirements are established by the review authority.

7.1.8 Vertical Alignment

Design controls for vertical alignment are shown in Table 7.1.1.

A. Permissible Roadway Grades

The minimum allowable grade for any roadway or alley is one-half (0.5) percent. The maximum allowable grade for any roadway is shown in Table 7.1.1. The maximum grade for an alley is subject to the approval of the City Engineering Division.

B. Changing Grades

Continuous grade changes or "roller-coastering" shall not be permitted. The use of grade breaks, in lieu of vertical curves, is not encouraged. Where the algebraic difference in grade (A) exceeds one percent (1.0%), a vertical curve is to be used.

C. Vertical Curves

All vertical curves shall be symmetrical. Design criteria for vertical curves are found in Table 7.1.1. The minimum grade within a sag (sump) vertical curve is five-tenths (0.50) of a percent. All vertical curves shall be labeled, in the profile, with length of curve (L) and K ($=L/A$).

D. Intersections

The following additional criteria shall apply at intersections.

- I. The grade of the "through" street shall take precedence at intersections. At intersections of roadways with the same classification, the more important roadway, as determined by the City Engineering Division, shall have precedence. Warp side streets to match through streets. See Section 7.1.6A above.
- II. The elevation at the point of tangency (PT) of the curb return on the through street is always set by the grade of the through street in conjunction with normal pavement cross slope.
- III. Carrying the crown of the side street into the intersecting through street is not permitted.
- IV. At an arterial-arterial intersection, a more detailed review of the entire intersection's drivability will be completed.

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E. Curb Returns

Minimum fall around curb returns, when turning water, shall be determined using a grade of 1.25% within the return. The maximum grade around a curb return is 3.00%. Show and label high point location, elevation and intersection of flow line in plan view if applicable. Grades shall not exceed requirements of PROWAG for ramp and crosswalk locations.

F. Offsite Design and Construction

The design grade and existing ground of all roadways that dead end due to project phasing, subdivision boundaries, etc., shall be continued in the plan and profile of the proposed design for at least three hundred (300) feet, or up to one thousand (1,000) feet if a future extension intersects with an existing roadway. This distance shall be no less than one thousand (1,000) feet when arterial roadways are being designed.

Connections with existing roadways shall be smooth transitions conforming to normal vertical curve criteria if the algebraic difference in grade (A) between the existing and proposed grade exceeds one percent (1.0%). When a vertical curve is used to make this transition, it shall be fully accomplished prior to the connection with the existing improvement. Field-verified slope and elevation of existing roadways shall be shown on the plans for a minimum distance of 300' beyond the end of the proposed improvements. The City Engineering Division may require a longer distance.

If the offsite roadway adjacent to the proposed development is not fully improved, the developer is responsible for the design and construction of a transition for the safe conveyance of traffic from the improved section to the existing roadway. The following formula shall be applied to the taper or lane change necessary for this transition:

$$L = WS^2/60$$

where

L = length of transition in feet

W = width of offset in feet

S = design speed per these design standards

The City Engineering Division should be consulted for any unusual transition conditions. Grade breaks greater than one percent are not allowed when matching existing dirt or gravel streets.

The cost of offsite pavement transitions shall be borne by the developer.

7.1.9 Medians

Median curbs should be integral curb and gutter (with spill curb) unless otherwise approved. Medians less than four (4) feet wide should be capped with M-4500 concrete a minimum of four (4) inches thick. Wider medians should be landscaped in accordance with the City of Bozeman Landscape and Irrigation Performance and Design Standards Manual. The minimum median width is 4 feet, measured from back-of-curb to back-of-curb.

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All medians or raised islands should be made clearly visible at night through the use of adequate reflectorizing and/or illumination. Flexible delineators shall be placed at the beginning and end of all medians, and at the point of any horizontal alignment change.

All median curbs and island curbs shall be painted yellow with epoxy paint.

7.1.10 Surfacing

Following are the requirements of the minimum transportation surfacing standards:

A. Roadways

The pavement thickness design will be based on the 1993 and 1998 *AASHTO Guide for Design of Pavement Structures*, or the current *AASHTO Mechanistic-Empirical Pavement Design Guide* for thickness design. A Pavement Design Report, based upon site specific soil data and design-year traffic loading conditions, prepared by a Professional Engineer, or other qualified professional approved by the City Engineering Division, shall be submitted to the City Engineering Division for approval prior to plan and specification submittal or concurrent with the plans and specifications.

The design shall be based on at least a 20-year performance period traffic volume. However, the minimum design lane Equivalent 18,000-lb Single Axle Load (ESAL) used in the pavement design shall not be less than 75,000-ESAL. The minimum asphalt pavement thickness for any new local roadway shall be three (3) inches. The minimum asphalt pavement thickness for any new collector or arterial roadway shall be four (4) inches. A minimum of six (6) inches of high quality untreated aggregate base shall be provided for designs utilizing asphalt pavement over untreated aggregate base.

The City Engineering Division may require intersections with roundabouts or traffic circles to be constructed with Portland cement concrete surfacing.

B. Railroad Crossings

All railroad crossings on streets shall be precast concrete panels as approved by Burlington Northern Santa Fe Railway for the full width of the roadway.

C. Sidewalks

All pedestrian sidewalks will be constructed with Portland cement concrete surfacing.

D. Shared Use Paths

All shared use paths will be constructed with asphalt. The City Engineering Division may approve alternative surfacing materials based on path location and surrounding environment.

E. Alleys

All alleys shall be constructed with asphalt surfacing.

7.1.11 Signs and Markings

- A. All signs and pavement markings placed in the right-of-way must conform with the approved guidance and design manuals, including the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD).

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- B. All sign designs shall comply with the current edition of “Standard Highway Signs” book published by the Federal Highway Administration.
- C. Speed limit signs shall be posted upon construction of new or newly-extended streets with speed limits in accordance with Chapter 36, Article 7 – Speed Limits, of the Bozeman Municipal Code as it may be amended from time to time. Spacing of speed limit signs on collector and arterial streets should not exceed one mile. Speed limit signs shall be installed to inform drivers that have turned onto local streets from an arterial or collector street. The City Engineering Division may also require speed limit signs be posted on local streets in other locations. Park and school zone speed limits shall be verified with the Director of Transportation and Engineering prior to signs being installed.
- D. Stop signs shall be installed on local streets where they intersect any collector or arterial streets. Stop signs shall be installed at the intersections of local streets. Assignment of right-of-way shall be based on the guidance provided in Chapter 2B of latest edition of the MUTCD. The City Engineering Division may require additional regulatory traffic control and pavement markings in accordance with the MUTCD.
- E. Pedestrian crossing signs shall be used at all midblock crossings and as further defined in this section.
- F. All pedestrian crossing, school crossing, and associated advanced warning signs shall have a fluorescent yellow-green background.
- G. Street name signs for publicly maintained roadways shall consist of white letters on a green background. Street name signs for privately maintained roadways shall consist of white letters on a blue background.
- H. Street name signs shall be installed at all new intersections in accordance with City of Bozeman Modifications to MPWSS.
- I. Parking shall be restricted using signs and curb markings within 20 feet of crosswalks at a minimum, or longer based on the evaluation of sight distance requirements and other considerations based on engineering judgment.
- J. Signing and marking of crosswalks shall be based on this section and guidance contained in the MUTCD, NACTO’s Urban Street Design Guide, and FHWA’s Guide for Improving Pedestrian Safety and Uncontrolled Crossings (FHWA-SA-17-072).
 - I. Standard Crosswalk markings (Type A) should be used:
 - a. At the intersection of two local streets on any uncontrolled approaches
 - b. Across local streets at the intersection with a collector or arterial street except as identified in Section II below.
 - II. High Visibility crosswalk markings (Type B) should be used:
 - a. On local streets at all non-intersection (midblock) crossings
 - b. On all legs of signalized intersections,
 - c. For all school crossing locations
 - d. For any uncontrolled movements (slip lanes) at signalized intersections

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- e. Across arterial and collector streets at local street intersections that have been identified as pedestrian corridors where there is no control on the arterial or collector street.
- K. Midblock crossings on arterial and collector streets require additional considerations and shall have countermeasures (signs, markings, signalization) installed as identified in FHWA's Guide on Improving Pedestrian Safety and Uncontrolled Crossings (FHWA-SA-17-072).
- I. At a minimum, midblock crossings on arterial and collector streets shall have high visibility pavement markings (Type B), pedestrian or school crossing signs and advanced pedestrian or school crossing signs. Streets having more than one through lane in each direction and a median shall have signs on both sides for each direction of travel.
- L. Unless otherwise approved, all pavement markings shall be pre-formed plastic tape, epoxy paint, or reflective thermoplastic. The materials for all markings shall be specified on the plans.
- M. The solid white edge line separating an on-street bike lane from the adjacent motor vehicle lane shall be 6" wide.
- N. Existing signs shall be removed or modified as necessary so as not to conflict with new streets or street extensions.

7.1.12 Monumentation

Monuments in monument boxes shall be provided in new or reconstructed streets at all section corners, quarter corners, and sixteenth corners.

7.1.13 Lighting

The Design Engineer shall consider the need for roadway lighting in the development of plans for any new or reconstructed roadways.

Street lighting consists of street lighting and pathway intersection lighting, and shall comply with the following requirements:

- A. All street lighting shall be operated and maintained through the creation of a new Special Improvement Lighting District (SILD), through the annexation to an existing SILD or through some other equivalent means approved by the City of Bozeman. The application to create or annex to an existing SILD shall be submitted to the City within 2 months of preliminary approval of the development. The approval to create or annex to a SILD shall be granted prior to final plat for a subdivision or Certificate of Occupancy if a final plat is not required.
- B. Street lighting shall be installed per [Section 38.270.030.4](#) of BMC in regard to completion time for improvements.
- C. Individual yard lights on private property shall not be considered in evaluating or satisfying the need for street lighting.
- D. Unless otherwise specified herein, installation of equipment for lighting shall conform to the requirements of "Bozeman Lighting and Electrical Specifications" (see Chapter 9).

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7.1.14 Bike Lanes/Paths

All bike lanes/paths shall be designed in accordance with the latest edition of the Urban Bikeway Design Guide. Bike lanes shall be marked and signed in accordance with best practice and in conformance with the MUTCD.

7.1.15 Alleys

- A. In developments where alleys are proposed, a 20-foot-wide right-of-way must be provided. The driving surface of the alley must be at least 16 feet wide.
- B. Alleys used for backing must be designed to provide the required aisle width.

7.1.16 Utility Culverts

Conduits placed in right-of-way to facilitate placement of future gas, electric, communication, or other utility lines shall have the structural strength to withstand HS-20 loading. Conduits shall have a minimum stiffness of 46 psi. Conduits shall be adequately sized to accommodate all anticipated utility lines.

7.1.17 Mitigation of Transportation Impacts

When the standards of this section are not met, improvements shall be made to mitigate the impact of the development on the transportation system.

A. Level of service standards.

All intersections of arterial and collector streets and intersections with arterial and collector streets must operate at a minimum, overall intersection level of service of "D" or better. Level of service (LOS) values shall be determined using the methods defined by the most recent edition of the Highway Capacity Manual. Unless specifically exempted by this section, the review authority may only approve a development if the LOS standards are met within the study area, defined in Section 3.2.4C.VII, in the design year. The design year is the projected year of full build out or 5 years from the date of application whichever is greater.

I. Exception:

If an intersection required to be studied by does not meet LOS "D" and the intersection has been fully constructed to its maximum lane and turning movement capacity, as defined in the latest transportation master plan, then an LOS of less than "D" is acceptable.

II. Exception:

The review authority may grant a waiver for an LOS of less than "D" at a specific intersection if the review authority determines:

- a. Granting a waiver for the intersection would not be contrary to public health and safety and is in the public interest;
- b. Improvements to the intersection to raise the overall level of service to a "D" or better are currently scheduled for commencement of construction within five years as shown on the most recently adopted Transportation Capital Improvement Plan;

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A waiver granted under this subsection is valid for the initial entitlement period of the project and applies only to the real property for which the waiver is granted. A request for the extension of the initial development approval relying upon an intersection level of service waiver is a material modification to the application per [Section 38.100.070](#) of BMC.

If the review authority does not grant a waiver from the level of service standard under this subsection, a subdivider or other site developer may request a variance from the requirements of this section. If a variance is granted from the requirements of this section, the variance applies only to the specific development proposal for which it was granted and must not be considered evidence for any other development proposal.

B. Local Street Volumes.

Local streets are not intended to carry more than 1,000 vehicles per day. Unless specifically exempted by this section, the review authority may only approve a development if the projected volumes on local streets within the study area, defined in Section 3.2.4, are below 1,000 vehicles per day in the design year. The design year is the projected year of full build out or 5 years from the date of application whichever is greater.

I. Exception:

If existing mitigation measures are already in place.

II. Exception:

The review authority may grant a waiver for projected local street volumes greater than 1,000 vehicles per day if the review authority determines that granting a waiver for the intersection would not be contrary to public health and safety and is in the public interest;

Mitigation measures should target controlling motor vehicle speed and volume on the local street using traffic calming treatments identified in FHWA's Traffic Calming ePrimer.

A waiver granted under this subsection is valid for the initial entitlement period of the project and applies only to the real property for which the waiver is granted. A request for the extension of the initial development approval relying upon an intersection level of service waiver is a material modification to the application per [Section 38.100.070](#) of BMC.

If the review authority does not grant a waiver from the level of service standard under this subsection, a subdivider or other site developer may request a variance from the requirements of this section. If a variance is granted from the requirements of this section, the variance applies only to the specific development proposal for which it was granted and must not be considered evidence for any other development proposal.

Chapter 8 - Lighting and Electrical

Chapter 8 Lighting and Electrical

8.1. RESERVED

Reserved for future use. See Appendix C for standards.

Glossary of Acronyms and Terms

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADD	Average Daily Demand
ADU	Accessory Dwelling Unit
ARM	Administrative Rules of Montana
ASTM	American Society for Testing and Materials
AutoCAD	Computer-Aided Design
AWWA	American Water Works Association
B.F.P.	Back Flow Preventor
BMC	Bozeman Municipal Code
BMPs	Best Management Practices
CFRs	Code of Federal Regulations
CN	Curve Number
COB	City of Bozeman
COB Mods	City of Bozeman Standard Modifications
CP	Control Point
DBH	Diameter at Breast Height
DCS	Design and Construction Standards
DIP	Ductile Iron Pipe
EPA	Environmental Protection Agency
ESAL	Equivalent Single Axle Load
ET	Evapotranspiration
FDC	Fire Department Connection
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GPAD	Gallons per Acre per Day
GPM	Gallons per Minute
HEC	Hydraulic Engineering Circular

HGL	Hydraulic Grade Line
HOA	Homeowners Association
HW	Headwater
ID	Identification
IFC	International Fire Code
IWR	Irrigation Water Requirement
LS	Land Surveyor
MCA	Montana Code Annotated
MDD	Maximum Daily Demand
MDEQ	Montana Department of Environmental Quality
MDT	Montana Department of Transportation
MFE	Municipal Facilities Exclusion
MPH	Miles per Hour
MPWSS	Montana Public Works Standard Specifications
MS4	Municipal Separate Storm Sewer System
MUTCD	Manual of Uniform Traffic Control Devices
NAVD88	North American Vertical Datum of 1988
NCDC	National Climate Data Center
NOI	Notice of Intent
NOT	Notice of Termination
NRCS	Natural Resources Conservation Service
OI&M	Operation, Inspection, and Maintenance
OS&Y	Outside Screw and Yoke
PE	Professional Engineer
PHD	Peak Hour Demand
POA	Property Owner's Association
POC	Point of Connection
PROWAG	Public Right-of-Way Accessibility Guidelines
PSI	Pounds per Square Inch
PT	Point of Tangency
PVC	Polyvinyl Chloride

RPR	Resident Project Representative
RTF	Runoff Treatment Flow
RTV	Runoff Treatment Volume
SCS	Soil Conservation Service
SFHA	Special Flood Hazard Area
SILD	Special Improvement Lighting District
SP	Special Permit
SR	SCS Runoff Curve Numbers
SRV	Survey
SWMM	Storm Water Management Model
SWPPP	Stormwater Pollution Prevention Plan
TM	Theoretical Maximum
TPH	Total Petroleum Hydrocarbon
TR-55	Technical Release 55
TSS	Total Suspended Solids
TV	Television
USGS	United States Geological Survey
W/S	Water /Sewer
WFPU	Water Facility Plan Update
WQV	Water Quality Volume

Appendix A - City of Bozeman Fire Line Standard

Fire Line Standard

Attachment A – Backflow Prevention and System Classification

Attachment B – Contractor’s Material and Test Certificate for Underground Piping

CITY OF BOZEMAN

FIRE SERVICE LINE STANDARD

Revised March 31, 2011

Revised October 2024

1. For all fire service lines (regardless of size), a City of Bozeman Water Service Application must be completed and approved prior to beginning work on the fire service line. Water Service Applications are submitted with the building permit to the City of Bozeman Building Division through the City's electronic plan review system.
2. Plans for all fire service lines will be reviewed by the City of Bozeman. The review and subsequent approval or denial will be for that portion of the proposed fire service line that starts at the point of connection to the City of Bozeman distribution system up to and including the backflow preventer and the flow detection device. The plans will be reviewed by the city of Bozeman Water Department and Engineering Department. Upon satisfactory completion of the review process, the plans will be approved through the City's electronic plan review system.

Installation of the fire service (regardless of size) will not begin until the plans have been approved by the City of Bozeman, a preconstruction meeting has been conducted, and a City of Bozeman Water Service Application has been completed. For maintenance of the fire service line after City of Bozeman Post-Warranty Acceptance refer to Item 18 of this Standard. The Owner shall be completely responsible for assuring the fire service line is properly/adequately sized to provide the flows necessary for the fire protection system being serviced by the proposed fire service line.

3. Plans for all proposed fire service lines shall be drawn to scale on 24-inch by 36-inch or 22-inch by 34-inch plan sheet(s) and shall include all essential details such as:
 - a. Size and location of all water supplies.
 - b. Size and location of all piping indicating, where possible, the class, type and depth of existing pipe, the class and type of new pipe to be installed, and the depth to which it will be buried. For proposed fire service lines 4" in diameter and larger the plans must include a profile drawing of the proposed fire service line from the point of connection at the existing main up to and including the system riser. The profile drawing must show the finished grade, depth of cover for the line, and if applicable, all other utilities which the fire service line will cross or be adjacent to.
 - c. Size, type and location of valves.
 - d. Classification of the system (See Attachment A).
 - e. Sprinkler and standpipe riser to be supplied by the system.
 - f. Location of fire department connections.
 - g. Size of orifice necessary to achieve the flushing flows required under NFPA 24.
4. All fire service lines not installed by the City of Bozeman Water Department shall be designed, inspected and certified by a Professional Engineer.

5. Regardless of fire service line size, a preconstruction meeting shall be conducted prior to construction of the fire service line.
6. All fire service lines (regardless of size), shall be flushed and pressure tested. All fire service lines 4" in diameter and larger shall also be disinfected and tested for bacteriological quality.
7. Fire service lines 4" in diameter and larger shall be installed, tested, and disinfected by a single Contractor from the point of connection at the City water main (or existing stub) to the first control valve (OS&Y) inside of the building. (Note Item 18 of this Standard for maintenance of the fire line.)
8. For all fire service lines 2" in diameter and smaller where no stub exists, a licensed contractor shall install the line from the main up to and including the first control valve (OS&Y) and double check valve inside the building. The Water Department shall tap the main at the owner's expense and inspect the line under line pressure before it is backfilled. A curb stop and box shall be installed at a point 8' past property line unless otherwise approved. Installation of the fire service line will not begin until the plans for the project have received City of Bozeman approval and a City of Bozeman Water Service Application has been completed.
9. The City of Bozeman will only accept fire service lines which are 1", 1 ½", 2", 4", 6", or 8" in diameter, unless specifically approved by the Engineering and Water Departments.
10. When tapping tees are used for the fire service line connection to the main, the Contractor shall install the tapping tee and valve and the City of Bozeman shall make the actual tap to the main at the Owner's expense.

The fire service line connection to the City water main without the use of a tapping tee will be made by the Contractor installing the appropriately sized tee in the water main. The Water Department will operate all valves for the shutdown of the line to install the tee. Provisions related to water service interruption and temporary water supply shall be in accordance with Montana Public Works Standard Specifications (MPWSS) and City of Bozeman Modifications to MPWSS. The City of Bozeman reserves the right to determine the likely extent of the main shut down based on the proposed work and Contractor experience and require the installation of temporary water services by the Contractor.

11. Material and installation of fire service lines shall comply with the following standards:
 - a. **Montana Public Works Standard Specifications (latest edition adopted by City of Bozeman).**
 - b. **City of Bozeman Modifications to the Montana Public Works Standard Specifications.**
 - c. **City of Bozeman Standard Drawings 02660-12 and 02660-13.**
 - d. **City of Bozeman Fire Service Line Standard.**
 - e. **NFPA 24, Installation of Private Fire Service Mains and Their Appurtenances, (latest edition).**
12. The City of Bozeman's requirements for the installation of double check valve assemblies and reduced pressure backflow prevention assemblies are as follows:
 - a. The first fitting inside of the building shall be a UL listed flanged American Flow Control, Kennedy or Mueller OS&Y valve the same size as the fire service line, for lines 4" and

larger. For lines 2" and smaller, the first fitting inside the building shall be a NIBCO T-104-0 OS&Y valve.

- b. All double check valve assemblies and reduced pressure backflow prevention assemblies shall be:
 - 1. UL or FM listed
 - 2. Approved by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research (USCFCCCHR) for operation in the proposed position (vertical or horizontal) as shown on the approved plans.
 - 3. Installed as shown on the approved plans.
 - c. A flow detection device shall be installed immediately following the double check valve assembly or the reduced pressure backflow prevention assembly (alarm check valve, flow/sensor alarm, meter, etc.) as shown on the approved plans.
 - d. A double detector check valve assembly may be used with a standard City of Bozeman meter (for Class I, II and III systems only). The meter loop of the double detector check valve shall have a double check valve assembly installed which meets the same installation criteria specified above in requirement b.
 - e. Horizontal installations must be a minimum of 2 feet clear above the finished floor.
 - f. The fire service riser must be a minimum of 2 feet clear from any outside wall.
 - g. The incoming fire service line shall be a minimum of 6.5 feet and a maximum of 7.5 feet below the finished grade.
 - h. All fire service lines appurtenances shall have a minimum pressure rating of 175 p.s.i.
 - i. All fire service lines 4" and larger shall be Class 51 ductile iron pipe.
 - j. Line Sizing: The double check valve assembly or reduced pressure backflow prevention assembly shall be equal in size to the outgoing pipe diameter (downstream).
13. Prior the City of Bozeman's Final Acceptance of the new fire service line (regardless of size), flushing and pressure testing of the line shall be completed in accordance with NFPA 24. All fire service lines 4" in diameter and larger shall also be disinfected and tested for bacteriological quality in accordance with Montana Public Works Specifications and City of Bozeman requirements. Results of all tests are to be submitted to the City of Bozeman Building Division through the City's electronic plan review system.
14. Prior the City of Bozeman's Final Acceptance of the new fire service line (regardless of size) the "Contractor's Material and Test Certificate for Underground Piping" (See Attachment B for example form) must be completed and submitted to the City of Bozeman Building Division through the City's electronic plan review system.
15. Prior to City of Bozeman's Final Acceptance of the fire service line, the following must be submitted by the Project/Design Engineer to the City Engineer:
- a. Submit stamped and signed final record drawings to the City review Engineer, including one set on mylar and one full-size set on paper. An electronic version of the record drawings shall also be submitted to the Engineering Division application portal. Record drawings must be certified by a professional Engineer licensed in the State of Montana.
 - b. A letter of certification from the project Engineer stating that the fire service line

was installed in accordance with the approved plans.

- c. Results of testing specified above and as required by the City of Bozeman Design and Construction Standards (e.g. trench backfill, pavement, etc.)
16. The fire service line will not be activated until all required flushing and testing has occurred, and test results and the Contractor's Material and Test Certificate for Underground piping has been submitted to the City. Occupancy for the building will not be granted before the backflow preventor has been successfully tested and the project has received Final Acceptance (Stage 9 of the Infrastructure Review Process).
17. The required two-year warranty period for the fire service line begins on the date of Final Acceptance. The City of Bozeman's Post-Warranty Acceptance of the fire service line will be based on the Final Acceptance and correction of any deficiencies found during the two-year warranty period.
18. Following the expiration of the two-year warranty period, the City of Bozeman will maintain, at its expense, the fire service line from the main up to the curb stop or curb valve, or to the property line or easement line, whichever is more. Any maintenance or repairs to the fire service line or its appurtenances beyond the point of City of Bozeman responsibility specified above shall be by a licensed contractor at the Owner's expense. The building owner shall also be responsible for maintenance, repairs, and testing of all fire service line piping and appurtenances beyond the first control valve (OS&Y) inside the building.
19. The building owner may operate the first control valve (OS&Y) inside of the building when necessary for maintenance or repairs. When the first control valve (OS&Y) inside of the building is shut off for any reason, the City of Bozeman Fire Department must be notified immediately and informed of the shutdown date, time and duration. **The building owner is completely responsible to ensure that this valve remains open at all times (except for maintenance or repairs) for the proper operation of the buildings fire protection system.**
20. Use of the fire service line shall be restricted to firefighting use, emergency use and approved auxiliary (e.g., closed loop heating/cooling systems) including routine testing and flushing. Combined use lines (i.e., domestic and fire) are not acceptable for all buildings except single family residences (SFRs). Separate service lines must be installed for individual domestic and fire services, except for SFRs. Fire sprinkler systems for SFRs may connect to the domestic supply inside the residence. Such connection must be made downstream of the backflow preventer. The backflow preventer must be a testable backflow preventer approved by the City of Bozeman's Backflow Prevention Specialist.
21. **Bonding Requirements.** Prior to Final Acceptance of the fire service line, the Contractor shall post a Maintenance Bond with the Owner equal to 20% of the actual cost of the improvements to correct any deficiencies in workmanship and/or materials which are found within the warranty period. The City of Bozeman shall be named as a dual obligee on the bond. The Maintenance Bond shall remain in full force for the two-year warranty period.
22. **Insurance Requirements.** The Owner shall require the Contractor to secure and maintain such insurance from and insurance company (or companies) authorized to write insurance in the State of Montana, with a minimum "A.M. Best Rating" of B+, VI, as will protect himself, his subcontractors, the Owner, and the City of Bozeman and their respective agents and employees from claims for bodily injury, death, or property damage which may arise from operations and

completed operations under the Agreement. The types and limits of coverage shall comply with the current edition of "Montana Public Works Standard Specifications". The Owner shall not authorize, nor shall the Contractor commence work under the Agreement until such insurance has been obtained and certificates of insurance, with binders, or certified copies of the insurance policy, have been filed with the Owner and the City of Bozeman.

All insurance coverages shall remain in effect throughout the life of the Agreement, except that the Contractor shall maintain the Commercial General Liability coverage for a period of at least one year following the substantial completion date for property damage resulting from occurrences during the Agreement period.

Each insurance policy shall contain a clause providing that it will not be cancelled by the insurance company without 30 days written notice to the Owner, and the City of Bozeman, of intention to cancel.

23. Warranty Period. If, within two years after Final Acceptance of the work by the City of Bozeman, any of the work is found to be defective or not in accordance with the Contract Documents, and upon written notice from the City of Bozeman, the Owner shall cause the Contractor to correct any work within seven (7) calendar days of said written notice. Should the Owner or Contractor fail to the written notice within the designated time, the city of Bozeman may correct the work at the expense of the Owner/Contractor.

ATTACHMENT A

Backflow Prevention and System Classification

The City of Bozeman requires that the plans for the proposed fire service line include a description of the system including the “Class” of the system and the backflow prevention to be installed with the system. This Attachment provides standards for determining the Class of the proposed system and the required backflow protection to accompany the specific system. The standards in this Attachment are based on recommendations in American Water Works Association Manual M14, *Recommended Practice for Backflow Prevention and Cross-Connection Control*, and City of Bozeman requirements.

Classification for Backflow Protection

Class 1. Direct connections from public water mains only; no pumps, tanks, or reservoirs; no physical connection from other water supplies; no antifreeze or other additives of any kind; all sprinkler drains discharging to atmosphere, dry wells or other safe outlets.

Class 2. Same as Class 1 except that booster pumps may be installed in the building after the first interior control valve (OS&Y).

Class 3. Direct connection from public water supply mains, plus one or more of the following: elevated storage tanks, fire pumps taking suction from aboveground covered reservoir or tanks; and pressure tanks. (All storage facilities are filled or connected to public water only, the water in the tanks is to be maintained in a potable condition. Otherwise, Class 3 systems are the same as Class 1.)

Class 4. Directly supplied from public mains, similar to Class 1 and Class 2, with an auxiliary water supply dedicated to fire department use and available to the premises, such as an auxiliary supply located within 1,700 feet of the pumper connection.

Class 5. Directly supplied from public mains and interconnected with auxiliary supplies, such as pumps taking suction from reservoirs exposed to contamination, or rivers and ponds; driven wells; mills or other industrial water systems; or where antifreeze or other additives are used.

Class 6. Combined industrial and fire protection systems supplied from the public water mains only, with or without gravity storage or pump suction tanks.

Required Protection

All systems regardless of Class require a means of backflow protection which must be approved by the City of Bozeman.

Class 1. Minimum backflow protection requirement for a Class 1 system is an approved testable double check valve assembly to prevent water from backflowing into the public potable water system. The double check valve assembly should be the same size as the fire service line to the building and installed immediately following the first interior OS&Y control valve as shown on the approved plans. (Refer to City of Bozeman Standard Drawing 02660-12 for specific requirements.)

Exception: Special conditions may exist on the site of Class 1 fire systems such that actual or potential contamination hazards are presented to the domestic water supply. Under these conditions an approved reduced pressure backflow prevention assembly, or an appropriately sized air gap, may be warranted and/or required by the City of Bozeman.

Class 2. Minimum backflow protection requirement for a Class 2 system is an approved testable double check valve assembly to prevent water from backflowing into the public potable water system. The double check valve assembly should be the same size as the fire service line to the building and installed immediately following the first interior OS&Y control valve as shown on the approved plans. (Refer to City of Bozeman Standard Drawing 02660-12 for specific requirements.)

Exception: Special conditions may exist on the site of Class 2 fire systems such that actual or potential contamination hazards are presented to the domestic water supply. Under these conditions an approved reduced pressure backflow prevention assembly, or an appropriately sized air gap, may be warranted and/or required by the City of Bozeman.

Class 3. Minimum backflow protection requirement for a Class 3 system is an approved testable double check valve assembly to prevent water from backflowing into the public potable water system. The double check valve assembly should be the same size as the fire service line to the building and installed immediately following the first interior OS&Y control valve as shown on the approved plan. (Refer to city of Bozeman Standard Drawing 02660-12 for specific requirements.)

Exception: Special conditions may exist on the site of Class 3 fire systems such that actual or potential contamination hazards are presented to the domestic water supply. Under these conditions an approved reduced pressure backflow prevention assembly, or an appropriately sized air gap, may be warranted and/or required by the City of Bozeman.

Class 4. The type of backflow protection for Class 4 systems will depend on the quality of the auxiliary supply. The type of backflow protection will be one of the following approved by the City of Bozeman: air gap or reduced-pressure backflow-prevention assembly. Reduced-pressure backflow-prevention assemblies should be the same size as the fire service line to the building and installed immediately following the first interior OS&Y control valve as shown on the approved plans. (Refer to city of Bozeman Standard Drawing 02660-13 for specific requirements.)

Class 5. The type of backflow protection for Class 5 systems will be either a reduced-pressure backflow-prevention assembly or an air gap. Reduced-pressure backflow-prevention assemblies should be the same size as the fire service line to the building and installed immediately following the first interior OS&Y control valve as shown on the approved plans. (Refer to City of Bozeman Standard Drawing 02660-13 for specific requirements.)

Class 6. Class 6 system protection would depend on the requirements of both industry and fire protection and could only be determined by a survey of the premises.

ATTACHMENT B

Sample Contractor's Material and Test Certificate for Underground Piping

Contractor's Material and Test Certificate for Underground Piping			
PROCEDURE			
Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job. A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.			
Property Name			Date
Property Address			
Plans	Accepted by Approving Authorities (Names): City of Bozeman		
	Address: 20 E. Olive Street, Bozeman MT 59715		
	Installation conforms to accepted plans: ☐ Yes ☐ No		
	Equipment used is approved: ☐ Yes ☐ No		
If no, state deviations:			
Instructions	Has person in charge of fire equipment been instructed as to the location of control valves and care and maintenance of this new equipment? ☐ Yes ☐ No		
	If no, explain:		
	Have copies of appropriate instructions and care and maintenance charts been left on premises? ☐ Yes ☐ No		
	If no, explain:		
Location	Supplies Buildings:		
Underground Pipes and Joints	Pipe Types and Class:		Type Joint:
	Pipe conforms to _____ standard		☐ Yes ☐ No
	Fittings conform to _____ standard		☐ Yes ☐ No
	If no, explain:		
	Joints needed anchorage clamped, strapped, or blocked in accordance with _____ standard		☐ Yes ☐ No
If no, explain:			
Test Description	Flushing:	Flow the required rate until water is clear as indicated by no collection of foreign material in burlap bags at outlets such as hydrants and blow-offs. Flush at flows not less than 25 gpm (95 L/min) for 1-inch pipe, 60 gpm (228 L/min) for 1.5-inch pipe, 100 gpm (379 L/min) for 2-inch pipe, 390 gpm (1476 L/min) for 4-inch pipe, 880 gpm (3331 L/min) for 6-inch pipe, 1560 gpm (5905 L/min) for 8-inch pipe, 2440 gpm (9235 L/min) for 10-inch pipe, and 3520 gpm (13,323 L/min) for 12-inch pipe. When supply cannot produce stipulated flow rates, obtain maximum available.	
	Hydrostatic:	Hydrostatic tests shall be made at not less than 200 psi (13.8 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.3 bar) for 2 hours.	
	Leakage:	New pipe laid with rubber gasketed joints shall, if the workmanship is satisfactory, have little or no leakage at the joints. The amount of leakage at the joints shall not exceed 2 quarts per hour (1.89 L/hr) per 100 joints irrespective of pipe diameter. The leakage shall be distributed over all joints. If such leakage occurs at a few joints, the installation shall be considered unsatisfactory and necessary repairs made. The amount of allowable leakage specified above can be increased by one fluid ounce per inch valve diameter per hour (30 mL/25 mm/hr) for each metal seated valve isolating the test section. If dry barrel hydrants are tested with the main valve open so the hydrants are under pressure, an additional 5 ounces per minute (150 mL/min) leakage is permitted for each hydrant.	

Flushing Tests	New underground piping flushed according to <u> NFPA 24 </u> standard ☐ Yes ☐ No		
	By (Company):		
	If no, explain:		
	How was flushing flow obtained? ☐ Public Water ☐ Tank or Reservoir ☐ Fire Pump	Through what type of opening? ☐ Hydrant Butt ☐ Open Pipe	
Flushing Tests	Lead-ins flushed according to <u> </u> standard ☐ Yes ☐ No		
	By (Company): Kruse Enterprises, Inc.		
	If no, explain:		
	How was flushing flow obtained? ☐ Public Water ☐ Tank or Reservoir ☐ Fire Pump	Through what type of opening? ☐ Y Connection to Flange and Spigot ☐ Open Pipe	
Hydrostatic Test	All new underground piping hydrostatically tested at <u> </u> psi for <u> </u> hours		Joints covered? ☐ Yes ☐ No
Leakage Test	Total amount of leakage measured: <u> </u> gallons <u> </u> hours		
	Allowable leakage: <u> </u> gallons <u> </u> hours		
Hydrants	Number installed:	Type and Make:	All operate satisfactorily? ☐ Yes ☐ No
Control Valves	Water control valves left wide open? ☐ Yes ☐ No		
	If no, state reason:		
Remarks	Hose threads of fire department connections and hydrants interchangeable with those of fire department answering alarm? ☐ Yes ☐ No		
	Date left in service:		
Signatures	Installing Contractor	Company:	
		Installer:	
	Tests Witnessed By:		
	For Property Owner (Signed):	Title	Date
	For Installing Contractor (Signed):	Title	Date
Additional explanation and notes:			

Appendix B – Random Sampling Example

Random Sampling Example

SAMPLING MATERIALS BY RANDOM NUMBER SAMPLING

1.1. SCOPE

This method provides a procedure, in the form of several examples, for selecting samples on an approximately random basis using a system of random numbers. To accomplish this selection, choose the random sample so that each unit of material (i.e., cubic yard, square yard, ton, etc.) has the same probability of being selected. Divide each material sampled into lots and establish a frequency of sampling.

1.2. PROCEDURE

- 1.2.1 Random numbers can be generated by some calculators by planting a seed number such as date, time of day, etc., expressed as a decimal between 0 and 1. Included in this method are two tables of random numbers for use. Enter the table in a random method, such as a blind placement of a pencil. After choosing the first random number in this manner, choose consecutive numbers, following a column (or row), until the entire table has been used. At that time, repeat the initial process of random entry into the table of numbers. This method will reduce the possibility of using a value from the table more than once.

- 1.2.2 Following are examples related to particular phases of highway construction:

EXAMPLE NO. 1

In this example, select station numbers for density coring of a 0.75-in. nominal- maximum mixture. Specifications require four density Gores for each 1 000 tons of mixture placed. The subplot size is 1000 tons with a frequency of four cores per subplot. The subplot of mixture in question will be placed on a 12-ft.-wide lane that is 4545 ft. long. The lift thickness of the 0.75-in. nominal-maximum mixture is 3.0 in. The job starts at Station No. 0+00.

Since four density cores are required for the entire 4545-ft. length, obtain one core for each 1136.25 ft. of pavement. Use the following steps to determine the station number and offset for each density core:

1. Refer to the random number table (seep. 5 for example).
2. Enter the table at any point. Select four consecutive numbers from the random number table. Use these numbers for finding the station number of the core site in each 1136.25-ft. section.
3. Multiply each random number by 1136.25 to determine the station number at which to obtain the density core. After determining the location of the first core, for each of the remaining cores, add increments of 1136.25 ft., to provide locations throughout the entire subplot length.

SAMPLE NO.	RANDOM NUMBER CALCULATION	STATION NUMBER
1	$0.420 \times 1136.25 = 477.23 + 0.00 = 477$	4 + 77
2	$0.859 \times 1136.25 = 976.04 + 1136.25^* = 2112$	21 + 12
3	$0.011 \times 1136.25 = 12.50 + 2272.50 = 2285$	22 + 85
4	$0.762 \times 1136.25 = 865.82 + 3408.75 = 4275$	42 + 75

**1136.25-ft. increments, as determined by the subplot length, provide resultant numbers throughout the entire subplot length.*

- According to Subsection 402.03.02 of the Standard Specifications, obtain cores no closer than three inches from the pavement edge or joint. To select the transverse distance from the pavement edge (left or right), select four additional consecutive numbers from the random number table (see p. 5 for example), and multiply each random number by 11.5 (12-ft. lane width minus the 0.25-ft. offset from each side). For this example, calculate the distance from 0.25 ft. inside of the right edge of the pavement.

SAMPLE NO.	RANDOM NUMBER CALCULATION	OFFSET FROM RIGHT EDGE
1	$0.062 \times 11.5 + 0.25 =$	1.0 ft.
2	$0.100 \times 11.5 + 0.25 =$	1.4 ft.
3	$0.409 \times 11.5 + 0.25 =$	5.0 ft.
4	$0.784 \times 11.5 + 0.25 =$	9.3 ft.

- Therefore, from the calculations above, conform to the coring schedule given below for this subplot:

SAMPLE NO.	STATION NUMMBER	OFFSET FROM RIGHT EDGE
1	4 + 77	1.0 ft.
2	21 + 12	1.4 ft.
3	22 + 85	5.0 ft.
4	42 + 75	9.3 ft.

With respect to this example, in other cases, the paving length and width will vary but use the same procedure for obtaining random locations.

EXAMPLE NO. 2

In this example, select trucks to sample for running air content, slump, and concrete cylinders on Class AA Concrete for a bridge deck pour.

The pour will consist of 250 cubic yards of concrete. The trucks will be hauling 10 cubic yards each. The testing frequency is one test for each 50 cubic yards; therefore, perform five tests. There will be at least five tests required. Use the following steps to select the trucks to sample:

1. Refer to the random number table (seep. 5 for example).
2. Select five consecutive numbers from the random number table. Use these numbers to determine which trucks to sample. Multiply each number by 50 (a lot size of 50 cubic yards) and divide the answer by 10 (cubic yards per truck) to determine which trucks to sample.

SAMPLE NO.	RANDOM NUMBER	CALCULATED VOLUME (cubic yards)	TRUCK SAMPLED
1	0.007	$X 50 = 0.35 + 0 = 0.35 / 10 = 0.04^*$	1st
2	0.922	$X 50 = 46.1 + 50^{**} = 96.1 / 10 = 9.6$	10th
3	0.729	$X 50 = 36.5 + 100 = 136.5 / 10 = 13.7$	14th
4	0.949	$X 50 = 47.5 + 150 = 197.5 / 10 = 19.8$	20th
5	0.606	$X 50 = 30.3 + 200 = 230.3 / 10 = 23.03$	24th

**When this answer contains a decimal, always round upward to the next highest whole number to determine the truck number.*

***Add increments of 50 cubic yards (lot size), increasing with each sample, in order to provide sampling throughout the full 250 cubic yards.*

EXAMPLE NO. 3

In this example, select the accumulated tonnage of Crushed Stone Base for gradation testing. The frequency for gradation testing of aggregate bases is one test per 2000 tons of material. Plan quantities show 10,000 tons of Crushed Stone Base exist on this project. This quantity will require five gradation tests.

Again, select five consecutive random numbers from the random number table (see p. 5 for example). Use these numbers to determine the accumulated tonnage at which to select the sample.

Multiply each number by 2000 to determine the accumulated tonnage for sampling. Add increments of 2000 tons (lot size), increasing with each sample, in order to provide sampling throughout the full 10,000 tons.

SAMPLE NO.	RANDOM NUMBER CALCULATION	ACCUMULATED TONNAGE
1	$0.658 \times 2000 = 1316 + 0 =$	1316
2	$0.747 \times 2000 = 1494 + 2000 =$	3494
3	$0.270 \times 2000 = 540 + 4000 =$	4540
4	$0.715 \times 2000 = 1430 + 6000 =$	7430
5	$0.418 \times 2000 = 836 + 8000 =$	8836

Obtain samples as near the above-listed accumulated tonnages as possible.

- 1.2.3 The system of selecting random samples can be related to periods of time, number of pieces, tons, etc. The key to randomness, using this method, relies heavily on the manner of entering the table. Do not use the same set of numbers repeatedly.

TABLE 1 RANDOM NUMBERS

.600	.504	.248	.230	.996	.462	.422	.054	.224	.121
.116	.227	.802	.349	.241	.956	.079	.632	.126	.677
.098	.726	.507	.607	.963	.410	.572	.777	.237	.851
.147	.867	.802	.416	.370	.377	.775	.256	.348	.148
.644	.067	.001	.158	.702	.148	.667	.217	.421	.149
.310	.531	.520	.560	.888	.287	.567	.251	.593	.571
.493	.235	.886	.178	.490	.007	.640	.343	.894	.079
.788	.272	.484	.487	.277	.922	.435	.716	.924	.304
.652	.523	.317	.601	.705	.729	.669	.435	.984	.239
.816	.045	.423	.943	.227	.949	.395	.931	.887	.242
.086	.585	.177	.851	.513	.606	.911	.253	.669	.328
.689	.755	.027	.183	.024	.658	.041	.512	.518	.910
.117	.029	.309	.017	.926	.747	.584	.570	.212	.504
.700	.989	.980	.532	.640	.270	.610	.257	.996	.978
.321	.431	.370	.814	.420	.715	.548	.148	.953	.450
.515	.775	.759	.438	.859	.418	.689	.924	.350	.724
.543	.575	.633	.097	.011	.170	.357	.429	.899	.087
.629	.502	.503	.036	.762	.280	.605	.518	.275	.017
.221	.882	.206	.415	.776	.548	.520	.417	.253	.808
.751	.446	.189	.776	.465	.936	.970	.467	.371	.077
.553	.160	.464	.309	.298	.304	.613	.512	.816	.270
.384	.778	.284	.435	.246	.319	.078	.695	.152	.637
.969	.740	.102	.093	.055	.155	.225	.782	.226	.250
.085	.125	.750	.900	.991	.887	.993	.183	.096	.542
.667	.355	.784	.803	.072	.206	.508	.385	.691	.127
.076	.968	.527	.749	.062	.075	.526	.292	.176	.310
.788	.943	.091	.141	.100	.040	.750	.870	.249	.345
.165	.422	.601	.095	.409	.897	.963	.271	.770	.100
.472	.201	.558	.725	.784	.025	.943	.040	.984	.011
.668	.708	.776	.490	.270	.868	.658	.954	.916	.955

TABLE 2 RANDOM NUMBERS

.605	.973	.319	.294	.236	.572	.216	.973	.931	.870
.720	.497	.679	.634	.299	.578	.743	.835	.062	.200
.918	.295	.295	.777	.854	.281	.867	.864	.374	.748
.294	.396	.441	.321	.655	.191	.205	.899	.807	.186
.089	.927	.802	.530	.937	.257	.530	.005	.539	.999
.591	.409	.668	.967	.993	.920	.812	.018	.578	.618
.494	.808	.410	.097	.633	.149	.547	.895	.829	.953
.021	.699	.597	.286	.982	.953	.913	.422	.291	.979
.926	.085	.758	.624	.491	.694	.496	.490	.949	.457
.351	.709	.461	.093	.498	.377	.639	.801	.388	.334
.329	.857	.949	.550	.095	.906	.596	.462	.891	.758
.126	.525	.834	.677	.045	.699	.568	.147	.902	.664
.572	.101	.066	.147	.069	.006	.979	.259	.765	.460
.728	.374	.402	.679	.601	.492	.002	.512	.529	.089
.524	.346	.698	.133	.013	.907	.992	.453	.883	.684
.176	.870	.306	.179	.071	.854	.086	.414	.973	.785
.031	.437	.512	.107	.842	.507	.458	.018	.881	.506
.826	.110	.065	.878	.182	.460	.442	.504	.075	.027
.945	.640	.283	.330	.163	.496	.767	.543	.921	.923
.948	.890	.677	.328	.075	.752	.207	.692	.268	.204
.232	.639	.425	.434	.795	.329	.941	.026	.867	.035
.896	.502	.074	.092	.203	.625	.541	.505	.835	.021
.643	.838	.357	.294	.592	.440	.676	.186	.304	.212
.552	.892	.843	.851	.685	.847	.963	.189	.604	.634
.623	.955	.024	.718	.534	.978	.962	.208	.645	.811
.988	.648	.182	.983	.128	.784	.606	.138	.208	.337
.326	.500	.874	.958	.826	.523	.462	.823	.955	.773
.130	.545	.756	.164	.418	.817	.707	.882	.984	.903
.907	.419	.705	.597	.655	.566	.546	.738	.614	.373
.859	.365	.476	.351	.154	.458	.645	.303	.631	.832

Appendix C – Bozeman Lighting and Electrical Specification

Standard Specifications for Lighting Materials and Installations

Roadway Luminaire Submittal Form

Pedestrian Luminaire Submittal Form

Standard Drawings

Street Lighting Method of Measurement

Street Lighting – Step-by-Step Luminance Method of Measurement

Street Lighting – Luminance Method of Measurement

Street Lighting Measurement Form

City of Bozeman

Standard Specifications for Lighting Materials and Installation

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Section I. General

These specifications for the provision of lighting installations are intended to provide a set of minimum standards that shall be followed for street lighting, pedestrian lighting and pathway lighting installations within the City of Bozeman public right-of-way or property. These standards, plans, and any special provisions shall apply to all materials supplied, methods, and procedures of work to be followed, and other general minimum requirements that shall be complied with before work is accepted by the City of Bozeman.

The City of Bozeman has adopted the following as part of these standard specifications:

- A Standard Specifications for Road and Bridge Construction (latest edition), Montana Department of Transportation, and all amendments and revisions pertaining thereto.
- B Manual on Uniform Traffic Control Devices (latest edition), Federal Highway Administration.
- C NFPA 70 - National Electrical Code (latest edition)
- D NESC - National Electrical Safety Code

The standard specifications outlined in this document are revisions and amendments to the Montana Department of Transportation Standard Specifications for Road and Bridge Construction. In situations where there is a conflict or question of interpretation, these specifications and any special provisions shall prevail.

These specifications, the plans, any special provisions, and all supplemental documents are essential parts of a contract and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for the complete work. In case of a discrepancy, figured dimensions shall govern over scaled dimensions; plans shall govern over standard specifications; and special provisions shall govern over plans and standard specifications.

Section II. Definitions

Development Review Committee (DRC) evaluates all proposals subject to the provisions of Chapter 38, the Unified Development Code within the Bozeman Municipal Code. The DRC is charged with reviewing items related to public health and safety.

Low Pedestrian Conflict occurs when adjacent to residential, rural or industrial land uses with very low volumes of nighttime pedestrian usage. These can occur in any of the cited street classifications but are typically suburban streets with single family dwellings, multi-family residential developments, and rural or semi-rural areas.

Medium Pedestrian Conflict occurs when adjacent to commercial and institutional land uses where a moderate numbers of pedestrians utilize the streets at night. Typical are downtown office areas, blocks with libraries, schools, churches, shopping centers, restaurants, parks, and streets with transit lines.

Pathway lighting is provided to light trails and pathways that are not adjacent to streets. Pathway lighting assemblies are typically 36 inches to 48 inches. The distribution of the light is directed towards the trail or pathway.

Pedestrian lighting is provided to light the sidewalk (attached or detached) along arterial, collector, local streets, public plazas, trails or other pedestrian areas. Pedestrian lighting assemblies are typically between 12 feet to 15 feet. The distribution of the light is directed towards the sidewalk.

Special Improvement Lighting District (SILD) an improvement district embracing street or streets or public highway therein or portions thereof and property adjacent thereto or property which may be declared by said council to be benefitted by the improvement to be made for the purpose of lighting such street or streets or public highway. All or any portion of the cost of installing and maintaining such lighting system is required to be paid by the owners of the property embraced within the boundaries of such districts.

Street lighting is provided for arterial, collector, and local streets where pedestrians and cyclists are generally present. The primary purpose of street lighting is to help the motorist identify obstacles, provide adequate visibility of pedestrians and cyclists, and assist in visual search tasks, both on and adjacent to the street. Street lighting assemblies are typically between 25 feet and 40 feet. The distribution of the light is directed towards the street.

Section III. Scope of Work.

A. General

The design engineer shall consider the need for street lighting, pedestrian lighting and pathway lighting, as specified in Section XII Lighting Criteria, in the development plans for any new or reconstructed roadways. The guidelines and specifications outlined here shall be applicable to lighting located within the City's Right of Way.

All street, pedestrian and pathway lighting shall be operated and maintained through the creation of a new SILD, through the annexation to an existing SILD or through some other equivalent means approved by the City of Bozeman. The application to create or annex to an existing SILD shall be submitted to the City within two months of preliminary approval of the development. The approval to create or annex to an SILD shall be granted prior to final plat for a subdivision or Occupancy if a final plat is not required.

Street lighting shall be installed per 38.570, BMC (in regards to completion time for improvements).

Individual yard lights on private property shall not be used for street lighting.

Section IV. Control of Work

A. General

Record drawings shall be provided to the City for all new and re-constructed lighting systems that are to be maintained by the City. Cut sheets of all equipment shall be provided with the record drawings.

For lighting projects in new subdivisions, record drawings shall be provided and a final inspection done before final plat approval.

For site plans that include lighting projects, record drawings shall be provided and a final inspection done before occupancy approval.

Contractor is required to submit record drawings and equipment cut sheets for any electrical work that alters an existing lighting system, prior to receiving full payment for project work.

B. Deviation Request

Deviations may be granted by the City Engineer. Appeals to denials of deviation requests shall be to the Director of Public Works. Refer to Section 38.570 for additional information.

Section V. Utility Clearances

A. Overhead Powerline Clearances

Light standard assembly locations must comply with National Electrical Safety Code (NESC) Rules regarding clearance requirements between phase conductor and streetlight and between primary conductor and streetlight.

Light standard assembly locations must comply with the Occupational Safety and Health Administration (OSHA) 1926.1408 minimum clearance distances to overhead power lines.

The City will not accept work that does not meet these clearance requirements or requires a qualified worker to maintain the lighting system.

B. Below-grade Utility Clearances

Light standard foundations shall be located to maintain a minimum horizontal clearance of 10 feet from the edge of foundation to the edge of any water line, sewer line, storm drain line or gas line. When paralleling water, sewer, storm and gas lines with lighting conduit, a 10-foot horizontal separation is preferred. Where 10 foot separation is impractical, a minimum of 5-foot horizontal separation will be allowed.

Section VI. Conduit

A. Plastic Conduit - PVC

All PVC conduits located under roadways, driveways, and other vehicular access areas shall be schedule 80 type EPC-80-PVC.

Conduits under non-vehicular locations may be schedule 40 type EPC-40-PVC.

PVC conduit shall be manufactured of high-impact PVC, and shall conform to industry standards and commercial standard CS-207-60 and NEMA TC 2.

All 90-degree conduit bends shall be factory 90-degree elbows that are schedule 80 PVC or PVC coated GRC.

Field conduit bends may be used for bends that are 60-degrees or less. When bending PVC conduit in the field, use a heater that is approved by the conduit manufacturer.

Bends in PVC conduit shall be made and conform to all appropriate sections of the National Electric Code or local codes governing bending radius, and the number of bends allowed as applicable for rigid conduit.

Conduit bends, except factory bends, shall have a radius of not less than six times the inside diameter of the conduit.

B. Plastic Conduit – HDPE

All HDPE conduit shall be factory lubricated, low friction, high-density conduit constructed of virgin high density conduit constructed of virgin high-density polyethylene resin. Conduit shall be capable of being coiled on reels in continuous lengths, transported, stored outdoors, and subsequently uncoiled for installation, without affecting its properties or performance.

Bored electrical conduit shall be HDPE and installed using trenchless technology of either jacked conduit or directional boring.

C. Steel Conduit

Steel conduit for exterior, surface mounted, above grade installations shall be Galvanized Rigid Conduit (GRC). Polyvinyl Chloride coated Galvanized Rigid Conduit (PVC coated GRC) may be used for below grade installations, encased in concrete and above grade where exposure to water is imminent.

GRC conduit shall comply with ANSI C80.1 and UL 6.

PVC coated GRC shall comply with NEMA RN 1. Coating thickness shall be a minimum of 0.040 inch (1mm), both inside and out.

D. Conduit Installation

All conduit direct buried in contact with earth shall be PVC, HDPE or PVC coated GRC. PVC conduit Installation through foundations (other than light standard foundations) shall have transition to GRC or PVC coated GRC prior to exposure above foundation.

Underground conduit shall have the following minimum diameter (ID) trade size conduit, unless otherwise approved by the Engineer.

1. Conduit Sleeves Under Roadways: 3 inch minimum
2. Conduit in Typical Trench: 2 inch minimum
3. Conduit from Pull Box / Splice Box to Foundation: 1 inch minimum
4. Conduit to Pathway Luminaires: 3/4 inch minimum

Conduits shall be placed two feet from back of curb.

All existing conduits shall be cleaned with a mandrel or cylindrical wire brush and all conduits (existing or new) shall be blown out with compressed air, before conductors or signal facilities are installed.

All empty spare conduits shall be installed with the following:

1. A nylon or polyester pull tape of at least 1250 lbs strength with footage marking tape.
2. For bored conduit installations that require complete intersection rewiring or new construction, a 12 AWG tracer wire shall be installed across every empty conduit leg, and conduit plugs shall be installed in all conduits.
3. Pull rope with footage tape, tracer wire, and conduit plugs shall be included in the price of electrical conduit.

When conduit is specified to be installed under existing pavement by directional line boring, the boring pits shall be kept a minimum of 2 feet clear of the edge of pavement whenever possible.

Conduit installed under pavement, sidewalk, dirt, sod or any condition other than under an existing

roadway shall be installed with not less than 24 inches of cover to the top of the conduit. Under existing roadway, conduit shall be installed with not less than 30 inches of cover to the top of the conduit. Conduit installed under railroad tracks shall be installed not be less than 42 inches below the bottom of the tie to the top of the conduit. [Refer to Figure 1 – Typical Conduit Burial Standard Detail].

Section VII. Pull Boxes / Splice Boxes

A. General

All pull / splice boxes and covers must be made of polymer concrete with fiberglass reinforcement with a traffic rating of TIER 22.

Pull / splice boxes shall be labeled "ELECTRIC" on pull / splice boxes containing electrical power or "LIGHTING" on all pull / splice boxes containing street lighting conductors. The labeling must be cast into the cover and not a separate independent tag. [Refer to Figure 2 – Typical In-Grade Pull Box / Splice Box Dimensions Standard Detail]

B. Pull Box / Splice Box Installation

When pull / splice boxes are located behind sidewalk or in non-pavement areas, they shall be surrounded by a 12 inch wide collar of class B concrete 6 inches deep. [Refer to Figure 3 – Typical In-Grade Composite Pull Box / Splice Box Detail]

Maximum distance between pull / splice boxes is 200 feet for street and pedestrian lights, and 100 feet for pathway lights.

Street crossings for conduit runs need to have a pull / splice box at each side of the street crossing.

Pull / splice boxes are to be installed at each street corner where conduit takes a 90 degree bend around the corner of the block.

Provide a Type 1 or Type 2 pull / splice box by each streetlight or pedestrian light with smaller 1 inch diameter conduit allowed going into light base from pull / splice box.

For pathway lights, conduit may be routed in and out of the foundation, with a minimum conduit size of 1 inch. Pull / splice boxes for pathway lights shall be placed at 90-degree bends around a corner, and at the minimum spacing listed above.

Box size shall be determined by the diameter of the Largest Trade Size Conduit (LTSC) installed in the box. For conductors 6 AWG or smaller, the box shall be sized (6) six times LTSC in width or length dimension. For conductors 4 AWG and larger, the box shall be sized (8) eight times LTSC in width or length dimension.

For future expansion, empty conduit, with nylon or polyester tape pull tape of at least 1250 lbs strength with footage marking tape, shall terminate in a pull / splice box. Stub spare conduit(s) out of the box and cap below grade at 2 feet from the box, in the direction of future expansion. Label conduit stub out(s) in pull / splice box "for future expansion to the *direction of expansion*".

Wire connections in pull / splice boxes should use water-proof, insulated multi-tap connectors, by Burndy, or IIsco, or equivalent.

Section VIII. Concrete Foundations

A. Light Standard Foundations

In locations where the roadway is not curbed, and/or in dirt, the top of the foundation shall be six inches above the grade of the edge of the pavement or as directed by the Engineer. The top of the foundation shall be finished smooth and have a 3/4 inch chamfered edge. [Refer to Figures 4, 5 and 6 – Typical Light Standard Foundation Electrical Details]

Where caisson foundations are located in the sidewalk, the caisson foundation shall be installed to 6 inch under finished curb or sidewalk grade or as directed by the Engineer. [Refer to Figure 4 – Typical Light Standard Foundation Electrical Details]

Where foundations are to be installed in dirt, landscaped areas, or any other situation where the top of the caisson is not being installed with an existing sidewalk or concrete improvement, the contractor shall use sono-tube on the top section of the caisson for finished appearance.

A structural engineer licensed in the state of Montana shall determine the foundation size (depth and diameter) and concrete reinforcement for the specific light standard configuration.

B. Concrete Foundation Pads

All lighting control center cabinets that are to be installed in concrete, shall have either, an approved anchor bolt template with bolts installed before concrete pour, or upon approval of the Engineer, be installed using approved concrete drop in style anchors. All lighting control center cabinets installed in areas other than concrete, shall be installed to their marked grade on a concrete foundation pad with 24" depth, sized to fit cabinet dimensions with 3 inch minimum to 6 inch maximum offset of concrete on all sides of the enclosure. Provide 3 foot x 3 foot step pad with a maximum slope of 1:24. [Refer to Figures 7a, 7b, 8 and 9 – Typical Lighting Control Center Standard Details]

C. Concrete Fill for Pedestal Type Cabinets

All pedestal type cabinets mounted on galvanized strut-channel supports shall have concrete filled post holes with a minimum depth of 36-inches and minimum diameter of 9-inches. [Refer to Figure 8 – Typical Lighting Control Center Pedestal Standard Detail]

Section IX. Wiring

A. General

All wiring shall be copper conductors installed in conduit to meet the National Electric Code.

Minimum size current carrying conductor for exterior installations shall be #10 AWG copper.

Furnish conductors of solid or stranded copper of the gauge shown in the contract.

Insulation for conductors must be Type THW, XHHW, XHHW-2, USE, RHH, RHW, THWN, and THWN-2. All insulation must be designed for 600 volts and meet NEC requirements.

All wiring shall be pulled into conduit using a nylon or polyester pull tape of at least 1250 lbs strength with footage marking tape.

Metal Clad cable (MC) or Armored Cable (AC) shall not be allowed in exterior applications.

Exterior lighting shall be powered at 120/240V-1PH-3W unless otherwise noted on the plans. Wiring color code shall be as follows:

Line 1 = Black

Line 2 = Red

Neutral = White (only required when 120V power is present)

Ground = Green

Section X. Bonding and Grounding

A. General

All PVC or PVC coated GRC conduits from a metered power source shall have a raceway ground conductor installed with the current carrying conductors, sized to the NEC. Ground conductor shall have the size increased to match current carrying conductor size increase for voltage drop purposes.

All light standard foundations for streetlights and pedestrian lights shall have a 5/8 inch diameter x 8 foot long, copper clad driven ground rod installed in the pull / splice box next to the light standard. Top of rod shall be a minimum of 4 inches below grade. Exothermic weld or underground rated lug connect a #6 AWG soft drawn bare copper conductor from rod through 1/2 inch trade size conduit in the foundation to the lug on the pole in the back of the hand hole.

In instances where no dedicated ground rod is present in the pullbox to clamp to the #6 bare copper conductor, the contractor shall clamp to the light pole foundation rebar cage. In this situation, the light pole foundation must be in direct contact with the ground (sonotube removed).

Pathway lights shall have the system grounding conductor bonded to the grounding lug inside each bollard.

All grounding electrodes shall be bonded together per the NEC.

Section XI. Lighting Control Centers and Metered Pedestals

A. General

All street lighting systems shall be metered separately from other uses, with the exception of streetlights installed in conjunction with traffic signal poles.

Lighting control centers and metered pedestals shall be located outside of the sight triangle and within the public right of way or easement at least 50 feet from intersection corners. The location shall be behind the sidewalk where possible and in the boulevard near the sidewalk when right of way does not allow for placement behind the sidewalk.

B. Installation

Electric services shall use NEMA Type 3R cabinets with hinged, lockable covers and 3/8" holes for a padlock.

Services shall be equipped with 3-way switches for hand-off-auto (HOA) operation. Wire photocell on/off control in the auto position.

Lighting control centers shall house electrically held lighting contactors that are 12-pole with 30 amp contacts rated at 600V, and 120V coils.

Street lighting circuits shall be automatically controlled with turn lock mounting delayed response photo cells. Lighting control centers shall have a 120V twist-lock receptacle type photoelectric cell with matching receptacle base attached to the assembly with heavy duty galvanized c-channel structure using 1 inch galvanized rigid conduit, mounted 8 feet above grade. Orient window of photocell to face north. Photocell to operate the lighting contactors for on/off control when HOA is in the auto position.

Meters shall be installed a minimum of 4 feet and maximum of 5 feet above grade to the center of the meter.

Section XII. Lighting Design Criteria

This section describes the luminaire selection and lighting layout for each street classification. Designers are required to submit the following to the City of Bozeman for all street lighting projects:

- Calculation summary (more information can be found in Section XII.D)
- Luminaire Submittal Form (found in Appendix A)

A. Lighting Controls

All street and pedestrian lights installed shall have on board dimmers to allow for dimming in the field after luminaires have been installed. Onboard dimmers will allow for city officials to be able to dim lights when residents are offended following new installations.

All streetlights shall have an ANSI 7-Pin receptacle to be compatible with future wireless control systems.

B. Intersections and Crosswalks

The same luminaires are to be used throughout the intersection. When an intersection is between two different street classifications, the higher street classification target criteria is used throughout the entire intersection. The recommended streetlight layout for an intersection is also dependent on whether the street classification calls for continuous or non-continuous lighting.

All traffic signal mounted streetlights shall meet the lighting requirements listed below. The intersection design shall ensure that the crosswalks are sufficiently lighted to light the vertical surface (body) of pedestrians in the crosswalk. This may require that additional streetlights be located before the intersection as shown in the Figures below.

Mid-block crossings and denoted crosswalks shall be lighted. Crosswalks can be denoted by striping, signage, flashing beacons, etc. Crosswalks are important parts of the streetscape and an appropriate lighting design will improve the visibility of pedestrians in the crosswalk. The lighting should be installed between the vehicle and the crosswalk (ie: half to one pole height before the crosswalk) to ensure that the body of the pedestrian is adequately lighted. If streetlights are installed above or immediately adjacent to the crosswalk, only the top of the pedestrian's head will be lighted making it difficult for motorists to see the pedestrian. Crosswalks and mid-block crossings shall be lighted to the Vertical Illuminance requirements in the table below. See Section D for instructions on how to set up a calculation for crosswalks and mid-block crossings.

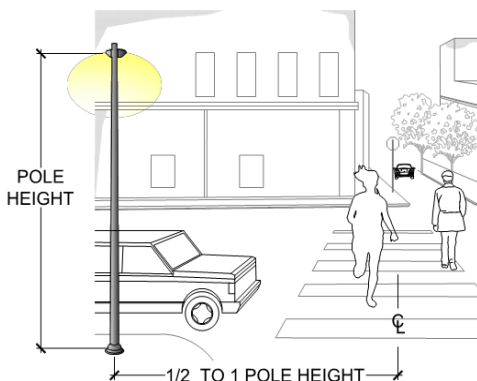


Figure 1: Streetlight Located Before Crosswalk

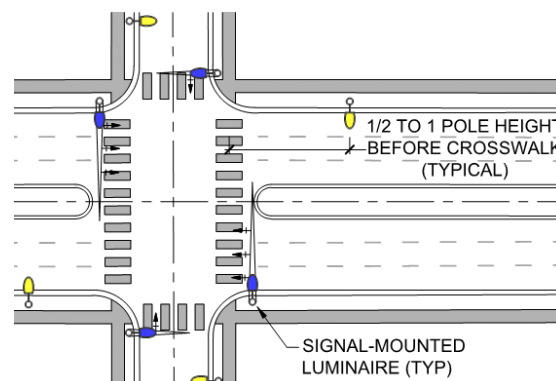


Figure 2: Streetlight Placement with Respect to

Table A: Intersection Target Horizontal & Vertical Criteria

Functional Classification	Adjacent Land Use	Average Horizontal Illuminance (Fc)	Uniformity Ratio (Fc _{avg} /Fc _{min})	Average Vertical Illuminance (Fc)	Luminaire Mounting Height (feet)	Recommended Mast Arm Length (ft)	Distribution	Max BUG Rating
Arterial / Arterial ¹	Commercial / Institutional	2.4	6	1.0	35-40	10	Type 2 or 3	3-0-3
	Residential / Industrial / Rural	1.7	6	0.8	30-35	10	Type 2 or 3	2-0-2
Arterial / Collector ¹	Commercial / Institutional	2.0	6	1.0	35-40	10	Type 2 or 3	2-0-2
	Residential / Industrial / Rural	1.4	6	0.7	30-35	10	Type 2 or 3	2-0-2
Arterial / Local ¹	Commercial / Institutional	1.9	6	0.8	35-40	10	Type 2 or 3	2-0-2
	Residential / Industrial / Rural	1.2	6	0.6	30-35	10	Type 2 or 3	2-0-2
Collector / Collector ²	Commercial / Institutional	1.7	8	0.8	30-35	6	Type 2 or 3	2-0-2
	Residential / Industrial / Rural	1.1	8	0.5	30-35	6	Type 2 or 3	1-0-2
Collector / Local ²	Commercial / Institutional	1.5	8	0.7	30-35	6	Type 2 or 3	1-0-2
	Residential / Industrial / Rural	0.9	8	0.5	30-35	6	Type 2 or 3	1-0-2
Local / Local >30mph	Commercial / Institutional	1.3	10	0.6	25-30	6	Type 2 or 3	1-0-1
	Residential / Industrial / Rural	0.7	10	0.5	25-30	6	Type 2 or 3	1-0-1
Local / Local <30mph	Commercial / Institutional	NA						
	Residential / Industrial / Rural	NA						

* A U2 BUG rating is acceptable when using a house side shield?

1. Arterial mid block crossing shall follow the arterial/arterial intersection criteria.

2. Collector mid block crossing shall follow the collector/collector intersection criteria.

Signalized, large intersections

This intersection type applies to:

- Arterial/Arterial
- Arterial/Collector

For a signalized intersection, with continuous lighting, the typical streetlight arrangement is interrupted by placing a streetlight half to one pole height in front of the crosswalk. This is called out as “1/2 to 1 pole height before crosswalk”. See the Crosswalk section for more information.

Additional streetlights should be located on signal poles if additional lighting is needed to meet the intersection criteria.

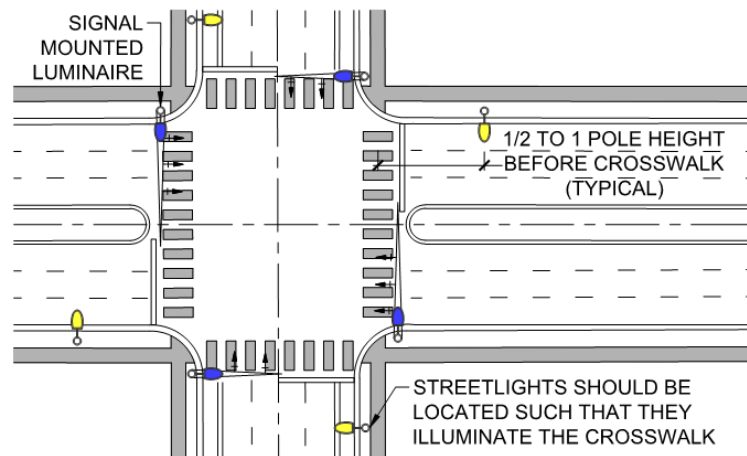


Figure 3: Signalized, Large Intersection

Non-signalized, large intersection

This intersection type applies to:

- Arterial/Collector
- Arterial/Local
- Collector/Collector

The larger street sections should be continuously lighted through the intersection. The typical streetlight arrangement is carried through the intersection. The streetlights should be located half to one pole height before the crosswalk, if it exists.

The smaller cross street should have at least one light located before the stop bar.

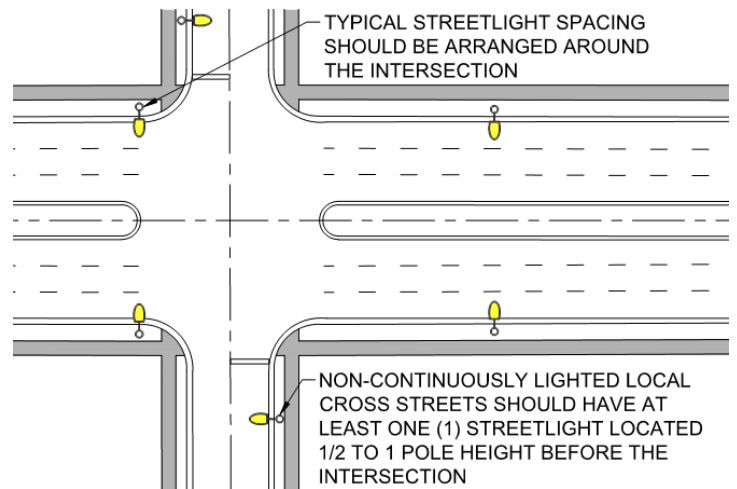


Figure 4: Non-Signalized, Large Intersection

Signalized, small intersection

This intersection type applies to:

- Arterial/Local
- Collector/Collector

Streetlights should be located half to one pole height before the crosswalk. This will light the people within the crosswalk. An additional streetlight located along the cross street should be included to better illuminate the crosswalk if necessary. Additional streetlights should be located on signal poles if additional lighting is needed to meet the intersection criteria.

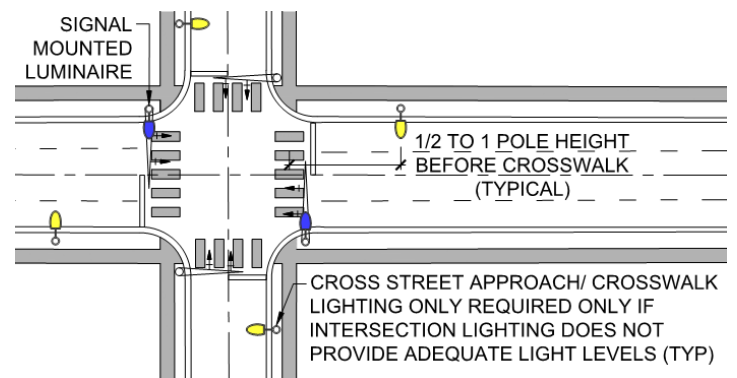


Figure 5: Signalized, Small Intersection

Non-signalized, small intersection

This intersection type applies to:

- Collector/Local
- Local/Local

At least one luminaire is to be placed at each intersection.

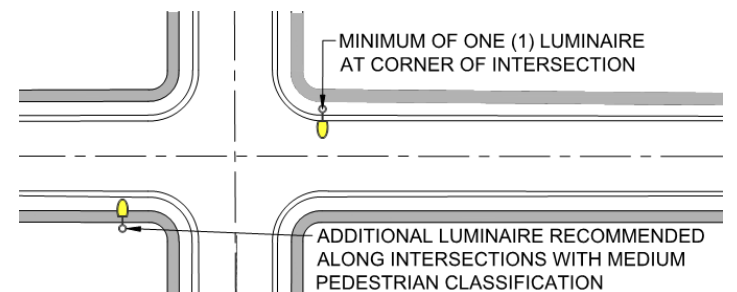


Figure 6: Non-Signalized, Small Intersection

Mid-Block Crosswalks

A streetlight shall be located one half to 1 mounting height in front of the crosswalk on both sides of the street for all mid-block crossings.

Figure 1: Streetlight Placement with Respect to Mid-Block Crossing

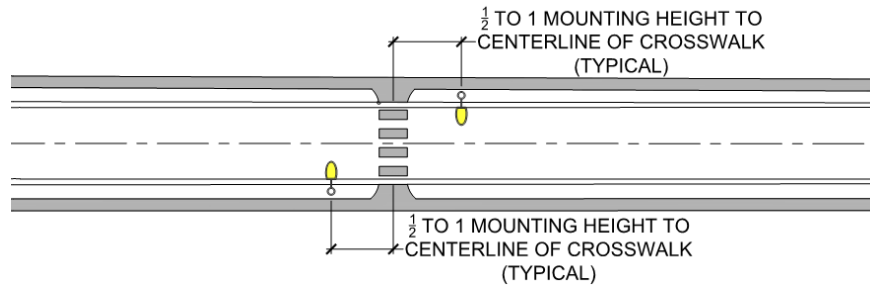


Figure 7: Mid-Block Crossing

C. Continuous Lighting on Streets

Provide continuous lighting for all arterial, collector, and local streets as specified in Table A. Lighting criteria varies for each street classification based on adjacent land use. Due to a higher pedestrian activity, streets located adjacent to commercial and institutional properties will have a higher lighting criteria. Commercial and institutional properties include churches, schools, retail areas, and restaurants. Streets located adjacent to residential, industrial, and rural properties, as well as office parks have a lower lighting criteria due to lower pedestrian activity. The lighting criteria and adjacent land use shall be evaluated on a block-by-block basis. Therefore, if a project is traveling through a residential area and passes by a school, the block that the school is on will have a higher criteria than the rest of the project. A house-side shield is highly recommended on all installations and may be needed to meet the required maximum BUG Rating. All streetlights shall have a U0 uplight rating, unless an external house side shield is being used. When an external shield is in use, light can be reflected upwards, therefore, when a shield is necessary to reduce light trespass, a U2 uplight rating is acceptable. Internal house side shields can maintain a U0 uplight rating and are preferred. All roadway calculations where a house-side shield is intended on being used shall be calculated with an .ies file that includes the shielding.

Designers should strive to meet the luminaire spacing that will provide the highest quality street lighting possible, but this is not always feasible. It is necessary to integrate lighting locations to coordinate with other improvements:

- Clearance from driveways (10 feet commercial and 5 feet residential).
- Clearance from fire hydrants (5 feet).
- Trees (centered in between trees or 10 feet from the tree trunk).

Place poles and luminaires near property lines wherever practical and avoid locations in front of doorways, windows, and lines of egress. A staggered luminaire arrangement is preferred but is not always feasible. Single sided arrangements should only be used when necessary.

Table B: New Construction Lighting Design Guidance.

Functional Classification	Adjacent Land Use	Average Luminance (cd/m ²)	Uniformity Ratio (L _{avg} /L _{min})	Luminaire Mounting Height (ft)	Arrangement	Lumin Output Range	Distribution	Max CCT	Max BUG Rating
Principal Arterial	Commercial / Institutional	0.9	5	30-35	Staggered	11,000 – 14,000	Type 2 or 3	3,000	B2-U0-G2
					Single Sided	Not Recommended			
	Residential / Industrial / Rural	0.6	6	30-35	Staggered	7,000 – 10,000	Type 2	3,000	B2-U0-G2
					Single Sided	7,000 – 12,000	Type 2	3,000	B2-U0-G2
Minor Arterial	Commercial / Institutional	0.6	6	30-35	Staggered	7,000 – 10,000	Type 2	3,000	B2-U0-G2
					Single Sided	7,000 – 12,000	Type 2	3,000	B2-U0-G2
	Residential / Industrial / Rural	0.4	8	30-35	Staggered	3,500 – 5,500	Type 2	2,700	B2-U0-G2
					Single Sided	5,000 – 7,500	Type 2	2,700	B2-U0-G2
Collector	Commercial / Institutional	0.5	10	25-30	Staggered	3,500 – 5,000	Type 2	3,000	B2-U0-G1
					Single Sided	4,000 – 6,000	Type 2	3,000	B2-U0-G1
	Residential / Industrial / Rural	0.3	10	25-30	Staggered	2,500 – 4,000	Type 2	2,700	B2-U0-G1
					Single Sided	3,500 – 4,500	Type 2	2,700	B2-U0-G1
Local		NA	NA	25-30	Intersections	2,500 – 4,000	Type 2	2,700	B2-U0-G1

* A U2 BUG rating is acceptable when using a house side shield.

* At time of publication, all Principal Arterial Streets except for Conttonwood Road are owned and maintained by MDT

All new installations and retrofits of streetlights shall conform to the standards set forth in Table B, based on street classification, adjacent land use, and luminaire arrangement.

D. Calculations

Lighting calculations are required for all street lighting projects for the City of Bozeman. Calculations shall be done in AGi32, DIALux, Visual, or comparable software, and include the following calculation grids:

- **Roadway Luminance**
 - A calculation grid is required for every lane of traffic and shall be oriented in the direction of travel spaced 10' OC along each lane, with two points across each lane.
 - Every section of roadway where criteria changes requires a separate calculation grid.
- **Intersection Illuminance**
 - Intersection calculations shall be done using horizontal illuminance grids that include the whole intersection, as well as all crosswalks associated with the intersections. Calculation points shall be placed in a 5'x5' grid.
- **Sidewalk Illuminance**
 - Horizontal sidewalk illuminance grids shall be placed on all sidewalks, spaced every 5'-10' OC along the sidewalk with two points across the sidewalk.
- **Light Trespass Illuminance**
 - Light trespass grids shall be located 5' past the edge of ROW, into private property. Light trespass grids shall be placed 5' AFF, oriented toward the street with calculation points every 5'-10' OC.
 - Light trespass calculation grids shall be separated based on adjacent land use. If the project goes from a residential area to a commercial area, a separate light trespass calculation grid will be required for each section of the project.
 - If a structure is within 5' from the property line, light trespass grid to be placed on the structure, 5' AFF.
 - Light trespass values shall not exceed the following:
 - Residential properties: 0.1Fc Maximum.
 - If this criteria is not feasible with proper shielding and distribution, a variance may be considered to allow up to 0.2Fc Maximum light trespass in residential areas. Designer will be required to submit a narrative describing the efforts to control light trespass to the City Engineer.
 - Commercial and mixed-use residential properties: 0.3Fc Maximum
- **Crosswalk Vertical Illuminance**
 - Vertical illuminance grids shall be placed in all crosswalks at 5' AFF, and oriented according to Figure 9. Calculation points shall be located along the center line of each crosswalk, placed every 5' OC.

Designers shall submit to the City a calculation summary table for each calculation grid and include the average illuminance or luminance, maximum illuminance or luminance, minimum illuminance or luminance, and Avg:Min ratio. Calculated values may vary from criteria by no more

than 10% above or below.

Calculations shall not include a light loss factor (LFF).

Figure 8: Intersection Calculation Grid Setup

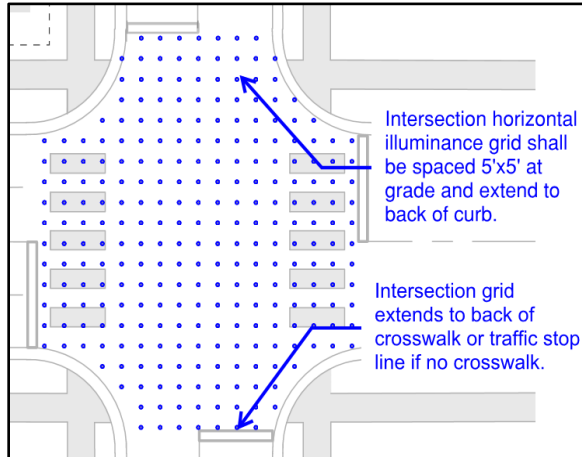


Figure 8: Horizontal Intersection Illuminance Grid

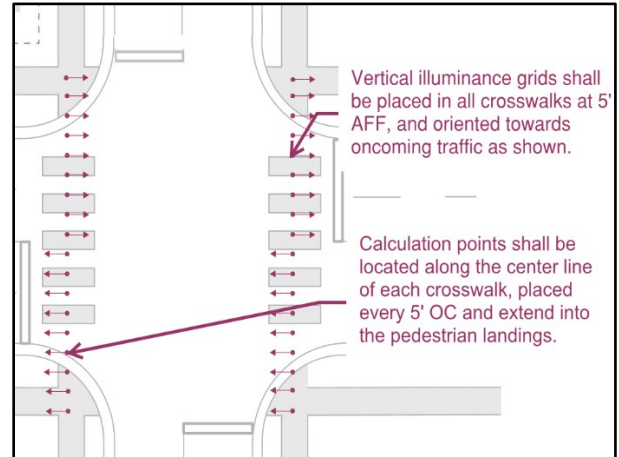


Figure 9: Vertical Intersection Illuminance Grid

Figure 10: Roadway, Sidewalk, and Light Trespass Calculation Grid Setup

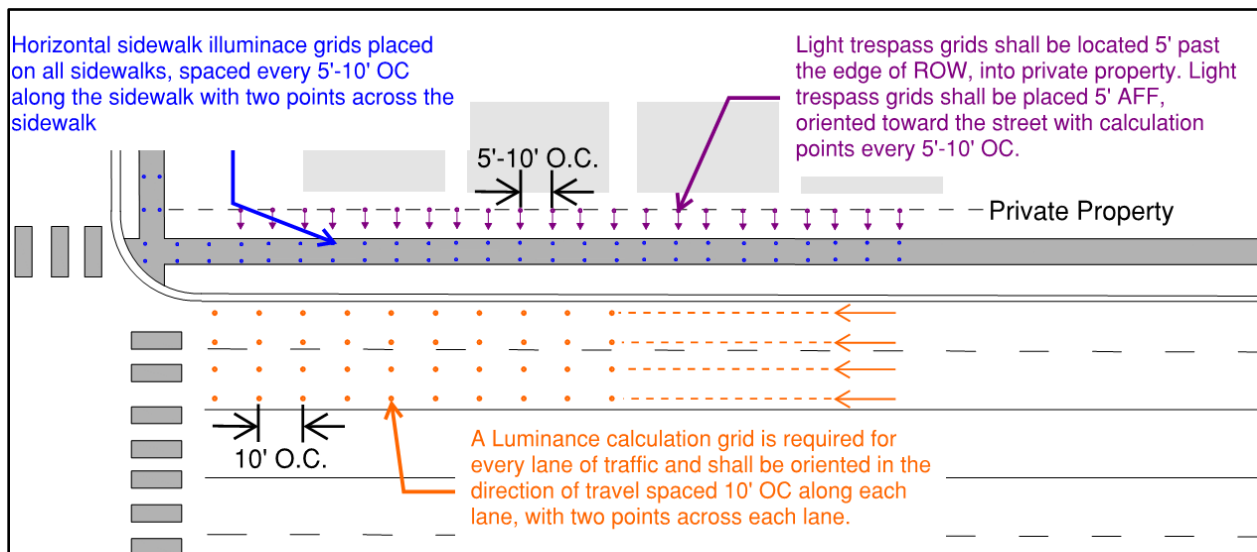


Figure 10: Calculation Grids for Roadway Luminance, Sidewalk Illuminance, and Light Trespass

E. Design Considerations.

In addition to the requirements outlined in Table B, the following layout criteria shall be used:

- When a streetlight location falls near an unlit intersection, the light shall be located at the intersection;
- Streetlights shall be located at property lines to the greatest extent possible, but not in conflict with other utility service providers;
- All proposed local streets within the proposed subdivision, having a curve of 300 feet or longer in length, shall have a streetlight in the middle of the horizontal curve or as required by the City Engineer;
- A streetlight shall be placed at the terminal ends of center median islands having trees and/or other fixed objects not having a breakaway design for speeds of 25 miles per hour or greater;
- Additional streetlights may be required by the DRC when potential traffic hazards are identified during plan review; and
- Street and pedestrian lighting arrangements with poles aligned on opposite sides of the street, rather than staggered are allowed.
- Mounting heights shall be measured from the grade of the street at the edge of the travelled way and shall comply with the requirements of Table B.

F. Pedestrian Lighting.

Pedestrian lighting is defined as luminaires mounted between 12ft and 15ft and shall be installed at 60 feet to 105 feet on center, as appropriate to coordinate with landscape and hardscape features. Two pedestrian lights shall be installed on opposite sides of the street at all intersections of pathways and local streets located within the proposed development or along existing streets or roads abutting the development, unless the pathway intersects the street at a lighted intersection. Pedestrian lights shall have a lumen output range of 2,000 – 3,500 lumens, and a maximum B.U.G. rating of B2-U1-G1. Pedestrian lights in special districts, including those along Main Street and Wilson Ave, will require special approval from a City Engineer. Spacing of pedestrian lights shall be determined by meeting the illuminance requirements outlined in Table C.

Table C. Pedestrian Lighting Guidance.

Adjacent Land Use	Average Horizontal Illuminance for Pedestrian Walkways in Maintained Footcandles	Illuminance Uniformity Ratio (avg/min)
Commercial or Institutional	0.5	4.0
Residential, Industrial or Rural	0.3	6.0

Source: *Roadway Lighting (RP-8)*, Illuminating Engineering Society of North America.

G. Pathway Lighting.

Pathway lights shall be installed along pathways through parks and other pathways that are detached from the street. All pathway lights shall comply with City of Bozeman specifications. Pathway lights shall have a height range of 40 - 48 inches, a lumen output range of 500 - 1,000 lumens, and a maximum wattage of 25 Watts.

Section XIII. Streetlight Luminaires

A. General

- All luminaires shall be light emitting diode (LED).
- Color temperature 3000K maximum, per ANSI C78.377-2011 standard.
- All luminaires shall be equipped with a surge suppression device with a minimum immunity level of 10kV.
- All luminaires shall have a field adjustable dimming system to allow for onsite dimming once installed.
- Shielding: All luminaires shall have standard house-side shielding options. Front-side shielding may also be required to control light trespass across the street. Front-side shields may be custom, but manufacturer standard shielding is preferred.
- New light installations will be evaluated by the City of Bozeman during the required 2-year warranty period immediately following project acceptance. The City may require the developer to modify light installations through shielding or dimming to get the desired light distribution.
- The contractor may be required to provide house side light shields to the City of Bozeman for each new luminaire as a condition of project acceptance.
- All luminaires shall have a minimum ingress protection (IP) rating of IP66, and shall be UL/ETL listed for wet locations.
- All luminaires shall be equipped with a 0-10V or DALI dimming driver, capable of receiving input line voltage 120V-277V. Driver shall comply with Federal Communication Commission (FCC) 47 Code of Federal Regulations (CFR) part 15 non-consumer radio frequency interference (RFI) and/or electromagnetic interference (EMI) standards. Minimum power factor (PF) shall be no less than 0.9 at full input power. Maximum total harmonic distortion (THD) shall be no greater than 20 percent at full input power.
- A minimum 10 year warranty is required for all parts and materials, required to repair or replace luminaire.
- All luminaires are to be equipped with an ANSI C136.41 7-pin receptacle. Shorting caps are to be installed on each luminaire.
- Luminaires are to have a Type II distribution. Type III distribution allowed on Principal Arterials and Large Signalized Intersections.
- Access to all internal parts requiring replacement shall not require tools (i.e., "tool-less entry").
- Luminaire shall be tested in accordance with IES LM79 and TM21 certifying photometric performance and rated life, respectively. LM79 (performance) and TM21 (predicted life) testing shall both be for the same luminaire's operating drive current as specified.
- Luminaires shall have a minimum L70 live of 100,000 hours based on IES TM21 testing.
- Luminaire system efficacy shall be no less than 125 lumens per input watt.
- Luminaire shall have an external label per ANSI C136.15 and internal label per ANSI C136.22.
- Luminaires shall be equipped with internal leveling bubble.
- Breakaway connections using sheer bolts must have a skirt to protect the bolts.
- Luminaires shall be powder coat finished black or powder coat finished to match pole, unless installed on a local street, then either dark brown or hunter green.
- Luminaire distribution shall be equal or less than the Illuminating Engineering Society of North America's (IES) TM 15-11 Backlight, Uplight, and Glare (BUG) ratings as specified in Table B.

B. Installation

Luminaires shall be mounted in accordance with the manufacturer's specifications.

Plumb or level all elements, symmetrically arrange, and securely assemble. Conceal all conductors in the poles and assembly.

Luminaires shall have an adjustable slipfitter-type mounting system for the installation on 1.25 inch (1.66 inch o.d.) to 2 inch (2.375 inch o.d.) outside diameter pipe tenons. Slipfitter shall consist of a two-piece clamp and four 9/16 inch hex bolts. Slipfitter shall allow for a vertical tilt adjustment of +/- 5 percent in order to mount plumb for a U0 rating.

C. Approved Manufacturers – Cobrahead Style [Refer to Figure 10 – Typical Street Light Standard Detail]

- GE Evolve LED Cobrahead
- Cree XSP (only to be used with a House-Side Shield and distribution Type II Long)
- Lumec Roadfocus

D. Approved Manufacturers – Bell Style [Refer to Figure 10 – Typical Streetlight Standard Detail]

- Lumec Domus
- Architectural Area Lighting Universe
- Or Pre-Approved Equal

Section XIV. Pedestrian Luminaires

A. General

- All luminaires shall be light emitting diode (LED).
- Color temperature maximum 3000K, per ANSI C78.377-2011 standard.
- All luminaires shall be equipped with a surge suppression device with a minimum immunity level of 10kV.
- All luminaires shall be equipped with a 0-10V or DALI dimming driver, capable of receiving input line voltage 120V-277V. Driver shall comply with Federal Communication Commission (FCC) 47 Code of Federal Regulations (CFR) part 15 non-consumer radio frequency interference (RFI) and/or electromagnetic interference (EMI) standards. Minimum power factor (PF) shall be no less than 0.9 at full input power. Maximum total harmonic distortion (THD) shall be no greater than 20 percent at full input power.
- A minimum 10 year warranty is required for all parts and materials, required to repair or replace luminaire.
- All luminaires are to be equipped with an ANSI C136.41 7-pin receptacle. Shorting caps are to be installed on each luminaire.
- Luminaires are to have either a Type III or Type V distribution. Type V distributions will be considered for special use through DRC review.
- Access to all internal parts requiring replacement shall not require tools (i.e., "tool-less entry").
- Luminaire shall be tested in accordance with IES LM79 and TM21 certifying photometric performance and rated life, respectively. LM79 (performance) and TM21 (predicted life) testing shall both be for the same luminaire's operating drive current as

specified.

- Internal house-side shield must be available.
- Luminaire system efficacy shall be no less than 125 lumens per input watt.
- Luminaire shall have an external label per ANSI C136.15 and internal label per ANSI C136.22.
- Luminaires shall be powder coat finished black or powder coat finished to match pole, unless installed on a local street, then either dark brown or hunter green.
- Luminaire distribution shall be equal or less than the Illuminating Engineering Society of North America's (IES) TM 15-11 Backlight, Uplight, and Glare (BUG) rating of B2 U0 G1
 - For applications approved for Type V distribution, the Backlight rating shall not apply.

B. Installation

Luminaires shall be mounted in accordance with the manufacturer's specifications.

Plumb or level all elements, symmetrically arrange, and securely assemble. Conceal all conductors in the poles and assembly.

C. Approved Products – Traditional Post-top Style [Refer to Figure 11 – Typical Post-Top Pedestrian Light Standard Detail]

- Sternberg Euro
- Architectural Area Lighting Providence
- Lumec Omniscape
- Or approved equal

D. Approved Products – Bell Style [Refer to Figure 12 – Typical Arm-Mount Pedestrian Light Standard Detail]

- Lumec Domus
- Architectural Area Lighting Universe
- Or approved equal

Section XV. Pathway Luminaires

A. General

- All luminaires shall be light emitting diode (LED).
- Color temperature maximum 3000K, per ANSI C78.377-2011 standard, +/- 275K.
- All luminaires shall be equipped with a surge suppression device with a minimum immunity level of 10kV.
- All luminaires shall be equipped with a 0-10V dimming or DALI driver, capable of receiving input line voltage 120V-277V. Driver shall comply with Federal Communication Commission (FCC) 47 Code of Federal Regulations (CFR) part 15 non-consumer radio frequency interference (RFI) and/or electromagnetic interference (EMI) standards. Minimum power factor (PF) shall be 0.9 at full input power. Maximum total harmonic distortion (THD) shall be 20 percent at full input power.
- A minimum 10 year warranty is required for all parts and materials, required to repair or replace luminaire.
- All luminaires are to be equipped with an ANSI C136.41 7-pin receptacle. For luminaires that are not supplied with integral 7-pin receptacles, provide the 7-pin receptacle in pole cap on the top of the pole. Shorting caps are to be installed on each

- luminaire.
- Luminaires are to have either a Type III or Type V distribution. Type V distributions will be considered for special use through DRC review.
- Luminaire shall be tested in accordance with IES LM79 and TM21 certifying photometric performance and rated life, respectively. LM79 (performance) and TM21 (predicted life) testing shall both be for the same luminaire's operating drive current as specified.
- Luminaire system efficacy shall be no less than 30 lumens per input watt.
- Luminaires shall be powder coat finished black.
- Vandal proof. Not flat heads, rounded heads.
- Concrete base, no direct burial
- Luminaire distribution shall be equal or less than the Illuminating Engineering Society of North America's (IES) TM 15-11 Backlight, Uplight, and Glare (BUG) ratings as follows:
 - B2 U1 G1
 - For applications approved for Type V distribution, the Backlight rating shall not apply.

B. Installation

Luminaires shall be mounted in accordance with the manufacturer's specifications.

Plumb or level all elements, symmetrically arrange, and securely assemble. Conceal all conductors in the assembly. [Refer to Figure 13 – Typical Pathway Light Standard Detail]

C. Approved Products

- Lithonia Lighting KBR8 LED Bollard
- Lithonia Lighting D-Series LED Bollard
- Or approved equal

Section XVI. Poles.

A. General

Unless specifically approved by the City Commission, the use of "Montana Angle", "Budget Angle", or similar style streetlight poles is prohibited.

All poles, mast arms, and luminaires for streetlights and signal poles shall be round, tapered steel with galvanized and painted finish with a 10 year warranty.

Poles for pedestrian lights shall be round, non-tapered steel, or aluminum, with optional decorative fluting, and galvanized and painted finish.

Unless a variance is granted, all future ARTERIAL AND COLLECTOR street and signal light poles shall be "Hunter Green" (RAL#6005), Moss Green, or similar in color, excepting that all future street and signal light poles in the Downtown Business District and North 7th Avenue TIF District shall be black, and further excepting that entryway streets into Montana State University (i.e. S. 8th Avenue, College Street, Kagy Boulevard, and S. 11th Avenue) may be dark Bobcat Blue.

The height of streetlight poles shall be determined based upon the lumen output and application. Refer to Lighting Design Criteria.

Streetlight luminaires shall have a mast arm of 6 feet for local and collector streets, or 10 feet for

principal and minor arterials. Longer mast arms will be evaluated on a case by case basis.

All streetlight poles shall be installed on a concrete foundation with the appropriate base for the application. [Refer to Figure 9 – Typical Streetlight Standard Details]

All poles, foundations, and breakaway bases shall meet the criteria set forth in the AASHTO publication Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals.

B. Installation

Streetlight poles shall be placed typically at five feet from back of curb.

Streetlight standards, pedestrian light standards and pathway lights shall have an access panel and cover near base for access to wiring, fusible, in-line, water tight, breakaway connectors on wiring in pole hand hole area such as Bussman type water tight fuse holders. [Refer to Figures 14, 15 and 16 – Typical Pole Base Standard Details]

Section XVII. Pole bases

A. General

Unless otherwise protected, a breakaway base should be provided for all streetlight standards within the clear zone along rural and high-speed urban highways, except where located within 1.5 times pole height from a bus stop. Non-breakaway bases shall be used for all pedestrian lights and pathway lights.

B. Breakaway Bolt Couplings.

Breakaway bolt couplings are aluminum connectors or sleeves that are designed to shear when the pole is hit. The bottom of the coupling is threaded onto the foundation anchor bolts, and the light standard is attached to the top of the coupling. Four couplings are used with each light standard. Where breakaway supports are required, use the breakaway bolt coupling unless it will not function with the approved light standard. A breakaway coupling skirt must be supplied and painted to match the pole color. [Refer to Figure 14 – Typical Breakaway Bolt Coupling Standard Details]

C. Frangible Transformer Base.

The frangible transformer base consists of a cast aluminum apron between the concrete foundation and the base of the pole. It is designed to deform and breakaway when hit by a vehicle bumper. Use the frangible transfer base where a breakaway base is justified but breakaway bolt couplings cannot be used. [Refer to Figure 16 – Typical Frangible Transformer Base Detail]

D. Non-Breakaway Anchor Base.

A non-breakaway anchor base consists primarily of a metal plate that is welded to the bottom of the light standard. The plate allows the light standard to be bolted directly to the foundation without an intermediate breakaway device. It does not meet AASHTO breakaway base criteria. [Refer to Figure 15 – Typical Non-Breakaway Pole Base Detail]

Section XVIII. Submittal Requirements

A. General

- Plan sheets showing pole locations, conduit locations, pull / splice box locations, and meter locations are required.
- For Street Lighting submittals, provide luminaire cutsheets showing compliance with

Table A. New Construction Lighting Design Guidance and Section XIII. Streetlight Luminaires,

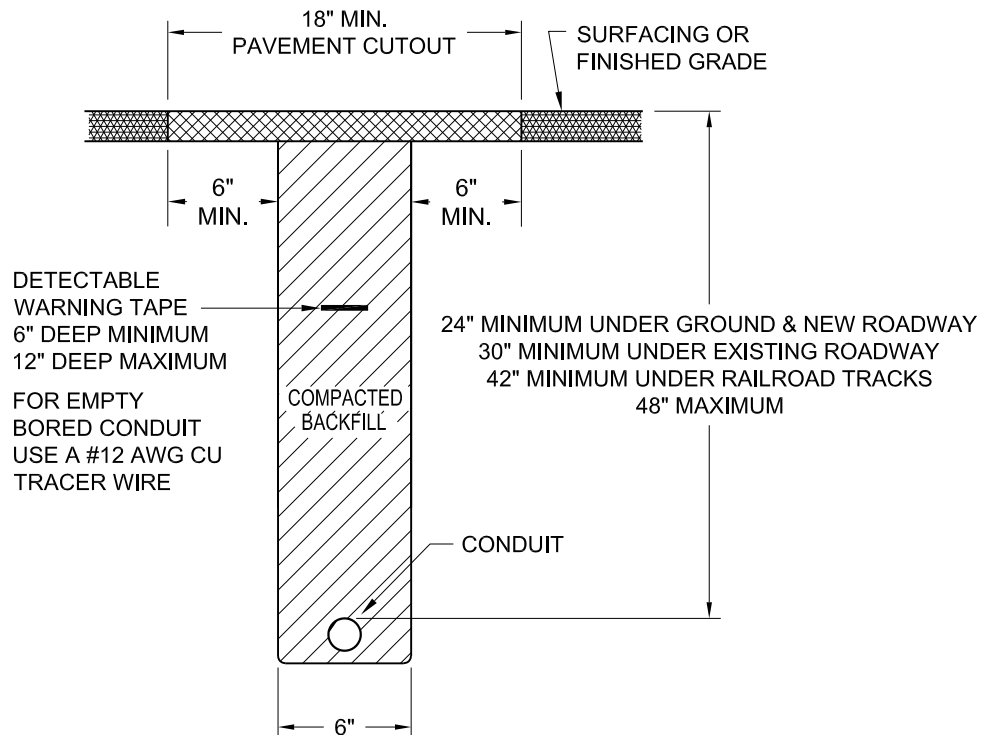
- For Pedestrian Lighting submittals, provide a Photometric Plan for new installations showing compliance with *Table C. Pedestrian Lighting Guidance*. Also provide luminaire cutsheets showing compliance with Section XIV. Pedestrian Luminaires.
- For Pathway Lighting submittals, provide luminaire cutsheets showing compliance with Section XII.J. Lighting Design Criteria – Pathway Lighting, and Section XV. Pathway Luminaires.
- Details of point of service, lighting control center, electrical one-line diagrams, pole foundations, poles, and luminaires are required.
- Prior to construction, submit shop drawings (cut sheets) for all material and equipment.
- Lighting calculations showing roadway luminance, intersection illuminance, sidewalk illuminance, and light trespass.

Roadway Luminaire Submittal Form

Luminaire Manufacturer & Catalog Number	=		
Street Classification	☐ Principal Arterial	☐ Minor Arterial	☐ Collector
	☐ Local (Commercial, Institutional) ☐ Local (Residential, Industrial, Rural)		
Adjacent Land Use	☐ Commercial, Institutional	☐ Residential, Industrial,	Rural
Luminaire Characteristics	Initial Luminaire Lumen Output =	System Wattage =	Luminaire Efficacy (lm/W) =
Correlated Color Temperature (CCT)	=		
Color Rendering Index (CRI)	=		
BUG Rating (per IES TM-15)	Backlight =	Uplight =	Glare =
IES Photometric Data in .ies Format	☐ Yes	☐ No	☐ Other
LED Retrofit Luminaire	☐ Yes	☐ No	
0-10V Dimmable Driver	☐ Yes	☐ No	
Field Dimmable	☐ Yes	☐ No	
Exterior Label (per ANSI C136.15) & Interior Label (per ANSI C136.22)	☐ Yes	☐ No	
Tool-Less Entry	☐ Yes	☐ No	
Luminaire Housing Finish	=		
Rated Life (IES TM-21)	=		
Ambient Temperature Range	Minimum Temperature=	Maximum Temperature=	
Vibration Rating (ANSI C136.31)	=		
UL Listing	☐ Wet Location	☐ Damp Location	IP Rating =
Passive Cooling System	☐ Yes	☐ No	
LED Compatible 7-pin Receptacle (ANSI C136.41)	☐ Yes	☐ No	☐ Control Module
Internal Wiring and Quick Disconnects	=		
Operating Voltage	Voltage =	Frequency (Hz) =	
Power Factor	=		
Total Harmonic Distortion	=		
Surge Protection (IEEE C62.41.2)	=		
Warranty Period	=		
Warranty Start Date	=		
Other Submittals	=		

Pedestrian Luminaire Submittal Form

Luminaire Manufacturer & Catalog Number	=		
Adjacent Land Use	☐ Commercial, Institutional	☐ Residential, Industrial,	Rural
Path or Sidewalk Lighting	☐ Path	☐ Sidewalk	
Luminaire Characteristics	Initial Luminaire Lumen Output =	System Wattage =	Luminaire Efficacy (lm/W) =
Correlated Color Temperature (CCT)	=		
Color Rendering Index (CRI)	=		
BUG Rating (per IES TM-15)	Backlight =	Uplight =	Glare =
IES Photometric Data in .ies Format	☐ Yes	☐ No	☐ Other
0-10V Dimmable Driver	☐ Yes	☐ No	
Field Dimmable	☐ Yes	☐ No	
LED Retrofit Luminaire	☐ Yes	☐ No	
Exterior Label (per ANSI C136.15) & Interior Label (per ANSI C136.22)	☐ Yes	☐ No	
Luminaire Housing Finish	=		
Rated Life (IES TM-21)	=		
Ambient Temperature Range	Minimum Temperature=	Maximum Temperature=	
Vibration Rating (ANSI C136.31)	=		
UL Listing	☐ Wet Location	☐ Damp Location	IP Rating =
LED Compatible 7-pin Receptacle (ANSI C136.41)	☐ Yes	☐ No	☐ Control Module
Internal Wiring and Quick Disconnects	=		
Operating Voltage	Voltage =	Frequency (Hz) =	
Power Factor	=		
Total Harmonic Distortion	=		
Warranty Period	=		
Warranty Start Date	=		
Other Submittals	=		



DETAIL NOTES

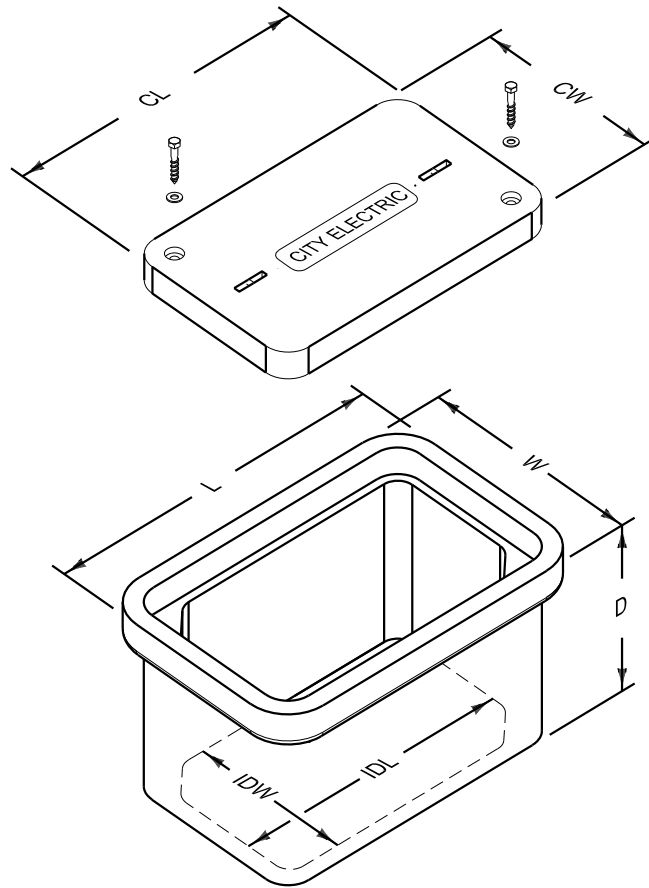
1. CONTRACTOR SHALL COORDINATE TRENCHING WITH OTHER UNDERGROUND UTILITIES. CONTRACTOR SHALL USE COMMON TRENCHES AT ALL ROAD CROSSINGS WHEREVER POSSIBLE.
2. 1-#12 AWG LOCATE WIRE AND A NYLON OR POLYESTER PULL TAPE WITH 1,250 LBS TEST STRENGTH AND FOOTAGE MARKINGS IN ALL EMPTY CONDUITS.

FIGURE 1

TYPICAL CONDUIT BURIAL STANDARD DETAIL

THE CITY OF BOZEMAN
ENGINEERING DEPARTMENT
20 E. OLIVE -- P.O. BOX 1230
BOZEMAN, MONTANA 59771-1230
PHONE: (406) 582-2280 -- FAX: (406) 582-2263





PULL BOX / SPLICE BOX - COMPOSITE MINIMUM DIMENSIONS								
TYPE 1			TYPE 2			TYPE 3		
L	=	20"	L	=	25"	L	=	32"
W	=	13"	W	=	15"	W	=	19"
D	=	12"	D	=	12"	D	=	20"
IDL	=	17"	IDL	=	21"	IDL	=	28"
IDW	=	10"	IDW	=	11"	IDW	=	15"
CL	=	18"	CL	=	23"	CL	=	30"
CW	=	11"	CW	=	13"	CW	=	17"

DETAIL NOTES

- BOX COVERS MUST BE POLYMER CONCRETE WITH FIBERGLASS REINFORCEMENT, TRAFFIC RATED TO TIER 22 AND BOLTED.
- BOX COVERS SHALL BE LABELED AS FOLLOWS:
 - "CITY ELECTRIC" ON ALL PULL BOXES CONTAINING CITY ELECTRICAL POWER.
 - "UTILITY ELECTRIC" ON ALL PULL BOXES CONTAINING UTILITY ELECTRICAL POWER.
 - "CITY LIGHTING" ON ALL PULL BOXES CONTAINING CITY OWNED STREET LIGHTING CONDUCTORS.
 - "UTILITY LIGHTING" ON ALL PULL BOXES CONTAINING UTILITY OWNED STREET LIGHTING CONDUCTORS.
 LABELING MUST BE CAST INTO THE COVER AND NOT A SEPARATE INDEPENDENT TAG.
- REFER TO N.E.C. ARTICLE 314 "PULL AND JUNCTION BOXES AND CONDUIT BODIES MINIMUM SIZE" FOR BOX SIZE REQUIREMENTS BASED ON CONDUIT AND WIRE SIZES

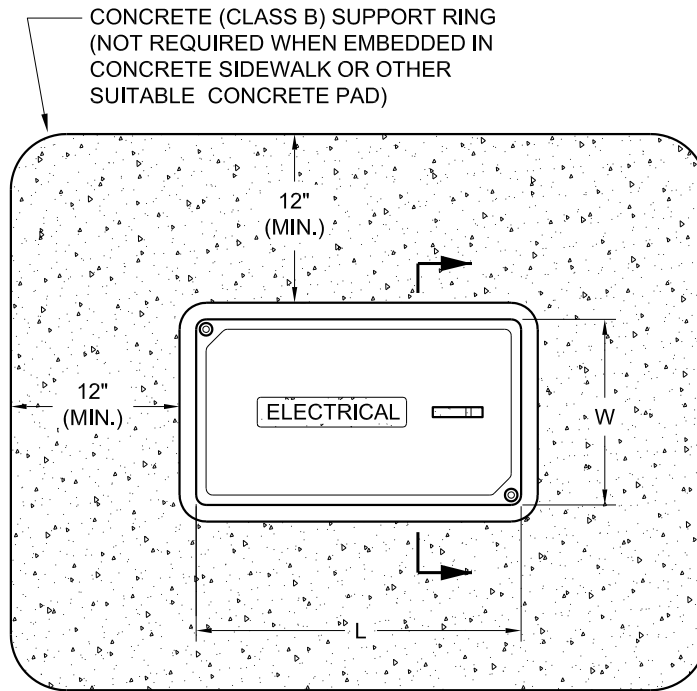
FIGURE 2

TYPICAL PULL BOX / SPLICE BOX MINIMUM DIMENSIONS STANDARD DETAILS

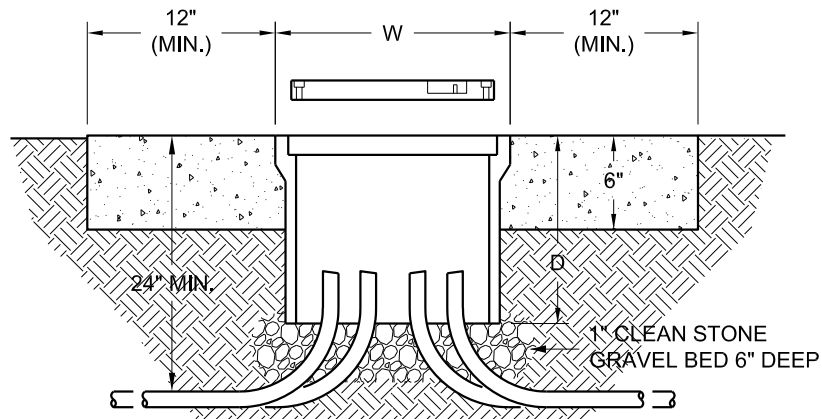
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PLAN VIEW



SECTION A-A

TYPICAL PULL BOX / SPLICE BOX

DETAIL NOTES

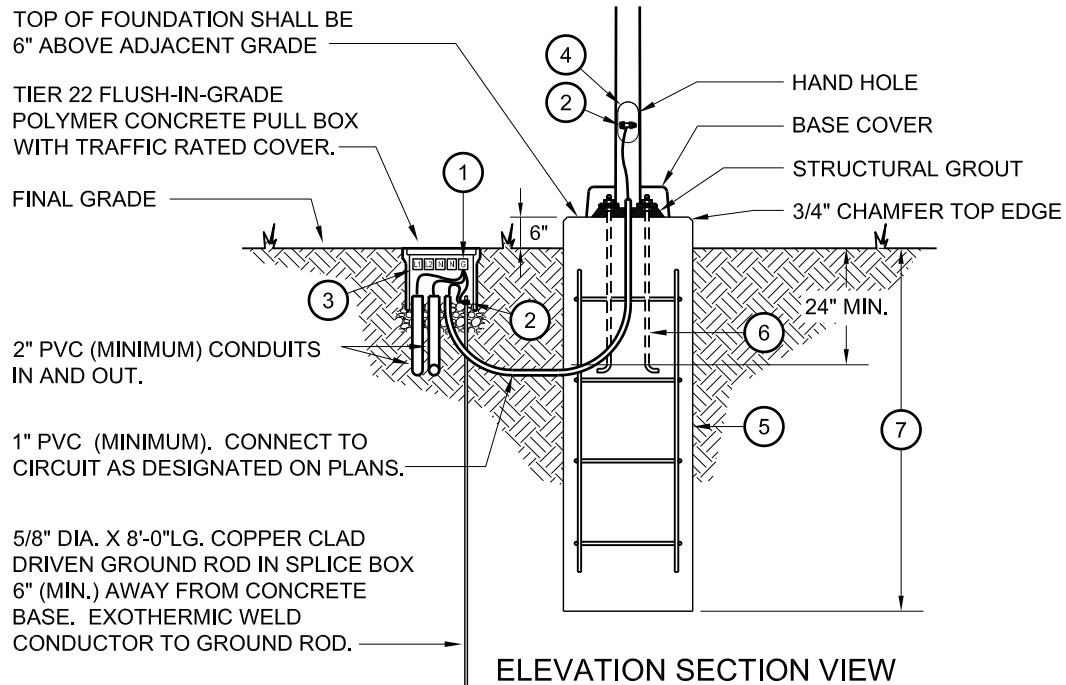
1. ALL PULL OR SPLICE BOXES SHALL BE TRAFFIC RATED TO TIER 22 MINIMUM.
2. REFER TO FIGURE 2 FOR PULL BOX SIZE REQUIREMENTS.

FIGURE 3

TYPICAL IN-GRADE COMPOSITE PULL BOX / SPLICE BOX DETAIL

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FOUNDATION DETAIL NOTES

- ① BOND RACEWAY GROUND TO GROUND ROD IN PULL BOX / SPLICE BOX.
- ② BOND (1-#6 SOFT DRAWN BARE CU) TO GROUND ROD IN PULL BOX / SPLICE BOX AND GROUNDING LUG IN POLE BASE HAND HOLE.
- ③ PROVIDE 3-TERMINAL UNDERGROUND RATED LUG CONNECTORS TO FIT #14AWG - #4AWG COPPER WIRE, BY BURNDY OR ILSCO NIMBUS OR APPROVED EQUAL. MAXIMUM OF (5) REQUIRED OR (1) FOR EACH CONDUCTOR IN HOME RUN.
- ④ AT EACH POLE BASE HAND HOLE, PROVIDE A BREAKAWAY, WATERPROOF, IN-LINE FUSE HOLDER BY EATON OR APPROVED EQUAL WITH FNQ-R 15A FUSE FOR EACH HOT AND A BREAKAWAY, WATERPROOF CONNECTOR ON NEUTRAL (IF REQUIRED).
- ⑤ LIGHT STANDARD FOUNDATION EMBEDMENT DEPTH, DIMENSIONS AND REINFORCEMENT SHALL BE DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF MONTANA. WELDING OF REBAR CAGES NOT PERMITTED.
- ⑥ DIMENSION FOR ANCHOR BOLT SPACING BY POLE MANUFACTURER.
- ⑦ DEPTH OF FOUNDATION PER STRUCTURAL ENGINEER.

GENERAL NOTE

FOUNDATION DETAILS ARE INCLUDED ONLY TO SHOW ELECTRICAL COMPONENTS.

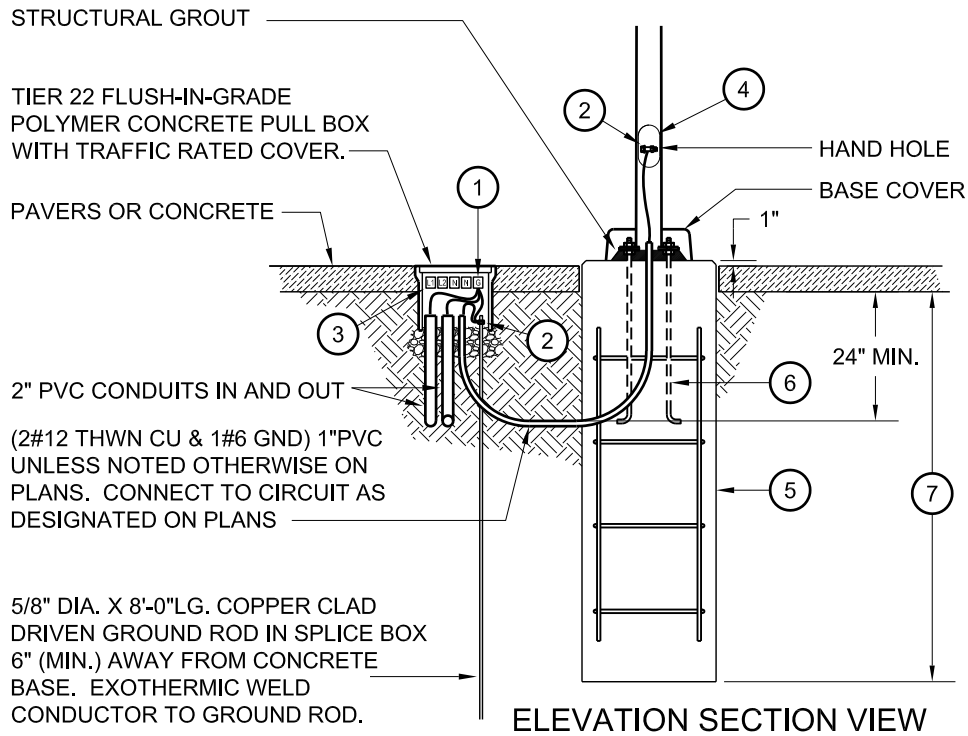
FIGURE 4

TYPICAL STREET LIGHT STANDARD FOUNDATION ELECTRICAL DETAIL IN SOFTSCAPE

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ENGINEERING DEPARTMENT
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FOUNDATION DETAIL NOTES

- ① BOND RACEWAY GROUND TO GROUND ROD IN PULL BOX / SPLICE BOX.
- ② BOND (1-#6 SOFT DRAWN BARE CU) TO GROUND ROD IN PULL BOX / SPLICE BOX AND GROUNDING LUG IN POLE BASE HAND HOLE.
- ③ PROVIDE 3-TERMINAL UNDERGROUND RATED LUG CONNECTORS TO FIT #14AWG - #4AWG COPPER WIRE, BY BURNDY OR ILSKO NIMBUS OR APPROVED EQUAL. MAXIMUM OF (5) REQUIRED OR (1) FOR EACH CONDUCTOR IN HOME RUN.
- ④ AT EACH POLE BASE HAND HOLE, PROVIDE A BREAKAWAY, WATERPROOF, IN-LINE FUSE HOLDER BY EATON OR APPROVED EQUAL WITH FNQ-R 15A FUSE FOR EACH HOT AND A BREAKAWAY, WATERPROOF CONNECTOR ON NEUTRAL (IF REQUIRED).
- ⑤ LIGHT STANDARD FOUNDATION EMBEDMENT DEPTH, DIMENSIONS AND REINFORCEMENT SHALL BE DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF MONTANA. WELDING OF REBAR CAGES NOT PERMITTED.
- ⑥ DIMENSION FOR ANCHOR BOLT SPACING BY POLE MANUFACTURER.
- ⑦ DEPTH OF FOUNDATION PER STRUCTURAL ENGINEER.

GENERAL NOTE

FOUNDATION DETAILS ARE INCLUDED ONLY TO SHOW ELECTRICAL COMPONENTS.

FIGURE 5

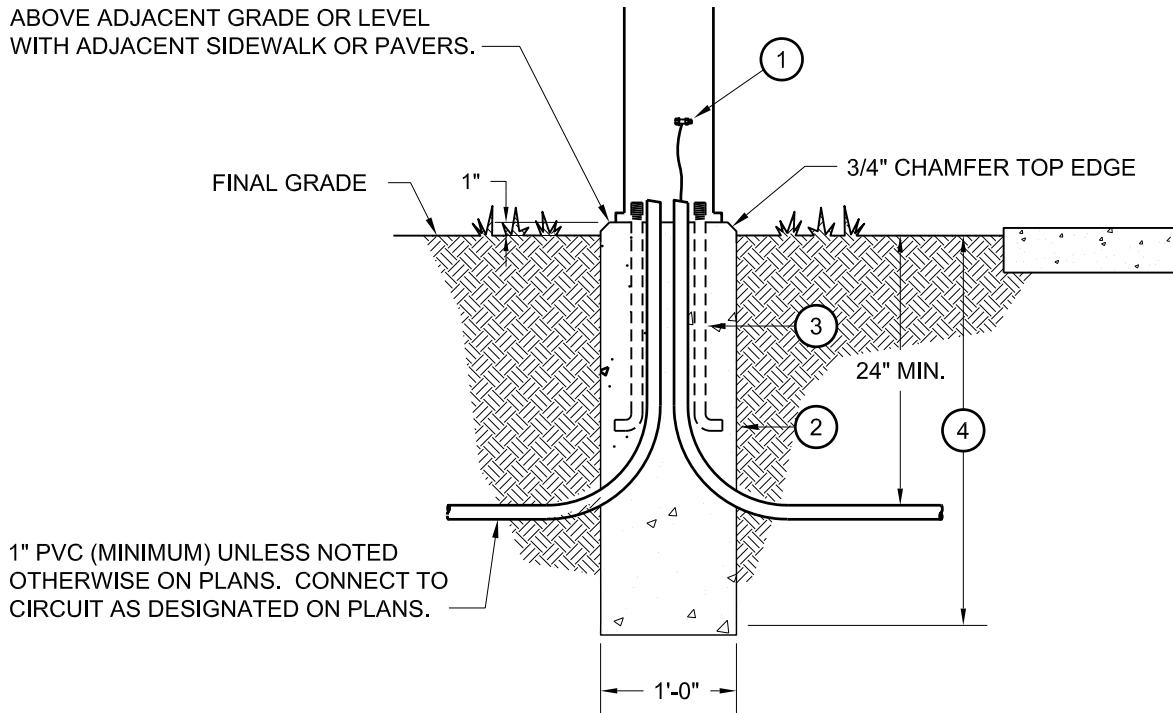
TYPICAL STREET LIGHT STANDARD FOUNDATION ELECTRICAL DETAIL IN HARDSCAPE

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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TOP OF FOUNDATION SHALL BE 1" ABOVE ADJACENT GRADE OR LEVEL WITH ADJACENT SIDEWALK OR PAVERS.



ELEVATION SECTION VIEW

FOUNDATION DETAIL NOTES

- ① BOND (1-#6 SOFT DRAWN BARE CU) TO GROUNDING LUG IN POLE BASE.
- ② LIGHT STANDARD FOUNDATION EMBEDMENT DEPTH, DIMENSIONS AND REINFORCEMENT SHALL BE DESIGNED BY A STRUCTURAL ENGINEER LICENSED IN THE STATE OF MONTANA.
- ③ DIMENSION FOR ANCHOR BOLT SPACING BY POLE MANUFACTURER.
- ④ DEPTH OF FOUNDATION PER STRUCTURAL ENGINEER.

GENERAL NOTE

FOUNDATION DETAILS ARE INCLUDED ONLY TO SHOW ELECTRICAL COMPONENTS.

FIGURE 6

TYPICAL PATHWAY LIGHT
STANDARD FOUNDATION
ELECTRICAL DETAIL

THE CITY OF BOZEMAN

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NOTE:
REFER TO FIGURE 7b FOR NOTES.

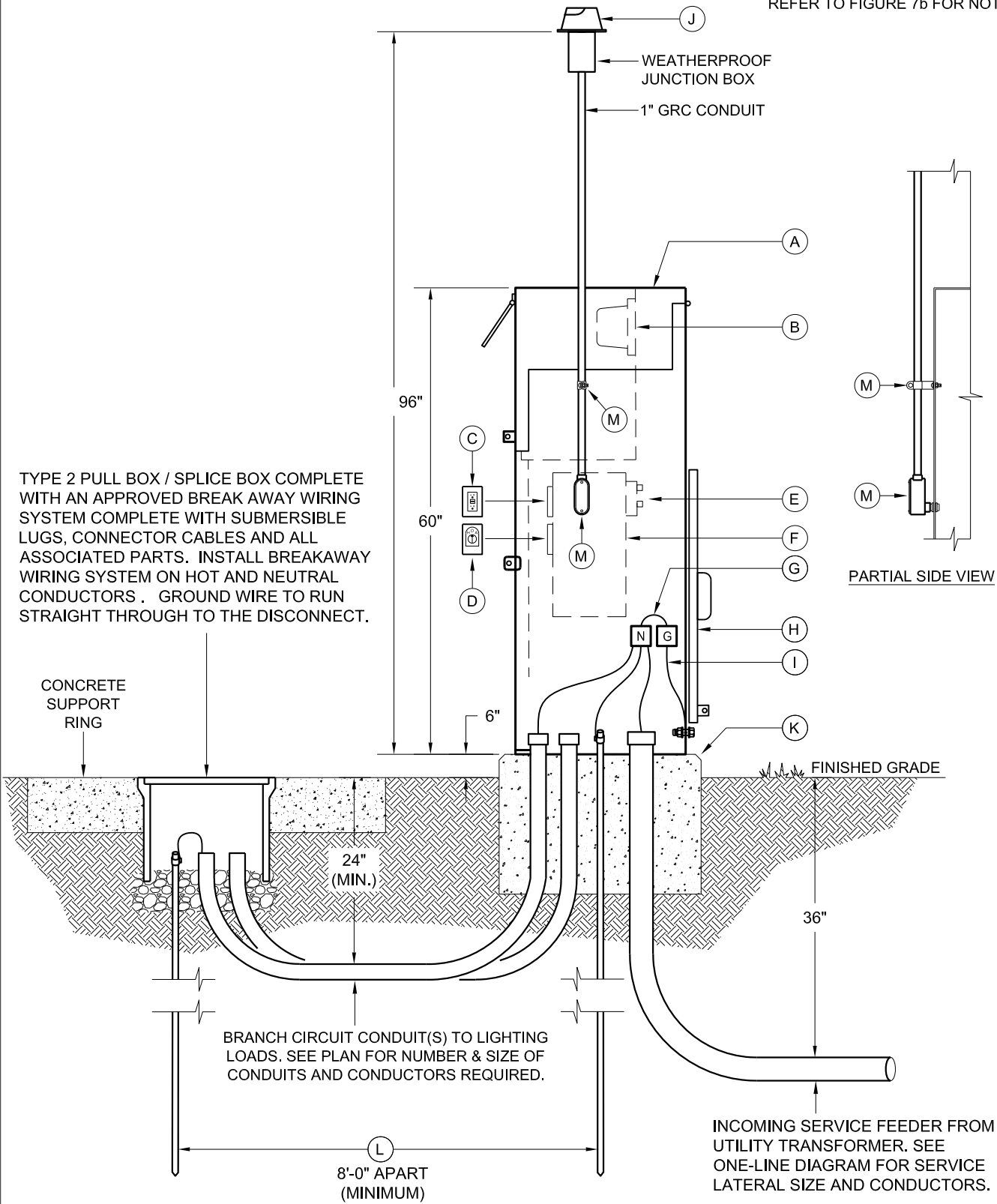


FIGURE 7A

TYPICAL LIGHTING
CONTROL CENTER CABINET
STANDARD DETAIL

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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BOZEMAN, MONTANA 59711-1230
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CABINET COMPONENT LIST

- (A) FULLY HINGED METER/TEST SECTION LOCKABLE COVER WITH HOLD OPEN ARM TO KEEP COVER FROM BLOWING SHUT. COMBINATION ALL-IN-ONE COMMERCIAL METER POWER PEDESTAL IN A NEMA 3R STAINLESS STEEL ENCLOSURE.
- (B) UTILITY METER INSIDE NEMA 3R ENCLOSURE. METER SHALL HAVE LEVER BYPASS AND INTERNAL LOCKING TAB ON METER COVER.
- (C) GFCI MAINTENANCE RECEPTACLE FLUSH MOUNTED IN PANEL DEAD FRONT INSIDE OF THE NEMA 3R ENCLOSURE.
- (D) HAND-OFF-AUTO SWITCH - 15A-2P, HOA SWITCH WITH LEGEND FLUSH MOUNTED IN PANEL DEAD FRONT INSIDE OF THE NEMA 3R ENCLOSURE.
- (E) UTILITY TERMINATION LANDING LUGS.
- (F) LOAD CENTERS WITH SERVICE MAIN AND BRANCH BREAKERS. ENGINEER SHALL PROVIDE PANEL SCHEDULE FOR BREAKERS REQUIRED.
- (G) PROVIDE NEUTRAL TO GROUND BONDING JUMPER.
- (H) LIFT OFF SERVICE COVER WITH PAD LOCK HASP.
- (I) CABINET GROUND BOND #6 BARE COPPER CONDUCTOR.
- (J) NEMA 3R 120V PHOTOELECTRIC CONTROL WITH 3-PRONG TWIST-LOCK RECEPTACLE BASE WIRED THROUGH THE H.O.A. SWITCH. THE PHOTOELECTRIC CONTROL SHALL BE MOUNTED TO A WEATHERPROOF JUNCTION BOX ON TOP OF A 1" GRC CONDUIT AT 96" ABOVE FINISHED GRADE. ORIENT PHOTOCELL WINDOW NORTHWARD TO MINIMIZE THE SUN'S INTERFERENCE.
- (K) REINFORCED CONCRETE (CLASS B) FOUNDATION PER STRUCTURAL ENGINEER LICENSED IN THE STATE OF MONTANA. MINIMUM 6" ABOVE GRADE, 3/4" CHAMFER ALL EXPOSED EDGES, 4" OVERLAP ON ALL SIDES.
- (L) 3/4" X 8'-0" Lg. COPPER CLAD DRIVEN GROUND ROD. EXOTHERMIC WELD OR UNDERGROUND RATED LUG CONNECT CONDUCTOR TO GROUND ROD. (2) REQUIRED - 8'-0" APART (MIN.)
- (M) PROVIDE 1" GRC LB AND THREADED CONNECTION FOR CABINET ENTRY. INSTALL CONDUIT HANGER WITH BOLT, BOLTED TO CABINET TO PREVENT CONDUIT MOVEMENT. ENSURE CONDUIT DOES NOT INTERFERE WITH OPERATION OF HINGED COVER.

TYPICAL CABINET REQUIREMENTS:

200AMP MCB, 120/240V-1Ø-3W STAINLESS STEEL, NEMA 3R, METER/ POWER PEDESTAL WITH SEPARATE SEALABLE AND LOCKABLE CUSTOMER SECTION WITH:

1. LOAD CENTER (ENGINEER SHALL PROVIDE SCHEDULE FOR # OF CIRCUITS) FOR ALWAYS ON LOADS THAT INCLUDE:
(APPLIES TO STREET LIGHTS AND PEDESTRIAN LIGHTS)
 - SERVICE ENTRANCE M.C.B. - ENGINEER TO PROVIDE SIZE ON THE PANEL SCHEDULE.
 - CONTROL POWER CIRCUIT BREAKER - ENGINEER TO PROVIDE SIZE ON THE PANEL SCHEDULE.
 - SWITCHED LOAD CENTER MAIN BREAKER - ENGINEER TO PROVIDE ON THE PANEL SCHEDULE.
 - BRANCH BREAKERS AS SHOWN - ENGINEER TO PROVIDE SIZE AND QUANTITY ON THE PANEL SCHEDULE.
 - CIRCUIT DIRECTORY TO DOCUMENT CONFIGURATION IN POCKET ON HINGED DOOR.
 - MAINTENANCE RECEPTACLE FLUSH MOUNTED IN DEAD FRONT INSIDE ENCLOSURE.
2. CONTROL CIRCUIT INCLUDING:
(ONLY APPLIES TO PATHWAY AND PEDESTRIAN LIGHTS THAT DO NOT HAVE INDIVIDUAL ANSI 7-PIN RECEPTACLES.)
 - PHOTOCELL RECEPTACLE, MOUNTED EXTERNALLY ON NEMA-3R ENCLOSURE.
 - ONE HAND-OFF-AUTO (HOA) SWITCH FLUSH MOUNTED IN DEAD FRONT.
 - ONE LIGHTING CONTACTOR CONTROLLING ONE LOAD CENTER IN THIS SECTION.
 - ONE 12-CIRCUIT LOAD CENTER PHOTOCELL ON/OFF CONTROLLED.
 - A CIRCUIT DIRECTORY TO DOCUMENT CONFIGURATION IN POCKET ON HINGED DOOR.

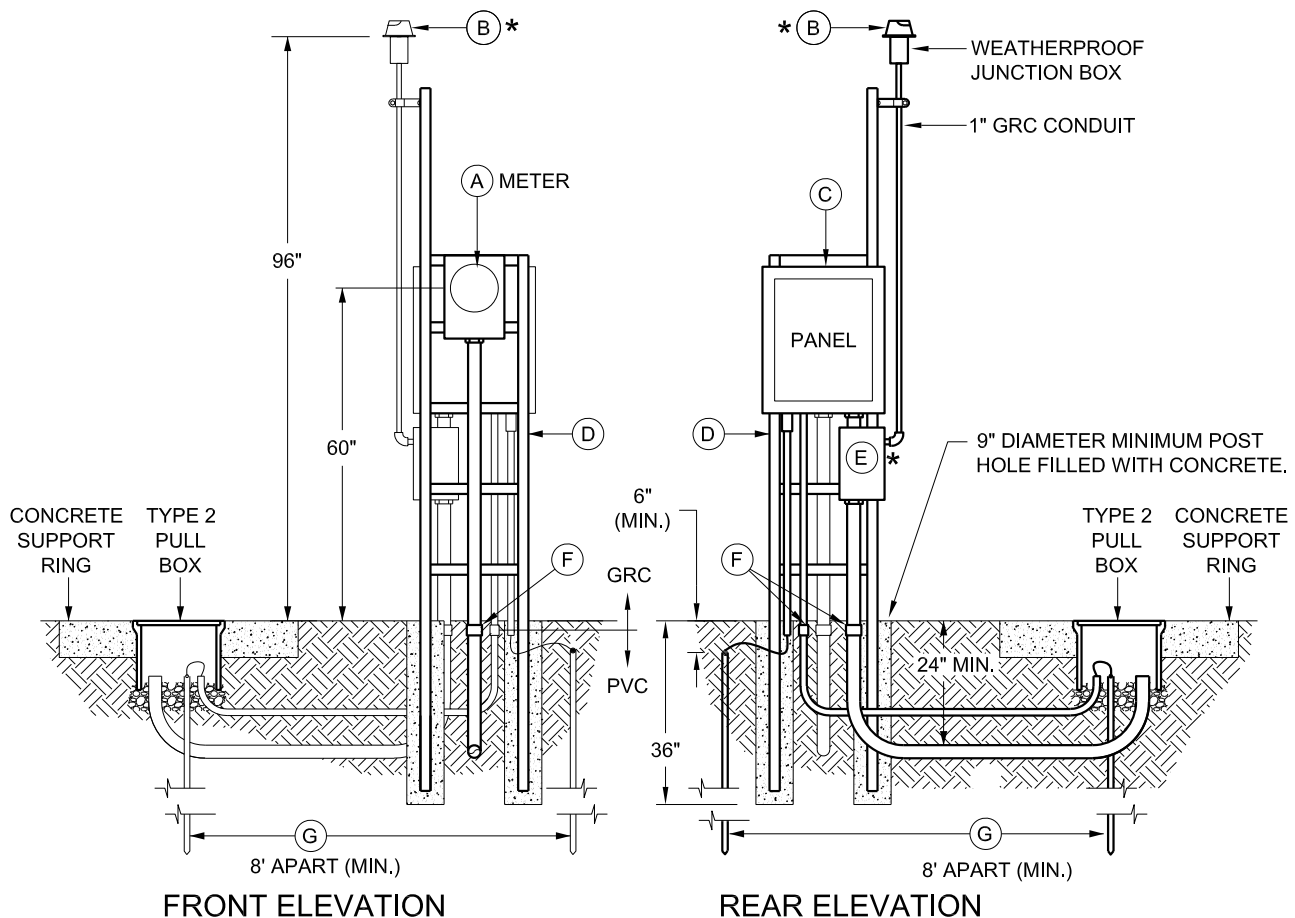
FIGURE 7B

TYPICAL LIGHTING CONTROL CENTER CABINET COMPONENT LIST

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
20 E. OLIVE -- P.O. BOX 1230
BOZEMAN, MONTANA 59711-1230
PHONE: (406) 582-2280 -- FAX: (406) 582-2263





LIGHTING CONTROL CENTER (PEDESTAL)

PEDESTAL COMPONENT LIST

- (A) 200A, 120/240V, NEMA 3R METER HOUSING CONFORMING TO UTILITY PROVIDER REQUIREMENTS.
 - * (B) NEMA 3R 120V PHOTOELECTRIC CONTROL WITH 3-PRONG TWIST-LOCK RECEPTACLE BASE WIRED THROUGH THE H.O.A. SWITCH. THE PHOTOELECTRIC CONTROL SHALL BE MOUNTED TO A WEATHERPROOF JUNCTION BOX ON TOP OF A 1" GRC CONDUIT AT 96" ABOVE FINISHED GRADE ORIENTED NORTHWARD TO MINIMIZE THE SUN'S INTERFERENCE.
 - (C) 200A, 120/240V-1Ø-3W, NEMA 3R SERVICE ENTRANCE RATED LOAD CENTER WITH COPPER BUS, SERVICE MAIN AND BRANCH BREAKERS AS LISTED ON ENGINEER PROVIDED PANEL SCHEDULE. PROVIDE SPACES FOR CIRCUITS AS DESIGNED PLUS A MINIMUM OF TWO AVAILABLE SPACES FOR FUTURE USE. PROVIDE NEUTRAL TO GROUND SERVICE ENTRANCE BOND PER N.E.C.
 - (D) HEAVY DUTY, GALVANIZED C-CHANNEL TYPE RACKING SET IN CONCRETE. PAINT TO MATCH PANEL COLOR. PROVIDE A MINIMUM OF (5) C-CHANNEL CROSS MEMBERS.
 - * (E) 30-AMP, 12-POLE, ELECTRICALLY HELD, LIGHTING CONTACTOR FURNISHED WITH 120-VOLT COIL, NEMA 3R ENCLOSURE WITH PAD LOCKABLE COVER AND HOA SWITCH MOUNTED INSIDE ENCLOSURE.
 - (F) PROVIDE TRANSITION FITTING (JUST BELOW GRADE) FROM PVC CONDUIT IN EARTH TO GRC CONDUIT ABOVE GRADE. PROVIDE 2-HOLE CONDUIT STRAPS ON ALL C-CHANNEL CROSS MEMBERS.
 - (G) (2) 3/4" x 8'-0" COPPER-CLAD DRIVEN GROUND RODS WITH APPROVED GROUND ROD CLAMP, 8'-0" (MIN.) APART AND 6" (MIN.) BELOW GRADE.
- * THESE TWO DEVICES (B & E ABOVE) ARE ONLY REQUIRED FOR PROJECTS WITH PAYWAY AND PEDESTRIAN LIGHTS THAT DO NOT HAVE INDIVIDUAL ANSI 7-PIN RECEPTACLES ON THE LUMINAIRES.

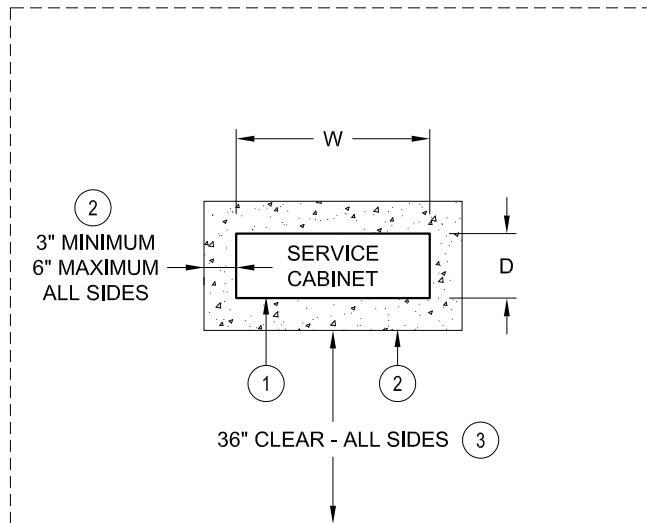
FIGURE 8

TYPICAL LIGHTING CONTROL CENTER METERED PEDESTAL STANDARD DETAILS

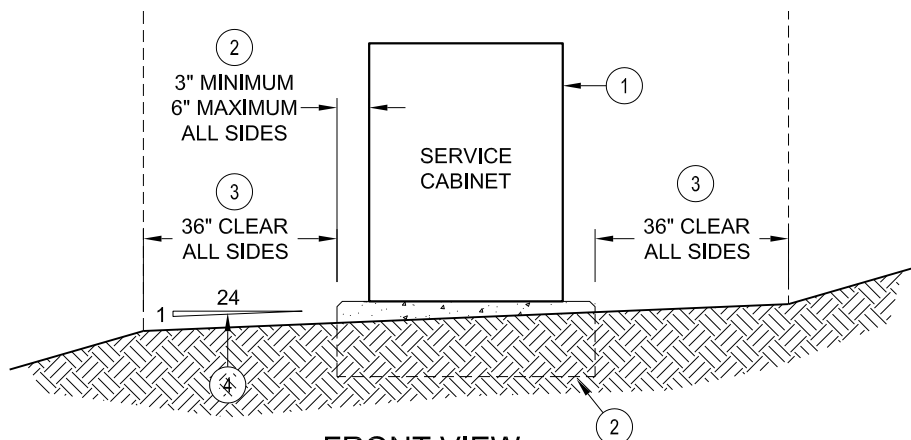
THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
20 E. OLIVE -- P.O. BOX 1230
BOZEMAN, MONTANA 59711-1230
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PLAN VIEW



FRONT VIEW

TYPICAL SERVICE CABINET DETAIL

DETAIL NOTES

- ① PREBUILT NEMA 3R SERVICE CABINET. REFER TO SERVICE CABINET DETAILS FOR MORE INFORMATION.
- ② REINFORCED CONCRETE (CLASS B) FOUNDATION PAD, PER STRUCTURAL ENGINEER LICENSED IN THE STATE OF MONTANA, WITH 1" CHAMFER ON ALL EXPOSED EDGES. EDGE OF CONCRETE TO EXTEND 3" (MINIMUM) OR 6" (MAXIMUM) BEYOND EDGE OF CABINET.
- ③ MINIMUM OF 36" CLEAR ZONE ON ALL SIDES OF CONCRETE PAD.
- ④ MAXIMUM OF 1:24 SLOPE IN CLEAR ZONE AREA.

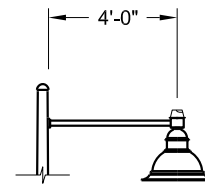
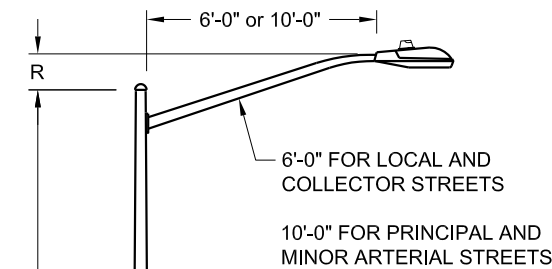
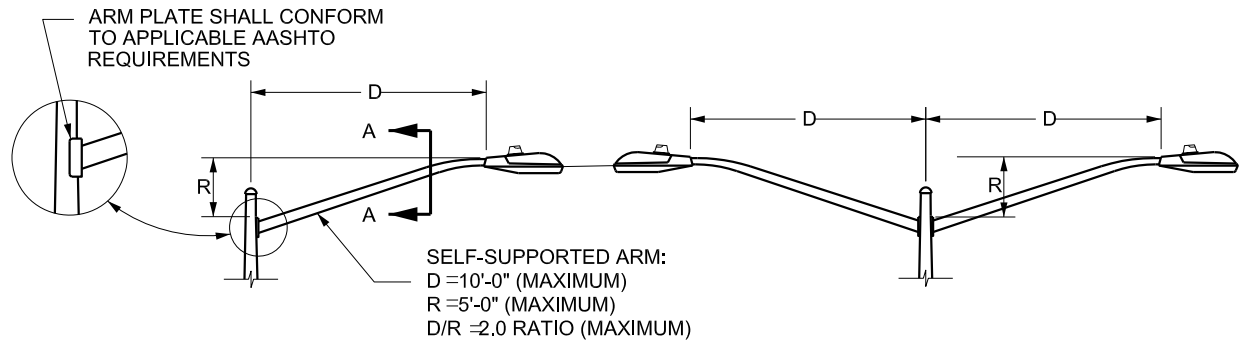
FIGURE 9

TYPICAL LIGHTING CONTROL
CENTER METERED PEDESTAL
STANDARD DETAILS

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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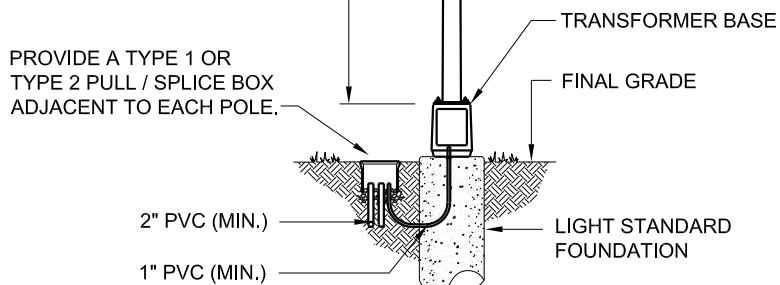




STREET LIGHT STANDARD.
 ROUND TAPERED STEEL POLE.

NOTES

1. ALL LUMINAIRES SHALL BE LED.
2. COLOR TEMPERATURE 3000K, PER ANSI C78.377-2011 STANDARD.
3. ALL LUMINAIRES SHALL BE EQUIPPED WITH A SURGE SUPPRESSION DEVICE WITH A MINIMUM IMMUNITY LEVEL OF 10KV.
4. ALL LUMINAIRES SHALL BE EQUIPPED WITH A 0-10V DIMMING DRIVER.
5. ALL LUMINAIRES SHALL BE EQUIPPED WITH AN ANSI C136.41 7-PIN RECEPTACLE AND PHOTOCCELL.
6. ALL LUMINAIRES SHALL HAVE EITHER TYPE II OR TYPE III DISTRIBUTION.



25 FT. TO 40 FT. STANDARD

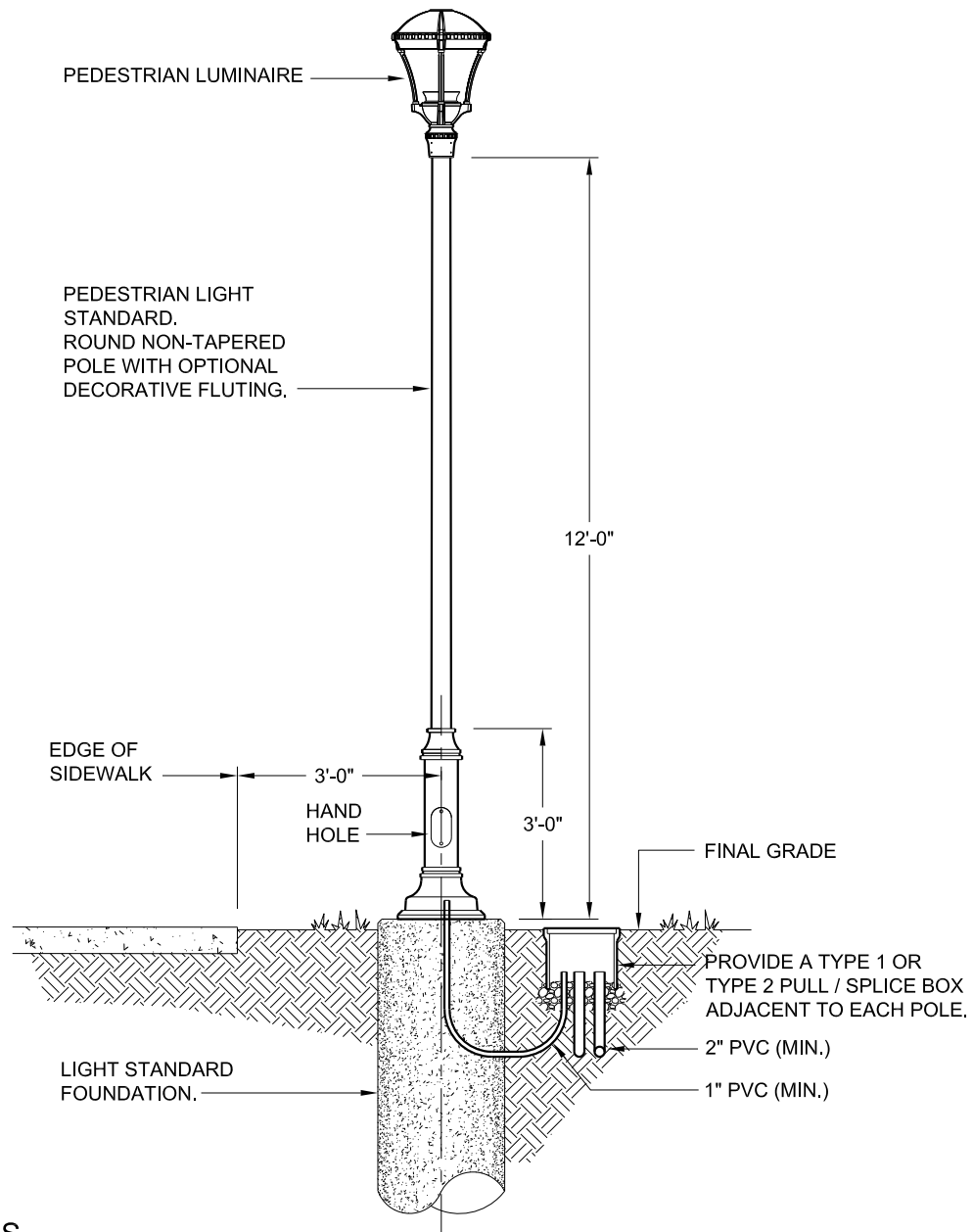
FIGURE 10

TYPICAL STREET LIGHT STANDARD DETAILS

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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 BOZEMAN, MONTANA 59711-1230
 PHONE: (406) 582-2280 -- FAX: (406) 582-2263





NOTES

1. ALL LUMINAIRES SHALL BE LED.
2. COLOR TEMPERATURE 3000K, PER ANSI C78.377-2011 STANDARD.
3. ALL LUMINAIRES SHALL BE EQUIPPED WITH A SURGE SUPPRESSION DEVICE WITH A MINIMUM IMMUNITY LEVEL OF 10kV.
4. ALL LUMINAIRES SHALL BE EQUIPPED WITH A 0-10V DIMMING DRIVER.
5. ALL LUMINAIRES SHALL BE EQUIPPED WITH AN ANSI C136.41 7-PIN RECEPTACLE AND PHOTOCCELL.
6. ALL LUMINAIRES SHALL HAVE EITHER TYPE III OR TYPE IV DISTRIBUTION.

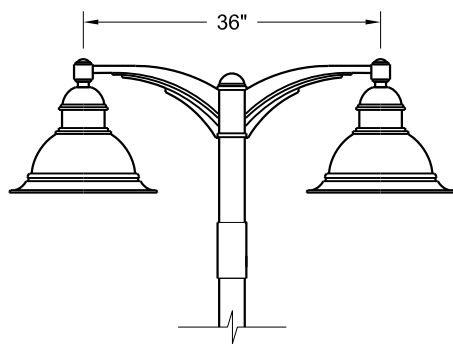
FIGURE 11

TYPICAL PEDESTRIAN LIGHT STANDARD DETAIL

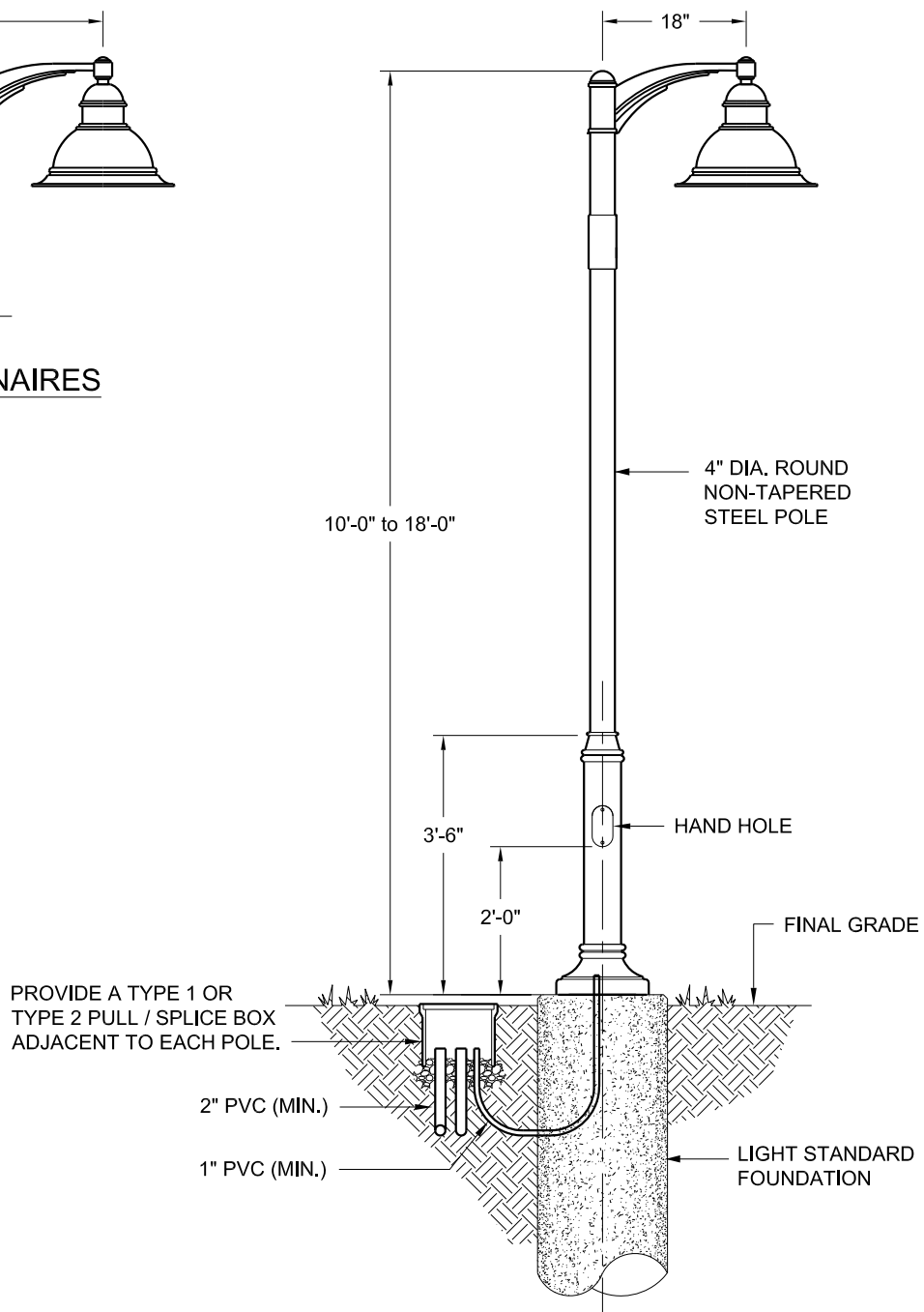
THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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BOZEMAN, MONTANA 59711-1230
PHONE: (406) 582-2280 -- FAX: (406) 582-2263





TWIN LUMINAIRES



NOTES

1. ALL LUMINAIRES SHALL BE LED.
2. COLOR TEMPERATURE 3000K, PER ANSI C78.377-2011 STANDARD.
3. ALL LUMINAIRES SHALL BE EQUIPPED WITH A SURGE SUPPRESSION DEVICE WITH A MINIMUM IMMUNITY LEVEL OF 10KV.
4. ALL LUMINAIRES SHALL BE EQUIPPED WITH A 0-10V DIMMING DRIVER.
5. ALL LUMINAIRES SHALL BE EQUIPPED WITH AN ANSI C136.41 7-PIN RECEPTACLE AND PHOTOCCELL.
6. ALL LUMINAIRES SHALL HAVE TYPE III DISTRIBUTION.

FIGURE 12

TYPICAL ARM MOUNT PEDESTRIAN
LIGHT STANDARD DETAIL

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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PHONE: (406) 582-2280 -- FAX: (406) 582-2263



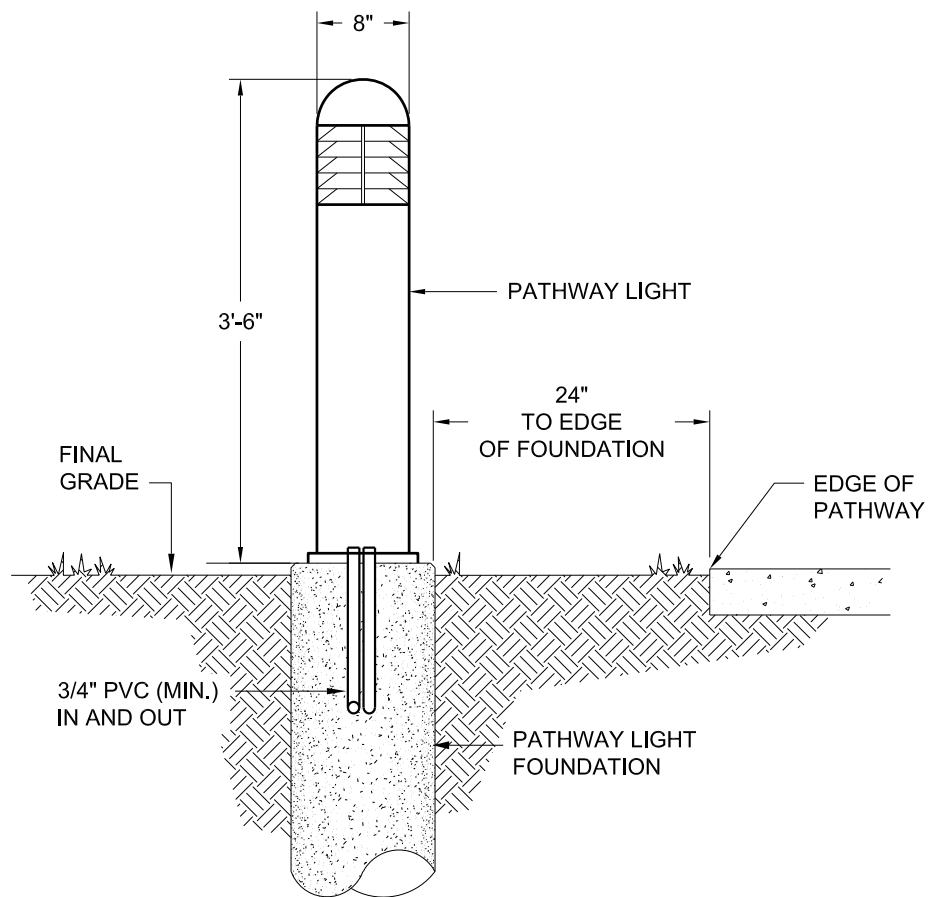


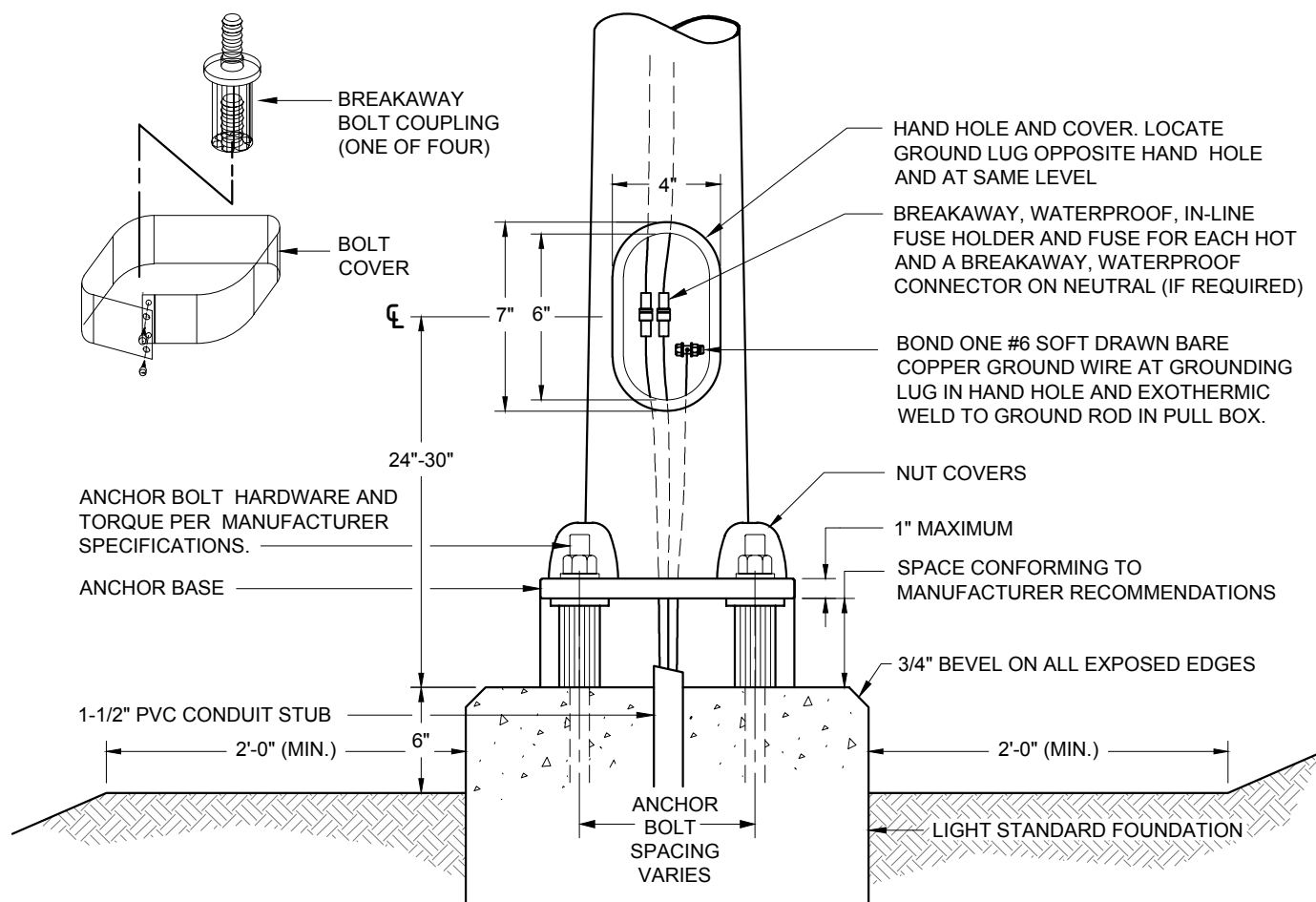
FIGURE 13

TYPICAL PATHWAY LIGHT STANDARD DETAILS

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
20 E. OLIVE -- P.O. BOX 1230
BOZEMAN, MONTANA 59711-1230
PHONE: (406) 582-2280 -- FAX: (406) 582-2263

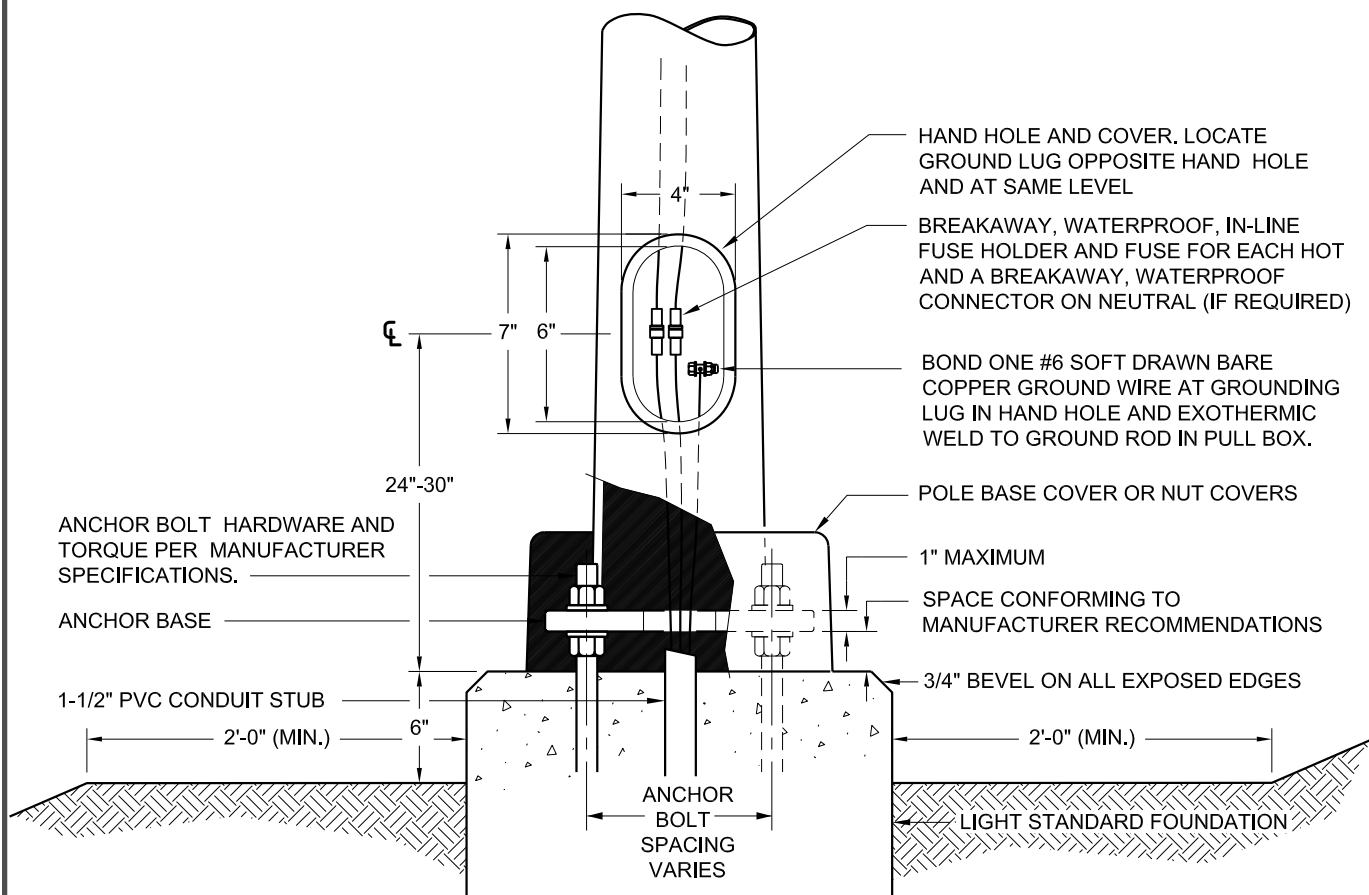




TYPICAL BREAKAWAY BASE DETAIL
FOR USE WITHIN CLEAR ZONE OR UNPROTECTED INSTALLATIONS.

NOTES

1. LIGHT STANDARD FOUNDATIONS MAY BE PRECAST CONCRETE OR CAST-IN-PLACE CONCRETE.
2. ALL CONDUCTORS SHALL BE SIZED IN CONFORMANCE WITH N.E.C. REQUIREMENTS IMSA 19-1 3 CONDUCTOR #14 AWG MINIMUM



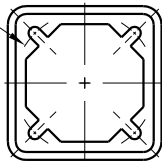
TYPICAL NON-BREAKAWAY BASE DETAIL
FOR USE ONLY OUTSIDE CLEAR ZONE OR IN PROTECTED INSTALLATIONS.

NOTES

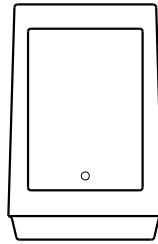
1. LIGHT STANDARD FOUNDATIONS MAY BE PRECAST CONCRETE OR CAST-IN-PLACE CONCRETE.
2. ALL CONDUCTORS SHALL BE SIZED IN CONFORMANCE WITH N.E.C. REQUIREMENTS IMSA 19-1 3 CONDUCTOR #14 AWG MINIMUM.



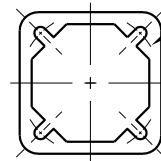
BOLT CIRCLE SHALL
MATCH FOUNDATION



BOTTOM PLATE



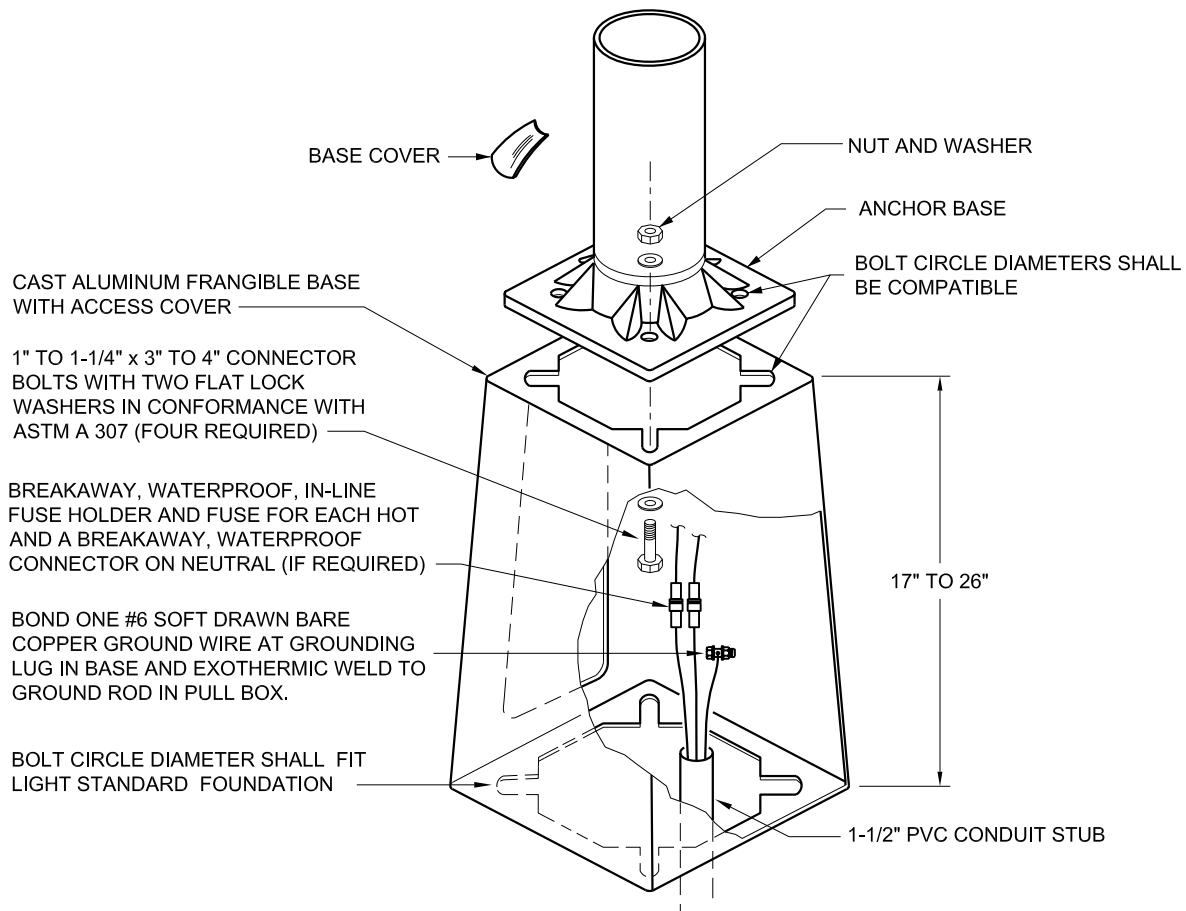
FRONT VIEW



BOLT CIRCLE SHALL
MATCH LIGHT
STANDARD BASE

TOP PLATE

NOTE: MATCH EXISTING BREAKAWAY TRANSFORMER BASE AS CLOSELY AS POSSIBLE.



NOTES

1. ALL BREAK-AWAY TRANSFORMER BASES SHALL CONFORM TO AASHTO "STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS".
2. LIGHT STANDARD FOUNDATIONS MAY BE PRECAST CONCRETE OR CAST-IN-PLACE CONCRETE.
3. ALL CONDUCTORS SHALL BE SIZED IN CONFORMANCE WITH N.E.C. REQUIREMENTS IMSA 19-1 3 CONDUCTOR #14 AWG MINIMUM.
4. HAND HOLE IS NOT REQUIRED IN THE POLE IF A BREAKAWAY TRANSFORMER BASE IS USED.

FIGURE 16

TYPICAL FRANGIBLE TYPE TRANSFORMER BASE DETAIL

THE CITY OF BOZEMAN

ENGINEERING DEPARTMENT
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City of Bozeman – Street Lighting Method of Measurement

Introduction

Street lighting luminance measurements are best taken on nights with clear skies, dry pavement and in areas with little to no light contribution from adjacent properties. Preliminary luminance measurements may be taken using OpticaLight, a luminance photo-mapping application on an iPad or iPhone. The recommended distance for taking luminance measurements with the OpticaLight App is 20-ft to 30-ft from the measurement point. The technician performing the luminance measurements shall complete the Street Lighting Measurement Form to record the measured street luminance values and the factors that may affect the lighting measurements. If the measurements from OpticaLight result in an average luminance that is below the acceptable tolerance from the luminance criteria, luminance measurements shall be re-taken using a calibrated luminance meter with a 1-degree or 1/3-degree measuring angle and +/- 2% accuracy.

Street Lighting Method of Measurement

1. **Intent:** There are many factors that can lead to differences between calculated street luminance and street luminance measured in the field. The intent of this report is to provide guidance for City of Bozeman field technicians to measure the luminance of street lighting installations to compare with luminance criteria. By first understanding the many factors that affect street luminance conditions and differences with calculated street luminance, technicians will be able to:
 - a. Determine which factors can be avoided by following these recommended methods;
 - b. Understand which factors can be accounted for and considered as reasonable variations; and
 - c. Identify which factors may need further investigation to troubleshoot any issues that need to be addressed in order to bring a non-compliant street lighting installation into compliance.
2. **Measured vs. Calculated Street Luminance:** The following factors affect the measurement of street luminance to some degree. Some factors can have a significant impact on the luminance and perceived brightness of the street surface, while other factors have a minimal effect.
 - a. **Pavement Conditions:** The street surface material, age and condition affects the reflectance, and therefore, the luminance and perceived brightness of the street surface.
 - i. **Type of Pavement:** The Illuminating Engineering Society's Recommended Practice for Roadway Lighting (RP-8-14) defines four pavement types (R1 – R4) that have different reflectance properties. The most common pavement types used within the United States are types R1 (typical concrete) and R3 (typical asphalt).
 1. R1: Mostly diffuse reflectance properties characteristic of Portland cement or asphalt surface with a minimum of 15% of the aggregates composed of artificial brightener aggregates.

2. R2: A combination of diffuse and specular reflectance characteristics of asphalt surfaces with aggregate composed of a minimum of 60% gravel of size greater than 10 mm. Also asphalt surfaces composed of 10% - 15% artificial brightener in aggregate mix.
 3. R3: Slightly specular reflectance typical of asphalt surfaces with dark aggregates, rough texture and some months of use. This surface is common in the United States.
 4. R4: Mostly specular surface typical of very smooth asphalt texture.
- ii. Age of Pavement: As pavement ages, the reflectance properties also change, particularly with asphalt pavement. Pavement reflectance can be measured using a standard 18% reflectance photo-gray card.
1. Concrete (type R1): The reflectance properties of concrete pavement are much more stable throughout the life of the pavement than asphalt.
 2. Asphalt (type R3): Fresh, newly laid asphalt is very dark. Over a period of 6 - 12 months from laying new asphalt, the pavement lightens and eventually stabilizes to be a more consistent reflectance. When measuring luminance of an asphalt street, the pavement reflectance should be measured by comparing the luminance of a standard 18% reflectance photo-gray card with the luminance of the pavement, using the following equation:

$$R_{pavement} = \frac{L_{pavement} \times R_{gray\ card}}{L_{gray\ card}}$$

$$R_{pavement} = \text{Reflectance of Pavement}$$

$$R_{gray\ card} = \text{Reflectance of Gray Card} = 0.18$$

$$L_{pavement} = \text{Luminance of Pavement}$$

$$L_{gray\ card} = \text{Luminance of Gray Card}$$

When measuring the pavement reflectance, the measurement of the pavement luminance and gray card luminance should be taken with the meter aimed at the same point, moving the photo-gray card instead of moving the meter. Moving the meter to aim at a different point may result in a different light level at the two points, introducing error into this measurement.

- iii. Wet Pavement: When pavement is wet, the street surface becomes more specular, affecting the reflectance and luminance of the street. Luminance measurements should not be taken when the pavement is wet.
- iv. Snow: When there is snow on the street, luminance and brightness of the street is significantly increased. Luminance measurements should not be taken when there is snow on the streets.

b. Atmospheric Conditions:

- i. Ambient Temperature: At higher ambient temperatures, electronic components operate at a lower efficiency, resulting in a reduction in lumen output from LEDs. At lower ambient temperatures, the electronic components operate at a higher efficiency, increasing the lumen output from LEDs. The effect of temperature will vary depending on the luminaire's thermal management design.
- ii. Cloudy Sky: Clouds increase the reflection of light pollution back to the ground. Particularly when the ground is covered with snow and the sky is overcast, there is more light contribution from sky glow than under clear sky conditions. Under cloudy sky conditions, luminance measurement shall be taken both with lights off and lights on to determine the contribution from reflected sky glow.
- iii. Humidity and Airborne Particulates: In high humidity or poor air quality conditions, more light is scattered in the air before reaching the roadway surface. If the effect of light scattering in the air is visible, luminance measurements should not be taken.

c. Ambient Lighting Conditions:

- i. Twilight: After sunset and before sunrise, is the period of twilight when the skylight fades into darkness. Twilight has three stages, civil twilight, nautical twilight and astronomic twilight. Street lighting measurements shall not be taken until Nautical Twilight to eliminate light contribution from the sky. Nautical Twilight can be determined using the Sunrise Sunset Calendar website: <http://www.sunrisesunset.com/USA/Montana.asp>

1. Civil Twilight: During civil twilight, electric lighting is not needed to clearly distinguish terrestrial objects. During clear evening's civil twilight, horizontal illuminance decreases from approximately 45 footcandles to 0.2 footcandles.
2. Nautical Twilight: During nautical twilight, the horizon is still clearly distinguishable. During a clear evening's nautical twilight, horizontal illuminance decreases from approximately 0.2 footcandles to 0.0008 footcandles.
3. Astronomical Twilight: By the end of astronomical twilight, the sky is dark enough for all astronomical observations.

- ii. Moonlight: On a clear night, full moonlight produces 0.01 footcandles, and a quarter moon produces 0.001 footcandles. The contribution, even from full

October 2016

Bozeman, Montana

Wednesday	
5	Twilight A: 5:49am Twilight N: 6:24am Twilight: 6:58am Sunrise: 7:28am Sunset: 6:58pm Twilight: 7:27pm Twilight N: 8:02pm Twilight A: 8:36pm Moonrise: 11:49am Moonset: 9:47pm

Excerpt from the Sunrise
Sunset Calendar website

moonlight, is generally not enough to effect the lighting measurement. However, technicians should note the phase of the moon and moonrise in the luminance measurement report. If measurements are taken during a full moon, the technician may also take luminance measurements with the lights turned off to establish the contribution from moonlight.

- iii. Light Spill from Adjacent Properties: Light contribution from adjacent properties may be significant, and should be accounted for by technicians when measuring street luminance. At sites where light spill from adjacent properties may affect street luminance measurements, technicians should measure the street luminance both with the streetlights turned off, and again with streetlights turned on.
- d. Electrical / Utility Conditions: Voltage supplied can affect the lumen output of a luminaire. Lower voltage may result in reduced lumen output and higher voltage may result in increased lumen output. Some variation in voltage is expected, but should not exceed +/- 5% from the design voltage at the luminaire. The following factors may affect the voltage supplied to a luminaire:
 - i. Wire Sizing: Voltage drop occurs over distance of electrical wiring, and is a function of the wire type, wire size, length of wire, ampacity of the electrical load and the supply voltage. Larger gauge wire has less voltage drop per linear foot than smaller gauge wire. For LED street lighting retrofit projects, the electrical load is most often being reduced from the original load. Since the existing wire was engineered for a higher load, it is typically over-sized for the new lower LED loads and voltage drop is not usually a concern.
 - ii. Wire Type: Copper wire has the best conductivity and longevity, maintaining its conductivity over time. Aluminum wire is more susceptible to corrosion and thermal expansion and contraction, which can affect the wiring connections and conductivity over time. In older street lighting installations, the age of the wiring may contribute to inadequate operating conditions.
 - iii. Conduit Type: For in-grade electrical wiring installations, PVC and HDPE conduit provides the best long-term protection of the wiring. While most new street lighting installations use these conduit types, some older street lighting may have been installed with galvanized rigid conduit (GRC) or even with direct bury cable (DBC) with no conduit protection. GRC and DBC installations can corrode or degrade over time, reducing the functional life of the wiring, which may contribute to inadequate operating conditions.
 - iv. Utility Supply Voltage: Voltage supplied by the utility to the Lighting Control Center may vary from the design voltage. If the voltage at the Lighting Control Center is more than 2% below the design voltage, the City should contact the electrical utility to help determine the cause.

e. Luminaire Manufacturing

- i. Manufacturing Quality: Optics and light output may vary between the sample luminaire that was used to create the photometry used in the lighting calculations and the actual luminaires installed in the field. While normal tolerances in the manufacturing process should be expected, the quality of manufacturing process may result in unacceptable variation from the specifications.
- ii. Luminaire Specifications: Luminaires have multiple options for different optical distributions and lumen outputs. If the installed luminaires do not match the specified and calculated luminaires, the measured light levels may vary significantly from designed levels.
- iii. Thermal Management: Heat from LEDs is emitted back through the circuit board that the LED is mounted to. If this heat is not adequately dispersed away from the circuit board, and the LEDs overheat, the light output degrades much faster.
- iv. LED Driver: The LED driver regulates the electrical voltage and current that is delivered to the LEDs. The electrical current is typically expressed in milliamps (mA). LEDs can be driven at multiple drive currents, with lower drive currents emitting less light and higher drive currents emitting more light. If the light output is too low, a higher drive current will increase the light output of the luminaire. Some drivers are designed with field selectable drive current that may be set to a higher drive current without replacing the driver.

f. Measuring Equipment

- i. Calibrated Luminance Meter: Calibrated luminance meters like the Konica Minolta LS-110 or LS-160 provide high accuracy luminance measurements at low light levels that are typical in street lighting applications. Luminance values can be measured at any distance.
- ii. OpticaLight iPhone/iPad Application: The OpticaLight iPhone/iPad application provides a less expensive option for measuring luminance. Luminance measurement from this application tend to be lower than the LS-110 luminance meter by 15% - 20% on average. The accuracy improves when measurements are taken at a distance of 20-ft to 30-ft from the measurement point. When there is high contrast, measurements may need to be taken at a closer range to reduce the area within the view, thereby reducing the contrast within the view.

g. Construction

- i. Light Pole Locations: As-built light pole locations may vary from designed locations to avoid conflicts that were unforeseen during the design phases. Light pole locations that vary significantly from the design may adversely impact the measured light levels on the street.

- ii. Light Pole Geometry: The pole height and mast arm length should match the design specifications. Variations in height or location of the luminaire may affect the measured light levels on the street.
- iii. Luminaire Orientation & Positioning: luminaires may be installed with a tilt or twist, resulting in the luminaire not being level, changing the light distribution from the intended design.

h. Light Loss Factors

Roadway lighting calculations are performed using light loss factors that reduce the lumen output of luminaires to ensure that adequate luminance is provided through the life of the lighting system as the light source ages and dirt accumulates on the luminaire. A lighting calculation using light loss factors results in the “maintained luminance” of the street. When a new lighting installation is being measured, these light loss factors should be close to 1.0, resulting in “initial luminance” of the street.

- i. Lamp Lumen Depreciation (LLD): For maintained lighting calculations, the Lamp Lumen Depreciation (LLD) factor for LED luminaires shall be 0.9.
- ii. Luminaire Dirt Depreciation (LDD): For maintained lighting calculations, the Luminaire Dirt Depreciation (LDD) factor for LED luminaires shall be 0.9.
- iii. Total Light Loss Factor (LLF): Multiplying the LLD(0.9) x LDD(0.9) results in a total Light Loss Factor (LLF) of 0.81.

References

European Road Lighting Technologies - Luminance Design and Pavement Reflection Factors

<http://international.fhwa.dot.gov/euroroadlighting/04.cfm>

"Furthermore, results of studies have shown that, in the case of porous asphalts, it typically takes between 6 months and a year for the pavement to stabilize in order to obtain reliable R-values."

"In an additional conversation with Werner Riemenschneider, however, he clarified that after the pavement had aged for 6 to 12 months, the Swiss typically found that the measured average values were within 15 percent of the average design value, usually on the high side."

"In the good cases the Belgians noted discrepancies of less than 10 percent, when comparing measured luminance levels against calculated levels for pavements, where the reflection characteristics have been determined."

"In Switzerland, experts emphasized the importance of dry roadways when conducting field measurements. There are, however, only a couple of summer months during which pavements are dry enough to be measured. In addition, the team heard warnings about dew points and pavement ages. It was noted that, during observations in cold weather (typically October through December), with a clear sky, when conditions were under the dew point, a water film could suddenly appear on the roadway. This film could provide a reflectance differential of 200 percent. Given these difficulties and variations in pavement reflection characteristics, the Swiss typically verify lighting installations with incident light measurements."

PNNL – Lumen Maintenance and Light Loss Factors

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22727.pdf

Twilight Envelope (3.2 lux) as a Visibility Criterion

<http://www.visualexpert.com/Resources/twilightcriterion.html>

During civil twilight, approximately the first half hour after sunset, ground illuminance in good weather declines by a factor of about 100, from roughly 330 lux to 3.2 lux.

American Meteorological Society

Civil Twilight: http://glossary.ametsoc.org/wiki/Civil_twilight

During a clear evening's civil twilight, horizontal illuminance decreases from ~585–410 lux to ~3.5–2 lux.

Nautical Twilight: http://glossary.ametsoc.org/wiki/Nautical_twilight

During a clear evening's nautical twilight, horizontal illuminance decreases from ~3.5–2 lux to ~0.008 lux.

Astronomical Twilight: http://glossary.ametsoc.org/wiki/Astronomical_twilight

During a clear evening's astronomical twilight, horizontal illuminance due to scattered sunlight decreases from ~0.008 lux to $\sim 6 \times 10^{-4}$ lux.

Sunrise/Sunset Calendar

<http://www.sunrisesunset.com/USA/Montana.asp>

This website provides calendars with sunrise/sunset information for specific locations, with appropriate adjustments for latitude, longitude and time zone. Information display options include

sunrise, sunset, moon phase, moonrise, moonset, civil twilight, nautical twilight and astronomical twilight.

City of Bozeman – Street Lighting Method of Measurement

Step-by-Step Street Luminance Measurement Method

1. Schedule and Prepare for Site Visit:

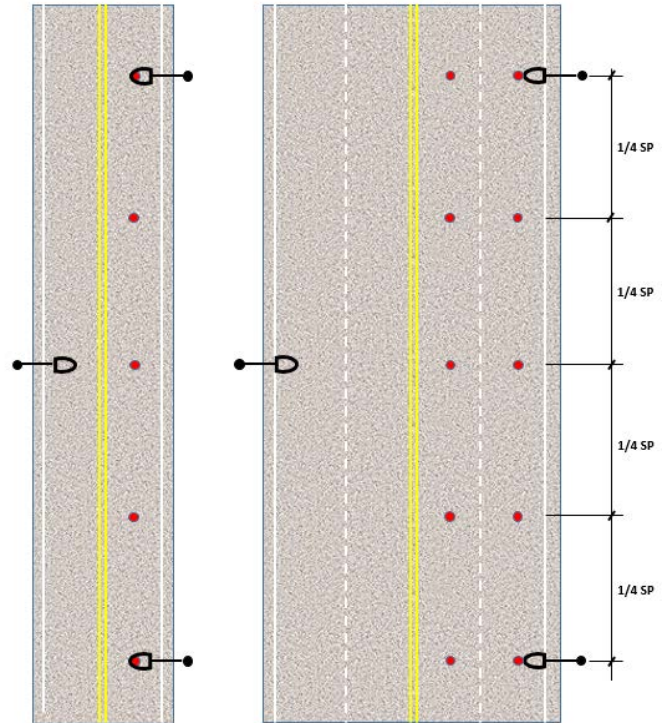
a. Determine Measurement Start Time:

Street lighting measurements shall not be taken until Nautical Twilight to eliminate light contribution from the sky. Nautical Twilight can be determined using the Sunrise Sunset Calendar website:
<http://www.sunrisesunset.com/USA/Montana.asp>

b. Arrange Traffic Control (if necessary)

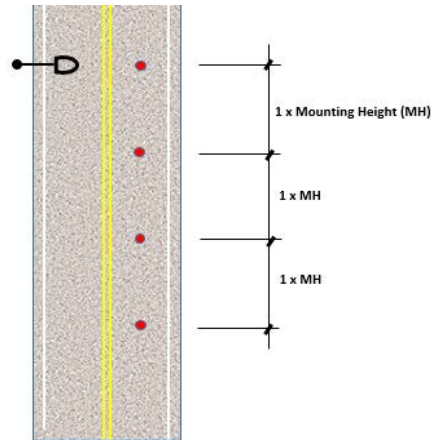
c. Resources & Equipment Needed

- i. Personal Protective Equipment (PPE)
 1. High Visibility Vest
 2. High Visibility Pants or Gators
 3. Hard Hat
- ii. Measuring Wheel or 200-ft Measuring Tape
- iii. Luminance Measurement Equipment
 1. iPad/iPhone with OpticaLight App, or
 2. Calibrated Luminance Meter
- iv. Photo-gray Card to measure pavement reflectance
- v. Camera
- vi. Street Lighting Measurement Form (Excel Spreadsheet) to record conditions taken in steps 2-4 below.



2. Record Field Conditions:

- a. Pavement Type (Concrete, Asphalt-New, or Asphalt-Aged)
- b. Pavement Conditions (dry, wet, or snow packed):
Only measure when pavement is dry
- c. Sky Conditions (clear, partly cloudy, overcast)
- d. Light spill from adjacent properties



3. Layout & Mark Measurement Points:

- a. Locate points in the center of each lane spaced at 1/4 of the street light pole spacing

4. Measured and Record Street Luminance:

- a. Select Luminance Measurement Equipment (OpticaLight or Calibrated Luminance Meter)
- b. Measure Pavement Reflectance
 - i. Measure Gray Card Luminance
 - ii. Measure Pavement Luminance at same location
- c. Measure Street Lighting Luminance
 - i. With OpticaLight, luminance measurements should be taken 20-ft to 30-ft away for most accurate readings.
- d. Measure Ambient Luminance (only required if there is significant contribution of light from adjacent sites)

City of Bozeman – Street Lighting Luminance Method of Measurement

The City of Bozeman Street Lighting Standards are based on roadway luminance criteria. Luminance is the intensity of light per unit area that is emitted from a surface in a given direction, expressed as candela per square meter (cd/m^2). The luminance of the roadway surface is the light reflected off of the pavement toward a driver. Accurate luminance measurements require a calibrated luminance meter with a $1/3^\circ$ – degree measuring angle and $\pm 2\%$ accuracy. Konica Minolta produces very high quality luminance meters the LS-160 is the current model offered by Konica Minolta (<http://sensing.konicaminolta.us/products/ls-160-luminance-meter/>), and the Konica Minolta LS-110 can be rented from Advanced Test Equipment Rentals (<http://www.atecorp.com/products/minolta/ls-110.aspx>).



Konica Minolta LS-160
Luminance Meter

For preliminary testing, there is a photographic luminance mapping application from OpticaLight (website) for iPad and iPhone. The OpticaLight App was tested and compared to measurements from a calibrated Konica Minolta LS-110 luminance meter. The accuracy of the OpticaLight App was found to be more accurate for measurements that were taken at close range (20ft to 30ft), and less accurate for more distant measurements.



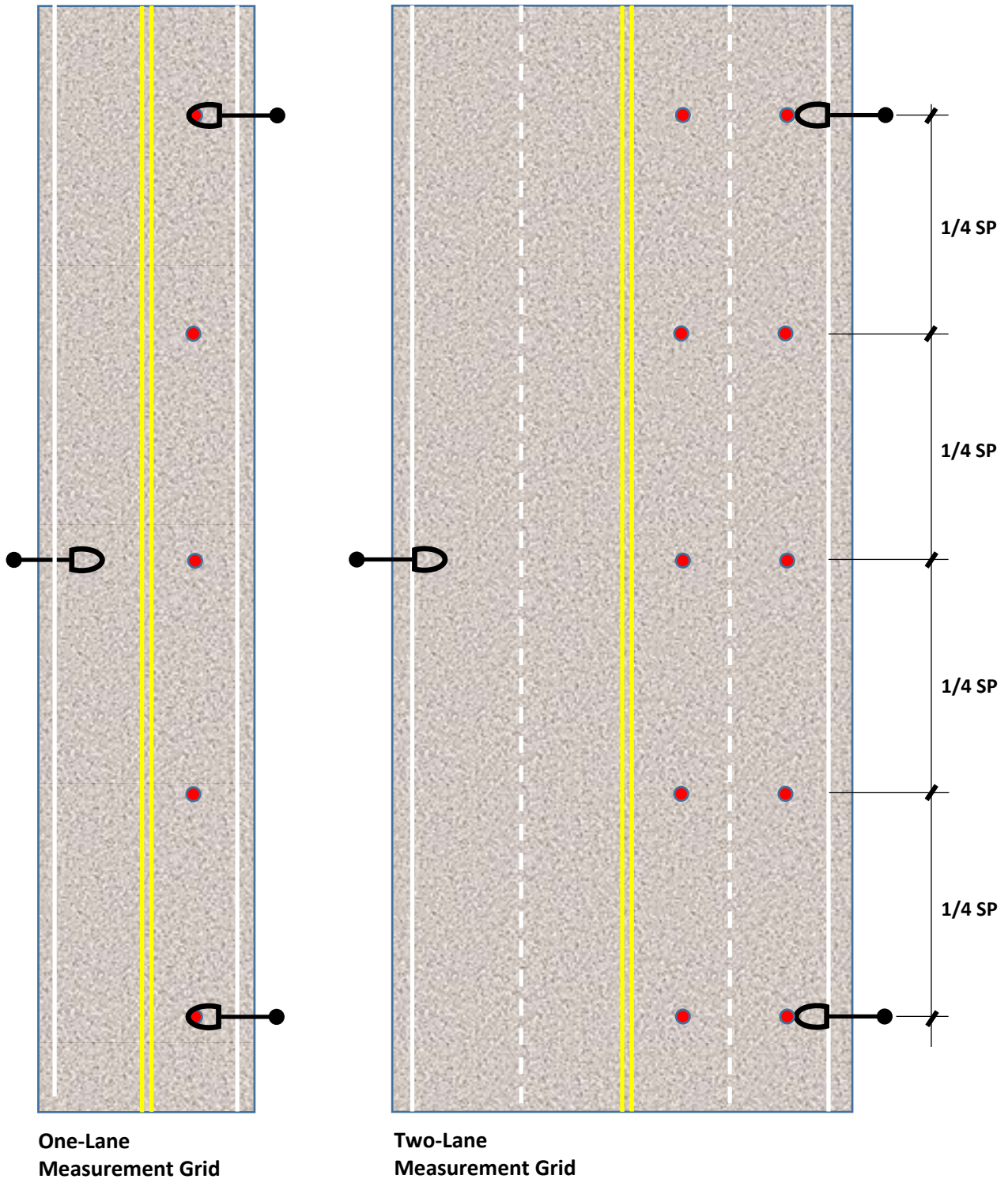
OpticaLight Photo Luminance Mapping App

Distant Measurements		
Optica Light App	Konica Minolta	% Difference
0.57	1.07	47%
0.31	0.44	30%
1.7	1.9	11%
1.8	1.97	9%
2.4	2.9	17%
0.65	0.86	24%
0.48	0.7	31%
Low	0.49	
1.13	1.29	24%
Near Measurements		
Optica Light App	Konica Minolta	% Difference
1.6	1.88	15%
6.1	6.9	12%
2.1	2.4	13%
0.33	0.44	25%
0.51	0.67	24%
0.32	0.39	18%
0.66	0.69	4%
0.41	0.43	5%
0.33	0.38	13%
1.5	1.55	3%
5.7	6	5%
0.13	0.2	35%
0.04	0.05	20%
1.52	1.69	15%

OpticaLight App vs. Konica Minolta
LS-110 Luminance Meter

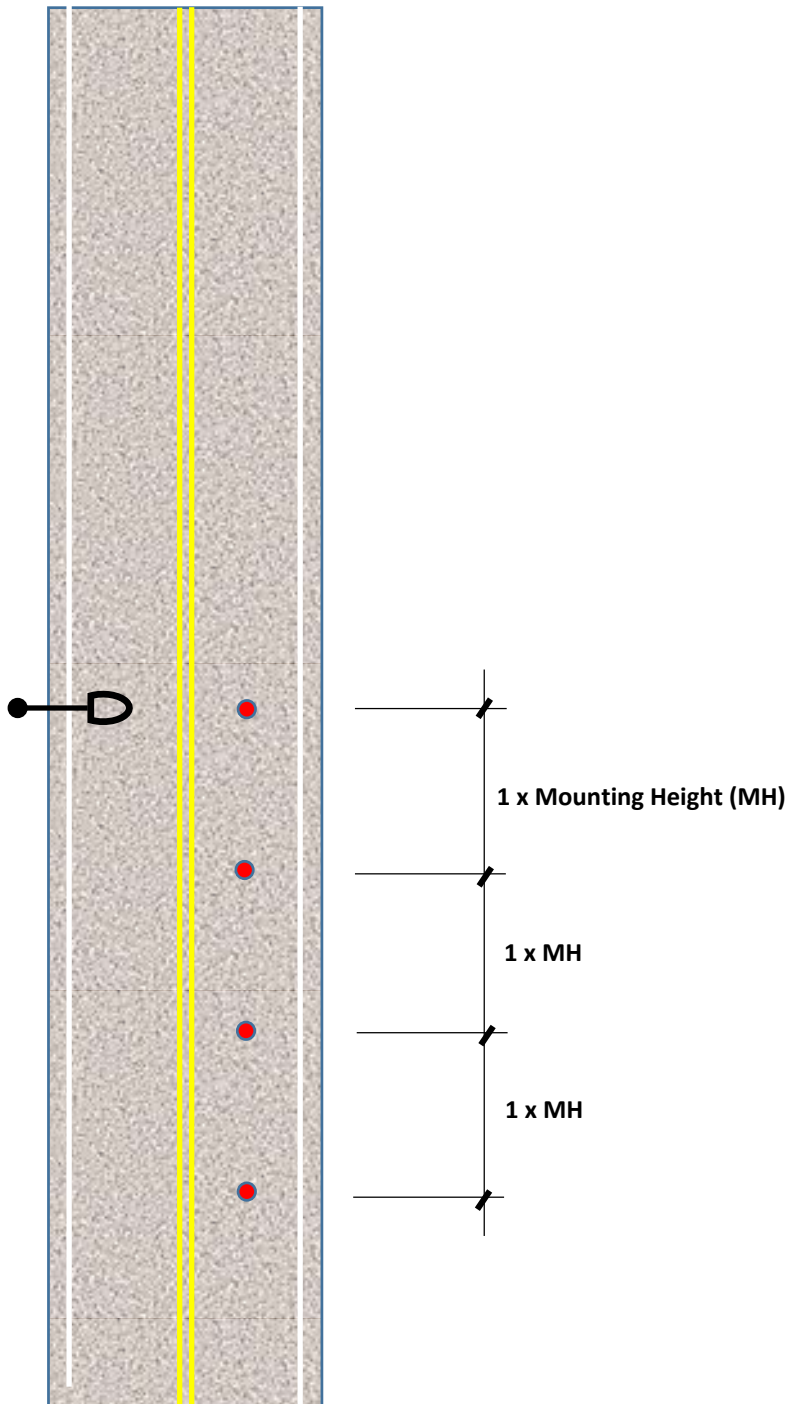


Luminance Measurement Grid





Luminance Measurement Grid

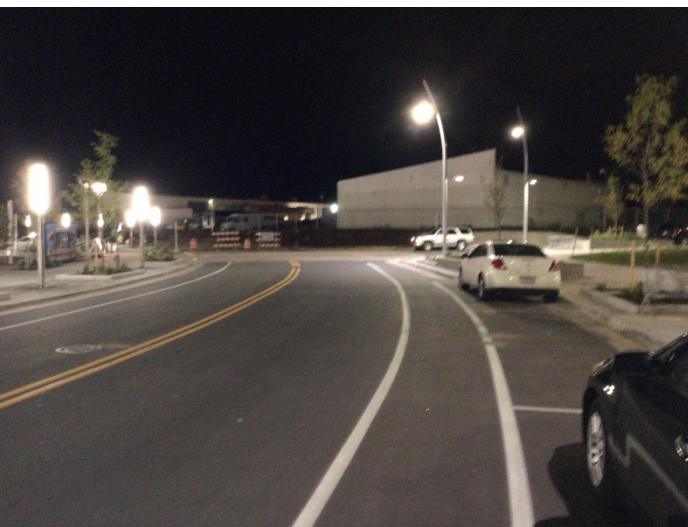
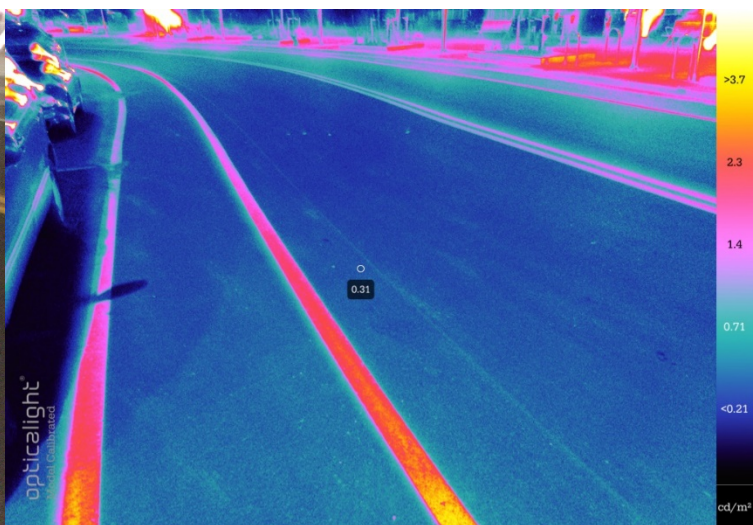
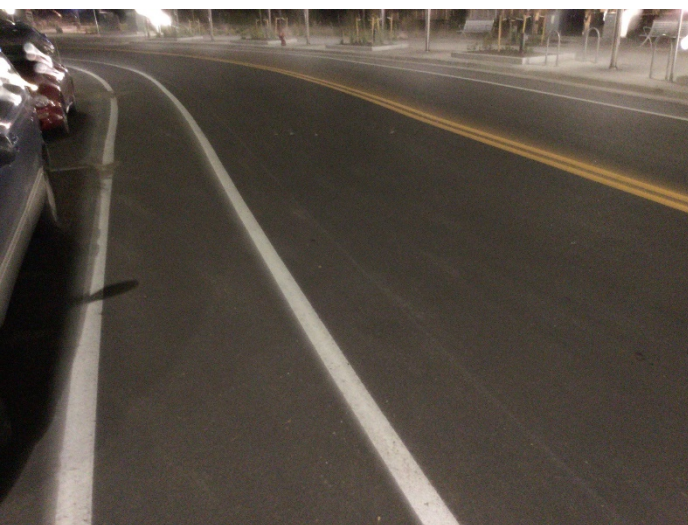
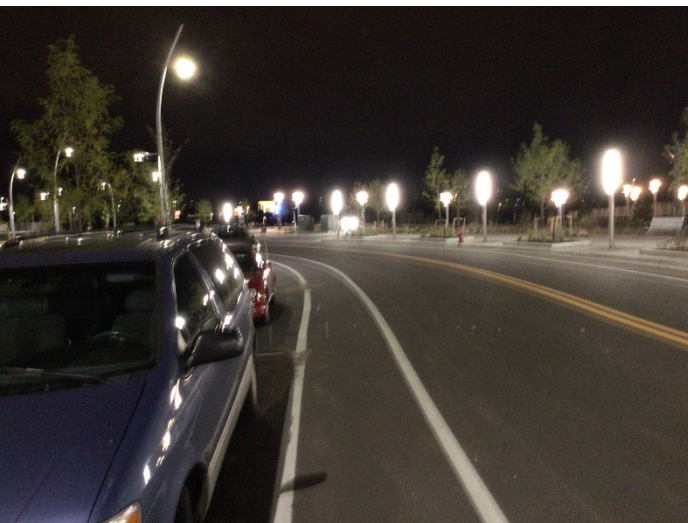


Single Luminaire
Measurement Grid

City of Bozeman – Street Lighting

Luminance Method of Measurement

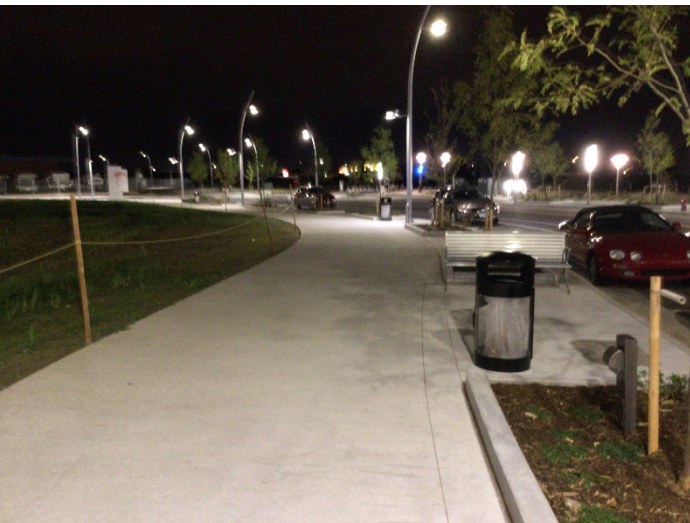
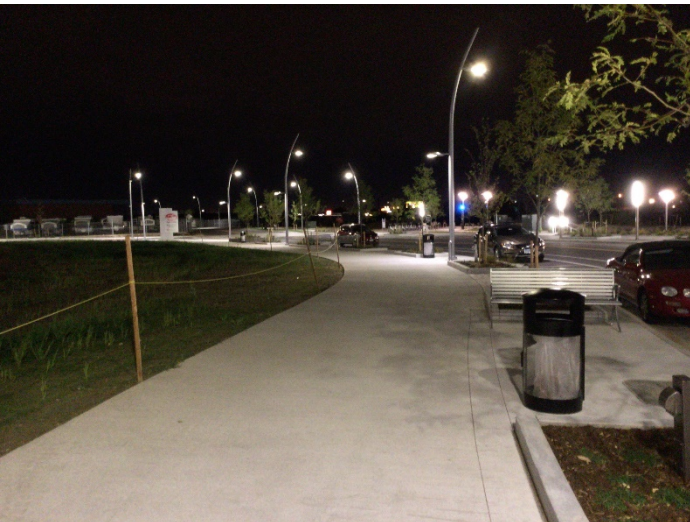
Opticalight Application Luminance Mapped Images



City of Bozeman – Street Lighting

Luminance Method of Measurement

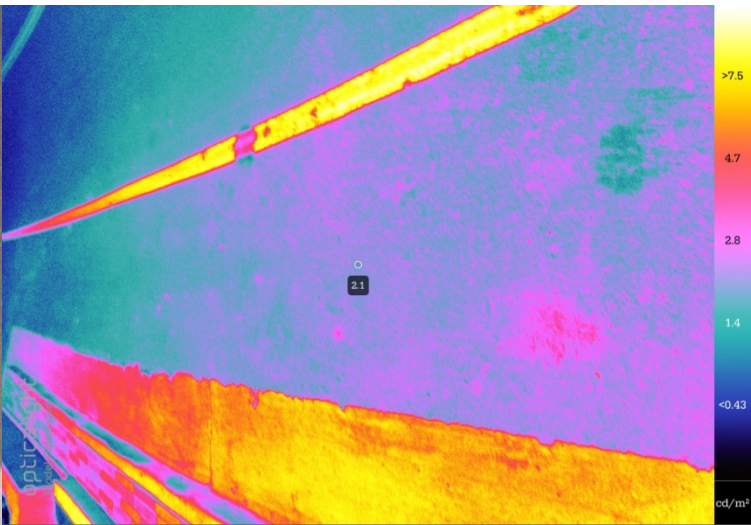
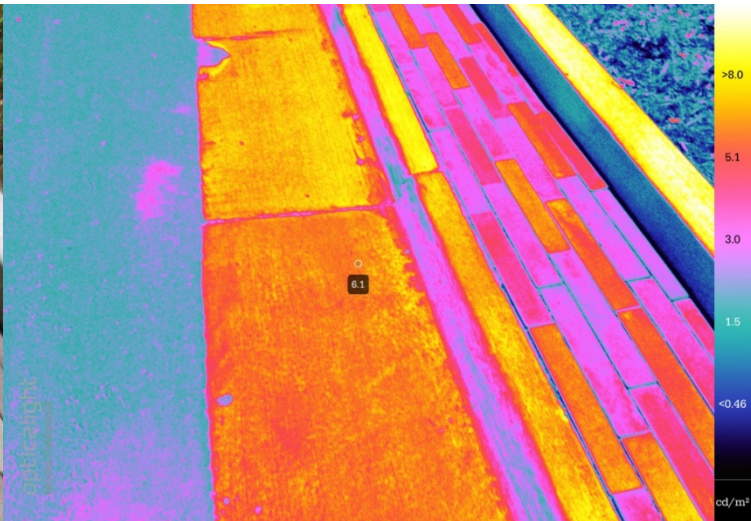
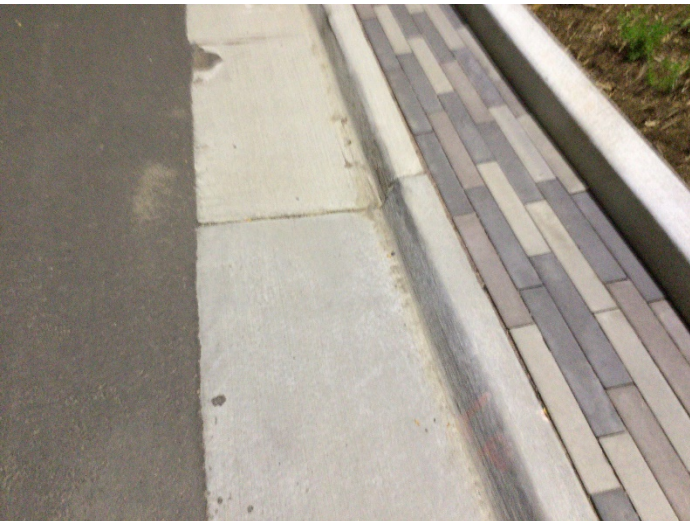
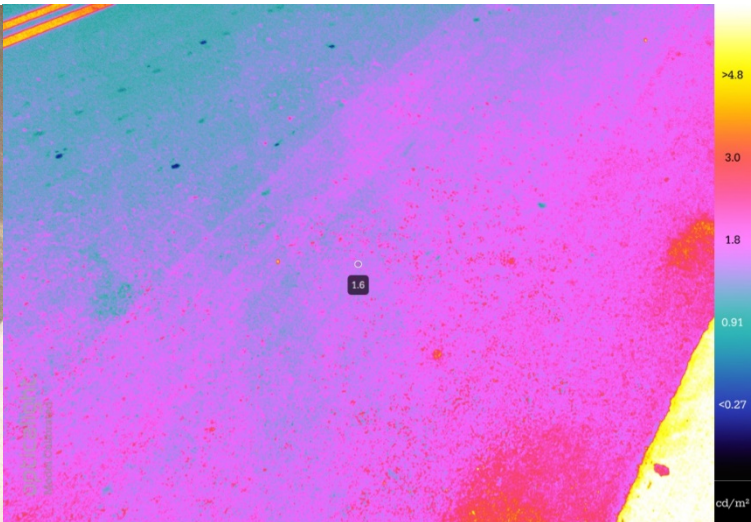
Opticalight Application Luminance Mapped Images



City of Bozeman – Street Lighting

Luminance Method of Measurement

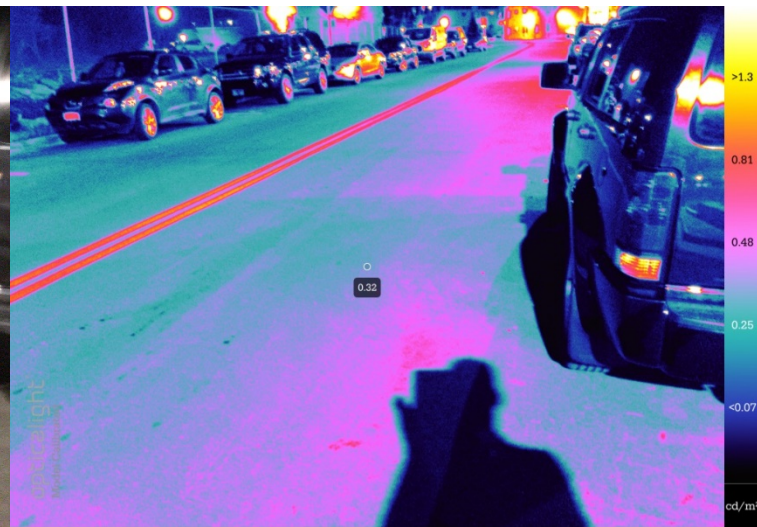
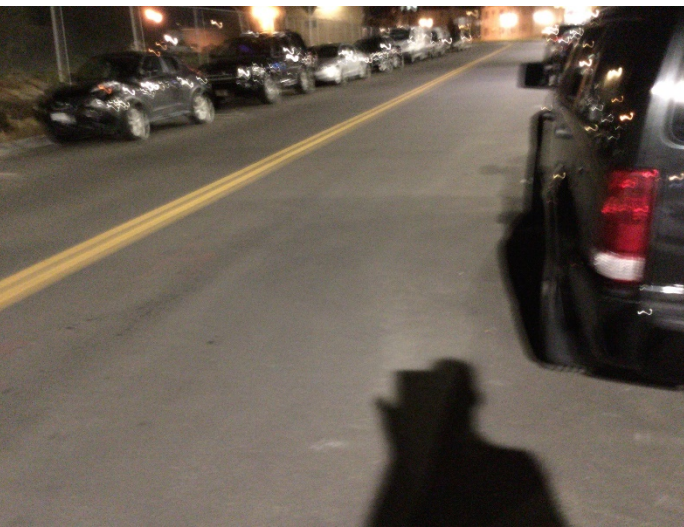
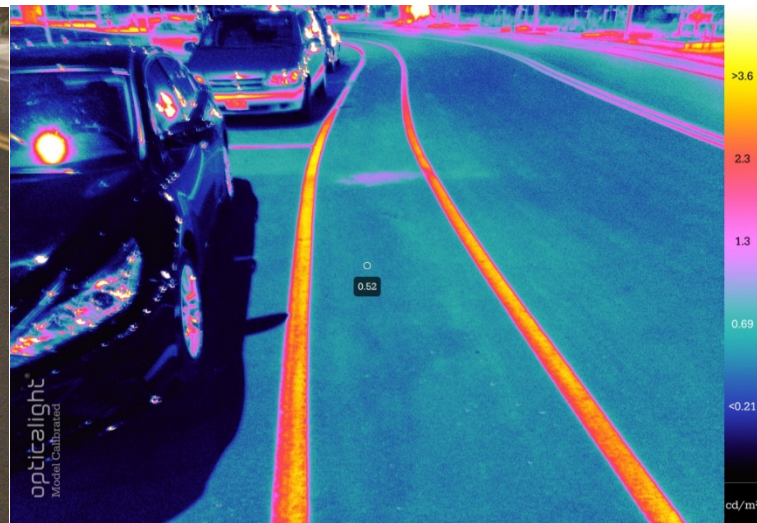
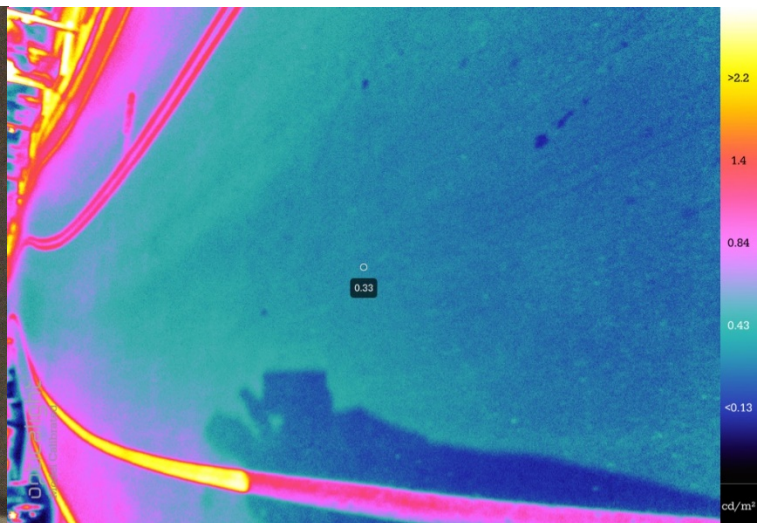
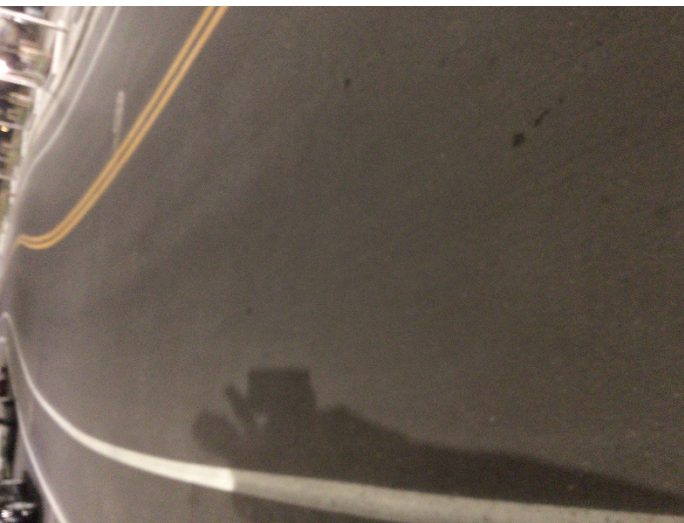
Opticalight Application Luminance Mapped Images



City of Bozeman – Street Lighting

Luminance Method of Measurement

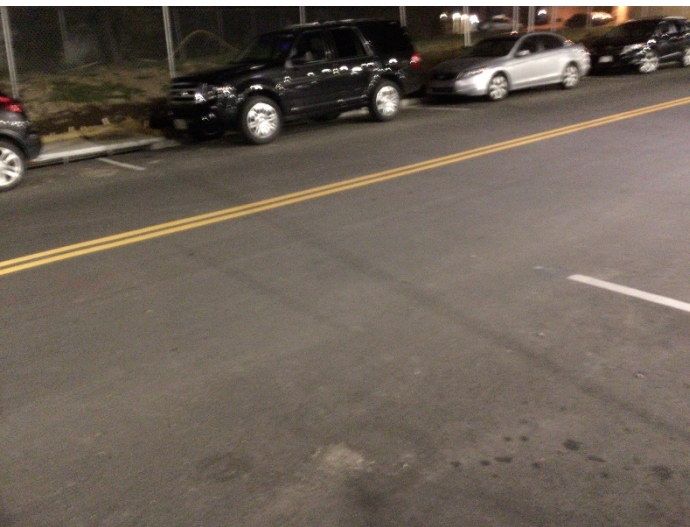
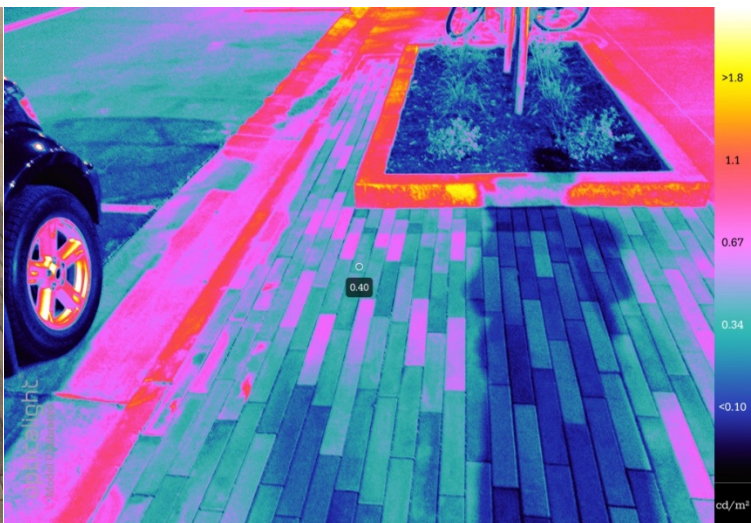
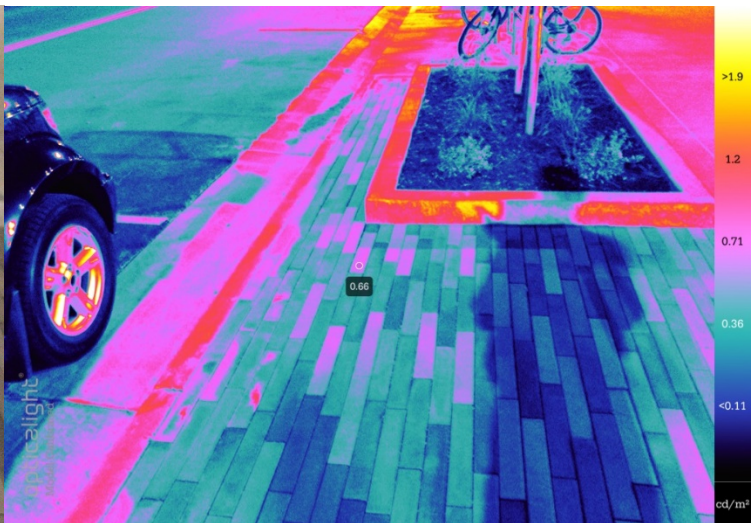
Opticalight Application Luminance Mapped Images



City of Bozeman – Street Lighting

Luminance Method of Measurement

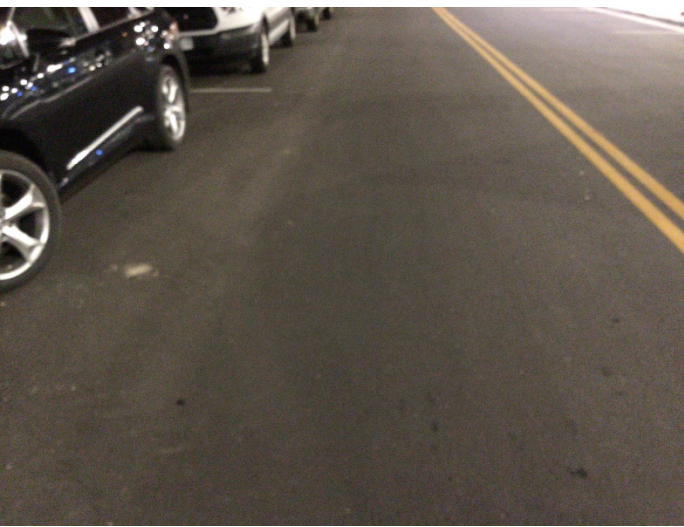
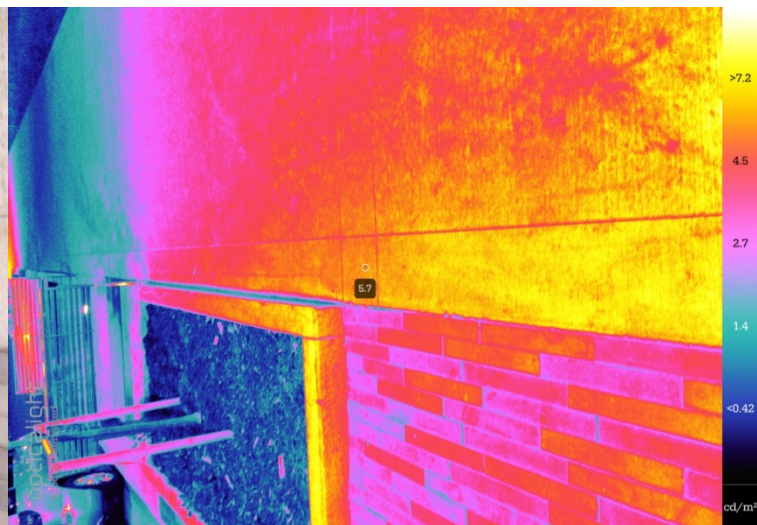
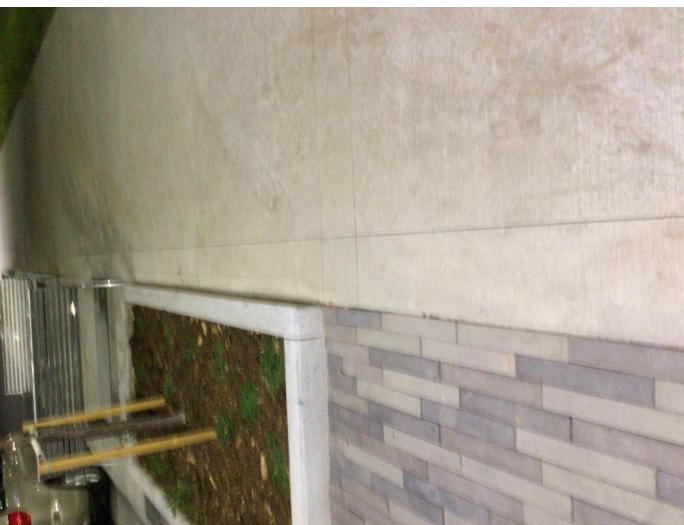
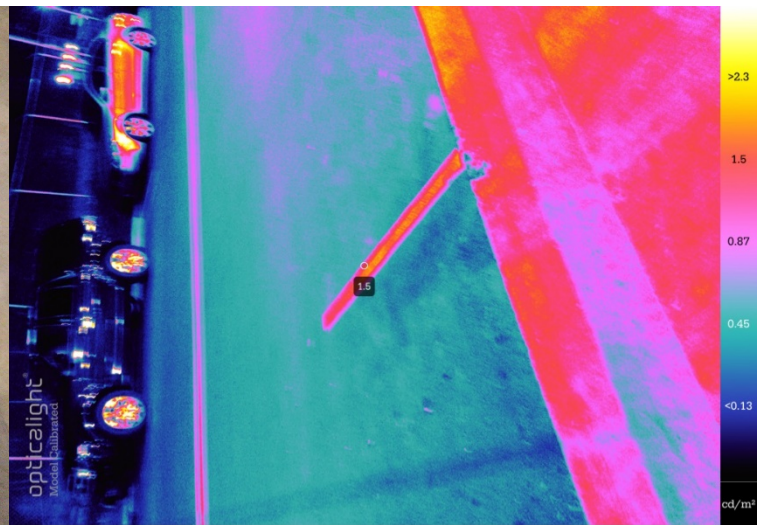
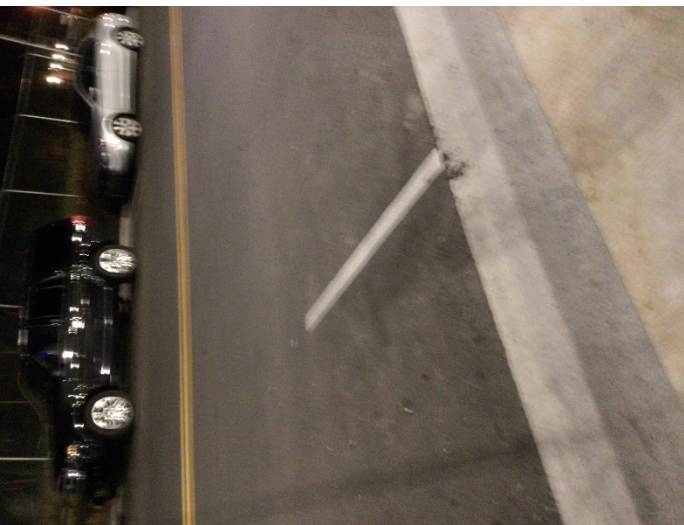
Opticalight Application Luminance Mapped Images



City of Bozeman – Street Lighting

Luminance Method of Measurement

Opticalight Application Luminance Mapped Images



City of Bozeman – Street Lighting

Luminance Method of Measurement

OpticaLight Application Luminance Mapped Images

