

CITY OF BROKEN ARROW

ENGINEERING DESIGN CRITERIA

MANUAL

ADOPTED BY CITY COUNCIL ON JUNE 21, 2010
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BROKEN ARROW CITY COUNCIL

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REVISION STATUS

<u>Revision</u>	<u>Date</u>	<u>Description</u>
0	06-21-10	Adopted by Council
1	01-28-11	Added Sections 4.9, 4.10 and 6.4.9 Revised Sections 4.6.6, 6.4.2, 6.4.5, 6.4.7, 6.4.8, 6.5.2, 6.6 and 9.2
2	02-20-24	Revision to entire Manual

PREFACE

The City of Broken Arrow intends for the criteria set forth herein to serve as the requirements for the engineering and design of all public infrastructure and private development infrastructure and are defined as:

Public Infrastructure – All water lines, sanitary sewer lines, storm sewer, and streets that are the City of Broken Arrow property.

Private Infrastructure – All water lines, sanitary sewer lines, storm sewer, and streets that are privately owned. Private water lines and private sanitary sewer lines will need to be preapproved by the Director of Engineering and Construction.

Any private infrastructure which may be dedicated to the City shall meet the minimum criteria specified within this manual. In addition, these requirements are to supplement all local, state, and federal building codes and regulations with respect to the engineering and design associated with said development. Where state or federal codes and regulations exceed those of the city, the more stringent requirements shall be met.

By setting forth these minimum standards, neither the City as an entity nor any of its staff members are making any representations, warranties, or assurances that these minimum engineering design criteria are sufficient to ensure the proper design and subsequent construction of the proposed improvements. To the contrary, the City of Broken Arrow is merely setting forth certain minimum engineering design standards necessary to promote the proper construction of the proposed improvements. Any person or entity owning land within the jurisdiction specified herein and developing improvements upon said land shall be solely responsible to rely upon their own properly licensed design professionals to accurately engineer and design the proposed improvements, whether public or private, which are capable of providing the services required of said improvements and which are adequate under all reasonably foreseeable circumstances for the purposes intended.

When the City, as represented by its staff, reviews and examines proposed improvement documents, including but not limited to design calculations and construction plans, for conformity to these criteria, such action is conducted and performed by the City merely to determine whether or not the minimum requirements set forth will be met. The designation of No Exceptions Taken or NET to the said documents does not imply, represent, warrant, or assure any person that the proposed improvements are adequate for the intended purposes, nor does it alleviate, relieve, or reduce the responsibility and/or liability of the required design professional.

ACKNOWLEDGEMENTS

The following City personnel served as instrumental Engineering Design Criteria Members responsible in the creation and development of this manual:

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Timothy Robins, P.E. -	Construction Division Manager
Brandy Parks, E.I. -	Assistant Utilities Director
Jason Dickeson, P.E., CFM	Community Development Project Engineer

REFERENCE LIST

City of Broken Arrow Plans and/or Documents:

Comprehensive Plan;
Master Park Plan;
Standard Construction Specifications
Transportation Planning and Policy Review and Recommendations Report, December 2008
Zoning Ordinance
Land Subdivision Code

Codes, Regulations, Standards, other:

American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets, Latest Edition
American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures, Latest Edition
American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, Latest Edition
American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications Manual, Latest Edition
American Association of State Highway and Transportation Officials (AASHTO) LRFD Guide Specification for Design of Pedestrian Bridges, Latest Edition
American Association of State Highway and Transportation Officials (AASHTO) M294, Material Specification, Latest Edition
American Concrete Institute ACI 318-08: Building Code and Commentary, Latest Edition
American Concrete Institute ACI 332-08: Code Requirements for Residential Concrete and Commentary, Latest Edition
American Concrete Institute ACI 350-06: Environmental Structures Code Requirements, Latest Edition
American Concrete Institute ACI 530-08: Building Code Requirement for Masonry Structures, Latest Edition
American Society of Civil Engineers ASCE 7-08: Minimum Design Loads for Buildings and Other Structures, Latest Edition
American Institute of Steel Construction AISC Manual of Steel Construction, LRFD, Latest Edition
American Institute of Steel Construction AISC 2008 Cold-Formed Steel Design Manual, Latest Edition
American Institute of Steel Construction AISC Manual of Steel Construction, ALLOWABLE STRESS DESIGN, Latest Edition
American Institute of Steel Construction AISC Manual of Steel Construction, Latest Edition
American Institute of Timber Construction AITC Timber Construction Manual, Latest Edition
American Land Title Association ALTA and the American Congress on Surveying and Mapping ACSM standards, Latest Edition
American Water Works Association AWWA D100-05: Welded Carbon Steel Tanks for Water Storage, Latest Edition

American Water Works Association AWWA D103-09: Factory-Coated Bolted Carbon Steel Tanks for Water Storage, Latest Edition

American Water Works Association AWWA D110-04: Wire- and Strand-Wound, Circular Prestressed Concrete Water Tanks, Latest Edition

American Water Works Association AWWA D115-06: Tendon Prestressed Concrete Water Tanks, Latest Edition

American Water Works Association AWWA M31: Manual of Water Supply Practices, Distribution System Requirements for Fire Protection, Latest Edition

Aluminum Association AA, Aluminum Design Manual, Latest Edition

Crane Manufacturers Association of America CMAA, Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist, Publication No. 74, , Latest Edition

Institute of Traffic Engineers ITE Trip Generation Manual , Latest Edition

International Building Code (IBC) as identified City of Broken Arrow, Code of Ordinances, Chapter 6: Buildings and Building Regulations, Article II, Section 6-16: Adoption, Latest Edition

National Concrete Masonry Association NCMA: Design Manual for Segmental Retaining Walls, Latest Edition

Occupational Safety and Health Act, Standards for Construction Industry, Latest Edition

Oklahoma Department of Transportation ODOT Policy on Driveway Regulations for Oklahoma Highways, Latest Edition

Open Channel Hydraulics by Ven te Chow, published by McGraw-Hill Book Company, 1959 or an approved equivalent

Telecommunications Industry Association and Electronic Industries of America TIA/EIA-222-G, Latest Edition

Transportation Research Board TRB Highway Capacity Manual HCM, Latest Edition

United States Access Board (USAB), Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, Latest Edition

United State Department of Transportation (USDOT) Federal Highway Administration (FHWA) Manual of Uniform Traffic Control and Devices (MUTCD), Latest Edition

United State Department of Transportation (USDOT) Federal Highway Administration (FHWA) Hydraulic Series No. 5: Hydraulic Design of Highway Culverts, Latest Edition

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1.0 GENERAL PROVISIONS

1.1 TITLE:

This Manual shall hereafter be known, cited and referred to as the Engineering Design Criteria Manual (EDCM) for the City of Broken Arrow, Oklahoma.

1.2 SCOPE:

The criteria established and set forth in this manual are the minimum acceptable standards of engineering and design for any and all public and/or private (unless otherwise noted) development that occurs within the City of Broken Arrow. All parties developing and constructing improvements within the City shall meet these minimum standards and are encouraged to exceed them where it is considered to be in the best interest of all parties.

1.3 AUTHORITY:

This Manual is hereby adopted under the authority granted by Oklahoma State Statutes.

1.4 JURISDICTION:

This Manual shall apply to all development and construction activity that occurs within the corporate limits of the City of Broken Arrow, Oklahoma.

1.5 IMPLEMENTATION:

The City shall prepare engineering and design criteria for the implementation in the course of the design of a construction improvement project. These criteria shall apply to all construction, whether public improvements and private improvements that will be donated to the public, started within the jurisdiction.

1.6 AMENDMENTS:

For the purpose of providing to the public improved health, safety and general welfare requirements, the Director of Engineering and Construction may make a recommendation to the Office of the City Manager, and the City Manager may from time to time amend the provisions imposed by these criteria without public hearings or notices being made. Amendments shall be effective as of the date of publication for its insertion into this manual.

1.7 VARIANCES:

Whenever the application of one of these criteria results in an unusual hardship or creates an unordinary conflict with the application of one or more criterion, the Director of Engineering and Construction may present an engineering grant variance request to the City Manager or designee. The City Manager or designee may at his/her discretion grant an engineering and construction variance or waive all or part of said criterion in order to produce a sound and reasonable design that is consistent with standard practice within the engineering and construction profession (Subdivision Regulation governs). The applicant shall prepare a Variance of Waiver Request Form provided in Appendix A – Use Engineering Variance Request and submit the document to the Director of Engineering and Construction for appropriate action.

2.0 SURVEYING AND RIGHT OF WAY ACQUISITIONS

2.1 INTRODUCTION:

This section of the Manual shall be known, cited, and referred to as the Surveying and Rights of Way Acquisition section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

This section shall reflect the most recent adoption of the State of Oklahoma criteria and requirements identified in the Oklahoma Administrative Code Title 59, Section 475; Title 65, Section 3; Title 245: Section 15, specifically Chapter 13 – Minimum Standards for Land Surveying and the Rules of Procedure. In case of conflict or contradiction, the most stringent criterion shall govern the design.

2.2 SURVEY CLASSIFICATION SYSTEM:

Surveying requirements defined as follows are for public properties and public projects. Requirements for private properties and projects remain the responsibility of the owner.

2.2.1 Class 1: ALTA/ACSM Survey

- A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the American Land Title Association (ALTA) and the American Congress on Surveying and Mapping (ACSM) standards, latest edition.
- B. The general purpose of this survey is associated with the purchase of real property to be owned by the City or one of its entities.

2.2.2 Class 2: Boundary Survey

- A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the State of Oklahoma Administrative Code statutes, latest codification, and corresponding amendments.
- B. The general purpose of this survey is associated with the acquisition of real property to be owned by the City or one of its entities or to obtain certain access, use and service rights as defined by the owner thereof.

2.2.3 Class 3: Topographical Survey

- A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the State of Oklahoma Administrative Code statutes, latest codification, and corresponding amendments or by standard of professional surveying practice, whichever is defined by the City on a case-by-case basis.
- B. The general purpose of this survey is associated with the collection of existing physical features, both at-grade and below-

grade features, as well as existing contour grades. Elevation Certificates for floodplain management purposes are included in this classification.

- 2.2.4 Class 4: Positional Survey
 - A. This class of survey shall meet the standard of professional surveying practice or that standard as defined by the City on a case-by-case basis.
 - B. The general purpose of this survey is associated with the collection of existing, at-grade physical features.
- 2.2.5 Class 5: Control Survey
 - A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the State of Oklahoma Administrative Code statutes, latest codification, and corresponding amendments.
 - B. The general purpose of this survey is to establish a horizontal and vertical control system for additional survey work.

2.3 SURVEY CONTROL SYSTEMS:

- 2.3.1 Horizontal Control System: All horizontal control points for any survey classification identified in Section 2.2 shall be tied to the Oklahoma Coordinate System, Oklahoma North Zone, Lambert Projection as defined in Oklahoma Administrative Code, Title 19, Section 60.
- 2.3.2 Vertical Control System: All vertical control points shall be tied to the North American Vertical Datum 1988 (NAVD 88).
- 2.3.3 Control Monuments:
 - A. Materials: Monuments shall be constructed of material capable of being detected with conventional instruments for finding ferrous or magnetic objects;
 - B. Size: Monuments of suitable size and depth shall be used;
 - C. Information: All monuments shall have affixed thereto a durable marker or cap bearing, at a minimum, the license number of the professional land surveyor in responsible charge for the placement of the monument.
 - D. Placement: Monuments shall be placed at all of the following platted subdivision locations:
 - 1. Boundary corners;
 - 2. Lot corners;
 - 3. Block corners;
 - 4. Angle points;
 - 5. Street centerline points of intersection;
 - 6. Street centerline points of curvature; and
 - 7. Arterial street intersections.

2.4 REAL PROPERTY ACQUISITION DOCUMENTS:

- 2.4.1 Conveyance Document: The Conveyance Document shall be prepared in accordance with the standard verbiage approved by the City for said type of acquisition.
- 2.4.2 Legal Description: The written Legal Description of said property shall be prepared in accordance with the format shown in Appendix B – Survey Documentation, Exhibit A. This document shall be signed, sealed, and dated by a licensed Professional Land Surveyor registered in the state of Oklahoma.
- 2.4.3 Plat of Survey Drawing: The Plat of Survey drawing of said property shall be prepared in accordance with the format shown in Appendix B – Survey Documentation, Exhibit A. This document shall be signed, sealed, and dated by a licensed Professional Land Surveyor registered in the state of Oklahoma.
- 2.4.4 Closure Certification Statement: The Closure Certification Statement for said property shall be prepared in accordance with the format shown in Appendix B – Survey Documentation, Exhibit A. This document shall be signed, sealed, and dated by a licensed Professional Land Surveyor registered in the state of Oklahoma.
- 2.4.5 Certified Property Ownership Report: This document certifies the record owner, property address, and all encumbrances, such as liens and judgments of record on said property, and all easements and rights-of-way of record on and along a specific parcel of land as of the date of the report. The report shall be prepared by a licensed and bonded Abstractor in the County wherein the property is situated.

2.5 REAL PROPERTY ACQUISITION TYPES AND REQUIREMENTS:

- 2.5.1 Fee Simple:
 - A. Appraisal or Appraisal Waiver, if deemed necessary by the Director of Engineering and Construction;
 - B. Conveyance Documents;
 - C. ALTA/ACSM Survey or Boundary Survey; D. Certified Property Report;
 - E. Legal Description;
 - F. Plat of Survey;
 - G. Closure Certified Statement;
 - H. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.
- 2.5.2 Permanent Easements:
 - A. Appraisal, if deemed necessary by the Director of Engineering and Construction;
 - B. Conveyance Documents;
 - C. Boundary Survey, if deemed necessary by the Director of Engineering and Construction;
 - D. Legal Description;

- E. Plat of Survey;
 - F. Certified Property Report, if deemed necessary by the Director of Engineering and Construction;
 - G. Closure Certified Statement;
 - H. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.
- 2.5.3 Temporary Easements:
- A. Conveyance Documents;
 - B. Legal Description;
 - C. Plat of Survey;
 - D. Closure Certified Statement;
 - E. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.
- 2.5.4. Deeds of Dedication:
- A. Conveyance Documents;
 - B. Legal Description;
 - C. Plat of Survey;
 - D. Closure Certified Statement;
 - E. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.

2.6 TYPES OF CONVEYANCE DOCUMENTS:

- 2.6.1 Fee Simple Types:
- A. General Warranty Deeds;
 - B. Special Warranty Deeds;
 - C. Deed of Dedications;
 - D. Trustee Deeds;
 - E. Quit Claim Deeds;
 - F. Others as approved by the City Legal Department.
- 2.6.2 Permanent Easement Types:
- A. Utility Easements;
 - B. Overland Drainage Easements;
 - C. Mutual Access Easements;
 - D. Others as approved by the City Legal Department.
- 2.6.3 Temporary Easement Types:
- A. Construction Easements;
 - B. Access Easements;
 - C. Others as approved by the City Legal Department.
- 2.6.4. Rights of Entry

3.0 EARTH CHANGE OPERATIONS AND POLLUTION PREVENTION MEASURES

3.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Earth Change Operations and Pollution Prevention Measures section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

3.2 DEFINITIONS:

- 3.2.1 EPA – Environmental Protection Agency
- 3.2.2 ODEQ – Oklahoma Department of Environmental Quality

3.3 PERMIT REQUIREMENTS:

- 3.3.1 All Earth Change Operations shall comply with the requirements of the City of Broken Arrow Earth Change Permit Ordinance.
- 3.3.2 All Earth Change Operations shall comply with the State of Oklahoma General Permit OKR10 for Storm Water Discharges from Construction Activities within the State of Oklahoma, effective date October 18, 2017 and any subsequent supplements and revisions. Any Storm Water Pollution Prevention Plan and subsequent Report shall be submitted to the City for review and acceptance prior to submittal to ODEQ.
- 3.3.3 All Earth Change Operations along the waterways of the United States shall comply with the federal regulations as set forth in the Clean Water Act, Section 401. The documents necessary to obtain said 401-permit and subsequent mitigation measures and the approved permit shall be submitted for information purposes to the Department of Engineering and Construction, Stormwater Division Manager.
- 3.3.4 All Earth Change Operations along the waterways of the State of Oklahoma shall comply with the federal regulations as set forth in the Clean Water Act, Section 404. The documents necessary to obtain said 404-permit and subsequent mitigation measures and the approved permit shall be submitted for information purposes to the Department of Engineering and Construction, Stormwater Division Manager.

3.4 TYPES OF EARTH CHANGE OPERATIONS GOVERNED:

- 3.4.1 Clearing and grubbing operations;
- 3.4.2 Top soil removal and replacement operations;
- 3.4.3 Grading operations;
- 3.4.4 Excavation operations;
- 3.4.5 Embankment and fill operations;
- 3.4.6 Trenching and backfilling operations;
- 3.4.7 Stream bank stabilization;

- 3.4.8 Berming or diking;
- 3.4.9 Tree removal of certain caliper; and
- 3.4.10 Other similar operations.

3.5 EARTH CHANGE CRITERIA:

- 3.5.1 Earth Change Volume – calculation shall be based upon neat-line cross-sections of the earth change operations limits less the top soil removal volume. The following methods of calculation shall be considered acceptable:
 - A. Average End Area Method – maximum cross-section spacing of 100 feet.
 - B. Prismoidal Method – maximum cross-section spacing of 200 feet.
 - C. Other methods must be approved by the Director of Engineering and Construction.
- 3.5.2 Compaction Considerations – volume calculations shall consider a minimum of 12% and a maximum of 15% compaction increases in all embankment and fill placement operations otherwise approved by the Director of Engineering and Construction.
- 3.5.3 Top Soil Operations - volume calculations shall consider the minimum removal of the top five (5) inches of soil and subsequent replacement of the same soil, otherwise approved by the Director of Engineering and Construction.
- 3.5.4 Excavations – all excavations shall comply with the requirements of Occupational Safety and Health (OSHA) Standards for the Construction Industry defined in 29 Code of Federal Regulations (CFR) Part 1926, Subpart P.

3.6 STORMWATER POLLUTION PREVENTION CONTROL MEASURES:

The following Best Management Practices (BMP) shall comply with the minimum standards as described in the United States Environmental Protection Agency, National Pollutant Discharge Elimination System (NPDES), Best Management Practice (BMP) Manual

- 3.6.1 Stormwater Runoff Control Measures:
 - A. Land grading
 - B. Permanent diversions
 - C. Preservation of natural vegetation
 - D. Temporary stabilized construction entrance
 - E. Check dams
 - F. Filter berms
 - G. Grass-lined swales/channels
 - H. Other measures as approved by the Director of Engineering and Construction
- 3.6.2 Erosion Control Measures:
 - A. Chemical stabilization
 - B. Mulching

- C. Permanent seeding
- D. Sodding
- E. Soil retention
- F. Dust control
- G. Soil roughening
- H. Geotextiles
- I. Gradient terraces
- J. Temporary slope drains
- K. Other measures as approved by the Director of Engineering and Construction

3.6.3 Sediment Control Measures:

- A. Temporary diversion dikes
- B. Wind fences and sand fences
- C. Brush barrier
- D. Silt fences
- E. Composite filter socks/fiber waddles
- F. Storm drain inlet protection
- G. Sediment basins and rock dams
- H. Sediment traps
- I. Construction entrances
- J. Other measures as approved by the Director of Engineering and Construction

3.7 STORMWATER POLLUTION PREVENTION PLAN CRITERIA:

A Stormwater Pollution Prevention Plan (SWP3) is required by all developers on any parcel of land that equals or exceeds one (1) acre of disturbed area in size or if the parcel is less than one acre if the activity is part of a “larger common plan of development or sale” that is greater than one acre. The following requirements shall be addressed in the plan. An example template is provided for individual use in the OKR10 located on ODEQ website.

3.7.1 Introduction:

- A. Project name
- B. Location
- C. Street address
- D. Owner information

3.7.2 Site and Activity Description (OKR10, Part 4):

- A. Pollutant description
- B. Construction activity description
- C. Intended sequence of construction
 - 1. Install stabilized construction entrance;
 - 2. Install silt fencing and perimeter controls;
 - 3. Clearing and grubbing;
 - 4. Stripping and stockpile of topsoil;
 - 5. Rough grading for paved areas;
 - 6. Install inlet protection;

- 7. Construct drainage ditches and underground utilities;
- 8. Finished grading for paved areas and drainage ditch;
- 9. Construct paved areas complete with curb and gutter if required;
- 10. Sod, seed and re-vegetate disturbed areas;
- 11. Remove accumulated silt and excess earth;
- 12. Remove all remaining temporary controls;
- 13. Perform final pavement wash down.
- 14. Remove BMPs after final stabilization.
- D. Total site area
- E. Runoff coefficient
- F. Pre-developed runoff coefficient
- G. Post-developed runoff coefficient
- H. General location map
- I. Construction drawings
 - 1. Site map
 - 2. Drainage maps
 - 3. Grading and paving plans
 - 4. Erosion and sediment control plans
 - 5. Protection of surface waters (OKR10, Section 3.3.1.A)
- J. Industrial discharge description
- K. Receiving waters
- 3.7.3 Permit requirements (OKR10,Part 4):
 - A. Copy of OKR10, effective date of October 18, 2017, or latest revision
 - B. Copy of the signed Notice of Intent (NOI)
- 3.7.4 Measures to protect endangered or threatened species (OKR10,Part 4):
 - A. Identification of endangered or threatened species
 - B. Identification of critical habitats
 - C. Implementation of best management practice to reduce danger
 - D. Copy of correspondence to United States Fish and Wildlife Service (USF&WS) and Oklahoma Department of Wildlife Conservation (ODCT).
- 3.7.5 Effect on historic and cultural preservation laws of Federal, State, Local and Native American (OKR10,Part 4)
- 3.7.6 Effect on water quality-impaired waters within 1 stream mile of an impaired stream (OKR10,Part 4)
- 3.7.7 Controls to reduce pollutants (OKR10, Part 4)
 - A. Erosion and Sediment Controls
 - B. Stormwater Control Measures
 - C. Pollution Prevention
 - D. Inspection, maintenance, corrective action
 - E. Monitoring (If applicable)
- 3.7.8 Maintenance (OKR10, Part 4)
- 3.7.9 Inspections (OKR10, Part 4)
- 3.7.10 Non-Storm water discharges (OKR10 Part 1 & Part 4): The following non-storm water discharge activities are authorized under the OKR10 General Discharge Permit for Construction Activities
All non-stormwater discharges must be documented in the SWP3:

- A. Fire hydrant flushing;
- B. Waters used to wash vehicles where detergents are not used;
- C. Water used to control dust;
- D. Potable water, including waterline uncontaminated flushing;
- E. Routine external building wash down which does not use soaps, solvents, and/or detergents and/or building wash-down from external surfaces that does not contain leachable hazardous substances;
- F. Pavement wash waters, provided spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where soaps, solvents and detergents are not used;
- G. Uncontaminated air conditioning or compressor condensate;
- H. Uncontaminated ground water or spring water;
- I. Foundation or footing drains where flows are not contaminated with process materials such as solvents or contaminated ground water;
- J. Landscape irrigation;
- K. Discharge or flows from emergency fire fighting activities will be allowed. Measures shall be taken by the permittee or site/facility, as soon as practical, to reduce any such pollutant releases to avoid or minimize the impacts on water quality and to ensure public health and safety;
- L. Uncontaminated flows from excavation dewatering activities will be allowed if operational and structural controls are used to reduce any pollutant releases in order to avoid or minimize the impacts on water quality.

3.7.11 Authorized Construction Support Activities (OKR10, Part 1):

The following specified construction support activities are allowed by the OKR10 Permit for construction activity provided that the activity is: (A) directly related to the construction activities; (B) that the support activity is not a commercial operation serving multiple unrelated construction projects by different operators; (C) appropriate control measures for the support activities are identified in the Storm Water Pollution Prevention Plan; and (D) the support activities are not located within the watershed of an Outstanding Resource Water.

- A. Concrete batch plants (OKR10 Addendum F)
- B. Asphalt batch plants (OKR10 Addendum F);
- C. Equipment staging yards;
- D. Material storage areas;
- E. Excavated material disposal areas;
- F. Borrow pit areas.

3.7.12 Limitations on Coverage (OKR10, Part 1):

The following items are activities are not authorized under the OKR10 General Discharge Permit for Construction Activities:

- A. Post construction discharges (OKR10, Part 1);
- B. Discharges mixed with non-storm water (OKR10, Part 4);

- C. Discharges covered by another permit (OKR10, Part 4
- D. Discharges threatening water quality (OKR10, Part 4);
- E. Discharges not protective of listed endangered species (OKR10, Part 4);
- F. Construction activity on Native American (Indian) Country Land (OKR10, Part 6);
- G. Construction activity for oil and gas operations and pipelines (OKR10, Part 4);
- H. Construction activities related to agriculture (OKR10, Part 4);
- I. New sources or new discharges of constituents of concern to impaired waters (OKR10, Part 4).

3.7.13 Modifications/Alterations

3.7.14 Contractor Certifications (OKR10, Part 4):

3.7.15 Inspection Logs (OKR10, Part 4):

- A. Person responsible for inspection must be a qualified person;
- B. At a minimum, a site inspection must be conducted once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater and within 24 hours of a discharge generated by snowmelt.

4.0 GEOTECHNICAL

4.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Geotechnical section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

4.2 GEOTECHNICAL INVESTIGATION REQUIREMENTS:

Geotechnical investigations are required on all facilities to be constructed for or dedicated to the City of Broken Arrow for public use, including roadways, drainage structures, buildings, water towers, pump stations, underground vaults, and other facilities as required by the Director of Engineering and Construction.

Based on the analysis of the soils properties of the site, state in the report whether the City standards with these soils are adequate or should particular standards be increased. If particular standards should be increased, provide a specification of the increased standard with both a drawing and an explanation.

4.3 FIELD INVESTIGATION PROCEDURES:

- 4.3.1 Equipment: Equipment shall be determined by a Geotechnical Engineer.
- 4.3.2 Subsurface Exploration: The Geotechnical Engineer shall conduct all subsurface exploration in order to obtain soil samples from the site using the split-barrel or thin-walled tube sampling procedures as detailed in ASTM specification D 1586 and ASTM specification D 1587, latest editions respectively.
- 4.3.3 All bore holes shall have material replaced in like kind, grouted, or backfilled in accordance with the Oklahoma Water Resources Board requirements or Oklahoma Department of Transportation

4.4 LABORATORY EXAMINATION PROCEDURES:

- 4.4.1 In-Situ Moisture Content Testing: The Geotechnical Engineer shall conduct all in-situ moisture content testing of the samples in accordance with ASTM specification D 2216, latest edition.
- 4.4.2 Atterburg Limits Testing: The Geotechnical Engineer shall conduct all Atterburg limits testing on the samples in accordance with ASTM specification D 4318, latest edition.
- 4.4.3 Grain Size Distribution Analysis: The Geotechnical Engineer shall conduct all grain size distribution analyses in accordance with ASTM specifications D 421 and D 1140, latest editions. All soil samples shall be classified in accordance with the Unified Soil Classification System (USCS) as well as the American Association of State Highway and Transportation Officials (AASHTO) Classification System.
- 4.4.4 One-Dimensional Consolidation Testing: The Geotechnical Engineer shall conduct one-dimensional consolidation testing in accordance with ASTM specification D 4546, latest edition.
- 4.4.5 Dry Density Testing: The Geotechnical Engineer shall conduct the maximum dry density of a soil sample in accordance with ASTM specification D 698, latest edition.

4.5 GEOTECHNICAL PROPERTIES:

4.5.1 Plasticity Index Parameters – (PI = LL – PL)

<u>Description</u>	<u>PI Range</u>
Trace amount of Plasticity	0 – 4
Low Plasticity Material	5 – 12
Slightly Plastic Material	13 – 17
Moderately Plastic Material	18 – 24
Highly Plastic	25 Plus

4.5.2 Soil Stiffness Parameters

<u>Description</u>	<u>Void Ratio (e) Range</u>
Very Soft Soils	$e > 2.5$
Soft Soil Material	$1.5 < e \leq 2.5$
Medium Soil Material	$0.5 < e \leq 1.5$
Stiff/Hard Soil Material	$e \leq 0.5$

4.6 DESIGN PARAMETERS:

If particular design values are not provided through laboratory testing methods, then the following design parameters shall be utilized unless other data is approved by the Director of Engineering and Construction.

4.6.1 Internal Angle of Friction

A. Cohesionless Soils

1. Drained Soil Condition (f')

<u>Soil Description</u>	<u>Range (Loose – Dense)</u>
Well Graded Gravel (GW)	$32^\circ - 40^\circ$
Poorly Graded Gravel (GP)	$32^\circ - 38^\circ$
Well Graded Sand (SW)	$30^\circ - 37^\circ$
Poorly Graded Sand (SP)	$29^\circ - 36^\circ$
Silty Sand (SM)	$29^\circ - 35^\circ$
Low Plasticity Silt (ML)	$27^\circ - 33^\circ$

2. Undrained Soil Condition (f)

Cohesionless soil will drain; therefore, this condition will be identical to the condition noted above.

B. Cohesive Soils

1. Drained Soil Condition (f')

<u>Soil Description</u>	<u>Range (Loose – Dense)</u>
Normally Consolidated Clays	$10^\circ - 22^\circ$
Overconsolidated Clays	$27^\circ - 35^\circ$

2. Undrained Soil Condition (f)

<u>Soil Description</u>	<u>Range (Soft – Stiff)</u>
Normally Consolidated Clays	0°
Overconsolidated Clays	0°

4.6.2 Ultimate Cohesion Value

A. Cohesionless Soils

Cohesionless Soils by definition contain no cohesive properties and thereby they exhibit no cohesive characteristics; therefore, ultimate cohesion value is zero:

$$C' = C_u = 0$$

B. Cohesive Soils

1. Drained Soil Condition (C')

<u>Soil Description</u>	<u>Range (Soft – Stiff)</u>
Normally Consolidated Clays	0 psf
Overconsolidated Clays	
Very Soft	0 psf
Soft	0 – 250 psf
Medium Stiff	251 – 500 psf
Stiff	501 – 1000 psf
Very Stiff	1001 – 1500 psf

2. Undrained Soil Condition (C_u)

<u>Soil Description</u>	<u>Range (Soft – Stiff)</u>
Normally Consolidated Clays	
Very Soft	0 – 250 psf
Soft	251 – 500 psf
Medium Stiff	501 – 1000 psf
Stiff	1001 – 2000 psf
Very Stiff	2001 – 4000 psf
Overconsolidated Clays	
Very Soft	0 psf
Soft	0 – 250 psf
Medium Stiff	251 – 500 psf
Stiff	501 – 1000 psf
Very Stiff	1001 – 1500 psf

4.6.3 Adhesion Values

A. Cohesionless Soils

Cohesionless Soils by definition contain no cohesive properties and thereby

they exhibit no cohesive characteristics. Therefore, ultimate cohesion value is zero which implies that the corresponding adhesion value is likewise zero:

$$C_a' = C_a = 0$$

B. Cohesive Soils

1. Drained Soil Condition (C_a')

$$2/3 C' \leq C_a' \leq 3/4 C'$$

2. Undrained Soil Condition (C_a)

$$1/2 C_u \leq C_a \leq 2/3 C_u$$

4.6.4 Horizontal Earth Stress Relationships

A. Cohesionless Soils

1. Drained Soil Condition

a. Active Horizontal Earth Stress (K_a') –

$$s_h = K_a' s_v$$

where:

$$K_a' = (1 - \sin\phi') / (1 + \sin\phi') \text{ for level backfills}$$

b. “At-Rest” Horizontal Earth Stress (K_o') -

$$s_h = K_o' s_v$$

where:

$$K_o' = (1 - \sin\phi')$$

c. Passive Horizontal Earth Stress (K_p') -

$$s_h = K_p' s_v$$

where:

$$K_p' = (1 + \sin\phi') / (1 - \sin\phi') \text{ for level backfills}$$

2. Undrained Soil Condition

a. Active Horizontal Earth Stress (K_a) –

$$s_h = K_a s_v$$

where:

$$K_a = (1 - \sin\phi) / (1 + \sin\phi) \text{ for level backfills}$$

b. “At-Rest” Horizontal Earth Stress (K_o) -

$$s_h = K_o s_v$$

where:

$$K_o = (1 - \sin \phi)$$

- c. Passive Horizontal Earth Stress (K_p) -

$$s_h = K_p s_v$$

where:

$$K_p = (1 + \sin \phi') / (1 - \sin \phi')$$
 for level backfills

B. Cohesive Soils (Not Allowed for Backfill Material)

1. Drained Soil Condition

- a. Active Horizontal Earth Stress (K_a') -

$$s_h = K_a' s_v - 2C' (K_a')^{1/2}$$

where:

$$K_a' = (1 - \sin \phi') / (1 + \sin \phi')$$
 for level backfills

C' = drained cohesion value

- b. "At-Rest" Horizontal Earth Stress (K_o') -

$$s_h = K_o' s_v - 2C' (K_o')^{1/2}$$

where:

$$K_o' = (1 - \sin \phi')$$

C' = drained cohesion value

- c. Passive Horizontal Earth Stress (K_p') -

$$s_h = K_p' s_v + 2C' (K_p')^{1/2}$$

where:

$$K_p' = (1 + \sin \phi') / (1 - \sin \phi')$$
 for level backfills

C' = drained cohesion value

2. Undrained Soil Condition (Considered as a temporary condition)

- a. Active Horizontal Earth Stress (K_a) -

$$s_h = K_a s_v - 2C_u (K_a)^{1/2}$$

where:

$$K_a = (1 - \sin \phi) / (1 + \sin \phi)$$
 for level backfills

C_u = undrained cohesion value

- b. “At-Rest” Horizontal Earth Stress (K_o) -

$$s_h = K_o s_v - 2C_u (K_o')^{1/2}$$

where:

$$K_o = (1 - \sin \phi')$$

C_u = undrained cohesion value

- c. Passive Horizontal Earth Stress (K_p) -

$$s_h = K_p' s_v + 2C_u (K_p')^{1/2}$$

where:

$$K_p = (1 + \sin \phi') / (1 - \sin \phi')$$
 for level backfills

C_u = undrained cohesion value

4.6.5 Minimum Surcharge Loading

- A. Active Loading Condition

$$s_s = K_a q_s$$

where:

$q_s = 100$ psf for general live loading and operation conditions;

$q_s = 200$ psf for general construction conditions;

$q_s = 300$ psf for heavy construction conditions.

- B. “At-Rest” Loading Condition

$$s_s = K_o q_s$$

where:

$q_s = 100$ psf for general live loading and operation conditions;

$q_s = 200$ psf for general construction conditions;

$q_s = 300$ psf for heavy construction conditions.

4.6.6 Recommended Minimum Equivalent Lateral Fluid Pressure (Refer to Appendix D - Geotechnical Relationships Documents)

- A. Active Loading Condition

$$s_a = K_a s_v = (40 \text{ psf/ft})h$$

- B. “At-Rest” Loading Condition

$$s_o = K_o s_v = (60 \text{ psf/ft})h$$

- C. Saturated Loading Condition

$$s'_{\text{sat}} = K_{\text{as}} s'_v = (90 \text{ psf/ft})h$$

D. Passive Loading Condition

$$s_p = K_p s_v = (360 \text{ psf/ft})h$$

Notes: (1) The above minimum equivalent pressures are recommended for use in the absence of geotechnical data.

(2) Ignore the depth of the soil above the frost line;

(3) Use a soil mobilization reduction factor for passive resistance of 2/3 to 3/4.

4.6.7 Passive Pressure Resistance Mobilization Factor

A. Cohesionless Soils

$$2/3 \leq F_m \leq 3/4 \quad (\text{Loose to Dense})$$

B. Cohesive Soils

$$1/2 \leq F_m \leq 3/4 \quad (\text{Soft to Stiff})$$

4.6.8 Soil to Foundation/Wall Friction Angle

A. Cohesionless Soils

1. Drained Condition (d')

$$\tan^{-1}[2/3(\text{Tanf})] \leq d' \leq \tan^{-1}[3/4(\text{Tanf})]$$

2. Undrained Condition (d)

Cohesionless soil will drain; therefore, this condition will be identical to the condition noted above.

B. Cohesive Soils

1. Drained Condition (d')

$$\tan^{-1}[1/2(\text{Tanf})] \leq d' \leq \tan^{-1}[2/3(\text{Tanf})]$$

2. Undrained Condition (d)

Undrained Cohesive soils do not exhibit particle to particle friction characteristics; therefore, this condition will not exist in practice.

4.6.9 Shear Strength

A. Cohesionless Soil Conditions

1. Drained Condition (S')

$$S' = R_v (\text{Tand}') + F_m P_p'$$

Where:

R_v = Total Resultant of Vertical Load;

P_p' = Total Horizontal Passive Resistance Force Capacity (Drained);

F_m = Passive Pressure Resistance Mobilization Factor (see Sect. 4.5.7).

d' = Soil to Foundation/Wall Friction Angle (Drained).

2. Undrained Condition (S_u)

$$S_u = R_v (\tan d) + F_m P_p$$

Where:

R_v = Total Resultant of Vertical Load;

P_p = Total Horizontal Passive Resistance Force Capacity (Undrained);

F_m = Passive Pressure Resistance Mobilization Factor (see Sect. 4.5.7).

d = Soil to Foundation/Wall Friction Angle (Undrained).

B. Cohesive Soil Conditions

1. Drained Condition

$$S' = R_v \tan d' + F_m P_p'$$

Where:

R_v = Total vertical load;

P_p' = Total horizontal Passive Resistance Force Capacity;

F_m = Passive Pressure Resistance Mobilization Factor (see Sect. 4.5.7);

d' = Soil to Foundation Friction Angle.

2. Undrained Condition

$$S_u = C_a A + F_m P_p$$

C_a = Soil Particle to Foundation Particle Adhesion.

4.7 STABILITY RATIOS FOR DESIGN:

4.7.1 Stability Against Overturning

A. Dense Sand, Stiff Clay or Rock Foundation Soil

$$F.S._{ot} \geq 1.5$$

B. Loose Sand or Soft Clay Foundation Soil

$$F.S._{ot} \geq 2.0$$

4.7.2 Stability Against Sliding

A. Dense Sand, Stiff Clay or Rock Foundation Soil

$$F.S._{sl} \geq 1.5$$

- B. Loose Sand or Soft Clay Foundation Soil

$$F.S._{sl} \geq 2.0$$

4.7.3 Stability Against Bearing

- A. Dense Sand, Stiff Clay or Rock Foundation Soil
1. Bearing Pressure Distribution Trapezoidal

$$F.S._{b} \geq 2.0$$

2. Bearing Pressure Distribution Triangular

$$F.S._{b} \geq 3.0$$

- B. Loose Sand or Soft Clay Foundation Soil
1. Bearing Pressure Distribution Trapezoidal

$$F.S._{b} \geq 3.0$$

2. Bearing Pressure Distribution Triangular

$$F.S._{b} \geq 4.0$$

4.7.4 Stability Against Buoyancy (Floatation/Uplift)

- A. Normal Saturated Soil Condition

$$F.S._{up} \geq 1.33$$

- B. Extreme Flood Condition

$$F.S._{up} \geq 1.25$$

4.8 SLOPE STABILITY:

Stability of slopes shall be performed by a licensed geotechnical engineer using industry standard slope stability methods unless directed otherwise by the Director of Engineering and Construction. State in the report the minimum slope stability angle.

4.9 SLOPE PROTECTION (REVTMENT) DESIGN:

Slope protection or revetment design shall comply with the United States Department of Transportation, *Federal Highway Administration Hydraulic Engineering Circular No. 11 – Design of Riprap Revetment* where applicable. Other methods of slope protection shall be considered on a case by case scenario.

4.10 SUBGRADE MODIFICATION PARAMETERS:

The following subgrade modification parameters refer to fine-grained materials that possess swell potential. A licensed professional geotechnical engineer registered in the State of Oklahoma shall test the subgrade material, classify the soil in accordance with standard industry classification indexes and provide requirements to reduce the swell potential of the subgrade soil in accordance with the following guidelines:

- 4.10.1 Subgrade Modification for Paving Facilities – Fine-grained subgrade materials shall be considered expansive when the material’s plasticity index (PI) is greater than 13. In the above identified case, the subgrade material shall be chemically modified with a stabilization method recommended by the engineer of record in order to reduce the plasticity index (PI) to 13 or less.
- 4.10.2 Subgrade Modification for Building Facilities – Fine-grained subgrade materials shall be considered expansive when the material’s plasticity index (PI) is greater than 10. In the above identified case, the subgrade material shall be chemically modified with a stabilization method recommended by the engineer of record in order to reduce the plasticity index (PI) to 10 or less.

4.11 SUBBASE FOR PAVING: ROCK SUBBASE MAY BE REQUIRED

The thickness of the subbase may be determined by minimum requirements in Section 6, or by the geotechnical investigation/engineering report recommendation.

5.0 STRUCTURAL

5.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Structural section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

5.2 DEFINITIONS:

- 5.2.1 AA – Aluminum Association
- 5.2.2 AASHTO – American Association of State Highway and Transportation Officials
- 5.2.3 ACI – American Concrete Institute
- 5.2.4 AISC – American Institute of Steel Construction
- 5.2.5 AISI – American Iron and Steel Institute
- 5.2.6 AITC – American Institute of Timber Construction
- 5.2.7 ASCE – American Society of Civil Engineers
- 5.2.8 ASD – Allowable Stress Design Method for steel structures or structural elements
- 5.2.9 ASTM – American Society for Testing Materials
- 5.2.10 AWWA – American Water Works Association
- 5.2.11 CMAA – Crane Manufacturers Association of America
- 5.2.12 IBC – International Building Code
- 5.2.13 ICC – International Code Council
- 5.2.14 IRC - International Residential Code
- 5.2.15 LRFD – Load Resistance Factor Design Method for steel structures or structural elements
- 5.2.16 NCMA – National Concrete Masonry Association
- 5.2.17 NDS – National Design Specification for Wind Construction
- 5.2.18 TIA/EIA – Telecommunication Industry Association and Electronic Industries of America
- 5.2.19 UDA – Unified Design Approach for concrete structures or structural elements
- 5.2.20 USD – Ultimate Strength Design Method for concrete structures or structural elements
- 5.2.21 WSD – Working Stress Design Method for concrete structures or structural elements

5.3 STRUCTURE CLASSIFICATION:

- 5.3.1 Building Structure – Any structure, enclosed or non-enclosed, that may be occupied at any time by people.
- 5.3.2 Bridge Structure – Any structure, which is not a part of a building element, that has a total span length, either due to a single span or the combination of multiple spans, of 20-feet or greater.
- 5.3.3 Non-Building/Bridge Structure – All other types of structures including, but not limited to, the following:
 - A. Elevated towers and tanks;
 - B. In-ground tanks, boxes, sumps;
 - C. Earth retaining structures;
 - D. Independent slab on-grade foundations not associated with buildings or bridges;

- E. Cranes, hoists, trolleys and monorails.

5.4 TYPES OF ACCEPTABLE CONSTRUCTION MATERIALS AND PROCESSES:

- 5.4.1 Concrete Material
 - A. Cast-in-Place
 - B. Pre-Cast
 - C. Tilt-Up Panel
- 5.4.2 Structural Steel Material
 - A. Hot Rolled
 - B. Cold Formed
- 5.4.3 Timber/Wood Material
- 5.4.4 Aluminum Material
- 5.4.5 Masonry Block
 - A. Concrete Masonry Units – Building Structures and Retaining Structures
 - B. Non-Mechanically Stabilized Earth Retaining Structures
 - C. Mechanically Stabilized Earth Retaining Structures
- 5.4.6 Others – Must be approved by the Director of Engineering and Construction

5.5 ACCEPTABLE DESIGN METHODS:

- 5.5.1 Building Structures
 - A. Structural Steel - LRFD method of design shall be used.
 - B. Concrete – UDA or USD methods shall be used.
- 5.5.2 Bridge Structures
 - A. Structural Steel – LRFD method of design shall be used.
 - B. Concrete – UDA or USD methods of design shall be used.
- 5.5.3 Non-Building/Bridge Structures
 - A. Structural Steel - LRFD or ASD methods of design may be used.
 - B. Concrete – UDA, USD or WSD methods may be used.

5.6 PRIMARY LOAD AND LOAD COMBINATION CRITERIA:

The following paragraph identifies the applicable design criteria that govern the determination of primary loads and appropriate load combinations for the specific type of structure identified in the above paragraph. The appropriate load combinations shall be determined based upon the specific design method used. In case of conflict or contradiction, the most stringent criterion shall govern the design.

- 5.6.1 Building Structures – All building type structures shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method specified in the current effective adoption of the International Building Code as identified City of Broken Arrow, Code of Ordinances, Chapter 6: Buildings and Building Regulations, Article II, Section 6-16: Adoption.
- 5.6.2 Bridge Structures – Bridge structures shall be categorized as vehicular type bridges and non-vehicular type bridges. Non-vehicular type bridges shall be design for and intended to carry pedestrian, bicyclists, equestrian riders, and light maintenance vehicles, but not designed and intended to carry typical roadway vehicles.

- A. Vehicular Type Bridge Structures - All vehicular bridge type structures shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in the AASHTO Bridge Design Specifications Manual, or latest edition as approved by the Director of Engineering and Construction.
 - B. Non-Vehicular Type Bridge Structures - All non-vehicular (pedestrian traffic only) shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in the AASHTO LRFD Guide Specification for Design of Pedestrian Bridges, latest edition as approved by the Director of Engineering and Construction.
- 5.6.3 Non-Building Structures - All non-building type structures shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method specified in ASCE 7-16: Minimum Design Loads for Buildings and Other Structures, or latest edition as approved by the Director of Engineering and Construction, unless considered as a specialized structure. Specialized structures shall be designed in accordance with the appropriate design code as defined by the industry.
- A. Water Storage Tanks:
 - 1. Steel Storage Tanks – shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in AWWA D100: Welded Carbon Steel Tanks for Water Storage, or latest edition, and AWWA D103: Factory-Coated Bolted Carbon Steel Tanks for Water Storage, latest edition.
 - 2. Prestressed Concrete Storage Tanks - shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in AWWA D110-04: Wire- and Strand-Wound, Circular Prestressed Concrete Water Tanks, or latest edition, and AWWA D115: Tendon Prestressed Concrete Water Tanks, latest edition.
 - B. Broadcast Structures – shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in TIA/EIA-222-G, or latest edition.
 - C. Crane/Trolley/Hoist/Monorail Support Structure - shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in CMAA: Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Running Trolley Hoist, Publication No. 74, latest edition.

5.7 STRUCTURAL ELEMENT DESIGN CRITERIA:

The following paragraph identifies the applicable design criteria that govern the design of the specific structural elements that collectively or individually function to serve as the load resistant structure or structures to transmit the primary loads and the corresponding load combinations to the ground.

5.7.1 Concrete Structures

- A. Building Structures
 - 1. Non-Residential – shall comply with the requirements specified in ACI 318: Building Code Requirements for Structural Concrete and Commentary, latest edition.
 - 2. Residential - shall comply with the requirements specified in ACI 332: Code Requirements for Residential Concrete and Commentary, latest edition.
- B. Bridge Structures - shall comply with the requirements specified in either ACI 318: Building Code Requirements for Structural Concrete and Commentary, or latest edition or the AASHTO Bridge Design Specifications, latest edition, whichever is more stringent.
- C. Non-Building/Bridge Structures
 - 1. Non-Environmental Structures – shall comply with the requirements specified in ACI 318: Building Code Requirements for Structural Concrete and Commentary, latest edition.
 - 2. Environmental Structures – shall comply with the requirements specified in ACI 350: Environmental Structures Code Requirements, latest edition.
 - 3. Prestressed Concrete Water Storage Tanks – shall comply with the requirements specified in AWWA D110: Wire- and Strand-Wound, Circular Prestressed Concrete Water Tanks, latest edition, and AWWA D115-06: Tendon Prestressed Concrete Water Tanks, latest edition.

5.7.2 Steel Structures

- A. Hot Rolled Steel:
 - 1. Building - shall comply with the requirements specified in the AISC Manual of Steel Construction, LRFD, latest edition.
 - 2. Bridge Structures - shall comply with the requirements specified in the AISC Manual of Steel Construction, LRFD, latest edition or the AASHTO Bridge Design Specifications for vehicular type bridges and LRFD Guide Specification for Design of Pedestrian Bridges, latest edition, whichever is more stringent.
 - 3. Non-Building/Bridge Structures – shall comply with the requirements specified in either the AISC Manual of Steel Construction, LRFD, latest edition or the AISC Manual of Steel Construction, ASD, 9th edition, dependent upon the design method of choice.
 - 4. Carbon Steel Water Storage Tanks - shall comply with the requirements specified in AWWA D100: Welded Carbon Steel Tanks for Water Storage, or latest edition, and AWWA D103: Factory-Coated Bolted Carbon Steel Tanks for Water Storage, latest edition.
 - 5. Broadcast Steel Structures - shall comply with the requirements specified in TIA/EIA-222-G, or latest revision.
 - 6. Crane/Hoist/Trolley/Monorail Support Structures – shall comply with the requirements specified in CMAA: Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Running Trolley Hoist, Publication No. 74, latest edition.

- B. Cold Formed Steel – shall comply with the requirements specified in the AISI Cold-Formed Steel Design Manual, latest edition.
- 5.7.3 Timber/Wood Structures
All timber/wood structures shall comply with the AITC Timber Construction Manual, latest edition. And the National Design Specification for Wood Construction.
- 5.7.4 Aluminum Structures – shall comply with the AA Aluminum Design Manual, latest edition.
- 5.7.5 Masonry Structures
 1. Building Structure- shall comply with the ACI 530: Building Code Requirement for Masonry Structures, latest edition.
 2. Mechanically Stabilized or Segmental Earth Retaining Structures – shall comply with the NCMA: Design Manual for Segmental Retaining Walls, latest edition.

6.0 TRANSPORTATION FACILITIES

6.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Transportation Facilities section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

6.2 DEFINITIONS:

- 6.2.1 AASHTO – American Association of State Highway and Transportation Officials
- 6.2.2 FHWA – Federal Highway Administration
- 6.2.3 ODOT – Oklahoma Department of Transportation
- 6.2.4 SN – Structural Number for Pavement Design
- 6.2.5 AC – Asphaltic Concrete
- 6.2.6 PCC – Portland Cement Concrete
- 6.2.7 PROWAG, Proposed Accessibility Guidelines for Pedestrian Facilities in Public Right-of-Way
- 6.2.8 ADA- Americans with Disability Act

6.3 STREET CLASSIFICATIONS:

- 6.3.1 Arterial Streets
 - A. Primary
 - B. Secondary
- 6.3.2 Commercial Streets
 - A. Minor
 - B. Collector
- 6.3.3 Industrial Streets
 - A. Minor
 - B. Collector
- 6.3.4 Residential Streets
 - A. Minor - A residential street that has unlimited driveway access and that connects to major residential streets. Minor residential streets are limited to 900 linear feet in length before they must connect to a major street.
 - B. Major – A residential street that has unlimited driveway access and connects to either an arterial or a residential collector street.
 - C. Collector – A residential street that has limited driveway and residential major street access and that connects to arterial streets.
- 6.3.5 Alleyway – A secondary means of vehicular access to serve abutting properties and not intended for general traffic circulation.

6.4 STREET DESIGN PARAMETERS:

- 6.4.1 Design Speed (Not necessarily the posted speed)
 - A. Arterial
 - 1. Primary – 50 mph
 - 2. Secondary – 45 mph

- B. Commercial
 - 1. Minor – 35 mph
 - 2. Collector – 40 mph
 - C. Industrial
 - 1. Minor – 35 mph
 - 2. Collector – 40 mph
 - D. Residential
 - 1. Minor – 25 mph
 - 2. Major – 30 mph
 - 3. Collector – 30 mph
- 6.4.2 Rights of Way – (Not subject to the provisions of Section 1.7)
- A. Arterial
 - 1. Primary – 120 feet
 - 2. Secondary – 100 feet
 - 3. Intersection – 130 feet with an additional 5 feet of utility easement along the perimeter of a property for a distance of 350 feet as measured from the section lines. In addition, a 25-foot by 25-foot corner clip shall be required at the intersection of the north/south right of way boundary with the east/west right of way boundary. Rights of ways shall transition at the end of the 350-foot distance back to existing right of way boundary along a 30 degree angle.
 - B. Commercial – 80 feet
 - C. Industrial
 - 1. Minor – 60 feet
 - 2. Collector – 80 feet
 - D. Residential
 - 1. RE Zoning – 60 feet
 - 2. Collector – 60 feet
 - 3. All other – 50 feet
 - 4. Intersections with Arterials – At least 70 feet of right-of-way shall be provided for the first 100 feet from the arterial street right-of-way tapering to the interior right-of-way at a 30 degree angle.
 - E. All Street Intersections with exception of residential street intersections – 25-foot by 25-foot corner clips shall be provided at every intersection. At intersections of two residential streets, the right-of-way shall be offset and follow the radius return.

6.4.3 Number of Lanes

- A. Arterial
 - 1. Two-lanes in undeveloped area or where turning movements are limited;
 - 2. Three-lanes on arterials where turning movements are not restricted;
 - 3. Four-lanes on arterials where turning movements are limited;
 - 4. Five-lanes on arterials where turning movements are not restricted;
 - 5. Six-lanes on arterials where turning movements are limited;
 - 6. Seven-lanes on arterials where turning movements are not restricted.

- B. Commercial and Industrial
 - 1. Two-lanes where no turning movements are limited;
 - 2. Three-lanes at intersection of two-lane with arterial;
 - 3. Three-lanes where turning movements are significant;
 - 4. Three- or four-lanes at intersection of three-lane with arterial.
 - 5. Four lane collector as directed and approved by Director of Engineering and Construction Department.
- C. Residential
 - 1. Two-lanes;
 - 2. Three-lanes at intersection with arterial.

6.4.4 Longitudinal Grades

- A. Arterial
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 6.0%
- B. Industrial
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 4.0%
- C. Commercial and Residential Collector
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 6.0%
- D. Residential Major and Minor
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 8.0%

6.4.5 Curbs and Gutters

- A. Arterial
 - 1. No curb and gutter on two-lane arterial. Use 4-foot paved shoulder. Asphalt safety edge is required if arterial is asphalt pavement.
 - 2. No curb and gutter on three-lane arterial. Use 4-foot paved shoulder. Asphalt safety edge is required if arterial is asphalt pavement.
 - 3. 6-inch barrier curb and gutter on four-lane arterial.
 - 4. 6-inch barrier curb and gutter on median and outside lanes of five-lane arterial.
 - 5. 8-inch barrier curb and gutter on six-lane arterial.
 - 6. 8-inch barrier curb on outside lanes of seven-lane arterial, 6-inch barrier curb on raised median.
- B. Commercial and Industrial
 - 1. 6-inch barrier curb and gutter on two-lane street;
 - 2. 6-inch barrier curb and gutter at intersection with four- or five-lane arterial;
 - 3. 8-inch barrier curb at intersection with six- or seven-lane arterial, transition to 6-inch from end of radius.
- C. Residential – (Not required in RE zoned subdivisions)
 - 1. 6-inch barrier curb and gutter on two-lane street;
 - a. 6” mountable curb and gutter may be used on private roads:
 - i. 4” mountable curb and gutter acceptable at

drive

2. 6-inch barrier curb and gutter at intersection with four- or five-lane arterial;
3. 8-inch barrier curb at intersection with six or seven lane arterial, transition to 6-inch from end of radius.

6.4.6 Pavement Medians

- A. Striped median on three-lane arterial where turning movements are allowed.
- B. No median on four-lane transitional arterial.
- C. Raised (6-inch) grass median on three-lane arterial where no turning movements are allowed.
- D. Raised (6-inch) grass median on five-lane arterial where no turning movements are allowed.
- E. Raised (6-inch) landscaped median on six-lane arterial where no turning movements are allowed.
- F. Raised (6-inch) landscaped median on seven-lane arterial where no turning movements are allowed.

6.4.7 Intersections and Driveways

- A. Intersections:
 1. Arterial to Arterial
 - a. Curb Radius – 50 feet minimum
 - b. Delta Angle – 87.5 degrees to 92.5 degrees
 2. Commercial to Commercial/Industrial
 - a. Curb Radius – 40 feet minimum
 - b. Delta Angle – 80 degrees to 100 degrees
 3. Commercial to Arterial
 - a. Curb Radius – 40 feet minimum
 - b. Delta Angle – 85 degrees to 95 degrees
 4. Industrial to Industrial/Commercial
 - a. Curb Radius – 40 feet minimum
 - b. Delta Angle – 80 degrees to 100 degrees
 5. Industrial to Arterial
 - a. Curb Radius – 45 feet minimum
 - b. Delta Angle – 85 degrees to 95 degrees
 6. Residential Major to Residential Collector
 - a. Curb Radius – 25 feet minimum
 - b. Delta Angle – 80 degrees to 100 degrees
 7. Residential Major/Collector to Arterial
 - a. Curb Radius – 35 feet minimum
 - b. Delta Angle – 85 degrees to 95 degrees
 8. Residential Minor to Residential Minor/Major
 - a. Curb Radius – 25 feet minimum
 - b. Delta Angle – 75 degrees to 105 degrees
- B. Driveways: (Within public Right-of-Way)
 1. Industrial Driveways
 - a. Width:
 - i. Minimum – 24 feet
 - ii. Maximum – 36 feet

- b. Curb Radius:
 - i. Minimum – 15 feet
 - ii. Maximum – 35 feet
 - c. Pavement Minimum Thickness:
 - i. Asphaltic Concrete – 9.5 inches
 - ii. Portland Concrete – 8 inches
 - iii. Aggregate Base – 6 inches
 - 2. Commercial Driveways
 - a. Width:
 - i. Minimum – 24 feet
 - ii. Maximum – 36 feet
 - b. Curb Radius:
 - i. Minimum – 10 feet
 - ii. Maximum – 20 feet
 - c. Pavement Thickness:
 - i. Asphaltic Concrete – 7.5 inch
 - ii. Portland Cement Concrete – 6 inch
 - iii. Aggregate Base – 6 inches
 - 3. Residential Driveways:
 - a. Width:
 - 1. Minimum – 12 feet
 - 2. Maximum – 25 feet
 - b. Curb Radius
 - 1. Abutting Residential – 5 feet
 - 2. Abutting Arterial – 10 feet
 - c. Pavement Thickness:
 - 1. Asphaltic Concrete – 7.5 inches
 - 2. Portland Concrete – 6 inches
 - 4. Maximum driveway grade shall not exceed 10% without approval from Director of Engineering and Construction.
- C. Offsets - (Not subject to the provisions of Section 1.7)
 - 1. Intersections
 - a. Residential Street jogs centerline to centerline offsets of less than 125 feet.
 - b. All other street classifications centerline to centerline offsets of less than 150 feet.
 - 2. Driveways
 - a. All driveways along an arterial or collector street shall be offset at least 250 feet from the centerline of an arterial or collector street intersection to the centerline of the driveway.
 - b. For non-residential or multi-family developments, the centerline of all driveways along an arterial or collector street shall align with the access point or be offset at least 200 feet from any access point on the opposite side of the street.

6.4.8 Geometrics

- A. Horizontal – Horizontal geometrics shall comply with American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Street, 2018 Edition or latest edition as approved by Director of Engineering and Construction.
 - 1. Minimum Tangent Segment at Intersections – A minimum tangent segment of 50 feet is required at streets intersecting an Arterial street and is recommended at all other intersections.
 - 2. Minimum Tangent Segment between Curves – A minimum tangent segment of 50 feet is required between reverse curves and is recommended between other horizontal curves.
- B. Vertical – Vertical geometrics shall comply with American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Street, 2018 Edition or latest edition as approved by Director of Engineering and Construction. See Appendix E, Table 6.2 for “K” Values.
 - 1. Minimum Tangent Segment at Intersections - A minimum tangent segment of 50 feet is required between the edge of an intersection, the curb line or traveled way, and either the beginning or the end of a vertical curve for streets intersecting with an arterial street and is recommended for all other intersections.
 - 1. If no vertical is to be included, the arterial street cross slope shall be extended a minimum of 50 feet from the edge of intersection, curb line or traveled way to the point of inflection (P.I.).

6.4.9 Traffic Control Measures

- A. T-Intersections – To the maximum extent possible, residential minor street intersection with either residential major or collector streets shall be three (3) way or “T” intersections. Four (4) way intersections involving residential minor streets and either residential major or collector streets shall be avoided unless dictated by design principles and standards.
- B. Four Way Intersections – All collector streets and residential major streets that intersect with an arterial street shall match the location of existing or proposed future collector and major streets of the adjoining subdivisions to provide a four (4) way intersection, unless topography or other limiting factors prohibit such an intersection.
- C. Non-Linear Curvature – All non-arterial streets shall limit tangent segments of a roadway to 900 feet or less before employing a reasonable, gradual curvilinear segment that meets the requirements identified in the Horizontal Geometrics section.

6.5 TYPICAL ROADWAY SECTIONS:

6.5.1 Lane Widths:

- A. Arterial Streets
 - 1. 3-Lane Arterial – 37 feet (12, 13, 12)
 - 2. 4-Lane Arterial – 48 feet (12, 12, 12, 12)
 - 3. 5-Lane Arterial – 61 feet (12, 12, 13, 12, 12)
 - 4. 6-Lane Arterial – 72 feet (12, 12, 12, 12, 12, 12)
 - 5. 7-Lane Arterial – 85 feet (12, 12, 12, 13, 12, 12, 12)

- B. Commercial Streets
 - 1. Minor – 30 feet (15, 15)
 - 2. Collector – 36 feet (18, 18)
 - C. Industrial Streets
 - 1. Minor – 32 feet (16, 16)
 - 2. Collector – 38 feet (19, 19)
 - D. Residential Streets
 - 1. Minor – 24 feet (12, 12)
 - 2. Major – 26 feet (13, 13)
 - 3. Collector – 30 feet (15, 15)
- 6.5.2 Pavement Thicknesses: Pavement thicknesses shall be in accordance with the AASHTO Guide for Design of Pavement Structures, 1993 Edition. Asphalt pavement section Structural Numbers (SN) shall comply with the Flexible Pavement Method and Concrete pavement section Structural Numbers (SN) shall comply with the Rigid Pavement Method. Refer to Section 4.10 for Subgrade Modification Parameters.
- A. Arterials
 - 1. Primary – SN shall equal 5.5 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2” Asphalt Wearing Course
 - 8” Asphalt Base Course
 - 8” Aggregate Base (with separator fabric)
 - 8” Recompacted Subgrade or 8” Modified Subgrade
 - b. Concrete Paving Section:
 - 9” PCC, Dowell Jointed
 - 8” Aggregate Base (with separator fabric)
 - 8” Recompacted Subgrade or 8” Modified Subgrade
 - 2. Secondary – SN shall equal 5.5 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2” Asphalt Wearing Course
 - 8” Asphalt Base Course
 - 8” Aggregate Base (with separator fabric)
 - 8” Recompacted Subgrade or 8” Modified Subgrade (may substitute ¾” AC Type S3 for Equivalent Aggregate, approx 2 ½”)
 - b. Concrete Paving Section:
 - 9” PCC, Dowell Jointed
 - 8” Aggregate Base (with separator fabric)
 - 8” Recompacted Subgrade or 8” Modified Subgrade
 - B. Commercial
 - 1. Minor – SN shall equal 4.6 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2” Asphalt Wearing Course
 - 7” Asphalt Base Course
 - 8” Aggregate Base (with separator fabric)

- 8" Recompacted Subgrade or 8" Modified Subgrade (may substitute ¾" AC Type S3 for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC, Dowell Jointed
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 - 2. Collector – SN shall equal 5.0 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Wearing Course
 - 7" Asphalt Base Course
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Subgrade or 8" Modified Subgrade (may substitute ¾" AC Type S3 for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 8" PCC, Dowell Jointed
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Subgrade or 8" Modified Subgrade
- C. Industrial
 - 1. Minor – SN shall equal 4.6 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Wearing Course
 - 7" Asphalt Base Course
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Sub-grade or 8" modified subgrade (may substitute ¾" AC Type S3 for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC, Dowell Jointed
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 - 2. Collector – SN shall equal 5.0 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Wearing Course
 - 7" Asphalt Base Course
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Subgrade or 8" Modified Subgrade (may substitute ¾" AC Type S3 for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 8" PCC, Dowell Jointed
 - 8" Aggregate Base (with separator fabric)
 - 8" Recompacted Subgrade or 8" Modified Subgrade
- D. Residential:

1. Minor/Major – SN shall equal 3.8 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 1 ½” Asphalt Wearing Course
 - 6” Asphalt Base Course (with separator fabric)
 - 6” Aggregate Base (with separator fabric)
 - 8” Recompacted Subgrade or 8” Modified Subgrade (may substitute 1” AC Type S3 for Equivalent Aggregate, approx 3”)
 - b. Concrete Paving Section:
 - 6” PCC
 - 6” Aggregate Base (with separator fabric)
 - 8” Recompacted Subgrade or 8” Modified Subgrade
2. Collector – SN shall equal 4.3 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2” Asphalt Wearing Course
 - 6” Asphalt Base Course
 - 6” Aggregate Base (with separator fabric); or
 - 8” Recompacted Subgrade or 8” Modified Subgrade (may substitute ¾” AC Type S3 for Equivalent Aggregate, approx 2 ½”)
 - b. Concrete Paving Section:
 - 7” PCC
 - 6” Aggregate Base (with separator fabric); or
 - 8” Recompacted Subgrade or 8” Modified Subgrade

6.5.3 Cross Slope:

- A. Arterial – 3/8 inch per foot
- B. Commercial:
 1. Minor – minimum 3/8 inch per foot
 2. Collector – minimum 3/8 inch per foot
- C. Industrial:
 1. Minor – minimum 3/8 inch per foot
 2. Collector – minimum 3/8 inch per foot
- D. Residential:
 1. Minor – minimum 3/8 inch per foot
 2. Major/Collector – minimum 3/8 inch per foot

6.6 PAVEMENT MATERIALS:

6.6.1 Arterial:

- A. Asphaltic Concrete:
 1. Base Course – Type S3 (PG 64-22 OK)
 2. Wearing Course – Type S4 (PG 70-28 OK) (Insoluble)
- B. Portland Cement Concrete - Class BA1

6.6.2 Commercial:

- A. Asphaltic Concrete:
 1. Base Course – Type S3 (PG 64-22 OK)
 2. Wearing Course – Type S4 (PG 70-28 OK) (Insoluble)

- B. Portland Cement Concrete - Class BA1
- 6.6.3 Industrial:
- A. Asphaltic Concrete:
 1. Base Course – Type S3 (PG 64-22 OK)
 2. Wearing Course – Type S4 (PG 70-28 OK) (Insoluble)
 - B. Portland Cement Concrete - Class BA1
- 6.6.4 Residential:
- A. Asphaltic Concrete:
 1. Base Course – Type S3 (PG 64-22 OK)
 2. Wearing Course – Type S4 (PG 64-22 OK) (Insoluble)
 - B. Portland Cement Concrete - Class BA1

6.7 SIDEWALKS AND TRAILS:

- 6.7.1 Geometrics – all sidewalk and/or trail geometric design shall comply with the American Association of State Highway and Transportation Officials (AASHTO). Guide for the Development of Bicycle Facilities, 2012, 4th Edition or latest edition as approved by the Director of Engineering and Construction and the United States Access Board (USAB), Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, July 23, 2004 or latest edition.
- 6.7.2 Access Way Standard Widths
- A. Sidewalk
 1. Residential Streets – 4 feet
 2. Industrial Streets – not required
 3. Commercial Streets – 5 feet (minimum of 18” from face of curb or 2’ from back of curb of decorative sidewalk concrete strip between concrete curb and sidewalk)
 4. Arterial Streets – 5 feet
 - B. Trails
 1. Locally Funded Projects – 8 feet
 2. Federally Funded Projects – 10 feet or as dictated by funding source.

7.0 TRAFFIC OPERATIONS

7.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Traffic Operations section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

7.2 DEFINITIONS:

- 7.2.1 AASHTO – American Association of State Highway and Transportation Officials
- 7.2.2 FHWA – Federal Highway Administration
- 7.2.3 HCM – Highway Capacity Manual
- 7.2.4 ITE – Institute of Traffic Engineers
- 7.2.5 MUTCD – Manual of Uniform Traffic Control and Devices
- 7.2.6 ODOT – Oklahoma Department of Transportation
- 7.2.7 TRB – Transportation Research Board

7.3 TRAFFIC SIGNALIZATION WARRANTS:

The following traffic signalization warrants required for the signalization of an arterial intersection shall comply with those warrants as depicted in the Federal Highway Administration MUTCD 2009 edition, or latest edition as approved by the Director of Engineering and Construction.

- 7.3.1 Eight-Hour Vehicular Volume
- 7.3.2 Four-Hour Vehicular Volume
- 7.3.3 One-Hour Peak Vehicular Volume
- 7.3.4 Pedestrian Volume
- 7.3.5 School Crossing
- 7.3.6 Coordinated Signal System
- 7.3.7 Crash Experience
- 7.3.8 Roadway Network
- 7.3.9 Intersection near a Grade Crossing

7.4 TRAFFIC SIGNALIZATION REQUIRED WARRANT RATIOS:

- 7.4.1 Arterial and Arterial Intersection Requirements – The Director of Engineering and Construction may require the signalization of an intersection if any of the warrants above are met.
- 7.4.2 Arterial and Non-Arterial Intersection Requirements – Each individual warrant identified above shall equal or exceed 125% of the minimum criteria in order to require a signalized intersection unless otherwise determined by City Administration.

7.5 TRAFFIC IMPACT ANALYSIS:

A Traffic Impact Analysis (TIA) shall be performed by a proposed development if the development meets the criteria of 100 vph or based upon the Oklahoma Department of Transportation Policy on Driveway Regulations for Oklahoma Highways 1996 edition, or later as approved by the Director of Engineering and Construction.

7.6 LEVEL OF SERVICE CRITERIA:

- 7.6.1 Intersections Analysis – The Level of Service (LOS) analysis for existing intersections shall comply with the processes and procedures identified in Chapter 16 of the Transportation Research Board Highway Capacity Manual 16th edition, or latest edition as approved by the Director of Engineering and Construction.
- 7.6.2 Arterial Analysis - The Level of Service (LOS) analysis for existing arterial roadways shall comply with the processes and procedures identified in Chapter 15 of the Transportation Research Board Highway Capacity Manual 16th edition or latest edition as approved by the Director of Engineering and Construction.
 - A. Arterial roadways shall be classified as urban arterials.
 - B. Other roads shall be classified in accordance with their specific use.

7.7 TRAFFIC COUNT DATA:

- 7.7.1 Arterial Traffic Count Data:
 - A. Annual Average Daily Traffic (AADT) Volume – Arterial AADT may be used from the City of Broken Arrow traffic count data performed for the appropriate intersection. This data is generally conducted around November of each year.
 - B. Peak Hour (PH) Volume – Arterial PH volume shall be either:
 - 1. Calculated from generally accepted relations between peak hour volumes for an arterial and AADT, or
 - 2. Statistically determined from field collected data.
- 7.7.2 Intersection Traffic Count Data:
 - A. Annual Average Daily Traffic Volume – AADT shall include the appropriate turning movements and be statistically generated from field collected data.
 - B. Peak Hour Traffic Volume – PHV shall include the appropriate turning movements and be statistically generated from field collected data.

7.8 TRIP GENERATION PROJECTIONS:

Trip generation for the specific type of development as well as the peak time, weekday versus weekend and morning versus evening, if appropriate, shall be estimated using the statistical data generated in the Institute of Traffic Engineers Trip Generation Manual 2017 edition, or latest as approved by the Director of Engineering and Construction.

7.9 AUXILIARY LANE CRITERIA:

- 7.9.1 Auxiliary Acceleration Lanes – Auxiliary acceleration lanes for developments shall not be constructed.
- 7.9.2 Auxiliary Deceleration Lanes – Auxiliary deceleration lanes may be required dependent upon the anticipated proposed turning movements for the development as estimated in accordance with the trip generation projections section.

7.10 INTERSECTION CONSTRUCTION GUIDE:

- 7.10.1 Detection – All intersections shall use video detection unless otherwise approved by the Director of General Services.
- 7.10.2 Wiring – All intersections shall locate the service wiring overhead unless otherwise approved by the Director of General Services.
- 7.10.3 Stacking Distance – Minimum approved stacking distance for a dedicated turning movement shall be 125 feet unless otherwise approved by the Director of Engineering and Construction.
- 7.10.4 Taper Runout Ratio – Minimum taper runout ratio required at an intersection in addition to the stacking distance shall AASHTO minimum criteria for the proposed design speed of the arterial or 10:1, whichever criteria produces the greater distance.

7.11 TRAFFIC SIGNAGE:

All traffic signage shall comply with the Federal Highway Administration MUTCD 2009 edition or latest edition as approved by the Director of Engineering and Construction.

7.12 TRAFFIC STRIPING:

All traffic striping shall comply with the Federal Highway Administration MUTCD 2009 edition or latest edition as approved by the Director of Engineering and Construction or the Oklahoma Department of Transportation striping standards, whichever is more stringent.

7.13 TRAFFIC CALMING DEVICES:

All traffic calming device requests shall be submitted to the Department of Engineering and Construction prior to design. Upon approval of the Director of Engineering and Construction, traffic calming devices may be designed in accordance with federal, state and local standards and acceptable practices. Proposed design must be submitted to Department of Engineering and Construction for approval from the Director prior to implementation. Devices may include, but not be limited to, the following:

- 7.13.1 Traffic Circles;
- 7.13.2 Traffic Roundabouts;
- 7.13.3 Traffic Speed Humps (Bumps, etc.)
- 7.13.4 Other Devices

7.14 PEDESTRIAN HYBRID BEACONS

Pedestrian Hybrid Beacons shall comply with Chapter 4F of the Federal Highway Administration MUTCD 2009 edition or latest edition as approved by the Director of Engineering and Construction

7.15 RECTANGULAR RAPID-FLASHING BEACONS

Rectangular Rapid-Flashing Beacons (RRFB) shall comply with Interim Approval 21 (IA-21) issued by the Federal Highway Administration on March 21, 2018 or later Federal Highway Administration/MUTCD requirements. See Appendix E, Exhibit 7.1 for Interim Approval 21 (IA-21).

8.0 WATER DISTRIBUTION

8.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Water Distribution section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

This section shall reflect the most recent adoption of the State of Oklahoma criteria identified in Oklahoma Administrative Code Title 252: Oklahoma Department of Environmental Quality; Chapter 626: Public Water Supply Construction Standards; Subchapter 15: Pump Facilities, Subchapter 17: Finished Water Storage and Subchapter 19: Distribution System. In case of conflict or contradiction, the more stringent criterion shall govern the design.

8.2 DISTRIBUTION LINE TYPES:

- 8.2.1 Transmission Lines – They are 24-inch diameter and larger in size:
 - A. Raw Water Transmission Lines – Lines from raw water source to Treatment Plant. No domestic taps are allowed on this type of line.
 - B. Treated Water Transmission Lines – Lines from Treatment Plant to Water Storage Tanks. No domestic taps are allowed on this type of line;
- 8.2.2 Feeder Lines – Connect Transmission Lines and Storage Tanks to Trunk Lines. They range from 12-inch diameter to 24-inch diameter in size and run along section line roads.
- 8.2.3 Trunk Lines – Connect Feeder Lines to Branch Lines. They range from 8- inch diameter to 12-inch diameter in size and run down collector and main residential entryway streets. Model in accordance with 8.4.1 shall be prepared.
- 8.2.4 Branch Lines – Connect Trunk Lines and Branch Lines to one another. They range from 6-inch in diameter to 8-inch in diameter.
- 8.2.5 Fire Suppression Lines – Separate water lines that provide water for fire suppression demand for individual industrial or commercial entities. These lines are generally privately owned.
- 8.2.6 Water Service Lines – Connects City water main to water meter or public line.
- 8.2.7 Customer Service Lines – Connect individual water meters to specific facilities. These lines are privately owned.

8.3 MATERIAL REQUIREMENTS:

(Refer to City of Broken Arrow Standard Construction Specifications, latest edition)

- 8.3.1 Trunk and Branch Lines: Use AWWA C-900, DR-14 material or an approved equal.
- 8.3.2 Feeder Lines (Greater than 12-inch): Use AWWA C-900, DR-18 material or an approved equal for 24 inch diameter lines or less. Use concrete or steel pipe in accordance with standard construction specifications for lines greater than 24 inches in diameter.
- 8.3.3
- 8.3.4 Transmission Lines: Greater than 24-inch lines and up to 48-inch lines: Use AWWA C-900, DR-18 or an approved equal.
- 8.3.5 Use Prestressed Concrete Cylinder Pipe (PCCP) in accordance with standard construction specifications for lines greater than 48 inches in diameter.

8.4 DISTRIBUTION SYSTEM DESIGN CRITERIA:

- 8.4.1 Hydraulic Model: All distribution lines shall be designed utilizing a hydraulic analysis based upon known or expected demand and minimum pressure requirements for normal operating condition, or as directed by the Director of Engineering and Construction. Calculations shall be submitted with engineering plans. Refer to Appendix G.
- 8.4.2 8.4.2 Minimum Pressure Requirement: Any point along and/or within the distribution system shall maintain a minimum of thirty-five (35) pounds per square inch (psi) of working pressure under normal operating conditions, unless approved by the Director of Engineering and Construction. Normal Operating Condition: Normal operating condition shall be defined as any flow condition through the distribution system including peak demand and fire flow, where fire suppression protection is provided.
- 8.4.3 Minimum Hydraulic Model Flow Rate: A minimum flow rate for a distribution system or segment of the system shall be calculated at not less than one (1) gallon per minute (gpm) per service connection.
- 8.4.4 Minimum Cover: Provide a minimum of 36 inches of soil cover over the water distribution line unless otherwise approved by the Director of Engineering and Construction or designee.
- 8.4.5 Maximum Cover: All water lines shall be buried no deeper than 8-feet unless otherwise approved by the Director of Engineering and Construction.
- 8.4.6 Waterline Installation: Waterlines shall not be installed below storm sewer lines or reinforced concrete boxes or unless otherwise approved by the Director of Engineering and Construction.
- 8.4.7 Looped Lines. All water lines shall be looped within a domestic distribution system. Calculations must be provided to show minimum ODEQ residual limits are met.
- A. All lines in a cul-de-sac arrangement shall be looped with a minimum 6 inch line. Lines in a cul-de-sac shall be the same diameter and material.
 - B. Water lines that terminate at locations which will be extended through anticipated temporary phased construction in the future shall have an automatic flushing device, which is metered and discharges to a stormwater system.
- 8.4.8 Air Release Apparatuses:
- A. Air Relief Valve and Vaults: Install air relief valve and vaults at high points along distribution system where air can accumulate within a line that is 12 inches or greater in diameter. Do not use automatic release system where flooding of the valve exhaust may occur.
 - B. Blow Off Valve: Install blow off valves at low points along distribution system to effectively remove accumulated sediments within a line that is 12 inches or greater in diameter. Extend the open end of the exhaust line from automatic valves to at least 1-foot above grade and terminate with a screened, downward-facing elbow.
 - C. Do not cross connect air release systems with any sewer collection system line.
- 8.4.9 Fire Hydrants:
- A. Hydrants shall not be installed on water lines less than 6-inch in diameter.
 - B. A gate valve shall be installed between the water main and the fire hydrant.

- C. Hydrants shall be spaced as follows (spacing shall be measured as the hose lays in the streets):
 1. Maximum spacing in residentially zoned areas shall be 500 feet with a maximum 250 feet to any point on the street;
 2. Maximum spacing in commercially and industrially zoned areas shall be 300 feet.
 3. Fire hydrants in commercial areas spacing shall comply with the most recent edition of the Nation Fire Code adopted by the City of Broken Arrow.

8.4.10 Water Valves:

- A. Minimum spacing of valves along the distribution system shall be as follows:
 1. At locations not more than one-half mile intervals on lines greater than 24 inches in diameter;
 2. At locations not more than one-quarter mile intervals on 12 inch to 24 inch diameter lines;
 3. At locations not more than one-eighth mile intervals on lines less than 12 inches in diameter.
- B. Additional valve locations along the distribution system shall be as follows:
 1. Valves shall be arranged such that each block within a subdivision can be isolated;
 2. Gate Valves shall be installed on 12” lines or less. Lines greater than 12” shall be butterfly valves in a vault, unless approved by the Director of Engineering and Construction.
 3. Valves shall be positioned at all water line intersections on a minimum of two branches in readily accessible locations;
 4. Valves shall be located at all changes of distribution system line type;
 5. Valve locations shall be marked on curbs.

8.4.11 Service Connections:

- A. Service connections shall be installed by the developer and located at the lot lines;
- B. Minimum service connection size:
 1. Single resident service connection shall be ¾ inch or greater;
 2. Dual service connection shall be 1 inch or greater.
- C. Service Connections shall not be installed on lines 12-inches in diameter or greater when other waterlines are in the vicinity, unless otherwise approved by the Director of Engineering and Construction.

8.5 WATER STORAGE SYSTEM DESIGN CRITERIA:

Water storage requirements shall comply with the criteria specified in the American Water Works Association (AWWA) Manual of Water Supply Practices M31: Distribution System Requirements for Fire Protection, fourth edition or latest edition as approved by the Director of Engineering and Construction or designee.

8.6 FIRE SUPPRESSION SYSTEM DESIGN CRITERIA:

System shall be designed to meet the 2018 International Fire Code or latest adopted code. Size all lines after a hydraulic analysis pursuant to the criteria specified in the American

Water Works Association (AWWA) Manual of Water Supply Practices M31: Distribution System Requirements for Fire Protection, fourth edition or latest edition as approved by the Director of Engineering and Construction or designee.

8.7 CONSTRUCTION PARAMETERS:

8.7.1 Location: Waterlines shall be located as shown in the Standard Construction Drawings.

8.7.2 Installation Conditions:

- A. Pipe shall be laid straight with respect to its horizontal alignment except for the use of standard bends or for allowable deflection in accordance with manufacturer's recommendations as approved by the Director of Engineering and Construction;
- B. Metal coated tracer wire shall be placed above the pipe material in accordance to construction standard details.

8.7.3 Trench Conditions:

- A. Trench width shall be in accordance to approved construction standard details;
- B. All pipe must be bedded in accordance with approved construction standard details.

8.7.4 Separation Conditions:

- A. Horizontal Separation (outside to outside):
 - 1. 5 feet from electrical, storm sewer, petroleum product lines, and other buried utilities;
 - 2. 10 feet from existing sanitary sewer lines;
 - 3. 50 feet from private water wells and petroleum product tanks;
 - 4. 15 feet from all septic tanks, absorption fields, or other sewage treatment or disposal systems.
 - 5. 5 feet from underground storm sewers.
- B. Vertical Separation: (measured edge of pipe to edge of pipe) Water lines must cross at least two feet above sanitary sewers and storm sewers, outside to outside. Where water lines are unable to maintain two feet above the three feet of cover, the main shall be located a minimum of two feet below the sanitary sewer line. The joints of both pipes shall be placed equidistant from the crossing. Where joints are placed closer than 10 feet to each line, the crossings shall be encased in concrete.
- C. Exceptions: If proper separation cannot be obtained, then construct sanitary sewer of same material as the water main. Pressure test the section in question from manhole to manhole.

8.7.5 Stream Crossing Conditions (HDPE Pipe Allowed)

- A. Aerial – Must be approved by the Director of Engineering and Construction;
- B. Below Grade – Are preferred and must have 4-feet of cover and a steel casing below the bottom of creek beds and valves located either side of the crossing. For crossings greater than 15 feet, install per ODEQ 252:656-19-2 requirements.
- C. Underwater Crossings – Provide a minimum cover of 2-feet over the pipe. For waterlines crossing a well-defined channel bottom greater than 15-feet in width, construct the waterline as follows:
 - 1. Design the pipe for river crossings and have flexible, restrained or welded

- watertight joints.
2. Provide valve at both ends of water crossings so that the section can be isolated for testing or repair. The valves must be easily accessible and not subject to flooding. The valve closest to the supply source must be in a manhole, and
 3. Make permanent taps on each side of the valve within the manhole to allow insertion of a small meter for testing to determine leakage and for sampling purposes.
- 8.7.6 Blocking – All fittings including tees, bends, plugs and hydrants shall be provided with joint restraints or a thrust reaction blocking device to prevent movement.
- 8.7.7 Casing – All water lines that are placed within a casing shall require restrained joints.

9.0 WASTEWATER COLLECTION

9.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Wastewater Collection section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

This section shall reflect the most recent adoption of the State of Oklahoma criteria identified in Oklahoma Administrative Code Title 252: Oklahoma Department of Environmental Quality; Chapter 656: Water Pollution Control Facility Construction Standards; Subchapter 5: Sanitary Sewer Standards and Subchapter 7: Pump Station Standards. In case of conflict or contradiction, the more stringent criterion shall govern the design.

9.2 MATERIAL REQUIREMENTS:

(Refer to City of Broken Arrow Standard Construction Specifications, latest edition)

9.2.1 Gravity Sewer Collection System:

- A. Collection systems 3 feet deep or less – C-900 PVC, SDR35 or an approved equivalent material. Must be concrete encased. Must be approved by the Director of Engineering and Construction.
- B. Collection systems greater than 16 feet deep – PVC, SDR 35 or an approved equivalent material for all pipe diameters.
- C. Collection systems greater than 16 feet to 25 feet deep:
 - 1. Diameters 15 inches or less - PVC, SDR 26 or an approved equivalent material;
 - 2. Diameters greater than 15 inches – C-900 PVC, DR 18 or an approved equivalent material.
- D. Collection systems greater than 25 feet deep:
 - 1. Diameters 15 inches or less - C-900 PVC, DR 18 or an approved equivalent material;
 - 2. Diameters greater than 15 inches – C-900 PVC, DR 18 or an approved equivalent material.
- E. Pipe materials, type, and size shall be consistent from manhole to manhole.
- F. DR-18 is acceptable in diameters larger than 15-inches if installed in residential or commercial collection systems. All trunk lines 15-inches in diameter and larger shall be SDR-35.

9.2.2 Force Main System:

- A. Force mains with diameter of 12-inches or less – PVC, AWWA C-900, DR-18 or an approved equivalent material;
- B. Force mains with diameters greater than 12-inches – PVC, AWWA C-900, DR-18 or an approved equivalent material
- C. Pipe material, type, and size shall be consistent throughout the force main system.

9.2.3 Lift Station: Shall be made of cast-in-place or pre-cast concrete sections in accordance with American Concrete Institute (ACI) 350-current edition or an approved equivalent material.

9.3 DESIGN CAPACITY:

Design sanitary sewer capacity for the ultimate future population that may be served by the individual line by using either of the following methods but not less than the minimum capacity requirements in Section 9.3.3:

- 9.3.1 Peak Hourly Flow (PHF) – use data for the given service area that considers:
 - A. Domestic usage;
 - B. Commercial and industrial usage;
 - C. Acceptable Peaking Factor for inflow and infiltration; plus
 - D. Known pumping needs.
- 9.3.2 Average Daily Flow (ADF) per Capita – 100 gallons per day per person (gpdpp).
- 9.3.3 Minimum Required Capacity (A drainage basin map showing the area for each pipe size used must be submitted):

<u>Drainage Area</u>	<u>Line Size</u>	<u>Firm Capacity</u>
Less than 154 Acres	8"	0.49 mgd
155 to 238 Acres	10"	0.76 mgd
239 to 540 Acres	12"	1.08 mgd
541 to 807 Acres	15"	1.62 mgd
808 to 1,174 Acres	18"	2.35 mgd
1,175 to 1,617 Acres	21"	3.24 mgd
1,618 to 2,065 Acres	24"	4.13 mgd
2,066 to 2,828 Acres	27"	5.65 mgd
2,829 to 3,745 Acres	30"	7.49 mgd
3,746 to 6,090 Acres	36"	12.18 mgd
6,091 to 9,189 Acres	42"	18.38 mgd
9,190 to 13,118 Acres	48"	26.24 mgd
13,119 to 17,962 Acres	54"	35.92 mgd
17,963 to 23,790 Acres	60"	47.58 mgd
23,791 to 30,675 Acres	66"	61.35 mgd

9.4 PEAKING FACTOR (PF):

- 9.4.1 Use field data gathered during peak usage times, generally early spring months of mid-February to mid-May; otherwise
- 9.4.2 If no field data is collected, then use 4.0 unless otherwise directed by the Director of Engineering and Construction.

9.5 DESIGN CRITERIA:

- 9.5.1 Gravity Collection System:
 - A. Minimum Pipe Diameter (d_{min}) – 8-inch;
 - B. Minimum Velocity (v_{min}) – 2 feet per second (fps);
 - C. Minimum Manning's Roughness Coefficient (n_{min}) – 0.013;
 - D. Minimum Pipe Slope (s_{min}):
 - 1. 8" diameter – 0.40%;
 - 2. 10" diameter – 0.29%;

3. 12" diameter – 0.22%;
 4. 14" diameter – 0.17%;
 5. 15" diameter – 0.15%;
 6. 16" diameter – 0.14%;
 7. 18" diameter – 0.12%;
 8. 21" diameter – 0.10%;
 9. 24" diameter – 0.08%.
- E. Maximum Velocity (v_{max}) – Unless otherwise approved by the Director of Engineering and Construction, maximum conveyance velocities in the gravity collection system shall not exceed 8 feet per second. This velocity shall be determined under average dry weather flow conditions.
 - F. Maximum Depth – All sanitary sewers shall be laid at depths to flowlines of 16 feet or less, unless otherwise approved by the Director of Engineering and Construction.
 - G. Maximum Manhole/Lamphole Spacing (s_{max}):
 1. Diameters of 12" or less – 300 feet;
 2. Diameters greater than 12" but less than 18" – 400 feet;
 3. Diameters of 18" or greater – 500 feet.
 4. Lampholes – 8" only 100 feet.
 - H. Manholes next to the right-of-way shall be placed 5 feet from the right-of-way in the utility easement.
- 9.5.2 Force Mains
- A. Minimum Pipe Diameter (d_{min}) – 4-inch;
 - B. Minimum Velocity (v_{min}) – 2 feet per second (fps) for low flow operating condition;
 - C. Maximum Velocity (v_{max}) – 8 feet per second (fps) for maximum (peak hour) operating condition;
 - D. Maximum Operating Pressure (Design Working Pressure) – 2/3 Rated pressure of the pipe material;
 - E. Design Pipe Material using Hazen and Williams Friction Roughness Values:
 1. PVC/HDPE Material – 140;
 2. Lined Iron or Steel – 120;
 3. Unlined Iron or Steel – 100.
 - F. Air-Relief Valves – Install at high points or other points as necessary.
 - G. Service Lines – No service line taps. Service lines shall not connect to trunk main lines unless approved by the Director of Engineering and Construction.

9.6 CONSTRUCTION PARAMETERS:

9.6.1 Laying Conditions:

- A. Gravity pipe shall be laid straight with respect to horizontal alignment between manholes;
- B. Pipe shall be laid at a constant slope with respect to vertical alignment between manholes;
- C. Metal tracer wire shall be placed above the force main pipe material in accordance to construction standard details.
- D. Minimum depth at the tap shall be 4.5 feet below the finish floor elevation.

- 9.6.2 Trench Conditions:
- A. Trench width shall be in accordance to approved construction standard details;
 - B. All pipe must be bedded in accordance with approved construction standard details;
 - C. Minimum cover shall be 36-inches, unless approved by the Director of Engineering and Construction or designee.
- 9.6.3 Separation Conditions (measured outside to outside of pipe):
- A. Horizontal Separation:
 - 1. 5 feet from electrical, gas and petroleum lines;
 - 2. 10 feet from water mains;
 - 3. 50 feet from private water wells and petroleum product tanks; and
 - 4. 300 feet from public water supply well.
 - B. Vertical Separation: Sanitary sewers must cross at least two feet below water mains, a single 20 foot crossing section must be centered so that the joints will be as far as possible from the water main. Partial sections of pipe shall not be used, unless approved by the Director of Engineering and Construction.
 - C. Exceptions: If proper separation cannot be obtained, then construct sanitary sewer of same material as the water main. Pressure test the section in question. Exceptions must be approved by the Director of Engineering and Construction.
- 9.6.4 Stream Crossing Conditions
- A. Aerial – Must be approved by the Director of Engineering and Construction;
 - B. Below Flowline – Are preferred and must have 4-foot of cover.
 - 1. Gravity Sewer must be place in steel casing and all joints restrained.
 - 2. Force Mains must be placed in steel casing and all joints restrained.
 - C. Manholes must be placed on each side of the bank of a water crossing at a distance of 1.5 times the depth of the manhole outside the bank.
- 9.6.5 Manhole Conditions
- A. Minimum Inside Diameter:
 - 1. 12-inch pipe or less – 4 feet;
 - 2. 15-inch to 21-inch pipe – 5 feet
 - 3. 22-inch to 36-inch pipe – 6 feet
 - 4. Greater than 36 inch pipe – special design approved by the Director of Engineering and Construction.
 - B. Minimum Vertical Depth – 4 feet;
 - C. Invert Drop– 0.10 foot shall be shown if the pipe lengths and slopes are measured and calculated from the wall to the manholes.
 - D. Angles – No acute angles between the incoming pipe and the outgoing pipe, all angles must be 90 degrees or greater.
 - E. Drop Manholes – required for any gravity sewer entering the manhole 24-inches or more above the manhole invert and specified as an internal drop or an external drop. Drops in 5 foot manholes and larger shall be internal drops.
 - F. Force Main Termination – Flowline must be 24-inches or less above the manhole flowline.

- G. Manholes subject to flooding or at risk of submersion shall have the top of rim placed a minimum of 1 foot above the 100 year floodplain water surface elevation and be secured with a watertight bolted down lid.
 - H. Minimum angle between pipe connections 15-inch in diameter or less – 90 degrees.
 - I. Minimum angle between pipe connections greater than 15-inch in diameter – 45 degrees.
 - J. Top of rim shall be flush with current or future pavement and 1 foot above 100 year flood elevation. Finished grade shall minimize ponding at manhole.
- 9.6.6 Grade adjustment rings shall be Cretex PRO-RING, or approved equal, and installed per manufacturer's instructions. Concrete grade rings are unacceptable. Lamphole Conditions
- A. Minimum Vertical Depth – 4 feet
 - B. Maximum Diameter – 8 inches
 - C. Maximum Length – Spacing from manhole to lamphole is 250 feet
- 9.6.7 Lift Stations (DEQ approval required – must comply with section 252-656-7-3 Submersible pump stations). Wet Suction lift pump stations are not allowed. Pumps must be in parallel. Pumps in series are not allowed.
- A. Wet Well – Submersible pumps must be installed with a back-up generator and adequate ventilation may be either continuous or intermittent. Style – Duplex System with one pump serving as a back-up pump;
 - B. Firm Capacity – Provide at least two pumps. With smallest pump out of service the remaining pump(s) must have the capacity to handle maximum sewage flows.
 - C. Minimum Suction Opening – 4 inches in diameter
 - D. Clog Protection – Pump intake must have screening devices to protect against clogging;
 - E. Controls – Provide control system that alternates operation of each individual pump.
 - F. Wet Well Volume – Effective wet well volume shall be sized based on the design average flow in order to adequately fill in 30 minutes or less (maximum hold time is 3-hours).
 - G. Pump Start Frequency – Each pump shall be sized adequately to start and stop less than 6 times per hour as a maximum. The longest duration between any pump stopping to the next pump starting must be 30 minutes or less;
 - H. Security – Provide secure site around lift station;
 - I. Alarm System – Provide an automatic alarm system capable of alerting appropriate personnel of an equipment failure before an overflow occurs;
 - J. Emergency Operations – One of the following must be met:
 1. On-site standby generator or engine-driven pump that has automatic means of activation during equipment or power failure – one hour of minimum storage at design flow above the alarm level is required;
 2. Portable engine-driven pump with a quick connect to the force main – four hours of minimum storage at design flow above the alarm level is required;
 3. 24 hours of storage at design flow above the alarm level with visual/audio alarm system as a minimum;

4. An on-site engine-driven pump with one hour of emergency storage at design flow above the alarm level and an automatic means of activation; or
 5. A portable engine-driven generator with four (4) hours of emergency storage at the design flow above the alarm level, a telemetry alarm system that communicates to the person in charge of the lift station, and a transfer switch with electrical system components that comply with the National Electrical Code requirements that is pre-wired to allow for a ready connection between the lift station and the portable generator.
- K. No emergency overflow basin shall be permitted within the City, unless approved by the Director of Engineering and Construction.
 - L. Flood Protection – Pump, mechanical and electrical equipment shall be protected from physical damage by the 1% chance (100-year return event) storm. Access to the station shall be maintained up to and including the 4% chance (25-year return event) storm;
 - M. Buoyancy – Lift station shall remain stable against buoyancy for extreme groundwater and flood conditions.
 - N. Flow Meters- Flow meters shall be installed at each lift station.
 - O. The SCADA system shall be integrated with BAMA’s city-wide SCADA system.

10.0 STORMWATER MANAGEMENT

10.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Stormwater Management section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma. In addition, this section was formerly known, cited and referred to as the Stormwater Criteria Manual.

This section shall comply with the most recent adoption of the City of Broken Arrow, Oklahoma, Code of Ordinances, Chapter 25: Stormwater Management.

10.2 RAINFALL DATA:

Total rainfall depths shall be specific to the City of Broken Arrow based upon the general site location.

10.2.1 Rainfall intensity values for durations greater than one (1) hour shall be developed in accordance with the procedures identified and the rainfall frequency atlases provided in the United States Department of Commerce (USDOC) and National Weather Bureau (NWS) Technical Publication No. 40 (TP-40), May 1961 edition.

10.2.2 Rainfall intensity values for durations of one (1) hour or less shall be developed in accordance with the procedures identified the National Oceanic and Atmospheric Administration (NOAA) and National Weather Service (NWS) Technical Memorandum entitled Hydro-35, June 1977 edition.

10.2.3 Rainfall intensity values may also be developed with the NOAA Atlas 14.

10.2.4 The totalized rainfall depth with respect to a specific time duration event for a given return frequency shall be equal to the minimum rainfall values provided in Appendix F, Exhibit F-1.

10.3 STORMWATER RUNOFF:

10.3.1 The approved stormwater runoff methods that shall be used to determine total and/or peak stormwater runoff rates, which subsequently may be used for the design of the individual components of the stormwater drainage system, are provided in Appendix F, Exhibit F-2 All other methods for determining peak runoff and corresponding storage volume must be approved in advance by the Local Administrator. These approved methods include the following:

- A. Rational Method;
- B. Soil Conservation Service (SCS) Method;
- C. Snyder's Method with Tulsa Modifiers; and
- D. Unit Volume Method.

- 10.3.2 Rational Method. The Rational Method may be used to determine peak flows for design of the stormwater drainage system in accordance with the limitations prescribed herein. However, the Rational Method shall not be allowed for detention storage volume calculations. Determination of the Rational Method runoff coefficient (C) requires the professional to exercise good engineering judgment. In an effort to facilitate good judgment, Appendix F, Exhibit D presents the recommended range of C values for specific land uses and surface characteristics that should be used. The principles detailed in the United States Department of Transportation, Federal Highway Administration Hydraulic Engineering Circular Number 22 (HEC-22): Urban Drainage Manual, latest edition, shall govern with respect to the application of the Rational Method, except where specifically modified herein.
- 10.3.3 Soil Conservation Service (SCS) Method. The SCS Method may be used to determine peak flows for design of the stormwater drainage system in accordance with the limitations prescribed herein. In addition, the SCS Method shall be allowed for detention storage volume calculations as prescribed herein as well. Determination of the SCS curve number (CN) requires the professional to exercise good engineering judgment. County soil maps shall be used in the determination of the corresponding curve number values in association with the specific land uses and surface characteristics that exist or that are proposed. The principles detailed in the United States Department of Transportation, Federal Highway Administration Hydraulic Engineering Circular Number 22 (HEC-22): Urban Drainage Manual, latest edition, shall govern with respect to the application of the SCS Method, except where specifically modified herein.

10.4 TIME OF CONCENTRATION:

Appendix F, Exhibit E presents the overland flow velocities for various ground covers to determine the sheet flow and shallow concentrated flow portions of travel time calculations. Manning's Formula shall be used to determine the velocity for travel time calculations for concentrated flow within swales, ditches, channels, and storm sewers.

10.5 STORMWATER DRAINAGE SYSTEM:

The stormwater drainage system shall individually or collectively include: the stormwater transmission system, the stormwater collection system, the stormwater conveyance system, the stormwater storage system, the stormwater discharge system, and the stormwater quality best management practice infrastructure system.

- 10.5.1 Stormwater Transmission System – shall include the individual elements that transmit stormwater runoff to a collection point. These elements shall generally be privately owned and shall include, but not be limited to, the following:
- A. Overland and sheet surface stormwater flow areas from both private and/or public property;
 - B. Subsurface groundwater flow areas from both private and/or public property;
 - C. Upper watershed channels

- 10.5.2 Stormwater Collection System – shall include the individual elements that accept and collect stormwater from both private and public property. These elements shall include, but not be limited to, the following items:
- A. Street inlets;
 - 1. Broken Arrow Recessed Inlet, Standard ST-29.
 - 2. Hood and Grate Inlet, In accordance with ODOT Design Standards and the approval of the Director of Engineering and Construction.
 - B. Area inlets;
 - C. Median drains;
 - D. Trench drains, with approval of the Director of Engineering and Construction;
 - E. Pipe inlets with a terminating structure;
 - F. Curb openings with upstream protection.
- 10.5.3 Stormwater Conveyance System – shall include the individual elements that convey stormwater to a discharge point or a storage facility. These elements shall include, but not be limited to, the following items:
- A. Roadway surface drainage system;
 - B. Underground pipe network;
 - C. Extended box structure network;
 - D. Open channel systems:
 - 1. Improved channels;
 - 2. Natural drainage ways;
 - 3. Borrow ditches;
 - E. Connection network:
 - 1. Junction boxes;
 - 2. Manholes.
- 10.5.4 Stormwater Storage System – shall include all on-line and/or off-line at-grade or below-grade detention facilities as well as retention facilities.
- A. Dry detention facilities: Dry detention facilities shall be provided with underground drainage or a concrete trickle channel to eliminate standing water after storm periods. These types of facilities may be used for recreational purposes and other approved uses to the maximum extent possible when not functioning as a detention facility.
 - B. Wet detention facilities: Wet detention facilities may be used on a limited basis and shall be approved only when the pond inflow is sufficient to maintain pond water surface levels and to preclude the water from stagnating.
 - C. Underground detention facilities: Underground detention facilities may consist of basins, tanks, and/or oversized piping networks.
 - D. Parking lot detention: Parking lot detention may be used provided the maximum 1% chance (100-year) stormwater depth is twelve (12) inches or less. Any repaving of the parking lot shall be evaluated for impact on volume and release rates and are subject to approval by the Local Administrator. All parking lot detention areas shall have a minimum of two signs posted identifying the detention pond area. The signs shall have a minimum of 1.5 square feet and contain the following message:

WARNING

This area is a Stormwater
Detention Facility and is subject to
periodic flooding to a depth of
(provide 1% chance storm design depth).

- E. Any suitable materials and geometry of the sign is permissible, subject to approval by the Local Administrator.
 - F. Retention facilities: Retention facilities may be used when the existing conditions runoff from a watershed would exceed the capacities of downstream facilities. The retention facility shall contain the 1% chance (100-year) stormwater runoff and release shall be by evaporation, infiltration or slow release at outflow rates less than existing levels.
- 10.5.5 Stormwater Discharge System – shall include all outfall control structures as well as the corresponding energy dissipators.
- A. Outfall control structures shall include, but not be limited to, the following items:
 1. Weir structures;
 2. Orifice flow device structures;
 3. Flume structures;
 4. Open channel flow structures;
 5. Pressurized flow structures;
 6. Spillway structures.
 - B. Energy dissipaters shall include, but not be limited to, the following items:
 1. Riprap apron as defined in section 10.2 of the HEC-14 manual;
 2. Grouted riprap only upon approval from the Director of Engineering and Construction;
 3. Pre-manufactured revetment;
 4. Concrete stilling and energy dissipation structures;
 5. Erosion Control Mats.

10.6 STORMWATER DRAINAGE SYSTEM GENERAL REQUIREMENTS:

- 10.6.1 The stormwater drainage system shall be designed to receive and pass the runoff from a 1% chance (100-year) storm under ultimate urbanization. In areas covered by the Regulatory Flood Area, that data shall govern. In areas not covered by the Regulatory Flood Area, the owner shall have a professional engineer prepare and submit a study area. The ultimate urbanized flow shall be confined within the said stormwater drainage system.
- 10.6.2 A minimum of the 1% chance (100-year) and the 20% chance (5-year) storm events shall be evaluated when designing the individual elements of the stormwater collection and conveyance systems and their subsequent stormwater discharge system.
- 10.6.3 A minimum of the 1% chance (100-year), 2% chance (50-year), 4% chance (25-year), 10% chance (10-year) and the 20% chance (5-year) storm events shall be evaluated when designing the individual elements of the stormwater storage system and its subsequent stormwater discharge system. Appendix F, Exhibit F presents storm frequency terminology for better clarification.
- 10.6.4 Site grading shall provide surface water drainage directly into a storm sewer, natural drainage course, improved channel, or paved street without crossing more than four (4) adjacent lots.
- 10.6.5 No inlets shall be designed for placement within driveways or entries unless individually approved by the Local Administrator.

- 10.6.6 Driveway approaches shall be designed and constructed so that the runoff from the 1% chance (100-year) storm shall not leave the roadway except in locations where the driveway is designed as part of the drainage system.
- 10.6.7 All storm sewers shall be profiled . Individual lot drains, French drains, retaining structures drains, etc. do not apply.
- 10.6.8 Submittals for drainage systems shall include the following required items for approval of drainage plans:
- A. Hydrology and hydraulics report
 - B. Storm sewer and drainage plans including as a minimum, drainage area map, tabulation sheet, plan sheets, profile sheets, drainage structure summary and analysis tables, pipe summary and analysis tables, special structures, and standard details.
 - C. Grading plan showing existing and proposed contours and/or spot elevations as necessary to show drainage system impacts to public and private properties. Development grading plans shall show proposed finished floors of habitable structures. Where runoff flows onto or leaves a site, the grading plan shall show the offsite topography with contours to document the runoff path.
 - D. Private storm sewers shall be clearly labeled on plans.

10.7 STORMWATER TRANSMISSION SYSTEM DESIGN REQUIREMENTS:

- 10.7.1 The overland flow portion of the drainage system shall be confined to dedicated rights-of-way, or drainage easements to assure the stormwater can pass through the development without inundating the lowest level of any building, dwelling, or structure.
- 10.7.2 An overland drainage easement shall be required for overland flows that immediately drain to a collection point and that are located outside of public right-of-way. No overland flows shall be allowed to adversely affect other private or public structures.
- 10.7.3 No overland or sheet flow transmission system, such as a side yard or backyard swale shall be graded in such a manner as to trap stormwater which in turn may potentially damage a building, dwelling, or structure.

10.8 STORMWATER COLLECTION SYSTEM DESIGN REQUIREMENTS:

- 10.8.1 The overland flow portion of the drainage system shall be confined to dedicated rights-of-way, or drainage easements to assure the stormwater can pass through the development without inundating the lowest level of any building, dwelling, or structure.
- 10.8.2 The stormwater collection system shall be designed either:
- A. To pass a minimum of the runoff from a 20% chance (5-year) storm in a pipe network together with an overland flow path with capacities so that the combination of the two will pass the runoff from a 1% chance (100-year) storm under ultimate urbanized conditions.; or
 - B. To pass the entire runoff from 1% chance (100-year) storm in the pipe network. Should the entire runoff from a 1% chance (100-year) storm be conveyed in an enclosed drainage network, grading shall be designed to convey the runoff from the 1% chance (100-year) storm overland in the event

of inlet or storm sewer blockage or bypass.

- 10.8.3 In either case, an overland drainage easement shall be required for overland flows that immediately drain to a collection point and that are located outside of public right-of-way. No overland flows shall be allowed to adversely affect other private or public structures.
- 10.8.4 In areas where ultimate flows are not planned for conveyance to a regional detention facility, the Local Administrator may reduce the capacity requirement to the existing condition flows.
- 10.8.5 The distance between inlets, as well as the distance to the first inlet on a street shall be determined by the lesser of the following:
 - A. Water depth due to runoff shall not exceed the top of the curb for the 1% chance storm (100-year); or
 - B. 600 feet
- 10.8.6 At sump locations, the water depth shall not exceed six (6) inches above the top of curb, or twelve (12) inches above the top of grate, whichever is less, for the 1% chance (100-year) storm. Where sump collection systems are used, an overflow route shall be provided in the event of a complete blockage of the inlet of pipe. If the inlets and pipe are sized for the 1% chance (100-year) storm, a sod overflow can be used. If a 20% chance (5-year) storm inlet and pipe system is designed, the overflow area shall be concrete lined. When a sod overflow structure is constructed, it shall be lined with Bermuda grass or approved equal and shall contain energy dissipators, if required at the outflow point.
- 10.8.7 Stormwater runoff from areas greater than one half (1/2) acre outside the roadway of arterial and collector streets shall be collected before it reaches the roadway. In no circumstance shall concentrated flows be allowed to discharge into arterial streets. Parking lots shall have internal drainage systems so as to reduce concentrated flow onto public streets. This requirement shall not apply to residential lots used as single-family residences. The Local Administrator may approve sheet flows to the subject streets when connecting to an underground storm sewer system is not economical. In sheet flow instances, the developer must prove no adverse impact to the traveling public, and that the street drainage system is capable of conveying the increased flows.

10.9 STORMWATER CONVEYANCE SYSTEM DESIGN REQUIREMENTS:

- 10.9.1 Open channel and/or ditch elements shall comply with the following requirements:
 - A. In areas where overland flows may cause problems, the Local Administrator may require that the entire runoff from the 1% chance (100-year) storm shall be conveyed through an enclosed drainage network.
 - B. Trapezoidal channels shall be designed with a hard-lined low-flow channel, such as concrete or rock. The low-flow channel shall branch off to pick up any storm sewers discharging into the channel. The top of the sides of the low-flow channel shall be a minimum of six (6) inches lower than the adjacent remaining channel bottom, to ensure that the drainage runs over and into the low-flow channel and does not erode around it. The minimum cross slope on the bottom of the trapezoidal channel shall be 2%. The easement for the trapezoidal channel shall include a ten (10) foot width on the top of

one bank for an access way.

- C. Borrow ditches, when allowed, shall not exceed four (4) feet in depth. Culverts shall be sized to adequately convey the borrow ditch flow. Borrow ditches shall be designed to convey the runoff from the 10% chance (10-year) storm as a minimum. The ditch side slopes shall be three (3) feet horizontal to one (1) foot vertical or flatter.
- D. Side slopes for grass-lined channels shall be 3:1 or flatter. Side slopes for concrete-lined channels shall be 1:1 or flatter for concrete placed against an existing slope or vertical or flatter where the side wall is formed.
- E. Culverts in borrow ditches shall be sized to pass the 10% chance (10-year) storm. The minimum culvert size shall be no less than eighteen (18) inches in diameter.
- F. The street edge of a culvert will be no closer than four (4) feet from the edge of pavement or back of curb.
- G. A storm sewer discharging into or collecting water from a borrow ditch shall be no closer than four (4) feet from the edge of pavement or back of curb.
- H. Roughness coefficients for channel design shall be as listed in Open Channel Hydraulics by Ven te Chow, published by McGraw-Hill Book Company, 1959 edition or an approved equivalent.
- I. The maximum velocity in an unlined ditch or grass-lined improved channel shall not exceed the erosive velocity for the soil type and in no circumstances exceed six (6) feet per second (fps) for the 1% chance (100-year) storm event.
- J. When the 1% chance (100-year) storm velocity in a drainage channel/ditch exceeds the erosive velocity or six (6) fps, whichever is less, erosion control measures such as energy dissipators and/or channel lining shall be placed in the area where the velocity exceeds erosive velocity or six (6) fps.
- K. Concrete-lined drainage channels shall contain the entire channel flow depth and one (1) foot above the peak 1% chance (100-year) storm water surface.
- L. The centerline radius of a curve on an improved channel shall be a minimum of three (3) times the top width of the design flow or 100 feet, whichever is greater.
- M. All improved channels shall be provided with a minimum of one (1) foot of freeboard above peak 1% chance (100-year) storm water surface.
- N. At all bends in improved channels, the amount of freeboard on the outside wall shall be increased by the following equation:

$$H = V^2(b)/64.4r$$

where:

H is height of freeboard in feet;

V is the average velocity in feet per second;

b is the width of the channel at the design water surface in feet; and

r is the radius of curvature of the channel centerline in feet.

- O. The increased freeboard height shall be maintained a minimum of one (1) channel width as measured at the 1% chance (100 year) water surface elevation upstream and downstream of the bend.

10.9.2 Closed conduit system elements shall comply with the following requirements:

- A. Storm sewer piping shall be constructed of reinforced concrete pipe (RCP),

high density polyethylene pipe (HDPE), or corrugated smooth interior polypropylene pipe (CPP), or double wall polyethylene corrugated pipe dependent upon the corresponding soil and loading conditions, unless otherwise approved by the Director of Engineering and Construction. Minimum pipe size shall be 18-inch diameter.

- B. Storm sewer pipes in arterial right-of-way shall be designed and constructed to withstand HS-20 traffic loading.
- C. Storm sewer pipes located under roadways shall be designed and constructed to withstand HS-20 traffic loading.
- D. When RCP is specified, it shall be furnished with omni-flex joints or equivalent. When RCP is specified in a non-cohesive soil, such as sugar sand, and the storm drain is within fifteen (15) feet of structure wrap joints with a non-woven geotextile 6-ounce fabric.
- E. Where storm sewers cross streets, they shall be backfilled with either Oklahoma Department of Transportation, Type A, aggregate base or flowable fill.
- F. Pipe and box culverts shall comply with the design requirements established in the United States Department of Transportation, Federal Highway Administration's Hydraulic Design Series Publication Number 5: Hydraulic Design of Highway Culverts. Culverts shall be examined for both inlet controlled and outlet controlled conditions for the design flows. The slope used for the design shall be the slope of the invert of the culvert.
- G. The Manning's Roughness Coefficient (n) value for closed systems shall be 0.013 for concrete culverts and at values per manufacturer's recommendations for other materials.
- H. No pipe shall be installed downstream having a diameter smaller than the pipe from which it is receiving flow unless approved by the Director of Engineering and Construction. This paragraph does not apply to detention facilities outlet pipes.
- I. Capacity of stormwater conveyance systems located downstream from any proposed development that produces a measurable increase in stormwater runoff shall be thoroughly investigated. Replacement, modifications or adjustments of the existing downstream conveyance system may be required of the developer by the City in order to convey the increased flow from the proposed development.
- J. Junctions between different pipe sizes shall be designed and constructed with the top inside of the downstream pipe no higher than the top inside of the upstream pipe.
- K. A manhole or junction box shall be required at all changes of grade, changes in alignment, changes of pipe material, and junction between two (2) or more different pipe sizes.
- L. The horizontal distance between pipes being placed in the same trench shall be a minimum of $2T + 6''$, where T is pipe thickness. This would include multiple pipe crossings for culvert purposes.
- M. Public storm sewers running parallel to public streets shall be placed behind the curb or pavement within the street ROW where possible. Storm sewers running directly or parallel underneath the pavement of public streets shall be avoided. Radius shall only be used for curves for large diameter pipes and shall be specially designed as

approved by the Director of Engineering and Construction.

- N. A minimum of twelve (12) inches cover shall be provided over conveyance system pipes and box culverts to the bottom of the subgrade, except when the box culvert structure is designed to transmit vehicular loading with the top at grade.
- O. Maximum spacing between manholes or junction boxes shall not exceed 600 feet.
 - 1. All junction boxes and manholes shall be designed with the standard manhole ring and cover at grade.
 - 2. All storm sewers shall be shown in profile, showing, size, type, grade, and 1% chance (100-year) storm flow rates and velocities. Profiles shall show the natural and proposed ground line at the center of the storm sewer. Energy grade line and hydraulic grade line shall be calculated and clearly shown.
 - 3. The radius of curve for a box culvert structure shall be a minimum of three (3) times the maximum width of the box structure, but not less than 50 feet.

10.9.3 Cross street conveyance system structures shall comply with the following requirements:

- A. Bridges - New span bridges shall have adequate capacity to pass the 1% chance (100-year) storm ultimate urbanized flows with one (1) foot of freeboard under the low chord. A backwater analysis shall be provided to illustrate compliance with this requirement and to insure there are no adverse downstream or upstream impacts.
- B. Culverts - New culverts under public roads shall have adequate capacity to pass the 1% chance (100-year) storm ultimate urbanized flows with a maximum water surface elevation not exceeding 6 inches below the lowest pavement (or gutter) elevation in the roadway sump. A backwater analysis shall be provided to illustrate compliance with this requirement and ensure there are no adverse downstream or upstream impacts.
- C. Reinforced concrete pipe (RCP) shall not be less than C- 76 Class III, unless approved by the Director of Engineering and Construction. Corrugated Polyethylene Pipe (CPP), is allowed for use in all street classifications and shall be installed as per manufacturers recommendations and as noted in the City of Broken Arrow Construction Standard Specifications.

10.9.4 Stub street conveyance systems shall comply with the following requirements:

When a stub street is included in a subdivision design, it shall include provisions for drainage of the stub street until such time as the stub street is connected to the extended street system. Design of stub streets will contain the following minimum provisions for drainage:

- A. Stub streets which drain into the development under design will not require special drainage structures.
- B. Stub streets which drain away from the development will require a drainage easement on the adjoining property with a 1% chance (100-year) storm flow capacity ditch to a point of natural drainage or concrete curb and gutter across the end of the street, with storm inlets tied to an operational storm sewer system.
 - 1. If a drainage easement is on the adjoining property:
 - a. When a stub street is shown that will allow stormwater flow to

- drain from one property to an adjoining property, separated by a defined lot line, subsection B will be enforced as described.
- b. When a stub street is shown to drain into a future phase, on the same parcel of land, under the same ownership, a drainage easement and ditch will not need to be obtained or designed. The overland flow from the proposed development will continue to flow overland as it previously did. When the next phase is designed the connecting street will pick up and convey the flow to the nearest inlet. If the remainder of the tract is sold, after the proposed subdivision is platted, the overland flow from the street will be considered an existing condition and will need to be accounted for by the next proposed use of the land.

10.10 STORMWATER STORAGE SYSTEM DESIGN REQUIREMENTS:

10.10.1 General Storage requirements shall comply with the following:

- A. Detention storage shall be required to accommodate excess runoff from all storms from the 20% chance (5-year) storm up to the 1% chance (100-year) storm. Excess runoff is that runoff generated due to urbanization which is greater than the runoff historically generated under existing conditions, for a given frequency storm. Detention facilities shall be designed so that the peak rate of discharge does not exceed that of the existing conditions.
- B. Peak release rates from private developments shall not exceed the existing runoff that occurred before private development for all storm frequencies up to and including the 1% chance (100-year) storm. The 20% chance (5-year), 10% chance (10-year), 4% (25-year), 2% chance (50-year), and 1% chance (100-year) storms shall be investigated at a minimum. Appendix F, Exhibit F presents storm frequency terminology for better clarification.
- C. Public regional detention facilities may be designed with 1% chance (100-year) storm outflow rates equal to or lower than pre-development values with possible increased flow rates for the 20% chance (5-year), 10% chance (10-year), and 2% chance (50-year) storms from pre-development flow rates under those conditions where downstream areas are not adversely impacted.
- D. If the development is situated in such a manner that the stormwater is discharged into a stormwater system which the Local Administrator determines will not be adversely affected, the developer may make a monetary payment or some other form of valuable consideration to the City in accordance with Section 25-207 of the Stormwater Management Ordinance, fee-in-lieu of must comply when constructing an onsite detention facility.
- E. Changes may be made to streams or channels within the Regulatory Flood Fringe Area; subject to approval of the Local Administrator, provided that:
 - 1. The volume of floodwater storage is not reduced;
 - 2. Neither downstream or upstream water surface elevations are adversely increased; and
 - 3. All required permits are obtained prior to starting work.

10.10.2 Detention Facility design shall comply with the following criteria:

- A. The design storm for detention facilities shall be a 24-hour storm, unless otherwise directed by the Director of Engineering and Construction.

- B. The three allowed methods for detention facility design are SCS Method, Snyder's Method with Tulsa Modifiers and Unit Volume Relationship Method. See Appendix F, Exhibit B to determine applicability of each method.
- C. The time increment used in developing the rainfall distribution shall be rounded off to the nearest whole time interval or to the nearest time increment. For the 24-hour storm, the maximum time increment shall be 5 minutes.
- D. The rainfall patterns shall be used in accordance with the modeling technique selected.
- E. For Snyder's Method with Tulsa Modifiers, the loss rates in determining the runoff/hydrograph shall be an initial loss of 0.5 inches and a uniform loss of 0.08 inches per hour for the subsequent hours once the initial losses are satisfied.
- F. All calculations for detention facilities shall be submitted for review by the City. The submittal shall include:
 - 1. The 20% chance, 10% chance, 2% chance, 1% chance, and 0.2% chance storm hydrographs for the proposed development and all upstream areas draining through the proposed development for existing and post- project conditions shall be determined. The detention facility does not have to route the 0.2% chance flows down to pre-project levels, but that flow value shall be used for emergency conditions. The detention facility and stormwater drainage system shall be designed to convey any offsite runoff that drains to it.
 - 2. Detention facility stage/area/outflow or stage/volume/outflow relationships.
 - 3. A stage versus time analysis through the facility.
 - 4. Outlet structure details.
 - 5. Applicable orifice or weir flow calculations for outlet structure and overflow spillway.
 - 6. Existing conditions and post-project conditions drainage area maps.
 - 7. For SCS Method, list soil classifications, curve number assumptions, and time of concentration/lag time calculations.
 - 8. For Snyder's Method, list time to peak (TL), peaking coefficient (Cp), and peak of unit hydrograph flow rate (qp) calculations.
 - 9. Supporting documentation to include HEC runs, a list of assumptions, and other data required to validate the information provided.
 - 10. All dikes and spillways on detention facilities shall have typical cross sections shown on the plans.
 - 11. Side slopes on storage facilities shall not be steeper than 3:1 (Horizontal:Vertical) from the top of the berm to the bottom of the pond, unless otherwise directed by the Director of Engineering and Construction.
 - 12. Detention facilities shall be provided with a trickle channel from the inlet(s) to the outlet structure to transmit low flows. The minimum slope of the bottom of the pond and trickle channel shall be 0.50%. Dry detention facilities shall be provided with either; a low flow concrete trickle channel with a minimum 0.50% channel slope,

a low flow turf reinforcement mat channel with a minimum 2.0% channel slope. The bottom of the pond sloping to the low flow channel(s) shall have a minimum slope of 2.0%.

13. The detention area shall be within a detention easement identified as a separate platted area; as appropriate, it may consist of one or more platted lots, a reserve area, or it may be dedicated by separate instrument. All detention facilities shall be placed within a dedicated easement. No detention facilities will be allowed in off-tract areas without written agreement between affected property owners and said agreement must be filed and recorded in County land records.
14. Provision for the maintenance responsibility of private dedicated facilities shall appear among the plat's restrictive covenants, or applicable law.
15. An access way at least twenty (20) feet wide shall be provided to any detention area. Access may be provided by frontage on a dedicated public street or by an access easement from a public street to the detention area. The access way shall have a maximum grade of twelve percent (12%).
16. If a detention facility is approved by the City to serve areas outside the development in which it is located, such additional areas shall be specifically identified in the provision for detention.
17. Any dam constructed for the purpose of storing water and under the jurisdiction of the Oklahoma Water Resources Board shall be designed, permitted, and inspected in accordance with the State of Oklahoma Administrative Code, Section 785.
18. Embankment slopes of all detention dams or dikes shall not be steeper than 3:1 and shall be constructed as earth filled and non-overflow type dams. Earthen portions of detention facilities shall be designed and constructed at or above the 1% chance storm event or at the 0.2% chance storm event, whichever is higher. Flows larger than those of the 1% chance storm event are not required to be detained. Freeboard requirements may be adjusted for detention facilities not utilizing earthen berm dams by the Director of Engineering and Construction.
19. All detention facilities shall be designed and constructed with an emergency spillway structure designed to pass the flow from the 1% chance flood event in the event of blockage of the outlet structure. Erosion control in the form of concrete lining, rip-rap, and dissipater blocks, etc. shall be provided where deemed necessary by the Director of Engineering and Construction. The emergency spillway elevation must be above the 100-year water surface elevation.
20. The detention report shall clearly show pre-project and post-project peak flows at all discharge points from the site to show that increased peak flows do not adversely affect offsite properties.
21. The executive summary of the report shall show how the pond functions and the flow rates off the property. The pond function shall include the top of bank, the spillway elevation, the 500-yr WSE, the 100-yr WSE, the 100-yr WSE with the outlet blocked, and the outlet

structure. The pre-development and post-development flows shall be shown at all locations where runoff flows off the property in the post-development condition. The report shall then provide the information as to how these numbers were determined.

22. All earth slopes and areas subject to erosion, such as, adjacent to trickle channels, inlet structures, and outlet structures, shall be slab sodded or protected with other erosion control measures. All other earth surfaces, within the designated detention area, shall have an established growth of grass. All grass covered areas shall be fertilized, watered and in an established growing condition prior to completion and approval of the detention facility.
23. Not needed based on Ordinance Section 25-206 wet ponds used on a limited basis and must be approved. Completion of construction of the detention facility shall occur before completion of construction of other proposed impervious areas onsite including buildings and parking lots.
24. Appendix F, Exhibit C presents a simplified unit volume detention curve that may be used to size the detention storage volume required for developments two (2) acres or smaller.

10.11 STORMWATER DISCHARGE SYSTEM DESIGN REQUIREMENTS:

10.11.1 Outfall/Discharge structures shall comply with the following design requirements:

- A. All drainage structures that discharge directly into a waterway shall have a concrete headwall/wingwall and apron. Precast concrete end treatments may be used with approval of the Director of Engineering and Construction.
- B. Outfall/discharge structures shall not be designed so that they will be submerged under a permanent pool of water unless approved by the Director of Engineering and Construction.
- C. All hydraulic control devices, such as weirs, orifices, and flumes shall comply with the design requirements identified in the United States Department of the Interior, Bureau of Reclamation Water Measurement Manual, current edition.

10.11.2 Permanent erosion control measures for discharge structures shall comply with the following requirements:

- A. When the 1% chance (100-year) storm outfall velocity at the discharge structure exceeds maximum permissible velocity or six (6) fps, whichever is less, permanent erosion control measures shall be installed, see Section 10.9.1.I. Permanent erosion control measurements may include dissipater blocks, riprap, and channel protection, or other measures as approved by the Local Administrator.
- B. Riprap design shall comply with the requirements of United States Department of Transportation, Hydraulic Engineering Circular Number 14 (HEC-14): Hydraulic Design of Energy Dissipators for Culverts and Channels, current edition.

10.12 MISCELLANEOUS STORMWATER REQUIREMENTS:

Reference the City's Ordinance for the following permits: fee-in-lieu of detention, stormwater development permits, floodplain development permits, floodplain development permit certificates of compliance, earth change permits, and state or federal stormwater related permits.

- A. State or Federal Permits/Approvals – Any projects requiring stormwater related state or national permits, approvals or certifications, including but not limited to FEMA CLOMR/LOMRs, U.S. Army Corps of Engineers 404 Permits, ODEQ 401 Certifications, ODEQ OPDES Permits, OWRB Dam Permits, and OWRB Stream Water Use Permits shall forward copies of those permit applications to the Local Administrator at time of application to the state or federal agency.

**APPENDIX A:
VARIANCE REQUEST**



**CITY OF BROKEN ARROW
ENGINEERING DESIGN CRITERIA
VARIANCE REQUEST**

VR _____ - _____

Project Title: _____ S-T-R ____ - ____ - ____

APPLICANT FIRM: _____ SUBMITTAL DATE: ____/____/____

CONTACT NAME: _____

CONTACT E-MAIL: _____

CONTACT PHONE: ____ - ____ - ____

APPLICANT TO ATTACH EXHIBITS OR PLANS SUPPORTING REQUEST

1.0 Engineering Design Criteria Regulation Section(s)/Number(s)-

2.0 Specific Reason(s) for Variance Request-

3.0 Engineers Recommendation to Resolve Conflict-

Applicant Signature

Date



**CITY OF BROKEN ARROW
ENGINEERING DESIGN CRITERIA
VARIANCE REQUEST**

VR _____ - _____

4.0 Community Development - Lead Engineer Recommendation-

Reviewer Signature

Date

5.0 Engineering & Construction Review Recommendation-

Reviewer Signature

Date

Engineering & Construction Director Recommendation

Approval Denial

Conditions of Approval or Denial _____

E&C Signature

Date

City Manager or Designee Determination

Approval Denial

Conditions of Approval or Denial _____

CM Signature

Date



**CITY OF BROKEN ARROW
CONSTRUCTION SPECIFICATIONS
VARIANCE REQUEST**

CV _____ - _____

Project Title: _____ S-T-R _____ - _____ - _____

APPLICANT FIRM: _____ SUBMITTAL DATE: ____/____/____

CONTACT NAME: _____

CONTACT E-MAIL: _____

CONTACT PHONE: ____ - ____ - ____

APPLICANT TO ATTACH EXHIBITS OR PLANS SUPPORTING REQUEST

1.0 Standard Construction Specification(s)/Detail(s)-

2.0 Specific Reason(s) for Variance Request-

3.0 Engineers Recommendation to Resolve Conflict-

Applicant Signature

Date



**CITY OF BROKEN ARROW
CONSTRUCTION SPECIFICATIONS
VARIANCE REQUEST**

CV _____ - _____

4.0 Community Development Lead Engineer Recommendation-

Reviewer Signature

Date

5.0 Engineering & Construction Review Recommendation-

Reviewer Signature

Date

Construction Manager Recommendation

Approval Denial

Conditions of Approval or Denial _____

CM Signature

Date

Engineering & Construction Director Determination

Approval Denial

Conditions of Approval or Denial _____

E&C Signature

Date

**APPENDIX B:
SURVEY AND RIGHTS OF WAY DOCUMENTS**

GENERAL WARRANTY DEED

This Indenture: Made this ____ day of _____ 20__, between _____, of Tulsa/Wagoner County, in the State of Oklahoma, party(ies) of the first part, hereinafter called Grantor(s) and CITY OF BROKEN ARROW, County of Tulsa/Wagoner, State of Oklahoma, party of the second part, hereinafter called Grantee.

WITNESSETH: That in consideration of the sum of Ten Dollars (\$10.00) and other goods and considerations, receipt of which is hereby acknowledged, said party grantor does, by these presents, grant, bargain, sell and convey unto Grantee, their heirs and assigns, all of the following described real estate, situated in the County of Tulsa/Wagoner, State of Oklahoma, to wit:

SEE EXHIBIT "A"

TO HAVE AND TO HOLD THE SAME, together with all and singular the tenements and appurtenances thereto belong or in any wise appertaining forever. And Grantor, their heirs, executors and administrators does hereby covenant, promise and agree to and with Grantee, at the delivery of these presents that they lawfully seized in their own right of an absolute and indefeasible estate of inheritance in fee simple, of and in all and singular the above granted and described premises, with the appurtenances; that the same are free, clear, and discharged and unencumbered of and from all former and other grants, titles, charges, estates, judgments, taxes, assessments and encumbrances of whatsoever nature and kind, EXCEPT: Easements and buildings, restrictions of record and special assessments not yet due, the grantor, _____ will WARRANT AND FOREVER DEFEND the same unto the Grantee, its heirs and assigns, against grantor, their heirs or assigns and all and every person or persons whomsoever lawfully claiming or to claim the same.

IN WITNESS WHEREOF, the Grantor, has hereunto set _____ hand the day and year above written.

State of Oklahoma)
)§.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this ____ day of _____, 20__, personally appeared _____, known to me to be the identical person(s) who executed the within and foregoing instrument in writing and acknowledged to me that he/she executed the same as his/her and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last written above.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked: _____
Project: _____

GENERAL WARRANTY DEED

(Oklahoma Statutory Form)

THIS INDENTURE, Made this ____ day of _____, 20__, between _____, Grantor, and the CITY OF BROKEN ARROW, OKLAHOMA, a municipal corporation, Grantee.

WITNESSETH, that in consideration of the sum of TEN AND NO/100 (\$10.00) DOLLARS, receipt of which is hereby acknowledged, said Grantor do(es), by these presents, grant, bargain, sell and convey unto said Grantee, its successors or assigns, all of the following described real estate, situated in the County of Tulsa/Wagoner, State of Oklahoma, to-wit:

SEE EXHIBIT "A"

EXEMPT FROM DOCUMENTARY STAMPS PURSUANT TO 68 O.S. 3202 (11).

TO HAVE AND TO HOLD THE SAME, together with all and singular the tenements, hereditaments and appurtenances thereto belonging or in any wise appertaining forever.

And said Grantor, for themselves and their heirs, executors, and administrators, does hereby covenant, promise and agree to and with said Grantee, at the delivery of these presents that he(she) is lawfully seized in his(her) own right of an absolute and indefeasible estate of inheritance in fee simple, of and in all and singular the above granted and described premises, with the appurtenances; that the same are free, clear, and discharged and unencumbered of and from all former and other grants, titles, charges, estates, judgments, taxes, assessments and encumbrances, of whatsoever nature and kind, EXCEPT: Easements, building restrictions of record and special assessments not yet due; and that Grantor will WARRANT AND FOREVER DEFEND the same unto the said Grantee, its successors or assigns, against said Grantor, his(her) heirs and assigns and every person or persons whomsoever lawfully claiming or to claim the same.

IN WITNESS WHEREOF, the said Grantor, has hereunto set his hand the day and year above written.

By: _____
Name:

By: _____
Name:

STATE OF OKLAHOMA)
) §.
COUNTY OF _____)

Before me, the undersigned, a Notary Public, in and for said County and State, on this ____ day of _____, 20__, personally appeared _____, to me known to be the identical person(s) who executed the within and foregoing instrument, and acknowledged to me that he/she executed the same as his/her free and voluntary act and deed for the purposes therein set forth.

GIVEN under my hand and seal the day and year last above written.

My Commission Expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ Checked: _____
Project: _____

**DEED OF DEDICATION
CORPORATION**

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, (Corporate name) by (signatory name), its (corporate officer), the owner(s) of the legal and equitable title to the following described real estate situated in the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, for and in consideration of the sum of One Dollar (\$1.00), cash in hand, paid by the City of Broken Arrow, Oklahoma, the grantee, and other good and valuable considerations, receipt of which are hereby acknowledged, do(es) hereby dedicate to the City of Broken Arrow for the benefit of the public, forever, the following described property, to wit:

SEE EXHIBIT "A"

together with all the improvements thereon and appurtenances there-unto belonging.

TO HAVE AND TO HOLD such property unto the City of Broken Arrow, grantee, its successors and assigns forever.

DATED this ___ day of _____, 20__.

(Corporate name)

By _____

State of Oklahoma)
)§.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this _____ day of _____, 20__, personally appeared _____, known to me to be the identical person(s) who subscribed the name of the maker thereof to the foregoing instrument as its (attorney-in-fact, president, vice-president, chairman or vice-chairman of the board of directors or mayor, as the case may be) and as the free and voluntary act and deed of such corporation for the uses and purposes therein set forth.

My Commission Expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

City Attorney

City Manager

Engineer _____ checked: _____

Project: _____

QUIT-CLAIM DEED

(Statutory)

THIS INDENTURE, made this ___ day of _____, 20___, between _____, husband and wife, Grantors, and _____, husband and wife, Grantees.

WITNESSETH, That Grantors, in consideration of the sum of TEN AND NO/100 (\$10.00) Dollars, and other good and valuable considerations, receipt of which is hereby acknowledged, do hereby quit-claim, grant, bargain, sell, and convey unto Grantees, their successors and assigns, forever, all their right, title, interest, and estate, both at law and in equity, of, in and to the following described real estate, situated in the County of Tulsa/Wagoner, State of Oklahoma, to-wit:

SEE EXHIBIT "A"

EXEMPT FROM DOCUMENTARY STAMPS PURSUANT 68 O.S. 3202 (3).

Together with all and singular the hereditaments and appurtenances thereunto belonging. TO HAVE AND TO HOLD the above granted premises unto the said Grantees, their successors and assigns forever.

IN WITNESS WHEREOF, Grantors have hereunto set their hand the day and year first above written.

By: _____

By: _____

STATE OF OKLAHOMA)
) §:
COUNTY OF _____)

Before me, the undersigned, a Notary Public in and for said County and State, on the ___ day of _____, 20___, personally appeared _____, husband and wife, to me known to be the identical persons who executed the within and foregoing instrument and acknowledged to me that he/she/they executed the same as his/her/their free and voluntary act and deed for the uses and purposes therein set forth.

Given under my hand and seal the day and year last above written.

My Commission Expires:

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked _____

Project: _____

UTILITY EASEMENT

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, the owner(s), of the legal and equitable title to the following described real estate, "Grantor," in consideration of the sum of One Dollar (\$1.00), cash in hand paid by the City of Broken Arrow, Oklahoma and other good and valuable considerations, receipt of which is hereby acknowledged, do(es) hereby assign(s), grant(s) and convey(s) to the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a municipal corporation, its successors and assigns, "Grantee," an easement and right of way over and across the following described real property and premises, situated in Tulsa/Wagoner County, State of Oklahoma to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, operating, and replacing utility lines and appurtenances.

Grantor agrees not to build or construct any building or buildings upon the permanent easement area. However, Grantor expressly reserves the right to build and construct sidewalks, streets and driveways, water mains, gas lines, electrical lines and other public service facilities across said premises herein described.

There is further granted the right to remove any tree or parts of trees, which in the judgment of the City may interfere with the construction of the applicable utilities.

PROVIDED, that the said Grantor, his/her heirs, executors, administrators and assigns, shall fully use and enjoy the said premises except as may be necessary for the purposes herein granted to the City, its successors or assigns.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed this _____ day of _____, 20____.

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____, 20____, personally appeared _____ to me known to be the identical person(s) who executed the within and foregoing instrument and acknowledged to me that he/she/they executed the same as his/her/their free and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer: _____ checked: _____

Project: _____

DRAINAGE EASEMENT

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, the owner(s) of the legal and equitable title to the following described real estate situated in the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, for and in consideration of the sum of One Dollar, cash in hand, paid by the City of Broken Arrow, Oklahoma and other good and valuable considerations, receipt of which are hereby acknowledged, do(es) hereby dedicate to the public, forever, the following described property, to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, maintaining, operating, and replacing drainage facilities and appurtenances.

The City is hereby given and granted the exclusive possession of said above described premises for the purposes aforesaid, and grantor(s), for him/her and their heirs, administrators, successors and assigns, covenant(s) and agree(s) that no building, structure, wall or other above ground obstruction will be placed, erected, installed or permitted upon the above described land; and further covenant(s) and agree(s) that in the event the terms of this paragraph are violated by the grantor(s) or any person in privy with them, such violation will be promptly corrected and eliminated immediately upon receipt of notice from City or City shall have right to remove or otherwise eliminate such violation, and grantor(s), his/her heirs, administrators, successors and assigns, shall promptly pay the actual cost thereof.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

DATED this ___ day of _____ 20__ .

State of Oklahoma)
)§.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this _____ day of _____, 20____, personally appeared _____, known to me to be the identical person(s) who executed the within and foregoing instrument in writing and acknowledged to me that he/she executed the same as his/her and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last written above.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked: _____
Project: _____

**DRAINAGE AND UTILITY
EASEMENT**

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____ the owner(s), of the legal and equitable title to the following described real estate, "owner(s)" in consideration of the sum of One Dollar (\$1.00), cash in hand paid and other good and valuable considerations, receipt of which is hereby acknowledged, do(es) hereby assign(s), grant(s) and convey(s) to the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a municipal corporation, its successors and assigns, "City", an easement and right of way over and across the following described real property and premises, situated in Tulsa/Wagoner County, State of Oklahoma to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, maintaining, operating, and replacing drainage facilities and appurtenances and any other utility lines and appurtenances at the City's sole discretion.

and granting this right of way to utilities that have right of way franchises with the City of Broken Arrow.

The City is hereby given and granted the exclusive possession of said above described premises for the purposes aforesaid, and owner(s), for him/her and their heirs, administrators, successors and assigns, covenant(s) and agree(s) that no building, structure, wall or other above ground obstruction will be placed, erected, installed or permitted upon the above described land; and further covenant(s) and agree(s) that in the event the terms of this paragraph are violated by the owner(s) or any person in privy with them, such violation will be promptly corrected and eliminated immediately upon receipt of notice from City or City shall have right to remove or otherwise eliminate such violation, and owner(s), his/her heirs, administrators, successors and assigns, shall promptly pay the actual cost thereof.

However, owner expressly reserves the right to build and construct sidewalks, streets and driveways, water mains, gas lines, electrical lines and other public service facilities across said premises herein described.

There is further granted the right to remove any tree or parts of trees, which in the judgment of the City may interfere with the construction of the applicable utilities.

PROVIDED, that the said owner(s), his/her heirs, executors, administrators and assigns, shall fully use and enjoy the said premises except as may be necessary for the purposes herein granted to the City, its successors or assigns.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

DATED this ___ day of _____, 20_.

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____ 20____, personally appeared _____ to me known to be the identical person(s) who executed the within and foregoing instrument as the free and voluntary act and deed of such person for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer: _____ checked: _____

Project: _____

**DRAINAGE EASEMENT
CORPORATE or PARTNERSHIP**

KNOW ALL MEN BY THESE PRESENTS:

That "Corporate name" by "signatory name", its "corporate officer" of Tulsa/Wagoner County, State of Oklahoma, the owner of the legal and equitable title to the following described real estate, party of the first part, in consideration of the sum of One Dollar, cash in hand paid, receipt of which is hereby acknowledged, do(es) hereby assign, grant and convey to the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a municipal corporation, party of the second part, its successors and assigns, an easement and right of way over and across the following described real property and premises, situated in Tulsa/Wagoner County, State of Oklahoma, to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, maintaining, operating, and replacing drainage facilities and appurtenances.

The City is hereby given and granted the exclusive possession of said above described premises for the purposes aforesaid, and grantor(s), for him/her and their heirs, administrators, successors and assigns, covenant(s) and agree(s) that no building, structure, wall or other above ground obstruction will be placed, erected, installed or permitted upon the above described land; and further covenant(s) and agree(s) that in the event the terms of this paragraph are violated by the grantor(s) or any person in privy with them, such violation will be promptly corrected and eliminated immediately upon receipt of notice from City or City shall have right to remove or otherwise eliminate such violation, and grantor(s), his/her heirs, administrators, successors and assigns, shall promptly pay the actual cost thereof.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

DATED this ___ day of _____ 20___. _____ (Corporate name)

By _____

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this ___ day of _____, 20___, personally appeared _____ for (Corp. Name) known to me to be the identical person(s) who subscribed the name of the maker thereof to the foregoing instrument as its (signatory officer or general partner) and as the free and voluntary act and deed of such corporation for the uses and purposes therein set forth.

My Commission Expires: _____

Notary Public
Approved as to Substance:

Approved as to Form:

Asst. City Attorney

City Manager

Engineer _____ checked: _____
Project: _____

**TEMPORARY CONSTRUCTION EASEMENT
CORPORATE or PARTNERSHIP**

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, by "signatory name", _____, its "corporate officer", the owner(s), of the legal and equitable title to the following described real estate situated in Tulsa/Wagoner County, State of Oklahoma, for and in consideration of the sum of One Dollar, cash in hand paid by the City of Broken Arrow, Oklahoma, a municipal corporation, and other good and valuable considerations, receipt of which are hereby acknowledged, does hereby grant and convey unto the said City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a temporary easement, through, over and under and across the following described property, situated in Tulsa/Wagoner County, to wit:

SEE EXHIBIT "A"

for a period of not more than _____ months from the date of this instrument. This grant of temporary right to use and occupy is given for the purpose of permitting the City of Broken Arrow, its employees, representatives, agents, and/or persons under contract with it, to use said described property in connection with the construction of _____

IN WITNESS WHEREOF, the parties have caused this instrument to be executed this _____ day of _____, 20____.

(Corporate name) _____
By _____
TITLE

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____, 20____, personally appeared for _____ for (Corp. Name) to me known to be the identical person(s) who executed the within and foregoing instrument as its (signatory officer or general partner) and as the free and voluntary act and deed of such corporation for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer: _____ checked: _____
Project: _____

**APPENDIX C:
EARTH CHANGE OPERATIONS AND POLLUTION
PREVENTION CONTROLS DOCUMENTS**

Stormwater Pollution Prevention Plan (SWP3)

Authorization No. OKR10#####

For Construction Activities At:

Project/Site Name
Project Site Location/Address
City, State, Zip Code
Project/Site Telephone Number

SWP3 Prepared For:

Company Name
Contact Person's Name
Address
City, State, Zip Code
Telephone Number

SWP3 Prepared By:

Company Name
Contact Person's Name
Address
City, State, Zip Code
Telephone Number

SWP3 Preparation Date:

___/___/_____

Estimated Project Dates:

Project Start Date: ___/___/_____
Project Completion Date: ___/___/_____

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Section 1: Stormwater Team and Project/Site Information

1.1 Stormwater Team

Stormwater team is responsible for overseeing development of the SWP3, making any modifications to it, implementing and maintaining control measures, taking corrective actions when required, performing site inspection and monitoring, supervising pollution prevention and waste management activities, providing staff training, and communicating changes in the SWP3 to the people working on the site. The following personnel, along with their role and responsibility, will be part of the **stormwater team** for my construction site:

Team Leader (Name/Title/Telephone)	Roles & Responsibilities

Team Member # 1 (Name/Title/Telephone)	Roles & Responsibilities

Team Member # 2 (Name/Title/Telephone)	Roles & Responsibilities

Team Member # 3 (Name/Title/Telephone)	Roles & Responsibilities

Team Member # 4 (Name/Title/Telephone)	Roles & Responsibilities

[Repeat as necessary]

1.2 Nature of Construction Activity and Project Information

Project/Site Name and Address	
Project/Site Name:	
Project/Site Street/Location:	
City:	County:
State:	ZIP Code:

General Description of the Project/Site: [Click here to enter text.](#)

Estimated project start date:	
Estimated project end date:	
Total area of the construction site:	(acres)
Estimated area to be disturbed:	(acres)
Estimated current impervious area at the site:	(acres)
Estimated impervious area after construction:	(acres)
Pre-construction runoff coefficient of the site:	
Post-construction runoff coefficient of the site:	
Purpose of the Construction Project/Site:	
<input type="checkbox"/> Residential <input type="checkbox"/> Commercial <input type="checkbox"/> Wind Farm <input type="checkbox"/> Road/Bridge <input type="checkbox"/> Other(s), please specify: Click here to enter text.	

Project Latitude/Longitude (for linear project, include latitude/longitude of start and end points)	
Latitude:	Longitude:
1. ___° ___' ___" N (degrees, minutes, seconds)	1. ___° ___' ___" W (degrees, minutes, seconds)
2. ___° N (decimal)	2. ___° W (decimal)
Latitude:	Longitude:
1. ___° ___' ___" N (degrees, minutes, seconds)	1. ___° ___' ___" W (degrees, minutes, seconds)
2. ___° N (decimal)	2. ___° W (decimal)
Method for determining latitude/longitude:	
<input type="checkbox"/> DEQ Flex-viewer	<input type="checkbox"/> EPA Website
<input type="checkbox"/> USGS topographic map	<input type="checkbox"/> GPS

Description of soil type(s) and fill materials:
Description of slopes (describe existing slopes and note any changes due to grading or fill activities):
Description of drainage patterns (describe existing drainage patterns and note any changes due to grading or fill activities):
Description of existing or baseline vegetation on or immediately surrounding the project area:
Climate/Rainfall Patterns - check the box that applies:
<input type="checkbox"/> (0-20" annual rainfall) <input type="checkbox"/> (20" -30" annual rainfall)
<input type="checkbox"/> (30"-40" annual rainfall) <input type="checkbox"/> (40" -50" annual rainfall)
<i>(Note: Annual rainfall data can be found at the following link: https://www.mesonet.org/index.php/weather/category/rainfall)</i>

1.3 Operators and Contactor's Contact Information

Operator(s) Information:		
Name:		
Address:		
City:	State:	Zip Code:
Operator's Point of Contact:		
Telephone Number:		
Email address:	Fax number:	

(Repeat for multiple operators by copying and pasting the above rows)

Contractor's Information:		
Name:		
Address:		
City:	State:	Zip Code:
Telephone Number:		
Email address:	Fax number:	

(If owner is a separate entity)

Sub-Contractor's Information:		
Name:		
Address:		
City:	State:	Zip Code:
Telephone Number:		
Email address:	Fax number:	

(If owner is a separate entity)

SWP3 Contact(s):	
SWP3 Contact Name (Primary):	
Telephone number:	
Email address:	Fax number:
SWP3 Contact Name (Backup):	
Telephone number:	
Email address:	Fax number:

1.4 Construction Support Activities *(if applicable)*

List of construction support activities that will be available at the construction project/site:

Type of Construction Support Activities ¹	Will be Present at the Construction Site?
Equipment Staging Yards	<input type="checkbox"/> Yes <input type="checkbox"/> No
Material Storage Areas	<input type="checkbox"/> Yes <input type="checkbox"/> No
Excavated Material Disposal Areas	<input type="checkbox"/> Yes <input type="checkbox"/> No
Borrow Areas	<input type="checkbox"/> Yes <input type="checkbox"/> No
Concrete Batch Plant ²	<input type="checkbox"/> Yes <input type="checkbox"/> No
Asphalt Plant ²	<input type="checkbox"/> Yes <input type="checkbox"/> No

(Note-1: Locate all the construction support activities on the site map. Appropriate/additional controls & measures are required for construction support activities. Support activities should not be located within the watershed of an Outstanding Resources Water (ORW).)

Note-2: Include Section 8 if you have Concrete Batch Plant and/or Asphalt Plant as construction support activities at your construction site. Exclude/delete Section 8 if you don't have Concrete Batch Plant and/or Asphalt Plant at your construction site.)

1.5 Sequence of Construction Activities

(Note: You may edit sequence of construction activities in the following table to reflect your project's sequences along with estimated start date and duration)

No.	Sequence of Construction Activities	Estimated Start Date	Duration (in Days)
1.	Construction access/entrance to site, construction routes, areas designated for equipment parking/staging area		
2.	Silt fences, berm or similar control measures as perimeter control		
3.	Land clearing and grading, site preparation (cutting, filling, and grading, sediment traps, barriers, diversions, drains, surface roughening)		
4.	Runoff control diversions, perimeter dikes, water bars, outlet protection		
5.	Inlet/outlet protection, sediment traps and/or sediment basin		
6.	Runoff conveyance system, stabilize stream banks, storm drains, channels, inlet and outlet protection, slope drains		
7.	Surface stabilization - temporary and permanent hydraulic mulching, hydroseeding, straw mulch, sodding, riprap		
8.	Building construction - buildings, utilities, paving etc.		
9.	Landscaping and final stabilization, top-soiling, trees and shrubs, permanent seeding, mulching, sodding, riprap		
10.	Removal of all structural controls where applicable		

1.6 Allowable Non-Stormwater Discharges

List of allowable non-stormwater discharges that will be present at the construction site:

No.	Type of Allowable Non-Stormwater Discharge	Likely to be Present at Construction Site?
1.	Fire hydrant flushing	<input type="checkbox"/> Yes <input type="checkbox"/> No
2.	Waters used to wash vehicles and equipment	<input type="checkbox"/> Yes <input type="checkbox"/> No
3.	Water used to control dust	<input type="checkbox"/> Yes <input type="checkbox"/> No
4.	Potable water including uncontaminated water line flushing	<input type="checkbox"/> Yes <input type="checkbox"/> No
5.	Routine external building wash down	<input type="checkbox"/> Yes <input type="checkbox"/> No
6.	Pavement washing waters	<input type="checkbox"/> Yes <input type="checkbox"/> No
7.	Uncontaminated air conditioning or compressor condensate	<input type="checkbox"/> Yes <input type="checkbox"/> No
8.	Uncontaminated, non-turbid discharges of ground water or spring water	<input type="checkbox"/> Yes <input type="checkbox"/> No
9.	Foundation or footing drains	<input type="checkbox"/> Yes <input type="checkbox"/> No
10.	Landscape Irrigation	<input type="checkbox"/> Yes <input type="checkbox"/> No
11.	Discharges from emergency fire-fighting activities	<input type="checkbox"/> Yes <input type="checkbox"/> No
12.	Uncontaminated construction dewatering water	<input type="checkbox"/> Yes <input type="checkbox"/> No

*(Note: You are required to identify the likely locations of these allowable non-stormwater discharges on your **site maps**.)*

Section 2: Site Description and Site Map

2.1 Receiving Waters/Discharge Information

Receiving Water body's Information: Stormwater discharges from this construction project will flow to the following receiving water body(ies).

No.	Name of the Receiving Waters	Is this surface water listed as impaired?	Cause of Impairment ¹	Has a TMDL ² been completed?	TMDL Pollutant(s)
1.		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	
2.		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	
3.		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	
4.		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	
5.		<input type="checkbox"/> Yes <input type="checkbox"/> No		<input type="checkbox"/> Yes <input type="checkbox"/> No	

(Note: Name of the receiving waters can be found at the DEQ website using the following link: <http://gis.deq.ok.gov/flexviewer/>. Cause of impairment and TMDL information can be found at the DEQ website using the following link: <http://www.deq.state.ok.us/WQDnew/waprogrms.html>)

¹ If you discharge to impaired water that is impaired for **Sediment and/or Turbidity and located within 1 mile**, you are required to comply with the additional requirements in Part 3.5.1 of OKR10 permit.

² Total Maximum Daily Load (TMDL)

Does the project/site discharge stormwater to an **Aquatic Resource of Concern (ARC)** or an **Outstanding Resource Water (ORW)**?

Yes No, If yes, I must comply with specific buffer requirements (see Part 3.5.2 of OKR10 permit) and stabilization deadlines requirements (see Part 3.5.2 of OKR10 permit).

Does the project/site discharge stormwater into a Municipal Separate Storm Sewer System (MS4)?

Yes No

If yes, what is the name of the MS4 operator? _____

Note: See Table R-5 in the [MS4 Permit's Factsheet](#) for the MS4s information.

2.2 General Location Map

Provide a general location map (e.g., DEQ GIS Data Viewer or U.S. Geological Survey (USGS) quadrangle map or aerial image from the internet) with enough detail to identify the location of your facility and all receiving waters for your stormwater discharges within one mile of the construction site (see Part 4.3.5.D of the OKR10 permit).

A **general location map** is included in **Attachment A** of this SWP3.

2.3 Site Map

SWP3 includes a legible site map or series of site maps/erosion and sediment control plans showing all the features (see also Part 4.3.5 of OKR10 permit) listed below:

- Pre-construction topographic view including vegetation, showing the location of
 - ✓ all surface water bodies within one mile of the site (including wetlands); and
 - ✓ direction of stormwater flow across the construction site (i.e., use arrows to show which direction stormwater will flow);
- Boundaries of property and identify the location(s) of:
 - ✓ Earth-disturbing activities;
 - ✓ boundary lines of any natural buffers;
 - ✓ approximate slopes before and after major grading activities,
 - ✓ areas of steep slopes, surface water crossings, Structures and other impervious surfaces upon completion of construction
- Locations of all structural and nonstructural controls/BMPs identified in the plan including showing the location of:
 - ✓ construction entrance/exit,
 - ✓ concrete wash-out area,
 - ✓ construction support activity areas such as locations of off-site materials, waste, borrow area, or equipment storage area;
 - ✓ stockpiled materials (sediment, topsoil, etc.), and
 - ✓ locations of all potential pollutant-generating activities;
- Locations where stormwater and allowable non-stormwater will be discharged off-site (should be continuously updated); sampling locations if project is subject to numeric limitations due to presence of an asphalt batch plant;
- Location where stabilization practices are expected to occur; Areas where final stabilization will be accomplished and no further construction phase permit requirements apply.

The **site map or series of maps** for this facility can be found in **Attachment B** of this SWP3 showing all the above-mentioned features in Part 2.3 of this SWP3.

Section 3: Construction Site Pollutants

3.1 Pollutant-Generating Activities

Potential sources of sediment to stormwater runoff:

Clearing and grubbing operations, grading and site excavation operations, vehicle tracking, topsoil stripping and stockpiling, landscaping operations

Potential sources of pollutants, other than sediment, to stormwater runoff:

- Combined Staging Area - small fueling activities, minor equipment maintenance, sanitary facilities, and hazardous waste storage.
- Materials Storage Area - general building materials, solvents, adhesives, paving materials, paints, aggregates, trash, etc.
- Construction Activity - paving, curb/gutter installation, concrete pouring/mortar/stucco, and building construction
- Concrete Washout Area

3.2 List of Potential Pollutants

List of Pollutants that can be present at the construction site:

(Note: Check all the boxes applicable to your project site; include additional pollutants, if necessary, in the space below)

Check	Materials/ Chemicals	Stormwater Pollutants	Location at the Site
<input type="checkbox"/>	Dirt from land disturbed area	Sediment	
<input type="checkbox"/>	Pesticides (insecticides, fungicides, herbicides, rodenticides)	Chlorinated hydrocarbons, organophosphates, carbonates, arsenic	
<input type="checkbox"/>	Fertilizer and dirt/soil	Nitrogen, phosphorous	
<input type="checkbox"/>	Plaster	Calcium sulphate, calcium carbonate, sulfuric acid	
<input type="checkbox"/>	Cleaning solvents	Perchloroethylene, methylene chloride, trichloroethylene, petroleum distillates	
<input type="checkbox"/>	Asphalt	Oil, petroleum distillates	
<input type="checkbox"/>	Concrete	Limestone, sand, pH, chromium	
<input type="checkbox"/>	Glue, adhesives	Polymers, epoxies	
<input type="checkbox"/>	Paints	Metal oxides, Stoddard solvent, talc, calcium carbonate, arsenic	
<input type="checkbox"/>	Curing compounds	Naphtha	

<input type="checkbox"/>	Wood preservatives	Stoddard solvent, petroleum distillates, arsenic, copper, chromium	
<input type="checkbox"/>	Hydraulic oil/fluids	Mineral oil	
<input type="checkbox"/>	Gasoline	Benzene, ethyl benzene, toluene, xylene, MTBE	
<input type="checkbox"/>	Diesel Fuel	Petroleum distillate, oil & grease, naphthalene, xylenes	
<input type="checkbox"/>	Antifreeze/coolant	Ethylene glycol, propylene glycol, heavy metals (copper, lead, zinc)	
<input type="checkbox"/>	Sanitary toilets	Bacteria, parasites, and viruses	
<input type="checkbox"/>			
<input type="checkbox"/>			
<input type="checkbox"/>			
<input type="checkbox"/>			

Section 4: Compliance with Federal and State Requirements

4.1 Endangered or Threatened Species Protection

Eligibility Criterion

Under which criterion listed in NOI is the construction project/site eligible for coverage under the OKR10 permit?

A

B

C

D

E

For reference purposes, the eligibility criteria listed in Part 1.2.2.E.2 of OKR10 permit are as follows:

- Criterion A.** The proposed construction site or land disturbing activity is not located within any of the corridors of the Federal or State identified Aquatic Resources of Concern, and further investigation is not required.
- Criterion B.** The proposed construction site or land disturbing activity is located within a corridor of a Federal or State identified Aquatic Resources of Concern. The SWP3 describes this area in relation to the identified water or watershed and specifies the measures to be employed to protect the endangered or threatened species or their critical habitat (see Parts 3.5.2 and 10 and Addendum A).
- Criterion C.** If one of those eligibility criteria under Part 1.2.2.E.2.b, d, or e cannot be met, applicants may use Addendum I Buffer Guidance to evaluate alternatives of buffer requirements and select equivalent sediment controls or contact DEQ for further consultation.
- Criterion D.** The applicant's federally approved construction activities are authorized by the appropriate Federal or State agency and that authorization addresses the Endangered Species Act Section 7 consultation for the applicant's stormwater discharge or stormwater discharge-related activities. Applicants selecting option d must include documentation from USFWS (U.S. Fish and Wildlife Service) or a qualified biologist that demonstrates Section 7 consultation has been completed. The SWP3 must comply with any conditions resulting from that consultation.
- Criterion E.** The applicant's stormwater discharges and stormwater discharge-related activities were already addressed in another operator's certification of eligibility under Part 1.2.2.E.2.a, b, c, or d. that included the applicant's project area. By certifying eligibility under Part 1.2.2.E.2.e, the applicant agrees to comply with applicable measures or controls upon which the other operator's certification under Part 1.2.2.E.2.b, c, or d. was based.

Note: For Criterion B, C, D, or E, you may subject to comply with additional requirements.

4.2 Federal, State, or Local Historic Preservation Laws

Will stormwater discharges or stormwater discharge-related activities (e.g., catch basin, pond, culver, etc.) affect a property that is protected by Federal, State, or local historic preservation laws? Yes No

If yes, describe any actions taken to mitigate those effects: [Click here to enter text.](#)

Describe how this determination was made: [Click here to enter text.](#)

4.3 TMDL Requirements

If a TMDL or watershed plan or local compliance plan has been approved for the waterbody, SWP3 must include all the applicable requirements in consistent with the TMDL or watershed plan or local compliance plan that are applicable to the stormwater discharges from the construction site.

Does the construction project/site discharge stormwater into a receiving stream that has an approved TMDL or watershed plan or local compliance plan?

Yes No

If yes, is there any waste load allocations (WLAs) and/or the TMDL's associated implementation plan requirements applicable to stormwater discharges from the construction activity?

Yes No

If yes, SWP3 must incorporate any limitations, conditions, or requirements applicable to permittee's discharges to ensure that the waste load allocations (WLAs) and/or the TMDL's associated implementation plan will be met within any timeframe established in the TMDL report or watershed plan. Monitoring and reporting of the discharges may also be required as appropriate to ensure compliance with the TMDL or watershed plan.

Note: *Approved TMDL reports or watershed plans can be downloaded from DEQ's website at <http://www.deq.state.ok.us/wqdnew/tmdl/index.html>*

Does the construction project/site discharge stormwater to the **Lake Thunderbird watershed**?

- Yes No

If **yes**, the following control measures will be used to meet the Lake Thunderbird TMDL requirements:

- Additional Pollutant Prevention or Discharge Monitoring** - You must comply with any additional requirements established by the local MS4 municipalities;
- Sites of Five Acres or Larger** - You must submit a copy of SWP3 to DEQ for review;
- Vegetated Buffer** - You must ensure that a vegetated buffer of at least 100 feet is retained or successfully established or planted between the area disturbed and all receiving streams. If the nature of the construction activity or the construction site makes a buffer impossible, you must provide equivalent controls. There are exceptions from this requirement for water crossings, limited water access, and stream restoration authorized under a CWA Section 404 permit;
- Sediment Basins** - For all drainage locations serving 5 or more acres disturbed at one time, you must use a temporary or permanent sediment basin and/or sediment traps to minimize sediment discharges;
- Site Inspection** - You must conduct site inspections once every 7 calendar days at a minimum, and within 24 hours of a storm event of 0.5 inches or greater and within 24 hours of a discharge caused by snowmelt;
- Corrective Actions** - You must implement corrective actions (e.g., repair, modify, or replace any stormwater control used at the site, clean up and dispose of spills, releases, or other deposits, or remedy a permit violation) by no later than 7 calendar days from the time of discovery. If it is infeasible to complete the installation or repair within 7 calendar days, you must document in your records why it is infeasible to complete the installation or repair within the 7 calendar days timeframe and document your schedule for installing the stormwater controls and making them operational as soon as practicable after the 7 days timeframe;
- Stabilization** - You must initiate stabilization measures immediately whenever earth-disturbing activities have permanently or temporarily ceased on any portion of the site and will not resume for a period exceeding 14 calendar days. You are required to complete the stabilization activities within 7 calendar days after the permanent or temporary cessation;
- Soil Nutrient Testing** - You are required to conduct a soil nutrient test to determine actual nutrient needs before applying fertilizer on your site. Fertilizer application must be limited to that necessary to meet actual needs on the site.
- Describe any additional measures or controls you will implement to comply with the Lake Thunderbird TMDL requirements: [Click here to enter text.](#)

Section 5: Stormwater Control Measures

The purpose of the implementation of different stormwater pollution controls is to reduce pollutants in the stormwater and the volume of stormwater leaving the construction site. All pollution control measures will be selected, installed, and maintained in accordance with the manufacturer's specifications and good engineering practices.

5.1 Stabilization Practices

Type of Site Stabilization Practice(s) that will be implementing at the construction project/site (select all that apply):

- Temporary Permanent Vegetative Non-Vegetative

Deadline to Initiate Stabilization: I shall initiate stabilization measures **immediately** whenever earth-disturbing activities have permanently or temporarily ceased on any portion of the site and will not resume for a period exceeding 14 calendar days.

Deadline to Complete Stabilization:

- I shall complete stabilization measures **as soon as practicable** but no later than 14 calendar days after the initiation of soil stabilization.
- My project/site is located in ARC/discharge to ORW; I shall complete stabilization measures **as soon as practicable** but no later than 7 calendar days after the initiation of soil stabilization.

Temporary Non-Vegetative Stabilization: The following **non-vegetative** controls/BMPs will be used to temporarily stabilize exposed portions of the construction site (*select all that apply*):

- Rolled erosion control products such as geotextiles, blankets or plastic cover Soil binders
- Straw mulch Wood mulch Compost Blanket Other, _____

If any of the above-referenced controls is used to temporarily protect areas that are being vegetative stabilized, one of the effective non-vegetative cover will be used to stabilize any such exposed portions of our site.

Temporary Vegetative Stabilization: The following **vegetative** controls will be used to temporarily stabilize the exposed portions of the construction site (*select all that apply*):

- Hydroseeding with mulch Sod Other, _____

Permanent Vegetative Stabilization: The following **vegetative** controls will be used to permanently stabilize the exposed portions of the construction site (*select all that apply*):

- Hydroseeding with mulch Sod Planted vegetation Other, _____

One of the following criteria will be used for vegetative cover:

- Provide a vegetative cover which covers 70% or more of the vegetation prior to commencing earth-disturbing activities and no large bare areas (10 square feet).

- Immediately after seeding, you must select, design, and install non-vegetative erosion controls that provide cover (such as **straw mulch, jute matting, and straw blankets**) to the area while vegetation is being established.

Stabilization Practices Record: A record of the dates when grading activities occur, when construction activities temporarily or permanently cease on a portion of the site, and when stabilization measures are initiated shall be included with the plan. Yes No

If No, explain: _____

A record of the dates when grading activities occur will be documented using the Grading & Stabilization Activity logs in **Attachment-I** of this SWP3.

5.2 Natural Buffers and/or Equivalent Sediment Controls

Buffer Compliance Alternatives

Are there any **waters of the State** that are located within 50 feet (or 100 feet if the construction site is located in ARC or ORW or Lake Thunderbird Watershed) of your construction disturbances as measured from the top of the bank to the disturbed portions of your site? Yes No

(Note: Waters of the State means all named/unnamed stream, creeks, rivers, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, storm sewers and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private located within the boundary of Oklahoma State.)

Construction Project/Site Location (check one only):

- My construction project/site isn't located in **ARC** or discharge to **ORW**
- My construction project/site is located in **ARC or ORW**
- My construction project/site is located in Lake Thunderbird Watershed or in a watershed with established TMDL that has Wasteload Allocation (WLA) for Construction Project

Check the compliance alternative that you have chosen:

- I will provide and maintain a 50 feet (or **100 feet** if the construction site is located in ARC or ORW or Lake Thunderbird Watershed) undisturbed natural buffer.

(Note (1): You must show the boundary line of the natural buffer on your site map.)

(Note (2): You must show on your site map how all discharges from your construction disturbances through the natural buffer area will first be treated by the site's erosion and sediment controls.)

- I will provide and maintain an undisturbed natural buffer that is less than 50 feet (or **100 feet** if the construction site is located in ARC or ORW or Lake Thunderbird Watershed) and is supplemented by additional erosion and sediment controls, which in combination achieves the sediment load reduction equivalent to required undisturbed natural buffer.

(Note (1): You must show the boundary line of the natural buffer on your site map.)

(Note (2): You must show on your site map how all discharges from your construction disturbances through the natural buffer area will first be treated by the site's erosion and sediment controls.)

- i. Width of natural buffer to be retained: _____
- ii. Method used to determine equivalent sediment load reduction:

- Addendum-I: Buffer Guidance in OKR10 permit
 - a. Soil Type: _____
 - b. Buffer Vegetation: _____

OR

- Site-specific calculation
 - a. Model or other tool used to estimate sediment load reductions:

 - b. Results of calculations: _____

 - c. Description of additional erosion and sediment controls used:

It is infeasible to provide and maintain an undisturbed natural buffer of any size; therefore, I will implement erosion and sediment controls that will achieve the sediment load reduction equivalent to a 50 feet (or 100 feet if the construction site is located in ARC or ORW or Lake Thunderbird Watershed) undisturbed natural buffer.

i. Rationale for concluding that it is infeasible to provide and maintain a natural buffer of any size:

ii. Method used to determine equivalent sediment load reduction:

- Addendum-I: Buffer Guidance in OKR10 permit
 - a. Soil Type: _____
 - b. Buffer Vegetation: _____

OR

- Site-specific calculation
 - a. Model or other tool used to estimate sediment load reductions:

 - b. Results of calculations: _____

 - c. Description of additional erosion and sediment controls used:

I qualify for one of the following exceptions (*select one that applies to your project/site*):

- There is no discharge of stormwater to the surface water that is located 50 feet from my construction disturbances.
- No natural buffer exists due to preexisting development disturbances that occurred prior to the initiation of planning for this project.
- Buffer disturbances are authorized under a CWA Section 404 permit.
- Buffer disturbances will occur for the construction of a water-dependent structure or water access area (e.g., pier, boat ramp, and trail).

5.3 Structural Controls/Best Management Practices (BMPs)

The table below listed Structural and Non-Structural Stormwater Controls/Best Management Practices (BMPs) that should be considered for every construction project/site to meet **the non-numeric technology-based effluent limitations, water-based effluent limitations and applicable numeric technology-based effluent limitations.**

The following BMPs will be used or implemented at the construction project/site (*select all that apply*):

Erosion Controls		Sediment Controls	
<input type="checkbox"/>	Preservation of Existing Vegetation	<input type="checkbox"/>	Silt Fence
<input type="checkbox"/>	Vegetative Swales	<input type="checkbox"/>	Silt Dikes
<input type="checkbox"/>	Hydroseeding with Mulch	<input type="checkbox"/>	Compost Sock
<input type="checkbox"/>	Hydraulic Mulch	<input type="checkbox"/>	Check Dam
<input type="checkbox"/>	Wood Mulching	<input type="checkbox"/>	Fiber Rolls
<input type="checkbox"/>	Straw Mulching	<input type="checkbox"/>	Storm Drain Inlet Protection
<input type="checkbox"/>	Compost Blankets	<input type="checkbox"/>	Outlet Protection/Velocity Dissipation Devices
<input type="checkbox"/>	Soil Binders	<input type="checkbox"/>	Earth Berms and Drainage Swales
<input type="checkbox"/>	Geotextiles and Mats	<input type="checkbox"/>	Sand Bag Barrier
<input type="checkbox"/>	Soil Preparation/Roughening	<input type="checkbox"/>	Gravel Bag Berm/Barrier
<input type="checkbox"/>	Sod	<input type="checkbox"/>	Sediment Basin
<input type="checkbox"/>	Streambank Stabilization	<input type="checkbox"/>	Sediment Trap
Tracking Controls		<input type="checkbox"/>	Rip-rap
<input type="checkbox"/>	Stabilized Construction Entrance/Exit	<input type="checkbox"/>	Gabions
<input type="checkbox"/>	Stabilized Construction Roadway	Non-Structural Controls	
<input type="checkbox"/>	Entrance/Exit Tire Wash	<input type="checkbox"/>	Phasing and Scheduling
<input type="checkbox"/>	Street Sweeping and Vacuuming	<input type="checkbox"/>	Dust Suppression
Other Structural Controls		<input type="checkbox"/>	Dust Suppression
<input type="checkbox"/>	Vegetative Buffers	<input type="checkbox"/>	Good Housekeeping
<input type="checkbox"/>	Non-Vegetative Stabilization	<input type="checkbox"/>	Preventive Maintenance
<input type="checkbox"/>	Concrete Waste Management	<input type="checkbox"/>	Preservation of Top Soil
<input type="checkbox"/>	Dewatering Controls	<input type="checkbox"/>	Minimizing Soil Compaction
<input type="checkbox"/>		<input type="checkbox"/>	Fertilizer Application Management
<input type="checkbox"/>		<input type="checkbox"/>	

Did you **include specifications** of all the selected structural BMPs with the SWP3?

Yes No, if no, explain the reason: [Click here to enter text.](#)

5.3.1 Perimeter Control

Permit requirement: *You must install controls along the perimeter of your site that will receive stormwater from your construction activities. (Examples of perimeter controls include, but are not limited to, silt fences, fiber rolls, filter berms, and temporary diversion dikes.)*

To comply with Part 3.3.1.C of OKR10 permit, I shall use the following type of perimeter control(s) at my construction site:

Perimeter Control Description: _____

Installation Date(s): _____

Maintenance Requirements: I shall remove sediment before it has accumulated to one-half of the above-ground height of any perimeter control. Silt fence will be inspected for rips or tears in the fabric, areas where the fence has been knocked down and areas where the fence has been undermined.

5.3.2 Sediment Track-Out

Permit requirement: *You must minimize the track-out of sediment onto off-site streets, other paved areas, and sidewalks from vehicles exiting your construction site. (Note: you may use most recent ODOT or OKC specifications for construction entrance/exit - use of aggregate stone with an underlying geotextile or non-woven filter fabric, or turf mats.)*

To comply with the Part 3.3.1.D of OKR10 permit, I shall use the following type of sediment track-out control at my construction site:

Track-Out Control/Construction Entrance/Exit Description: _____

Installation Date(s): _____

Maintenance Requirements: I shall minimize the track-out of sediment onto off-site streets, other paved areas, and sidewalks from vehicles exiting our construction site.

Track-out Removal/Cleaning:

- I shall remove the track-out by sweeping, shoveling, or vacuuming these surfaces, or by using other similarly effective means of sediment removal.
- I shall remove the deposited sediment by the **end of the same work day** in which the track-out occurs or by the end of the next work day if track-out occurs on a non-work day where sediment has been tracked-out from my construction site onto the surface of off-site streets, other paved areas, and sidewalks.
- I am prohibited from hosing or sweeping tracked-out sediment into any stormwater conveyance (unless it is connected to a sediment basin, sediment trap, or similarly effective control).

5.3.3 Stockpiled Sediment or Soil

Permit requirement: *You must control discharge of stormwater from Stockpiled Sediment or Soil.*

To comply with the Part 3.3.1.E of OKR10 permit, I shall use temporary perimeter sediment barrier such as *berms, dikes, fiber rolls, silt fences, sandbag, or gravel bags* to protect from contact with stormwater (including run-on).

I shall use appropriate cover or temporary stabilization such as *mulching or hydro-mulching* to avoid direct contact with precipitation or to minimize sediment discharge.

Installation Date(s): _____

Maintenance Requirements: I shall not hose down or sweep soil or sediment accumulated on pavement or other impervious surfaces into any stormwater conveyance (unless connected to a sediment basin, sediment trap, or similarly effective control), storm drain inlet, and/or surface water.

5.3.4 Minimize Dust

Permit requirement: *You must minimize the generation of dust to avoid pollutant discharges to the extent feasible through application of water or other dust suppression techniques.*

Dust Control Description: To comply with the permit requirement and to avoid any pollutants, particularly soil/sediment, from being discharged into surface waters, I shall apply/spray water using spray truck or sprinklers to minimize the generation of dust from my construction site.

5.3.5 Minimize the Disturbance of Steep Slopes

Permit requirement: *You must minimize the disturbance of steep slopes (i.e., slopes of 40% or greater).*

Steep Slope Control Description: _____

Installation Date(s): _____

Maintenance Requirements: [Click here to enter text.](#)

5.3.6 Preserve Topsoil

Permit requirement: *You must preserve native topsoil on your site, unless infeasible; you must stockpile and reuse it in areas that will be stabilized with vegetation.*

Topsoil Control Description: I shall preserve native topsoil on our site as much as possible and practicable.

Maintenance Requirements: I shall stockpile and reuse preserved top soil in areas that will be stabilized with vegetation.

5.3.7 Minimize Soil Compaction

Permit requirement: *In areas of your site where final vegetative stabilization will occur or where infiltration practices will be installed, you must minimize soil compaction.*

Soil Compaction Control Description: In areas of your site where final vegetative stabilization will occur or where infiltration practices will be installed, I shall restrict vehicle and/or equipment use in these areas to avoid or minimize soil compaction.

5.3.8 Protection of Storm Drain Inlets

Permit requirement: *If you discharge to a storm drain inlet that you have access to, you must install protection measures that remove sediment from your stormwater discharge. (Examples of inlet protection measures include **fabric filters, sandbags, or gravel barriers** -- Install inlet protection measures that remove sediment from your discharge prior to entry into the storm drain inlet.)*

Storm Drain Inlet Control Description: [Click here to enter text.](#)

Installation Date(s): _____

Maintenance Requirements: I shall clean, or remove and replace the protection measures as sediment accumulates, the filter becomes clogged, and/or performance is compromised. Where there is evidence of sediment accumulation adjacent to the inlet protection measure, I shall remove the deposited sediment by **the end of the same work day** in which it is found or by the end of the following work day if removal by the same work day is not feasible.

5.3.9 Constructed Stormwater Conveyance Channels

(Note: Examples of velocity dissipation devices include check dams, sediment traps, riprap, or grouted riprap at outlets, include design specifications)

Stormwater Conveyance Channel Control Description: [Click here to enter text.](#)

- If Silt dikes/Check dams are **used in series**, I shall space them at appropriate interval so that **the base of the upstream dike is at the same elevation as the top of the next downstream dike**. Spacing of silt dikes/check dams is indicated on the site plans of SWP3.

Installation Date(s): _____

Maintenance Requirements: all check dams/rip-rap will be inspected during facility inspection for erosion, undermining or breeches. Any damage will be repaired immediately.

5.3.10 Sediment Basins

Permit requirement: For common drainage locations that serve an area of 10 or more acres disturbed at one time (or 5 acres if it is located in ARC), a temporary (or permanent) sediment basin shall be provided where attainable until final stabilization of the site.

Are 10 or more (or 5 or more if site discharges to an ORW/ARC) acres draining to a common point?

- Yes No

Is a sediment basin included in the project? Yes No

If yes, what is the designed capacity for the storage?

- 3600 cubic feet per acre: _____

OR

- 2-year, 24 hour storm: _____

OR

- Other criteria were used to design basin: _____

If no, explain why no sedimentation basin was included and describe required natural buffer areas and other controls implemented instead: _____

Maintenance Requirements: I shall keep the sediment basin in effective operating condition and remove accumulated sediment to maintain at least ½ of the design capacity of the sediment basin at all times.

5.3.11 Dewatering Practices

Permit requirement: *You are prohibited from discharging stormwater that is removed from excavations, trenches, foundations, vaults, or other similar points of accumulation associated with a construction activity, unless such waters are first effectively managed by appropriate controls.*

Dewatering Practice Description: [Click here to enter text.](#)

Installation Date(s): _____

Maintenance Requirements: [Click here to enter text.](#)

5.3.12 Other Stormwater Controls

Stormwater Control Practice # 1

Description: [Click here to enter text.](#)

Installation Date(s): _____

Maintenance Requirements: [Click here to enter text.](#)

Stormwater Control Practice # 2

Description: [Click here to enter text.](#)

Installation Date(s): _____

Maintenance Requirements: [Click here to enter text.](#)

Section 6: Pollution Prevention Controls

6.1 Spill Prevention and Responses

Spill Prevention

Is there an existing Spill Prevention Control and Countermeasure (SPCC) plan developed for the site?

Yes No, if yes, keep a copy of the SPCC plan onsite with this SWP3.

If No, describe procedures for quickly stopping, containing, and cleaning up spills, leaks, and other releases:

Emergency Spill Notification

In case of a toxic or hazardous material spill, notify:	Phone Numbers
Project Manager/Team Leader	
Emergency – Fire, Police	911
County Local Emergency Planning Committee (LEPC)	
DEQ Spill Reporting Hotline (24-hr)	800-522-0206
NRC (National Response Center)	800-424-8802

6.2 Waste Management Procedures

All wastes generated at the construction site, including, but not limited to, clearing and demolition debris, sediment removed from the site, construction and domestic waste, hazardous or toxic waste, and sanitary waste, shall be prevented from being discharged to Waters of the State. The following BMP measures will be used to handle trash disposal, hazardous or toxic waste, sanitary waste, recycling, and proper material handling:

- Trash Dumpsters:** dumpsters will have a secure watertight lid, will be closed during precipitation or not in use, and will be placed away from stormwater conveyances and drains, and meet all federal, state, and municipal regulations. Only trash and construction debris from the site will be deposited in the dumpster. No construction materials will be buried on site.

- Hazardous Waste Containment:** hazardous waste materials will be stored in appropriate and clearly marked containers and segregated from other non-waste materials.

- Portable Toilets:** portable toilets will be secured to prevent tipping, located away from stormwater inlets and conveyances. These toilets will be anchored with the ground to prevent any tipped or knocked over and/or sand bags around to ensure wastewater doesn't mix with the stormwater.

- Recycling Bins/Dumpsters:** wood pallets, cardboard boxes, and other recyclable construction scraps will be disposed of in a designated dumpster for recycling. The dumpster will have a secure watertight lid, will be closed during precipitation or not in use, and will be placed away from stormwater conveyances and drains and meet all local and state solid-waste management regulations.

- Proper Material Handling:** containers will be tightly sealed when not in use, and excess paint shall be disposed of according to Oklahoma requirements and manufacturer's recommendations. Minimum amounts of fertilizer, as recommended by the manufacturer, will be used. Upon application the fertilizer will be worked into the soil to limit exposure to stormwater. Contents of partially used bags will be transferred to a sealable plastic bin, and then stored in a covered area.

- Good housekeeping:** construction debris, trash, and other floatable material will be collected and prevented from becoming a pollutant source on the following schedule:
[Click here to enter text.](#)

- Minimizing exposure:** construction products, materials, chemicals, and wastes will be stored in such a way that they are prevented from coming into contact with stormwater (e.g., plastic sheeting or temporary roofs).

- Designated concrete washout:** all concrete washwater will be directed into a leak-proof container or pit. The container or pit will be designed so that no overflows can occur due to inadequate sizing or precipitation and located as far away as possible from surface waters and stormwater inlets or conveyances. I shall use *compacted clay liner, 20 mil synthetic liners or similar equivalent liners* to make the pit leak proof.

- Other: [Click here to enter text.](#)

6.3 Prohibited Discharges

The following discharges from the construction project/site are prohibited under the permit, and are considered a violation should any occur.

- Wastewater from the washout of concrete, unless managed by an appropriate control as described in Part 3.3.3.B.4 of OKR10 permit;
- Wastewater from the washout and cleanout of stucco, paint, form release oils, curing compounds and other construction materials, unless managed by an appropriate control as described in Part 3.3.3.B.4 of OKR10 permit;
- Fuels, oils, or other pollutants used in vehicle and equipment operation and maintenance;
- Soaps, detergents or solvents used in vehicle and equipment washing; and
- Toxic or hazardous substances from a spill or other release.

In the event that one of these above-mentioned discharges occurs, I will take corrective action consistent with Part 7.4 of this SWP3.

Section 7: Procedures and Documentations

7.1 Maintenance and Repair

I shall ensure that all pollution prevention controls installed in accordance with the requirements of OPDES Construction General Permit OKR10 and remain in effective operating condition and are protected from activities that would reduce their effectiveness. All structural BMPs (i.e. all the Erosion & Sediment Controls) that require a repair of any kind (due to normal wear and tear, or as a result of damage) or require maintenance in order for the control to continue operating effectively shall be required/maintained in accordance with the OPDES Construction General Permit requirements. At a minimum, maintenance will be performed in the following specific instances:

- for perimeter controls, whenever sediment has accumulated to $\frac{1}{2}$ or more the above-ground height of the control (Part 3.3.1.C of OKR10 permit);
- where sediment has been tracked-out onto the surface of off-site streets or other paved areas (Part 3.3.1.D of OKR10 permit);
- for inlet protection measures, when sediment accumulates, the filter becomes clogged, and/or performance is compromised (Part 3.3.1.J of OKR10 permit); and
- for sediment basins, as necessary to maintain at least $\frac{1}{2}$ of the design capacity of the basin (Part 3.3.1.L of OKR10 permit).
- for all structural BMPs, repair of any kind (due to normal wear and tear, or as a result of damage) or maintenance will be performed in order for the BMPs to continue operating effectively.

7.2 Approval from Local Office

- I shall check/already checked local offices (city and county offices) to ensure SWP3 for my construction activities is consistent with requirements of the City and/or County Offices.
- I shall update the SWP3, if necessary, to make consistent with any changes applicable to protecting surface water resources in sediment erosion site plans or site permits, or stormwater management site plans or site permits approved by local officials for which I received written notice.

7.3 Inspections

(Note: An inspector must be knowledgeable in the principles and practices of erosion and sediment controls and pollution prevention to assess conditions at the construction site that could impact stormwater quality, and the effectiveness of any stormwater controls.)

Person Responsible for Inspections: [Click here to enter text.](#)

General Procedures: During each inspection, the following areas of the construction site will be inspected:

- Cleared, graded, or excavated areas of the site;
- Stormwater controls (e.g., perimeter controls, silt dykes, check dams, sediment basins, inlets, exit points etc.) and pollution prevention practices (e.g., pollution prevention practices for vehicle fueling/maintenance and washing, construction product storage, handling, and disposal, etc.) at the site;
- Material, waste, or borrow areas covered by the permit, and equipment storage and maintenance areas;
- Evidence of a spill, leak, or other type of pollutant discharge, or failure to have properly cleaned up a previous spill, leak, or other type of pollutant discharge;
- Areas where stormwater flows within the site, stormwater discharge points;
- Identify any other incidents of non-compliances observed; and
- Areas where stabilization has been implemented.

Inspection Frequency:

- Once every 7 calendar days** and within 24 hours of the end of a storm event of 0.5 inches or greater, since my project is located in **ARC** or discharge to an impaired water.
- Once every 14 calendar days** and within 24 hours of the end of a storm event of 0.5 inches or greater.

Reductions in Inspection Frequency (if applicable):

- For the reduction in inspections resulting from stabilization: **Once per month** for the portion of the site that was stabilized per Part 3.3.2 of OKR10 permit.

Rain Gauge to Measure Qualified Storm Event of 0.5 inches or greater:

Location of the Rain Gauge: [Click here to enter text.](#)

Inspection Report Forms:

Inspection Report Form has been prepared in accordance with the requirements of Part 4.3.13 of OKR10 permit. A copy of the Inspection Report Form that will be used during construction of this project included in [Attachment E](#) of this SWP3.

7.4 Corrective Action

General: Corrective actions are actions taken to modify, replace, or reinstall any stormwater control used at the site; clean up and dispose of spills, releases, or other deposits; or remedy a permit violation.

Corrective actions are triggered only for specific, more serious conditions. For any of the following conditions, a new or modified control shall be installed **no later than 7 calendar days** from the discovery:

- A required stormwater control was never installed or was installed incorrectly, or not in accordance with the corresponding OKR10 permit requirement;
- A stormwater controls needs to be repaired or replaced (beyond routine maintenance required in Part 4.3.12 of OKR10 permit);
- A stormwater control is not effective enough for the discharge to meet applicable water quality standards;
- A prohibited discharge (Parts 3.1 and 3.3.3.A of OKR10 permit) is occurring or has occurred; or
- DEQ or MS4 Operator requires corrective action as a result of permit violations found during a inspection.

- I shall immediately take all reasonable steps to minimize or prevent the discharge of pollutants until a permanent solution is installed and made operational, including cleaning up any contaminated surfaces so that the material will not discharge in subsequent storm events. I shall conduct corrective action(s) for each of the above-mentioned triggering conditions should they occur at my construction site.

Person Responsible for Corrective Actions: [Click here to enter text.](#)

Corrective Action Schedule/Specific Action Frequency:

- I shall perform all Corrective Actions (modify, replace, or reinstall), if identified, **no later than 7 calendar days** from the time of discovery.

Corrective Action Forms:

Corrective Action Report Form has been prepared in accordance with the requirements of Part 4.3.14 of OKR10 permit. A copy of the Corrective Action Report Form that will be used during construction of this project included in [Attachment F](#) of this SWP3.

7.5 Employee Training

Person Responsible for Staff Training

Name: _____ Title: _____

Staff Training Requirements

Prior to the start of earth-disturbing activities, personal with the following responsibilities shall be trained to understand all the requirements of this SWP3:

- Proper design, installation, and maintenance/repair of stormwater controls.
- The proper application and storage of chemicals.
- Proper Inspection and corrective actions.

At minimum, all Personnel must be trained to understand:

- The location of all stormwater controls and the maintenance requirements for each of the control.
- The pollution prevention requirements outlined in this SWP3.
- When and how to conduct inspections, record applicable findings and take necessary corrective actions.

Frequency/Schedule of Employee Training: _____

(Note: Employee training shall be conducted at least annually or more often if employee turnover is high).

Employee training records and documentations shall be maintained using the **Employee Training Report** located in **Attachment G** of this SWP3.

7.6 Notification of Change of Ownership (NCO) for Individual Lots

- SWP3 will include documents if lots are sold and transfer to other new operator(s), (see Part 2.2.3 of OKR10 permit). Documents will be included under **Attachment M** of this SWP3.
- NCO is not applicable to my project/site.

7.7 Sub-contractor Certifications

- Sub-contractor certification forms will not be used for this project.
- DEQ's sub-contractor certification form (**Attachment M**) will be used and kept onsite with the SWP3.
- A form other than DEQ's form will be used and kept onsite with the SWP3.

7.8 Record Keeping and Record Retention

- I shall retain copies of the SWP3 and all reports required by the 2017 OKR10 permit, and records of all data used to complete the NOI to be covered by this permit, for a **period of at least 3 years** from the date that the site is finally stabilized.

7.9 Posting a Notice

- I shall post a notice near the main entrance of the construction site with the following information:
 - The OPDES permit number for the project or a copy of the NOI if a permit number has not yet been assigned;
 - The name and telephone number of a local contact person;
 - A brief description of the project; and
 - Location of the SWP3

A **sample copy of the Notice** is included in **Attachment M** of this SWP3.

Section 8: Additional Monitoring (if applicable)

(Note: Only applicable if you have Concrete Batch Plant and/or Asphalt Plant that is covered under your OKR10 authorization)

8.1 Support Activity Covered by this Plan

Concrete Batch Plant Asphalt Plant Both Not Applicable

8.2 Representative Outfall(s)

Are there substantially identical outfalls? Yes No

If yes, which outfalls are substantially identical? _____

Which outfall(s) will be sampled? _____

8.3 Structural & Non-Structural BMPs

Perimeter control and retention/detention pond will be installed. All exposed areas will be kept clean and orderly manner to minimize exposure. Structural controls will be maintained to keep these effective and operational.

8.4 Quarterly Visual Monitoring

In addition to routine site inspection, quarterly visual monitoring, qualified facility inspector will perform quarterly visual monitoring:

1. Quarterly visual monitoring assessments will be conducted using the form in **Attachment J** of this SWP3. Each drainage point will be visually inspected on a quarterly basis. If no qualifying storm event occurs during a monitoring quarter, this will be noted on the quarterly visual monitoring report for that quarter.
2. Samples will be collected from each outfall, will be examined and documented observations of color, odor, clarity, floating solids, settled solids, suspended solids, foam, oil sheen, and other obvious indicators of stormwater pollution using the quarterly visual monitoring form and will occur during daylight hours (e.g., normal working hours).
3. Completed quarterly visual monitoring forms will be kept with the SWP3.

8.5 Comprehensive Site Compliance Evaluation

1. A comprehensive site compliance evaluation will be conducted at least once annually. If the project is less than one year, at least one inspection will be conducted, which will include all areas where industrial materials or activities are exposed to stormwater and areas where spills and leaks have occurred within the past **3 years**.

2. A report resulting from this inspection will be submitted to DEQ by **March 1** of the year following the monitoring period using the form in **Attachment K** of this SWP3.

8.6 Numeric Effluent Limitation Monitoring for Asphalt Plant

1. Stormwater discharges from asphalt plants must comply with the limitations and monitoring requirements listed below.

Parameter	Limitation	Monitoring Frequency	Sample Type
Total Suspended Solids	23 mg/L, daily max.	1/year	Grab
	15 mg/L, 30-day avg.		
Oil and Grease	15 mg/L, daily max.	1/year	Grab
	10 mg/L, 30-day avg.		
pH	6.5 - 9.0, min. and max.	1/year	Grab

2. Annual monitoring period is from **January 1 to December 31**. If the project is less than one year, at least one sample must be collected.
3. Laboratory analyses for the parameters specified above must be performed by a laboratory certified by DEQ for those parameters.
4. Monitoring will be performed on a storm event that results in an actual discharge from the construction site (at least **0.1 inch** of stormwater event defined as a **measurable storm event**) that follows the preceding measurable storm event by at least 72 hours (3 days).
5. A minimum of one grab sample will be collected within the first 30 minutes of the discharge resulting from a measurable storm event. If it is not practicable to take the sample during the first 30 minutes, the sample must be collected as soon as practicable after the first 30 minutes and document why it was not possible to take samples within 30 minutes.
6. Monitoring information will be submitted on a discharge monitoring report (DMR) form (see **Attachment L**) by **March 1** of the year following the monitoring period.
7. If an exceedance of a numeric effluent limit occurs, follow-up monitoring will be conducted within 30 calendar days, or during the next qualifying storm event, of implementing corrective actions.

Person(s) and positions of person(s) responsible for monitoring: [Click here to enter text.](#)

Sample location(s): [Click here to enter text.](#)

Monitoring Schedules: [Click here to enter text.](#)

8.7 Additional Procedures for Concrete Batch Plant

Is there a mobile batch plant associated with this construction project/site?

No Yes, If yes, permit number: OKG11_____

How long will the batch plant be utilized?

Less than 180 days
 Greater than 180 days

Will wastewater be used for dust suppression?

No Yes, If yes, the following requirements must be met:

- a. The wastewater to be land applied shall be free from visible sheen of oil or globules of oil or grease and shall have a pH of between 6.5 s.u. and 9.0 s.u.
- b. The wastewater to be land applied for dust suppression shall be visually inspected prior to land application. An inspection log shall be maintained at the site and made available to DEQ personnel upon request.
- c. There shall be no land application of wastewater in areas where the depth to maximum seasonal groundwater level is less than 2 feet in accordance with OAC 252:616-5-1(b)(2)(E).
- d. There shall be no land application of wastewater during periods of precipitation or when soil is saturated or frozen.
- e. There shall be no runoff of wastewater from the land application site(s).
- f. The permittee shall keep a logbook which records the time and date, the source and the volume of wastewater used, and the area to which the wastewater .

Describe the liner used for any surface impoundments: [Click here to enter text.](#)

Is the bottom of all surface impoundments at least 15 feet above groundwater levels?

No Yes

The following berm/dike slope requirement will be followed:

- For sites utilized less than 180 days, a 1:2 (1 vertical to 2 horizontal) slope
- For sites utilized more than 180 days, a 1:3 (1 vertical to 3 horizontal) slope

Section 9: SWP3 Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: _____ **Title:** _____

Signature: _____ **Date:** _____

Section 10: SWP3 Modifications

I shall maintain records of modifications that will be made per Part 4.3.19 of OKR10 permit, and other reasons in **Attachment H** of this SWP3:

[Click here to enter text.](#)

Section 11: SWP3 Attachments & Additional Documentation

The following documentations are attached to the SWP3:

Attachment A – General Location Map

A copy of general location map is included in Attachment A.

Attachment B – Site Map(s)

Copy of the site map(s) is/are included in Attachment B.

Attachment C – 2017 OKR10

Note: it is helpful to keep a printed-out copy of the 2017 OKR10 so that it is accessible to you for easy reference. However, you do not need to formally incorporate the entire 2017 OKR10 into your SWP3. As an alternative, you can include a reference to the permit and where it is kept at the site.

Attachment D – Notice of Intent (NOI)

A copy of your NOI is included in Attachment D.

Attachment E – Inspection Report

A copy of the Routine Facility Inspection Report Form is included in Attachment E.

Attachment F – Corrective Action Report

A copy of Corrective Action Report Form is included in Attachment F.

Attachment G – Employee Training Report

A copy of Employee Training Log is included in Attachment G.

Attachment H – SWP3 Modifications Log

A copy of Report on SWP3 Modifications/Amendments Log is included in Attachment H.

Attachment I – Site Stabilization Log

A copy of Site Stabilization Log is included in Attachment I.

Attachment J – Quarterly Visual Monitoring Report

A copy of Quarterly Visual Monitoring Report Form is included in Attachment J.

Attachment K – Annual Site Evaluation Report

A copy of Annual Comprehensive Site Compliance Evaluation Report (ACSCER) form is included in Attachment K.

Attachment L – Discharge Monitoring Report (DMR)

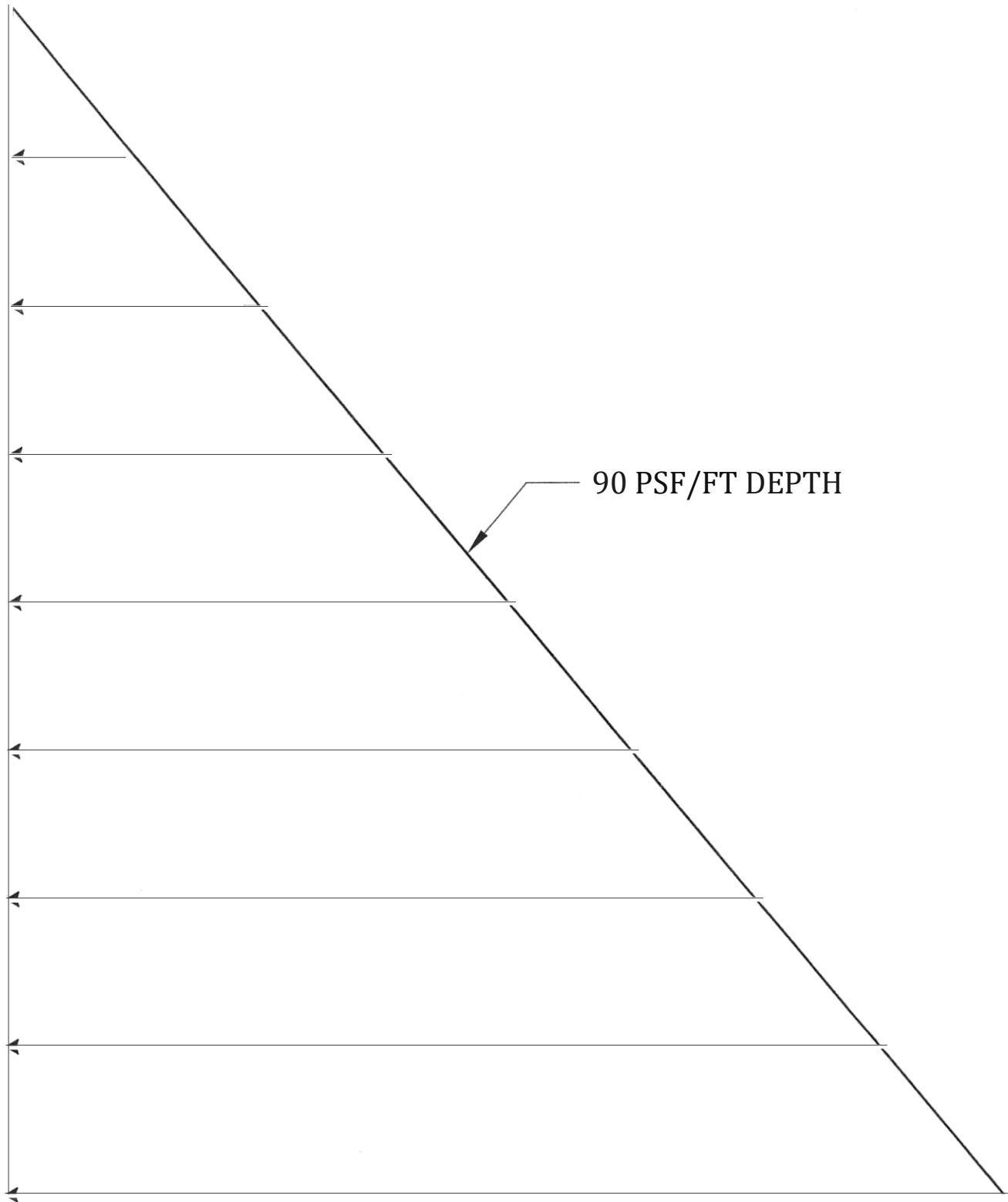
A copy of Discharge Monitoring Report (DMR) is included in Attachment L.

Attachment M – NCOs and Other Documentations

Any other Documentation required by this Permit is included in Attachment M.

**APPENDIX D:
GEOTECHNICAL RELATIONSHIPS DOCUMENTS**

Equivalent Fluid Pressure Diagram



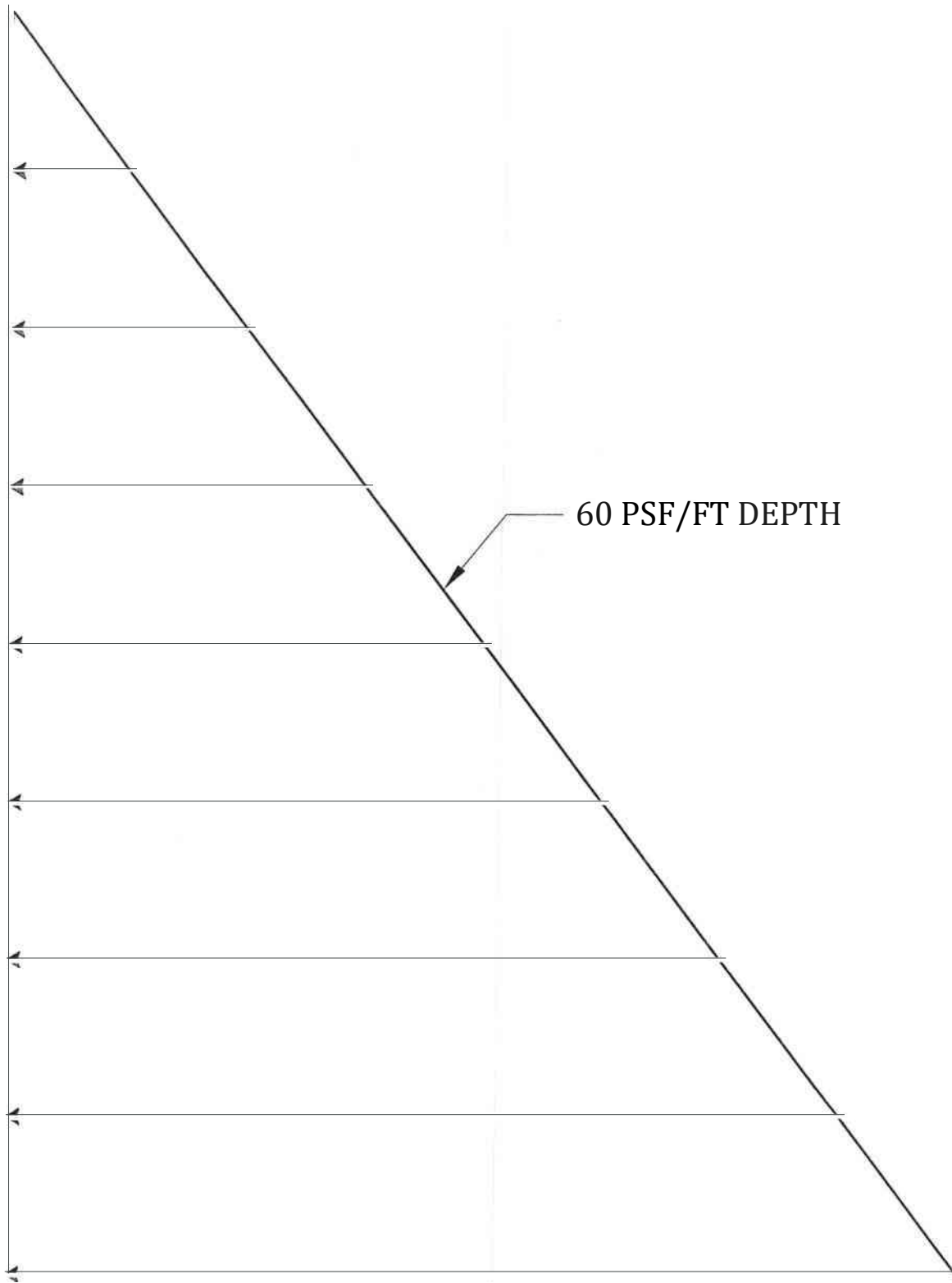
Recommend Minimum Saturated Lateral Earth Pressure



CITY OF
BROKEN ARROW
Where opportunity lives

*Engineering & Construction Department
Equivalent Fluid Pressure Diagram
Exhibit C-1*

Equivalent Fluid Pressure Diagram



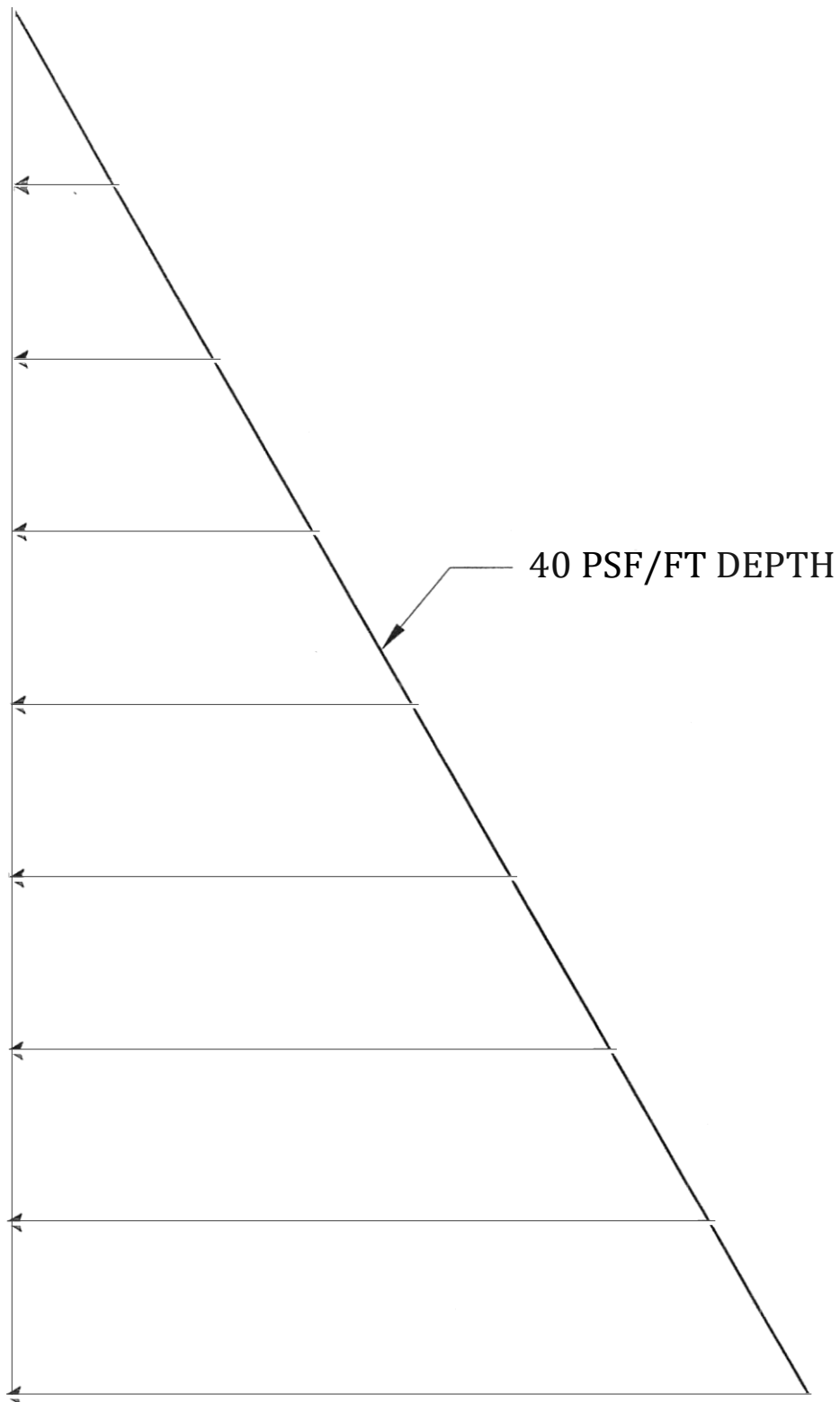
Recommend Minimum "At-Rest" Lateral Earth Pressure



CITY OF
BROKEN ARROW
Where opportunity

*Engineering & Construction Department
Equivalent Fluid Pressure Diagram
Exhibit C-2*

Equivalent Fluid Pressure Diagram



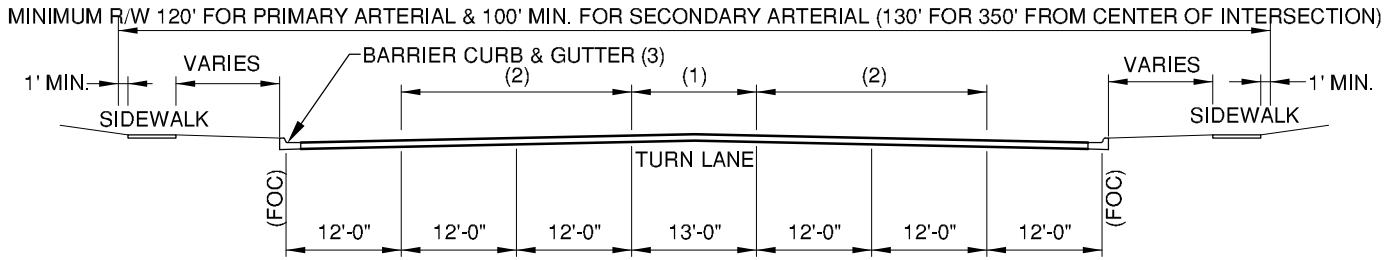
Recommend Minimum Active Lateral Earth Pressure



**APPENDIX E:
TRANSPORTATION FACILITIES DOCUMENTS**

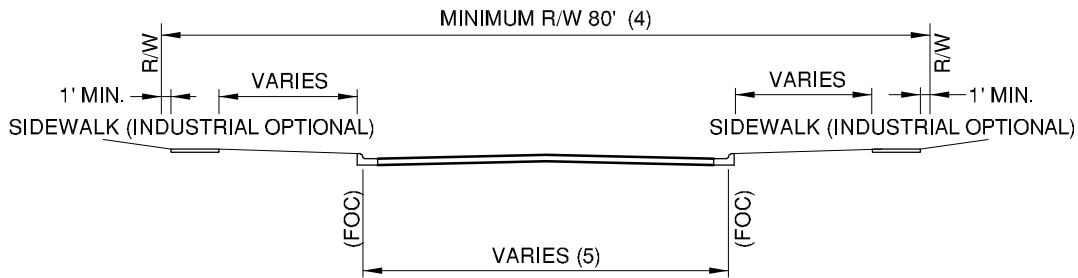
EXHIBIT 6.1

STREET AND ROADWAY STANDARDS



- (1) OMIT TURN LANE ON TWO, FOUR OR SIX LANE ARTERIALS.
- (2) 7-LANE ARTERIAL SHOWN. OMIT LANE/LANES FOR THREE OR FIVE-LANE ARTERIALS.
- (3) 6" BARRIER CURB AND GUTTER FOR 4 AND 5-LANE ARTERIALS.
8" BARRIER CURB AND GUTTER FOR 6 AND 7-LANE ARTERIALS.
- 2 AND 3-LANE ARTERIALS MAY UTILIZE 4" WIDE PAVED SHOULDERS INSTEAD OF CURB AND GUTTER.

ARTERIAL



- (5) MINOR
COMMERCIAL=30'
INDUSTRIAL=32'
COLLECTOR
COMMERCIAL=36'
INDUSTRIAL=38'

(4) 60' FOR MINOR INDUSTRIAL STREETS

COMMERCIAL/INDUSTRIAL COLLECTOR OR MINOR STREET

NOTES:

SIDEWALK LOCATION-SIDEWALKS SHALL BE IN THE STREET RIGHT-OF-WAY AT LEAST ONE FOOT AWAY FROM THE PROPERTY LINE AND AT LEAST FIVE FEET FROM THE ULTIMATE STREET CURB LOCATION. PUBLIC SIDEWALKS CAN BE LOCATED ON PRIVATE PROPERTY WITH A SIDEWALK EASEMENT.

ALL ARTERIAL UTILITIES EXCEPT STORMWATER AND SIGNALS ARE TO BE PLACED IN UTILITY EASEMENTS.

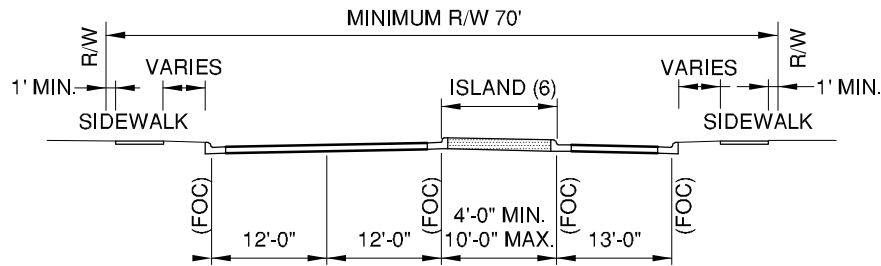
SEE THE CURRENT CITY OF BROKEN ARROW ENGINEERING DESIGN CRITERIA MANUAL (EDCM) SECTION 6.5.2 FOR MINIMUM PAVEMENT SECTIONS.

LEGEND:

R/W=RIGHT OF WAY
FOC=FACE OF CURB

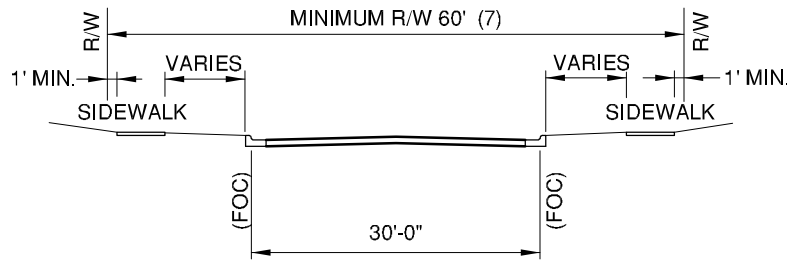
CROSS SECTIONS
NOT TO SCALE

EXHIBIT 6.1 (CONT.) STREET AND ROADWAY STANDARDS



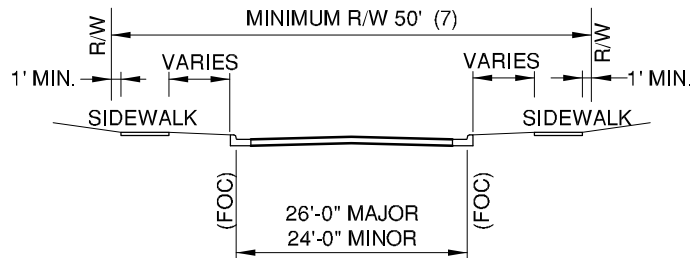
(6) RAISED, SUNKEN, OR PAINTED ISLAND

RESIDENTIAL SUBDIVISION ENTRANCE (FROM AN ARTERIAL)



(7) MINIMUM R/W 60' FOR RE ZONING

RESIDENTIAL COLLECTOR



(7) MINIMUM R/W 60' FOR RE ZONING

RESIDENTIAL STREET

NOTES:

SIDEWALK LOCATION-SIDEWALKS SHALL BE IN THE STREET RIGHT-OF-WAY AT LEAST ONE FOOT AWAY FROM THE PROPERTY LINE AND AT LEAST FIVE FEET FROM THE ULTIMATE STREET CURB LOCATION. PUBLIC SIDEWALKS CAN BE LOCATED ON PRIVATE PROPERTY WITH A SIDEWALK EASEMENT.

ALL ARTERIAL UTILITIES EXCEPT STORMWATER AND SIGNALS ARE TO BE PLACED IN UTILITY EASEMENTS.

SEE THE CURRENT CITY OF BROKEN ARROW ENGINEERING DESIGN CRITERIA MANUAL (EDCM) SECTION 6.5.2 FOR MINIMUM PAVEMENT SECTIONS.

LEGEND:

R/W=RIGHT OF WAY
FOC=FACE OF CURB

CROSS SECTIONS
NOT TO SCALE

TABLE 6.1 - STREET DESIGN STANDARDS

Roadway Design Item	Notes	Arterial		Commercial		Industrial		Residential			Section
		Primary	Secondary	Collector	Minor	Collector	Minor	Collector	Major	Minor	Reference
Right-of-Way											
Widths	1, 2, 7	120'	100'	80'	60'	80'	60'	60'	50'	50'	6.4.2.
Pavement Width											
7-Lane Section		85'	NA	NA	NA	NA	NA	NA	NA	NA	6.5.1.
6-Lane Section		72'	NA	NA	NA	NA	NA	NA	NA	NA	6.5.1.
5-Lane Section		61'	61'	NA	NA	NA	NA	NA	NA	NA	6.5.1.
4-Lane Section		48'	48'	NA	NA	NA	NA	NA	NA	NA	6.5.1.
3-Lane Section	3	37'	37'	41'	41'	41'	41'	41'	41'	41'	6.5.1.
2-Lane Section		26'	26'	36'	30'	38'	32'	30'	26'	24'	6.5.1.
Pavement Design											
Assumed Tandem Axle Load		65 kips	65 kips	56 kips	56 kips	65 kips	65 kips	56 kips	36 kips	36 kips	
Assumed Single Axle Load		40 kips	40 kips	30 kips	30 kips	40 kips	40 kips	30 kips	20 kips	20 kips	
Assumed Average Daily Traffic	4	Traffic	Traffic	2000-6000	2000-6000	2000-6000	2000-6000	2000-6000	300-700	300-700	
Design Speed		50 mph	45 mph	40 mph	35 mph	40 mph	35 mph	30 mph	30 mph	25 mph	6.4.1.
Concrete Design											
Min PCC Pavement Thickness	5	9"	9"	8"	7"	8"	7"	7"	6"	6"	6.5.2.
Min Aggregate Base Thickness	6	8"	8"	8"	8"	8"	8"	6"	N/A	N/A	6.5.2.
Min Subgrade Modification	6	8"	8"	8"	8"	8"	8"	8"	8"	8"	6.5.2.
Asphalt Design											
Min AC Wearing Course		2"	2"	2"	2"	2"	2"	2"	1 1/2"	1 1/2"	6.5.2.
Min AC Base Thickness		8"	8"	7"	7"	7"	7"	7"	6"	6"	6.5.2.
Min Aggregate Base Thickness	6	8"	8"	8"	8"	8"	8"	6"	6"	6"	6.5.2.
Min Subgrade Modification	6	8"	8"	8"	8"	8"	8"	8"	8"	8"	6.5.2.
Geometric Design											
Min Grade		0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	6.4.4.
Max Grade		6.0%	6.0%	6.0%	6.0%	4.0%	4.0%	6.0%	8.0%	8.0%	6.4.4.
Min Centerline Radius		1125'	1125'	821'	544'	821'	544'	208'	208'	208'	
Min Stopping Sight Distance		425'	360'	305'	250'	305'	250'	200'	200'	155	

Notes

1. Right of Way at Arterial/Arterial Intersections is 130' for the first 350', measured from section line.
2. Right of Way at all street intersections, except for residential streets, to include corner clip of 25' by 25'.
3. Three lane section for Commercial, Industrial and Residential are at intersections with Arterial. Width Includes 4' median.
4. Average Daily Traffic for Arterials is determined from actual traffic counts.
5. Dowel Jointed PC Concrete Pavement on all except Residential
6. With Separator Fabric.

TABLE 6.2

Vertical Curve K Values

2018 AASHTO - A Policy on Geometric Design of Highways and Street, 7th Edition

Table 3-35. Design Controls for Crest Vertical Curves Based on Stopping Sight Distance

U.S. Customary				Metric			
Design Speed (mph)	Stopping Sight Distance (ft)	Rate of Vertical Curvature, K_a		Design Speed (km/h)	Stopping Sight Distance (m)	Rate of Vertical Curvature, K_a	
		Calculated	Design			Calculated	Design
15	80	3.0	3	20	20	0.6	1
20	115	6.1	7	30	35	1.9	2
25	155	11.1	12	40	50	3.8	4
30	200	18.5	19	50	65	6.4	7
35	250	29.0	29	60	85	11.0	11
40	305	43.1	44	70	105	16.8	17
45	360	60.1	61	80	130	25.7	26
50	425	83.7	84	90	160	38.9	39
55	495	113.5	114	100	185	52.0	52
60	570	150.6	151	110	220	73.6	74
65	645	192.8	193	120	250	95.0	95
70	730	246.9	247	130	285	123.4	124
75	820	311.6	312				
80	910	383.7	384				

^a Rate of vertical curvature, K , is the length of curve per percent algebraic difference in intersecting grades (A), $K = L/A$.

Table 3-37. Design Controls for Sag Vertical Curves

U.S. Customary				Metric			
Design Speed (mph)	Stopping Sight Distance (ft)	Rate of Vertical Curvature, K^a		Design Speed (km/h)	Stopping Sight Distance (m)	Rate of Vertical Curvature, K^a	
		Calculated	Design			Calculated	Design
15	80	9.4	10	20	20	2.1	3
20	115	16.5	17	30	35	5.1	6
25	155	25.5	26	40	50	8.5	9
30	200	36.4	37	50	65	12.2	13
35	250	49.0	49	60	85	17.3	18
40	305	63.4	64	70	105	22.6	23
45	360	78.1	79	80	130	29.4	30
50	425	95.7	96	90	160	37.6	38
55	495	114.9	115	100	185	44.6	45
60	570	135.7	136	110	220	54.4	55
65	645	156.5	157	120	250	62.8	63
70	730	180.3	181	130	285	72.7	73
75	820	205.6	206				
80	910	231.0	231				

^a Rate of vertical curvature, K , is the length of curve (m) per percent algebraic difference intersecting grades (A), $K = L/A$.

**APPENDIX E:
EXHIBIT 7.1**

**MUTCD – INTERIM APPROVAL FOR OPTIONAL USE
OF PEDESTRIAN-ACTUATED RECTANGULAR
RAPID-FLASHING BEACONS AT UNCONTROLLED
MARKED CROSSWALKS (IA-21)**

DATE 3/20/2018, CORRECTION ISSUED 3/21/2018



U.S. Department
of Transportation
Federal Highway
Administration

Memorandum

Correction issued 3/21/2018

Subject: **INFORMATION:** MUTCD – Interim Approval
for Optional Use of Pedestrian-Actuated
Rectangular Rapid-Flashing Beacons at
Uncontrolled Marked Crosswalks (IA-21)

Date: MAR 20 2018

From: Martin C. Knopp 
Associate Administrator for Operations

In Reply Refer To:
HOTO-1

To: Federal Lands Highway Division Directors
Division Administrators

Purpose: The purpose of this memorandum is to issue an Interim Approval for the optional use of Rectangular Rapid-Flashing Beacons (RRFB) as pedestrian-actuated conspicuity enhancements for pedestrian and school crossing warning signs under certain limited conditions. Interim Approval allows interim use, pending official rulemaking, of a new traffic control device, a revision to the application or manner of use of an existing traffic control device, or a provision not specifically described in the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD). State and local agencies must request and receive permission to use this new Interim Approval, designated IA-21, from the Federal Highway Administration (FHWA) in accordance with the provisions of Section 1A.10 of the MUTCD before they can use the RRFB, even if prior approval had been given for Interim Approval 11 (IA-11), now terminated. The issuance of this new Interim Approval does not reinstate IA-11 either in whole or in part.

Background: The Florida Department of Transportation has requested that the FHWA issue an Interim Approval to allow the use of RRFBs as pedestrian-actuated conspicuity enhancements to supplement standard pedestrian and school crossing warning signs at uncontrolled marked crosswalks. The RRFB does not meet the current standards for flashing warning beacons as contained in the 2009 edition of the MUTCD, Chapter 4L, which requires a warning beacon to be circular in shape and either 8 or 12 inches in diameter, to flash at a rate of approximately once per second, and to be located no less than 12 inches outside the nearest edge of the warning sign it supplements. The RRFB uses rectangular-shaped high-intensity light-emitting-diode (LED)-based indications, flashes rapidly in a combination wig-wag and simultaneous flash pattern, and may be mounted immediately adjacent to the crossing sign.

Research on the RRFB: The City of St. Petersburg, Florida, experimented with the RRFB at 18 pedestrian crosswalks across uncontrolled approaches and submitted its final report in 2008. In addition to “before” data, the city collected “after” data at intervals for one year at all 18 sites and for two years at the first two implemented sites. For the first two sites, the city collected data for overhead and ground-mounted pedestrian crossing signs supplemented with standard circular yellow flashing warning beacons, for comparison purposes, before the RRFBs were installed. The data showed higher motorist yielding rates at crosswalks where the RRFBs had been installed in comparison to lower rates for standard warning beacons. The higher yielding rates were sustained even after two years of operation, and no identifiable negative effects were found. The St. Petersburg data also showed that drivers exhibit yielding behavior much farther in advance of crosswalks with RRFBs than with standard circular yellow flashing warning beacons.

In addition to the St. Petersburg locations, experimentation with RRFBs was also conducted at other uncontrolled marked crosswalks in Florida and other States. Data from locations other than St. Petersburg was limited, but did show results similar to those found in St. Petersburg.

The Texas Transportation Institute (TTI) conducted a Federally funded research project¹ that developed and tested a new flash pattern for the RRFB that was shown to be at least as effective as the flash pattern that was initially tested in St. Petersburg, Florida, and that showed that mounting the RRFB unit above the sign was at least as effective as mounting the RRFB unit below the sign. In this project, the results were generally favorable, however there was a wide range of yielding rates, with some as low as 19 percent. This broad range indicates that there might be certain factors or characteristics of locations at which the RRFB might not be effective.

A separate project² conducted by TTI examined data from multiple projects to determine various factors that influenced driver yielding rates at RRFB locations. In this project, the researchers found that intersection configuration, presence of a median refuge, crossing distance, approach to the crossing, and one-way vs. two-way traffic significantly affected the rate of driver yielding. Additional factors including posted speed limit, mounting of the beacons (overhead or roadside), and the type of crossing and sign—Pedestrian (W11-2) or School (S1-1) sign compared with the Trail Crossing (W11-15) sign—were also significant.

¹ Fitzpatrick, K., R. Avelar, M. Pratt, M. Brewer, J. Robertson, T. Lindheimer, and J. Miles. *Evaluation of Pedestrian Hybrid Beacons and Rapid Flashing Beacons*. Report No. FHWA-HRT-16-040, pp. 88-106. Texas Transportation Institute, College Station, Texas. July 2016.
<https://www.fhwa.dot.gov/publications/research/safety/16040/index.cfm>

² Fitzpatrick, K., M. Brewer, R. Avelar, and T. Lindheimer. *Will You Stop for Me? Roadway Design and Traffic Control Device Influences on Drivers Yielding to Pedestrians in a Crosswalk with a Rectangular Rapid-Flashing Beacon*. Report No. TTI-CTS-0010. Texas A&M Transportation Institute, College Station, Texas. June 2016.
<https://www.fhwa.dot.gov/publications/research/safety/16040/index.cfm>
<https://static.tti.tamu.edu/tti.tamu.edu/documents/TTI-CTS-0010.pdf>

FHWA Evaluation of Results: The Office of Transportation Operations reviewed the available data in 2008 and considered the RRFB to be highly successful for the applications tested (uncontrolled marked crosswalks). The RRFB offers significant potential safety and cost benefits because it achieves high rates of compliance at a low relative cost in comparison to other more restrictive devices that provide comparable results, such as full midblock signalization or pedestrian hybrid beacons.

The FHWA granted interim approval status to the RRFB on July 16, 2008, and designated that action as Interim Approval 11 (IA-11).

The FHWA was later informed that the concept of the RRFB had been patented by a private company. Because patented traffic control devices are not allowed to be included in the MUTCD, are not allowed to be given interim approval status, and are not allowed to be a part of an official experiment, the FHWA terminated Interim Approval 11 on December 21, 2017.

The FHWA has confirmed that the patents on the RRFB device that was the subject of Interim Approval 11 have been expressly abandoned and the concept of the RRFB is now in the public domain. Because of this action, the RRFB is once again eligible for interim approval status and the FHWA is issuing this new Interim Approval for the RRFB.

Interim Approval 11 (IA-11) remains terminated. Agencies that previously had been approved to use RRFBs under IA-11 are not covered by this new Interim Approval to install new RRFBs. If agencies that had approval under IA-11 wish to continue to install new RRFBs, then they must submit a new request to the FHWA and agree to comply with the terms and conditions of IA-21.

This Interim Approval does not create a new mandate compelling installation of RRFBs, but will allow agencies to install this traffic control device, pending official MUTCD rulemaking, to provide a degree of enhanced pedestrian safety at uncontrolled marked crosswalks.

Conditions of Interim Approval: The FHWA will grant Interim Approval for the optional use of the RRFB as a pedestrian-actuated conspicuity enhancement to supplement standard pedestrian crossing or school crossing signs at uncontrolled marked crosswalks to any jurisdiction that submits a written request to the Office of Transportation Operations. A State may request Interim Approval for all jurisdictions in that State. Jurisdictions using RRFBs under this Interim Approval must agree to the following:

- Comply with the Technical Conditions detailed in this memorandum;
- Maintain an inventory list of all locations at which the RRFB is installed; and
- Comply with all the conditions as listed in Paragraph 18 of Section 1A.10 of the MUTCD.

In addition, any agency that receives this approval must acknowledge agreement with the following:

- That an agency will furnish its list of locations where implemented if requested by FHWA;
- That FHWA has the right to rescind this Interim Approval at any time; and
- That issuance of this Interim Approval does not guarantee that the provisions, either in whole or part, will be adopted into the MUTCD.

1. General Conditions:

- a. Each RRFB unit shall consist of two rapidly flashed rectangular-shaped yellow indications with an LED-array-based light source, and shall be designed, located, and operated in accordance with the detailed requirements specified below.
- b. The use of RRFBs is optional. However, if an agency opts to use an RRFB under this Interim Approval, the following design and operational requirements shall apply, and shall take precedence over any conflicting provisions of the MUTCD for the approach on which RRFBs are used:

2. Allowable Uses:

- a. An RRFB shall only be installed to function as a pedestrian-actuated conspicuity enhancement.
- b. An RRFB shall only be used to supplement a post-mounted W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with a diagonal downward arrow (W16-7P) plaque, or an overhead-mounted W11-2, S1-1, or W11-15 crossing warning sign, located at or immediately adjacent to an uncontrolled marked crosswalk.
- c. Except for crosswalks across the approach to or egress from a roundabout, an RRFB shall not be used for crosswalks across approaches controlled by YIELD signs, STOP signs, traffic control signals, or pedestrian hybrid beacons.
- d. In the event sight distance approaching the crosswalk at which RRFBs are used is less than deemed necessary by the engineer, an additional RRFB may be installed on that approach in advance of the crosswalk, as a pedestrian-actuated conspicuity enhancement to supplement a W11-2 (Pedestrian), S1-1 (School), or W11-15 (Trail) crossing warning sign with an AHEAD (W16-9P) or distance (W16-2P or W16-2aP) plaque. If an additional RRFB is installed on the approach in advance of the crosswalk, it shall be supplemental to and not a replacement for the RRFBs at the crosswalk itself.

3. Sign/Beacon Assembly Locations:

- a. For any approach on which RRFBs are used to supplement post-mounted signs,

at least two W11-2, S1-1, or W11-15 crossing warning signs (each with an RRFB unit and a W16-7P plaque) shall be installed at the crosswalk, one on the right-hand side of the roadway and one on the left-hand side of the roadway. On a divided highway, the left-hand side assembly should be installed on the median, if practical, rather than on the far left-hand side of the highway.

- b. An RRFB unit shall not be installed independent of the crossing warning signs for the approach that the RRFB faces. If the RRFB unit is supplementing a post-mounted sign, the RRFB unit shall be installed on the same support as the associated W11-2, S1-1, or W11-15 crossing warning sign and plaque. If the RRFB unit is supplementing an overhead-mounted sign, the RRFB unit shall be mounted directly below the bottom of the sign.

4. Beacon Dimensions and Placement in the Sign Assembly:

- a. Each RRFB shall consist of two rectangular-shaped yellow indications, each with an LED-array-based light source. The size of each RRFB indication shall be at least 5 inches wide by at least 2 inches high.
- b. The two RRFB indications for each RRFB unit shall be aligned horizontally, with the longer dimension horizontal and with a minimum space between the two indications of at least 7 inches, measured from the nearest edge of one indication to the nearest edge of the other indication.
- c. The outside edges of the RRFB indications, including any housings, shall not project beyond the outside edges of the W11-2, S1-1, or W11-15 sign that it supplements.
- d. As a specific exception to Paragraph 5 of Section 4L.01 of the 2009 MUTCD, the RRFB unit associated with a post-mounted sign and plaque may be located between and immediately adjacent to the bottom of the crossing warning sign and the top of the supplemental downward diagonal arrow plaque (or, in the case of a supplemental advance sign, the AHEAD or distance plaque) or within 12 inches above the crossing warning sign, rather than the recommended minimum of 12 inches above or below the sign assembly. (See the example photo that is shown below.)

5. Beacon Flashing Requirements:

- a. When actuated, the two yellow indications in each RRFB unit shall flash in a rapidly flashing sequence.
- b. As a specific exception to the requirements for the flash rate of beacons provided in Paragraph 3 of Section 4L.01, RRFBs shall use a much faster flash rate and shall provide 75 flashing sequences per minute. Except as provided in Condition 5f below, during each 800-millisecond flashing sequence, the left and right RRFB indications shall operate using the following sequence:

The RRFB indication on the left-hand side shall be illuminated for approximately 50 milliseconds.

Both RRFB indications shall be dark for approximately 50 milliseconds.

The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.

Both RRFB indications shall be dark for approximately 50 milliseconds.

The RRFB indication on the left-hand side shall be illuminated for approximately 50 milliseconds.

Both RRFB indications shall be dark for approximately 50 milliseconds.

The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.

Both RRFB indications shall be dark for approximately 50 milliseconds.

Both RRFB indications shall be illuminated for approximately 50 milliseconds.

Both RRFB indications shall be dark for approximately 50 milliseconds.

3/21/2018

Both RRFB indications

The RRFB indication on the right-hand side shall be illuminated for approximately 50 milliseconds.

Both RRFB indications shall be dark for approximately 250 milliseconds.

- c. The flash rate of each individual RRFB indication, as applied over the full flashing sequence, shall not be between 5 and 30 flashes per second to avoid frequencies that might cause seizures.
- d. The light intensity of the yellow indications during daytime conditions shall meet the minimum specifications for Class 1 yellow peak luminous intensity in the Society of Automotive Engineers (SAE) Standard J595 (Directional Flashing Optical Warning Devices for Authorized Emergency, Maintenance, and Service Vehicles) dated January 2005.
- e. To minimize excessive glare during nighttime conditions, an automatic signal dimming device should be used to reduce the brilliance of the RRFB indications during nighttime conditions.
- f. Existing RRFB units that use the flashing sequence that was specified in the Interim Approval 11 memorandum and a subsequent interpretation (the RRFB indication on the left-hand side emits two slow pulses of light after which the RRFB indication on the right-hand side emits four rapid pulses of light followed by one long pulse of light) should be reprogrammed to the flash pattern specified above in Condition 5b as part of a systematic upgrading process, such as when the units are serviced or when the existing signs are replaced.

6. Beacon Operation:

- a. The RRFB shall be normally dark, shall initiate operation only upon pedestrian actuation, and shall cease operation at a predetermined time after the pedestrian actuation or, with passive detection, after the pedestrian clears the crosswalk.
- b. All RRFB units associated with a given crosswalk (including those with an advance crossing sign, if used) shall, when actuated, simultaneously commence operation of their rapid-flashing indications and shall cease operation simultaneously.
- c. If pedestrian pushbutton detectors (rather than passive detection) are used to actuate the RRFB indications, a PUSH BUTTON TO TURN ON WARNING LIGHTS (R10-25) sign shall be installed explaining the purpose and use of the pedestrian pushbutton detector.
- d. The duration of a predetermined period of operation of the RRFBs following each actuation should be based on the procedures provided in Section 4E.06 of the 2009 MUTCD for the timing of pedestrian clearance times for pedestrian signals.
- e. The predetermined flash period shall be immediately initiated each and every time that a pedestrian is detected either through passive detection or as a result of a pedestrian pressing a pushbutton detector, including when pedestrians are detected while the RRFBs are already flashing and when pedestrians are detected immediately after the RRFBs have ceased flashing.
- f. A small pilot light may be installed integral to the RRFB or pedestrian pushbutton detector to give confirmation that the RRFB is in operation.

7. Accessible Pedestrian Features:

- a. If a speech pushbutton information message is used in conjunction with an RRFB, a locator tone shall be provided.
- b. If a speech pushbutton information message is used in conjunction with an RRFB, the audible information device shall not use vibrotactile indications or percussive indications.
- c. If a speech pushbutton information message is used in conjunction with an RRFB, the message should say, "Yellow lights are flashing." The message should be spoken twice.

Any questions concerning this Interim Approval should be directed to Mr. Duane Thomas at duane.thomas@dot.gov.



Figure 1. Example of an RRFB dark (left) and illuminated during the flash period (center and right) mounted with W11-2 sign and W16-7P plaque at an uncontrolled marked crosswalk.

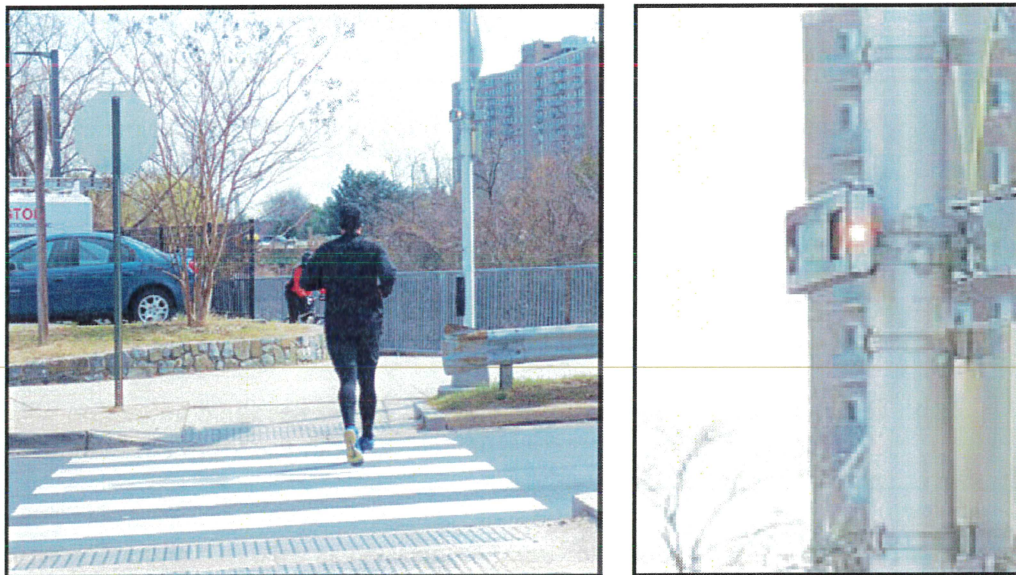


Figure 2. View of pilot light to pedestrian at shared-use path crossing with median refuge. Enlargement of pilot light at right.



Figure 3. Example of pedestrian pushbutton and R10-25 sign with pilot light for pedestrian actuation.

cc:
Associate Administrators
Chief Counsel
Chief Financial Officer
Directors of Field Services
Director of Technical Services

**APPENDIX F:
STORMWATER MANAGEMENT DOCUMENTS**

EXHIBIT A

RAINFALL DEPTHS AND INTENSITIES RATIONAL METHOD

RAINFALL DEPTHS						
Rainfall Duration	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-Minute	0.492	0.575	0.637	0.729	0.802	0.875
10-Minute	0.821	0.960	1.064	1.220	1.342	1.464
15-Minute	1.050	1.228	1.362	1.560	1.717	1.873
30-Minute	1.440	1.747	1.969	2.292	2.544	2.795
60-Minute	1.845	2.287	2.601	3.053	3.405	3.755

Source: National Weather Service Hydro 35 and Department of Commerce and National Weather Bureau Technical Publication No. 40.

RAINFALL INTENSITIES						
Rainfall Duration	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-Minute	5.900	6.896	7.641	8.753	9.629	10.500
10-Minute	4.927	5.762	6.386	7.318	8.052	8.781
15-Minute	4.200	4.913	5.446	6.241	6.867	7.490
30-Minute	2.879	3.494	3.938	4.583	5.088	5.590
60-Minute	1.845	2.287	2.601	3.053	3.405	3.755

Source: National Weather Service Hydro 35 and Department of Commerce and National Weather Bureau Technical Publication No. 40.

RAINFALL DEPTHS SCS METHOD

24-Hr Duration						
Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Broken Arrow	4.02	5.22	6.15	7.14	8.05	9.00

Sources: Soil Conservation Service Technical Release No. 55 and U.S. Weather Bureau Rainfall Atlas of the United States.

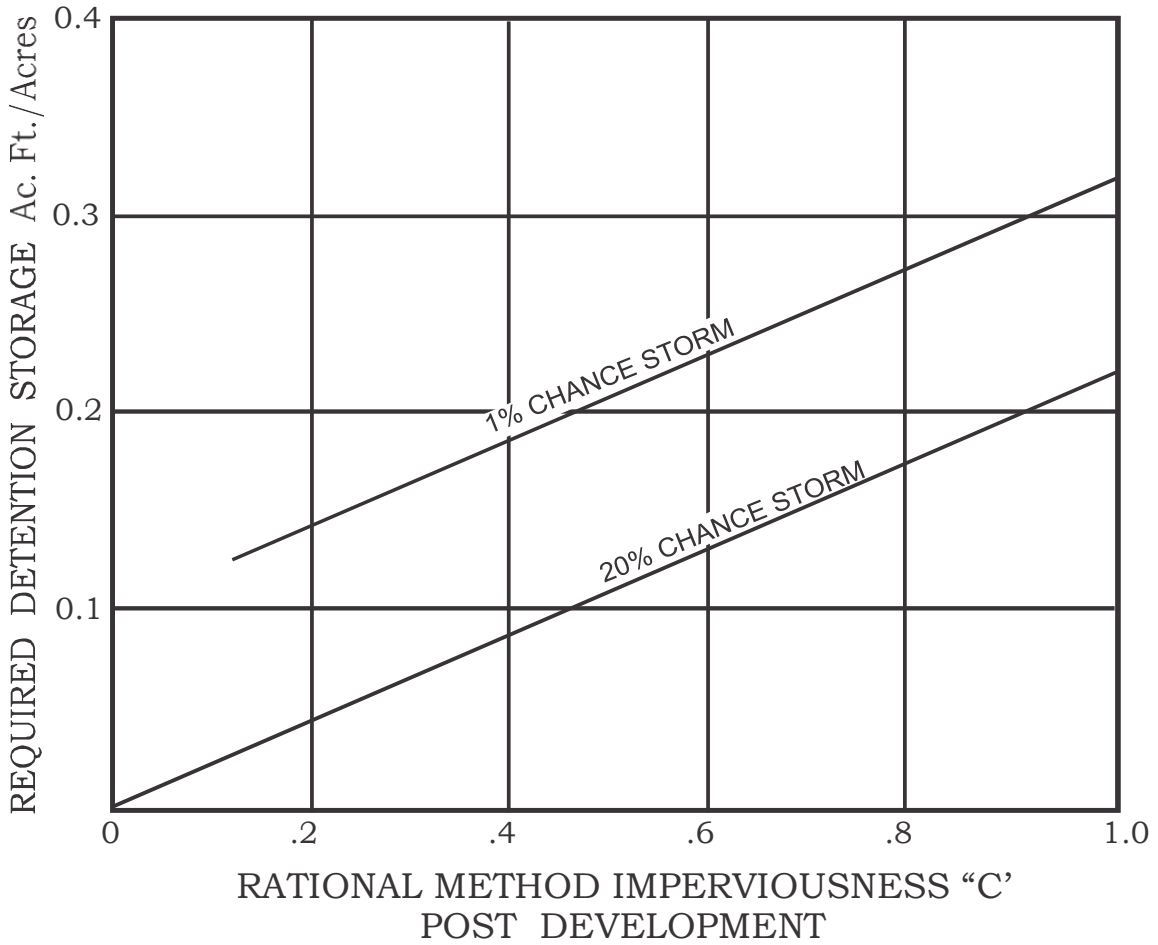
EXHIBIT "B"

APPROVED RUNOFF METHODS

Method	Applicable For		Min. Drainage Area (Acres)	Max. Drainage Area (Acres)
	Peak Flow Calcs	Volume Calcs		
Rational Method	Yes	No	0	200
SCS Method	Yes	Yes	0	2000
Snyder's Method With Tulsa Modifiers	Yes	Yes	10	None
Unit Volume Table	No	Yes	0	2

EXHIBIT "C"

UNIT VOLUME DETENTION CURVES



REFERENCE: CITY OF TULSA STORMWATER MANAGEMENT
CRITERIA MANUAL, March 1994

EXHIBIT "D"

RUNOFF COEFFICIENTS AND PERCENT IMPERVIOUSNESS		
Land Use Or Surface Characteristic	Percent Imperviousness	Runoff Coefficients
BUSINESS: Commercial Areas Neighborhood Areas	70 to 95 60 to 80	0.70 to 0.95 0.50 to 0.70
RESIDENTIAL Single Family Multi-unit (detached) Multi-unit (attached) ½ acre lot or larger Apartments	30 to 60 45 to 55 65 to 75 25 to 40 65 to 75	0.30 to 0.60 0.40 to 0.60 0.60 to 0.75 0.25 to 0.40 0.50 to 0.70
INDUSTRIAL Light uses Heavy Uses	70 to 80 80 to 90	0.50 to 0.80 0.60 to 0.90
PARKS, CEMETERIES	4 to 8	0.10 to 0.25
PLAYGROUNDS	10 to 20	0.20 to 0.35
SCHOOLS	40 to 60	0.50 to 0.60
RAILROAD YARDS	35 to 45	0.20 to 0.35
UNDEVELOPED AREAS Cultivated Pasture Woodland Offsite flow analysis (land use not defined)	30 to 70 20 to 60 5 to 40 35 to 55	0.35 to 0.60 0.25 to 0.50 0.10 to 0.40 0.45 to 0.65
STREETS Paved Gravel	90 to 100 50 to 70	0.80 to 0.90 0.55 to 0.65
DRIVES AND WALKS	90 to 100	0.80 to 0.90
ROOFS	85 to 95	0.80 to 0.90
LAWNS Sandy soils Clayey soils	5 to 10 10 to 30	0.10 to 0.20 0.13 to 0.35

EXHIBIT "E"

Figure 15-4 Velocity versus slope for shallow concentrated flow

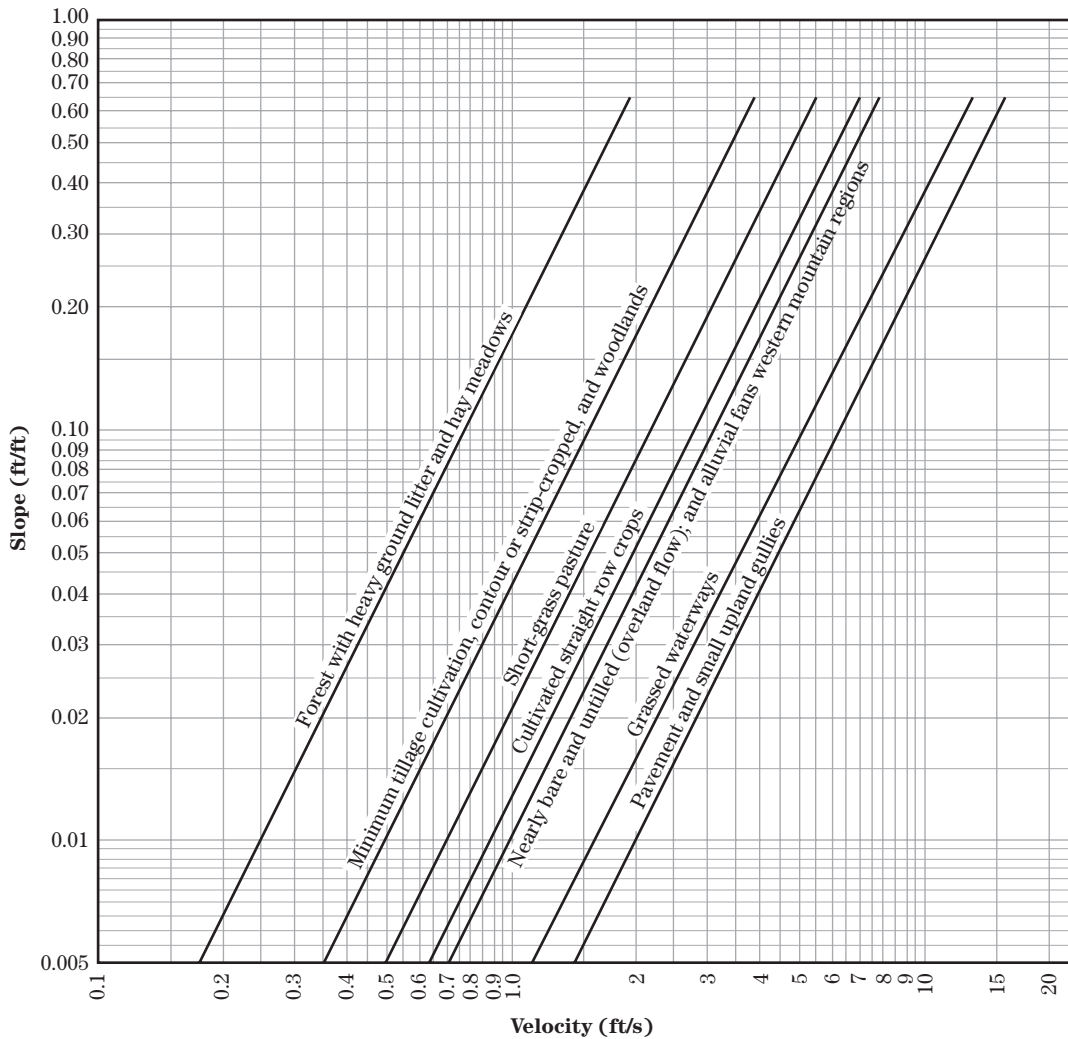


Table 15-3 Equations and assumptions developed from figure 15-4

Flow type	Depth (ft)	Manning's <i>n</i>	Velocity equation (ft/s)
Pavement and small upland gullies	0.2	0.025	$V = 20.328(s)^{0.5}$
Grassed waterways	0.4	0.050	$V = 16.135(s)^{0.5}$
Nearly bare and untilled (overland flow); and alluvial fans in western mountain regions	0.2	0.051	$V = 9.965(s)^{0.5}$
Cultivated straight row crops	0.2	0.058	$V = 8.762(s)^{0.5}$
Short-grass pasture	0.2	0.073	$V = 6.962(s)^{0.5}$
Minimum tillage cultivation, contour or strip-cropped, and woodlands	0.2	0.101	$V = 5.032(s)^{0.5}$
Forest with heavy ground litter and hay meadows	0.2	0.202	$V = 2.516(s)^{0.5}$

EXHIBIT “F”

STORM FREQUENCY TERMINOLOGY TABLE

Modern Terminology	Past Terminology
0.2% Chance Storm	500 – Year Storm
1% Chance Storm	100 – Year Storm
2% Chance Storm	50 – Year Storm
10% Chance Storm	10 – Year Storm
20% Chance Storm	5 – Year Storm

EXHIBIT "G"

Table 2-5
Suggested Maximum Permissible Mean Channel Velocities

Channel Material	Mean Channel Velocity, fps
Fine Sand	2.0
Coarse Sand	4.0
Fine Gravel ¹	6.0
Earth	
Sandy Silt	2.0
Silt Clay	3.5
Clay	6.0
Grass-lined Earth (slopes less than 5%) ²	
Bermuda Grass	
Sandy Silt	6.0
Silt Clay	8.0
Kentucky Blue Grass	
Sandy Silt	5.0
Silt Clay	7.0
Poor Rock (usually sedimentary)	10.0
Soft Sandstone	8.0
Soft Shale	3.5
Good Rock (usually igneous or hard metamorphic)	20.0

Notes:

1. For particles larger than fine gravel (about 20 millimetres (mm) = 3/4 in.), see Plates 29 and 30.
2. Keep velocities less than 5.0 fps unless good cover and proper maintenance can be obtained.

Source: United States Army Corps of Engineers, Engineer Manual No. 1110-2-1601. Dated 30 June 1994

**APPENDIX G:
HYDRAULIC GRADE LINE INFORMATION**

HYDRAULIC GRADE LINE INFORMATION

WATER LEVELS AT TIGER HILL TANK

HIGH WATER LEVEL OF TANK	48 FT	911.00 FT
NORMAL OPERATING LEVEL OF TANK	30 FT	893.00 FT
LOW WATER LEVEL OF TANK	15 FT	878.00 FT

HYDRAULIC GRADE LINE - HIGH SERVICE PUMP STATION

MAXIMUM OPERATING LEVEL (HGL)	951 FT	30.0 MGD
MINIMUM OPERATING LEVEL (HGL)	918 FT	6.0 MGD

HIGH SERVICE PUMP STATION DISCHARGE PRESSURES

DISCHARGE PRESSURE AT 6.0 MGD	120.35 psi
DISCHARGE PRESSURE AT 30.0 MGD	134.63 psi