City of Wentzville

Wentzville Missouri

The Crossroads of the Nation

Engineering Design Criteria

Engineering Division
1001 Schroder Creek Boulevard
Wentzville, Missouri 63385
636--327-5101
636-639-2057 Fax

City of Wentzville

Engineering Design Criteria

Approved Date: 9/11/2019

Table of Contents

1. General Instructions, Permits, and Fees

1.01 Projects Requiring Review by the City of Wentzville

All public or private sewerage, public water mains, drainage works or other public improvements proposed to be constructed, altered or reconstructed by any person or corporation, public or private, within the corporate limits of the City of Wentzville, requires review by the City. This includes any altering of any storm drainage channel, site drainage or flood plain within City limits.

1.02 Submission, Review and Approval of Plans and Specifications

Designs, plans and specifications of all sewerage, water mains, drainage works and streets proposed to be constructed, altered or reconstructed by any person or corporation, private or public, within City limits, shall be submitted to the City for review, revision, approval or rejection. In addition, for projects with facilities requiring industrial pretreatment, an Industrial Wastewater Survey Form must be completed and a set of plans submitted to the Wastewater Department. Such designs, plans and specifications (excluding house connections, curb cuts, etc.) shall be prepared and sealed by a Professional Engineer, registered in the State of Missouri, and shall meet minimum standards of the City and Missouri Department of Natural Resources before approval is granted.

1.02.01 Engineering Review Fee

Prior to the acceptance of any plans for review or the approval of plans, an Engineering Review Fee in the amount of $150.00, plus $10 per lot for residential developments, and $10 per acre for all other developments shall be paid to the City. This fee covers the review of the plans for conformance with City standards. Failure to submit fees in a timely manner could delay the review and approval of plans. No plans will be approved until all required fees have been paid.

After plans have been approved, subsequent changes submitted to the City require a new Engineering Review Fee to be paid to the City to cover the review of the proposed changes. Any development that is divided into phases after initial plan approval shall require a separate new Engineering Review Fee for each phase of the development. No approval shall be made of plans or construction permit issued until applicable fees have been paid.

Engineering Review Fees will be credited towards (i.e. deducted from) the Construction Permit Fee.

Engineering Review Fee	
Development Type	Fee
Residential	$150 + $10 per lot
All Other Developments	$150 + $10 per acre

1.03 Procedures for Plan Review

1.03.01 Preliminary Conferences

At any time prior to formal submission of project plans, the owner's Engineer can arrange for a preliminary conference to obtain informal guidance in project Plan preparation. Preliminary conferences are encouraged, especially in unique or unusual situations, to-expedite the subsequent formal review and approval process.

1.03.02 Required Submittals

An “Engineering Improvement Plan Submittal Checklist” shall be required with all projects and shall be submitted with the original project submittal. A copy is included in the back of this manual. Plan Review may be delayed if all required information is not provided.

To facilitate the plan review before approval for construction, the Engineer shall submit with the plans all necessary data, maps, computations and check lists in support of the designs and plans. The following listed requested information is a minimum and may be supplemented by any additional information which the Engineer considers to be helpful in the review process.

1. The following information shall be provided, as applicable:

    a. Engineer's name, mailing address and telephone number.

    b. Owner and/or developer's name, mailing address and telephone number.

    c. Accurate location of property relative to an intersection.

    d. Total acreage of property and impervious acres if other than residential.

    e. Land use of the improvement area, i.e.; commercial, residential, etc.

    f. The City of Wentzville reference number shall be used in all subsequent correspondence concerning the project, and shall be utilized as soon as possible after issued.

    g. If the submittal is a revision or addendum to a previous project, the previous project shall be properly identified, and the particulars of the revision or addendum shall be described. Submittals of revisions or addendums to previously approved plans will require an application and submittal fee. Any revision to previously approved plan shall be clouded on the plans and accompanied by a letter describing in detail the change to the previously approved plan.

2. Number of Copies of Plans and Supporting Data to be Submitted:

Plans shall be complete and the required number shall be submitted according to the table below.

Type of Permit/Review	Number of Plans Required for Review	Number of Plans Required for Final Review & Approval	Reports/Calculations Required
Clearing & Grading	1	4	2
Construction (Site Improvements)	1	6	2 - Storm & Detention 2 - Water System 2 - Flood Study
Lift Station	1	7	3 - Engineering Report

1.03.03 Return of Plans Without Review

Plans lacking the required information or those that are difficult to read or interpret due to poor drafting, poor arrangement or poor writing, will be returned without review for correction, additional information, or redrafting as may be required.

1.03.04 Return of Plans for Revision

On completion of the review, a letter with comments with requested revisions and notations would be sent to the applicant and Engineer for revision of the original tracings. The assigned City of Wentzville Engineering Project Number shall be shown in the lower right corner of each sheet upon re-submittal of the plans. Additional sets of plans for further review or final approval will then be requested.

1.03.05 Failure to Revise or Correct Plans Promptly

Plans returned to the Owner's Engineer for revision, correction or additional information shall be modified and returned to the City within one year for final approval or the project will be considered abandoned. Further review will be continued only upon re-submittal as a new project, complete with all necessary data, review fees, etc.

1.03.06 Period of Validity for Approved Plans

Final approval of improvement plans shall expire two (2) years after the date of such approval by the City unless a construction permit is issued by the City and has not expired. If approval lapses, plans shall be resubmitted and conform to the current (most recent edition of the) Engineering Design Criteria and Standard Specifications and requirements of the City of Wentzville.

1.04 Improvement Plan Requirements

Sealing of Plans by Registered Engineers, Land Surveyors and Architects - The Missouri Board of Registration for Engineers, Land Surveyors and Architects is rigidly enforcing Missouri law in regard to the requirements for the practice of these professions. In this regard, professional seals and signatures are required on all plans, specifications, estimates, plats, reports, surveys or other like documents and must be affixed to every sheet in a set of documents. However, the first page of bound reports may be sealed in lieu of

each sheet of the report. Following is a general list of documents for which professional seals are required:

1.04.01 ENGINEER'S SEAL REQUIRED The following is a general list of documents for which a Professional Engineer's Seal shall be required:

Circulation Plan (if engineering is involved)
Concept/Site Plan
Construction Plans
Improvement Plans
Flood Plain Study (for proposed change in the flood limits)
Grading Plan
Storm or Sanitary Plans
Hydraulics
Soil Study
Structures
Engineering Reports
Utility Companies-For Major Facilities, Structures, Etc.
Traffic Reports
Record Plans-Final Measurement Plans (As-built Drawings)
City of Wentzville Improvement Plans
Department Consultant Plans
Department In-House Plans
Department Major Maintenance Projects

1.04.02 SURVEYOR'S SEAL REQUIRED The following is a general list of documents for which a Professional Surveyor's Seal shall be required:

Record Plans (As-built Drawings)
Record Plat
Right-of-Way Plans
Land Surveys
Topographic Surveys
Subdivisions
Bench Marks and Level Notes
Monuments
Floodplain (identify existing line only-no change in flood limits)
Department In-House Surveys

1.04.03 IMPROVEMENT PLAN STANDARDS

All plans submitted shall be no larger than 24" x 36" maximum.

Required Plan Sheets (and minimum requirements)

1. Cover Sheet

   a. The name of the project and type of plan (i.e. grading, improvement plans, etc.)

b. Location map showing the relationship of the project site to the surrounding street network and a key map showing the lot configuration and any phase lines of the project with the phase included in the plan set shaded
c. Title block showing name and address of developer and engineering firm
d. Standard City of Wentzville General Notes and Project Notes (See back cover of this manual)
e. Additional notes desired by the engineer of record or developer, but which will not be an official part of the City of Wentzville Engineering Division approval or permit
f. Sheet index
g. Legend
h. City of Wentzville Engineering Project #, lower right corner

2. Overall plan with key for proposed improvements (if multiple sheets for each type of plan)

3. Flat Plan

a. City of Wentzville Engineering Project # in lower right corner
b. Outboundary information and adjacent property information
c. Lot information (lot lines, lot numbers, addresses, etc.)
d. Sanitary sewer system including lateral locations (existing and proposed)
e. Easements (existing and proposed)
f. Storm water management system (existing and proposed)
g. Street network including street names, right of way width (public or private notation), street pavement width, stationing (PC & PT locations), and cul-de-sac, rounding and street radii
h. Sidewalks including handicap ramps with callout for detail for each handicap ramp
i. North arrow
j. Graphic scale
k. Street lights
l. Street signage and striping
m. Existing vegetation and proposed clearing limits
n. Watercourse top of bank and buffer limits
o. Phase lines
p. Type of entrance

4. Grading Plan

a. City of Wentzville Engineering Project # in lower right corner
b. Items included on Flat Plan
c. Existing contours (2’ intervals for residential projects, 1’ intervals for commercial projects)
d. Proposed contours (2’ intervals for residential projects, 1’ intervals for commercial projects)
e. Spot elevations as needed
f. Sediment and erosion control BMPs

g. Limits of offsite grading easements, with copy of recorded easement
h. Watercourse top of bank and buffer limits
i. Phase lines (phased grading may be different than improvement phases)
j. North arrow
k. Graphic scale

5. Water Plan
   a. City of Wentzville Engineering Project # in lower right corner
   b. Items included on flat plan (grayscale)
   c. Water distribution system including all fittings and appurtenances.
   d. Service lines, including domestic, irrigation, fire lines, meters and service line casings (residential subdivisions)
   e. Any required easements for offsite extensions, with copy of recorded easement
   f. North arrow
   g. Graphic scale
   h. Phase lines

6. Street Profiles
   a. City of Wentzville Engineering Project # in lower right corner
   b. Existing and proposed ground profiles
   c. Stationing
   d. Existing and proposed elevations every 25’
   e. Storm sewer curb inlet locations with station
   f. Vertical curve and super-elevation data
   g. Street name
   h. Street cross-section Standard Construction Detail number and limits
   i. Phase line
   j. Station of intersecting street(s)
   k. Cul-de-sac and intersection warping (can be on separate sheet(s))

7. Sanitary and storm sewer profiles
   a. City of Wentzville Engineering Project # in the lower right corner
   b. Existing and proposed ground profiles
   c. Stationing
   d. Pipe size, material and slope
   e. Structure type and numbers
   f. Flowline and top elevations
   g. Utility crossings (i.e. storm, sanitary and water) with flowline elevations and pipe sizes of crossing utilities
   h. Concrete encasements and cradles
   i. Grid with elevations
   j. Hydraulic grade line (storm sewers only)
   k. Design flow (storm sewers only and sanitary sewers sized for flow)
   l. Horizontal and vertical scales
   m. Phasing, as required
   n. Granular backfill and compacted fill areas noted as required

o. Rip rap blanket or energy dissipation designs noted (stone sizing to be provided with supporting calculations as needed)

8. Drainage area map
   a. City of Wentzville Engineering Project # in the lower right corner
   b. Items included on grading plan
   c. Drainage areas to each inlet
   d. Hydrologic calculation of each drainage area to each inlet (area, PI factor and flow)
   e. Cumulative drainage area and flow in each pipe run
   f. Offsite areas draining onto the site. Offsite areas shall be shown to their limits, include on a separate sheet if necessary
   g. Ponding limits for each storm event in lakes, detention basins and ponding areas
   h. Any required ponding or stormwater drainage easements with copy of recorded easement
   i. North arrow
   j. Graphic scale

9. Landscaping Plans

   a. Landscaping Plans approved by the Planning Department shall be incorporated into the site improvement plans, for informational purposes, and to insure that there are no conflicts with other site improvements, whether public or private.
   b. Landscaping Plans which are part of the Water Quality Requirements shall be incorporated into the improvement plans, showing the proposed Stormwater pond/pools/wetlands and buffer. Plans shall indicate how aquatic and terrestrial areas will be vegetatively stabilized and established, in accordance with Chapter 6 of these Design Criteria. Landscaping Plans which are part of the Water Quality Requirements shall be complementary with, and supplement the Landscaping Plans approved by the Planning Department.

10. Specific Construction Details (details not included in City of Wentzville Standard Construction Details).

   a. City of Wentzville Engineering Project # in the lower right corner.
   b. Include only those standard details that are not included in the City of Wentzville Standard Construction Details. If details must be included for bidding purposes, a notation that the detail is only included for bidding purposes, and is not part of the City's approval, as only those Details included in the City's Standard Specifications and Construction Details are to be used during construction.

1.05 Construction Permits

1.05.01 General

Any person, firm or corporation desiring to construct, install, relocate, connect or reconnect any sanitary sewer, water main, stormwater sewer or drainage facility, or street, whether public or private, within the City of Wentzville city limits shall cause plans and specifications therefore to be prepared by a registered professional engineer, licensed in the State of Missouri, and shall cause the same to be submitted to the City for examination, revision, and approval according to the design standards of the City. Such approval shall be a condition precedent to the issuance of a permit for the construction of such facilities, and no such facilities shall be constructed without a permit therefore from the City. All such plans and specifications shall be prepared in such form and manner as may be prescribed by the City.

The submittal of all Project information shall be verified by the checklists provided herein. It shall be the responsibility of the submitting Engineer to see that all applicable information, listed on the checklists, is provided to the City of Wentzville. This includes the design information as well as information on the plans and specifications.

1.05.02 Prevailing Law

At the time of permit application, all approved improvement plans must conform to prevailing Federal, State and County requirements in addition to these criteria. Agencies with jurisdiction include, but are not limited to:

- Federal Emergency Management Agency (FEMA)
- Federal Highway Administration (FHA)
- U. S. Army Corps of Engineers (USACE)
- U.S./Missouri Department of Transportation (MoDOT)
- U.S. Department of Justice (USDOJ)
- Missouri Department of Natural Resources (MoDNR)
- St. Charles County

1.05.03 Application for Construction Permit

An “Application for Construction Permit” shall be required with all projects and shall be submitted with the original project submittal. A copy is included in this manual.

1.05.04 Construction Permit Fee

A construction permit fee will be required before the issuance of a construction permit. The fee will be determined as indicated in the table below and the applicant will be notified as part of the review process.

Construction Permits – Site Development		
Permit Type	Fee	Expiration
Grading	$150 + $10 per lot (residential) $150 + $10 per acre (all other)	2 years
Construction – Site Developments (All Zoning Districts)	2% of the estimated cost of public improvements as determined by an engineer's estimate and approved by the City.	2 years

1.05.05 Construction Escrow or Letter of Credit

Prior to the issuance of construction permits, and the start of construction, the developer shall establish an escrow account guaranteeing the completion of improvements. The escrow amount shall be based on an engineer's estimate and approved by the Engineering Department.

1.05.06 Permit Expiration and Extension

Construction permits shall become null and void if construction has not started within (90) days of issuance. All constructions permits will expire if construction has not been completed within two years. Prior to the Construction Permit expiration, an applicant may request a permit extension for one year upon approval by the Board of Aldermen.

1.05.07 Cancellation of Permits and Refunds of Fees and Deposits

A refund of the permit fee and inspection deposit and cancellation of the construction permit will be made for any permit which has not expired upon receipt of a written statement from the Owner that the project has been abandoned. The construction permit must be submitted with the written statement.

1.06 Inspections & Testing

Field inspections and testing are required on all items of work performed under construction permits. Prior to the start of construction and work being undertaken, the City shall be contacted a minimum of 48 hours prior to, in order to arrange for inspections and to insure that all applicable tests are being conducted. Specifics on required tests may be found in the City's Standard Specifications and Construction Details. All work performed after hours or on weekends will be subject to an inspection fee. Call Engineering at 636-639-2037 for the current inspection fee rate. See Chapter 9 for additional information on inspections.

NOTE: Inspections are required on everything before being covered.

ALL INSPECTIONS FROM THE CITY REQUIRE A MINIMUM OF 48 HOURS NOTICE BY CALLING 636-639-2037.

1.07 Location of Existing Utilities

Before excavating, and for location of existing utilities, contact:

Missouri One Call - 1-800-DIG-RITE
(48 hours notice required) (1-800-344-7483)
Missouri One Call will provide a Serial Number. Keep number on the job site.

1.08 Definitions

In addition to words or terms that may be defined elsewhere in this manual, the following words and terms shall have the meanings defined below:

AASHTO – American Association of State Highway and Transportation Officials.

Access Connection - A driveway, intersection, turnout or other means of providing for vehicles to move between the public roadway and abutting private property. The minimum distance between access connections on the same side of the roadway is measured from center-to-center of adjacent access connections.

Access Street - A public roadway providing an access connection for vehicles to move between the public roadway and abutting private property or proposed site.

ADA – Americans with Disabilities Act.

Allowable Release Rate – The Pre-developed or existing condition peak flow corresponding to a selected rainfall frequency event.

Applicant – The utility company, contractor, developer or individual seeking permission to work within the right-of-way of any roadway under the jurisdiction of the City of Wentzville, or seeking approval to construct improvements, whether public or private, on private property, in compliance with development plans approved by the BOA..

Applied Shear Stress – Stress applied by flowing water, parallel or tangential to the face of the channel bank. Shear stress is a force that tends to cause deformation of bank materials by slippage along a plane or planes parallel to the imposed stress.

Architect – A professional architect registered in the State of Missouri.

Arterial Road System – The system of roads classified by the Department of Public Works which provides the principal routes for arterial type traffic in the City of Wentzville.

Articulated Concrete Block – Interlocking precast concrete blocks, typically placed on a geotextile fabric to create an interlocking matrix for channel bank or shoreline protection and erosion control.

Auxiliary Lane - That portion of adjoining the traveled way for speed change, turning, decelerating, accelerating, or other purposes supplementary to through traffic movement.

Average Daily Traffic (ADT) - A unit defined as the average amount of vehicles per day that pass a specific point. It is usually used to describe the amount of traffic using a roadway segment or performing a specific traffic movement.

AWWA – American Water Works Association

Backfill – The material used to fill an excavation.

Backwater – The rise in water surface elevation caused by some obstruction such as a narrow bridge opening, buildings or fill material that limits the area through which the water shall flow.

Band Width - The time in seconds that traffic can flow uninterrupted through a coordinated traffic control system.

Bank-Full Discharge – The discharge that will fill the low-flow channel in a natural channel. Sometimes referred to as the dominant discharge or stream forming flow.

Bank-Full Elevation – The elevation in the channel where water surface reaches the top of the low flow channel. When the water surface rises above the bank-full elevation, it spills over onto the bank-full floodplain. The bank-full elevation generally corresponds to the bank-full discharge.

Bank-Full Floodplain – The bank-full floodplain is a low, vegetated terrace, formed by the bank-full discharge. Bank-full floodplains reduce stress on the streambanks when the flow crests the internal floodplain, and the velocity and shear stress decrease as flow spreads across the floodplain.

Bank-Full Width – The width of flow at bankfull elevation, as measured across the channel.

Base Flood – The flood having a one (1) percent chance of being equaled or exceeded in any given year. The base flood, adopted by the Federal Emergency Management Agency, is the 100-year flood.

Basement – The lowest level or story of a structure which has its floor below grade on all sides.

Bedding – The material on which the pipe or conduit is supported and protected.

Bench Mark – A definite point of known elevation and location and of more or less permanent character. The identity and elevation shall be based on United States Geological Survey (U.S.G.S.) Datum.

BMP – Best Management Plan. A plan which describes those methods and procedures used to control erosion on a site during construction so as to reduce to a minimum the passage of sediment or silt from off the site and onto other property, whether public or private. This plan needs to be submitted for approval to the City and for areas greater than 1 acre to the Missouri Department of Natural Resources for approval. The plan also needs to be maintained on the site during the duration of grading and construction operations.

Block – An area of land surrounded by public highways, streets, streams, railroad rights-of-way, parks, rural land, drainage channels or other similar areas or facilities.

BOA – Board of Alderman of the City of Wentzville.

BOD_5 – "Biological Oxygen Demand"; the quantity of oxygen utilized in the biochemical oxidation of organic matter in five (5) days as determined by Standard Methods and expressed in milligrams per liter.

Building – A structure that is affixed to the land, has one or more floors, one or more external walls and a roof, and is designed or intended.

Building Line (Setback) – A line or lines on a plat designating the area outside of which buildings may not be erected, except landings, open balconies and roof overhangs, as permitted in the Zoning Ordinance.

City – The City of Wentzville, Missouri.

City Engineer – The City Engineer of the City of Wentzville Missouri.

Change in Use - A change in the use of a property causing the trip generation of the property to increase by more than 100 vehicles in any 60-minute interval or to increase by more than 10%, whichever is less. Or, resulting in a change in the mix of passenger vehicles and large vehicles of more than 10%. Or, resulting in the direction from which vehicles entering or leaving the site to change by more than 20%.

Channel – A natural or artificial water course.

Common Land – The land set aside for open space including storm water, retention lakes, ponding, or recreational use for the owners of residential lots in a subdivision. This land is conveyed by the developer in fee simple absolute title by a warranty deed to the Trustees. The trust indenture for common land shall provide that it be used for the sole benefit, use and enjoyment of the lot owners present and future and shall be the maintenance responsibility of the trustees of the subdivision. No lot owner shall have the right to convey his interest in common land except as an incident of his ownership of a regularly platted lot.

Corner Clearance - The distance from an access connection to the nearest intersection. The distance is measured from center-to-center from the intersecting roadway to the adjacent access connection.

Corridor Plan - A plan identifying the location and features of access connections to a specific section of public roadway. The plan will show the following: (1) access connections to be retained, existing access connections to be modified or closed and new access locations,

(2) the location of existing traffic signals and proposed future signals, including those to be relocated, (3) the type and width of any median, (4) the location and type (full or directional) of all median openings including existing openings to be retained, modified or closed and proposed future openings.

Critical Shear Stress – The shear stress at which erosion begins for a given channel bed or bank material.

Cross Access – A commonly shared or used private pedestrian way or vehicular driveway that internally connects or serves two or more adjacent properties.

Cross Section – A one-dimensional line, drawn perpendicular to the contours, to represent the open channel flow conveyance at that location.

Culvert – A closed conduit for the free passage of surface drainage water under a highway, railroad, or other embankment.

Curve, Long – A curve having a (centerline) radius equal to or greater than fifty (50) feet.

Curve, Short – A curve having a (centerline) radius of less than fifty (50) feet.

Dedication – The process by which the owner gives approved sanitary sewers, water mains, storm sewers, streets and other public improvements to the City for the public use and maintenance.

Department – The City of Wentzville Department of Public Works.

Design Speed – On existing roadways design speed shall be the 85th percentile speed of motorists on the roadway as established by radar studies, or 5 m.p.h. greater than the posted speed limit, whichever is greater. On new roadways design speed shall be 5 m.p.h. greater than the anticipated posted speed limit. For non-residential and residential streets with pavement width of 32’ or less, the design speed shall be the anticipated posted speed limit.

Detention – The temporary storage of stormwater runoff in ponds, parking lots, depressed grassy areas, buried underground tanks, etc., for future release. Used to delay and attenuate flow.

Developed Runoff Rate – The peak flow corresponding to a selected rainfall event as a result of developed site conditions.

Developer – The person, firm or corporation who develops and improves a tract pursuant to the requirements of this text and the Subdivision and Zoning Ordinances.

Development – The act of changing the state of a tract of land after it’s function has been purposefully changed by man including, but not limited to, structures on the land and alterations to the land.

Differential Runoff – The difference in rate and volume of stormwater runoff from a parcel or project between its undeveloped natural condition and its developed condition.

Directional Median Opening - An opening is a non-traversable median that is designed to accommodate a specific movement, such as a left-turn or u-turn, and prohibit all other movements.

Director of Public Works – The Director of Public Works of the City of Wentzville, Missouri.

District - The City of Wentzville resides in District 6 of the Missouri Department of Transportation.

District Engineer - The Engineer in charge of District 6 of the Missouri Department of Transportation.

Division – The Engineering Division of the City of Wentzville Public Works Department, headed by the City Engineer.

Drainage Facility – Any system of artificially constructed drains, including open channels and sewers used to convey stormwater, surface or groundwater, either continuously or intermittently to natural water courses.

Drive, Multi-Family Access – A private way or driveway which affords a means of vehicular access to parking areas and bays and to abutting building in a multiple dwelling unit subdivision.

Driveway – A privately maintained travel way used for vehicular access to a site and distribution within a site, not including sidewalks.

Driveway, Common (Party) – A single driveway providing vehicular access to two adjoining properties.

Drop – A structural configuration where flow falls into a structure from an incoming pipe.

Drop Structure – A type of grade control that disrupts the flow pattern in a river or stream by producing a pooling of water behind the structure and a rapid drop in surface gradient for water flowing over the structure.

Easement – A grant by a property owner to the public, a corporation, or a person, for the use of land for a specific purpose.

Easement, Common Ground – A grant by the developer to the Trustees of a subdivision for the use of land areas surrounded by public rights-of-way.

Easement, Cross Access – A designated private access way for the servicing of aisles or driveways that internally connect two or more properties.

Easement, Multiple Family Access – A designated private access way for the servicing of parking areas and bays and to abutting building developed as multi-family dwellings.

Easement, Permanent Drainage – A grant by a property owner to the City for the purpose of improving, constructing, repairing and maintaining drainage structures.

Easement, Permanent Footing – A grant by a property owner to the City for the purpose of improving, constructing, repairing and maintaining a retaining wall footing.

Easement, Permanent Road Improvement, Maintenance, Utility, Sewer and Sidewalk – A grant by a property owner to the City for the purposes of improving, constructing, repairing and maintaining roadway improvements, public or private utilities, storm and/or sanitary sewers and sidewalks.

Easement, Permanent Sidewalk, Sewer and Utility – A grant by a property owner to the City for the purpose of improving, constructing, repairing and maintaining sidewalks, sewers and utilites.

Easement, Permanent Sight Distance – A grant by a property owner to the City for the purpose of controlling and directing grading and the installation and maintenance of plant material, trees and/or structures by the property owner in a manner that will provide and insure sight distance for motorist as required by the City.

Easement, Permanent Stormwater Control – A grant by a property owner to the City for the purpose of improving, constructing, repairing and maintaining stormwater drainage facilities.

Easement, Permanent Stormwater Control Access – A grant by a property owner to the City to provide for access and upkeep of the area within designated stormwater control easements.

Easement, Permanent Traffic Signal – A grant by a property owner to the City for the purpose of improving, constructing, repairing and maintaining traffic signals and appurtentant structures.

Easement, Permanent Utility – A grant by a property owner to a public or private utility company for the purpose of improving, constructing, repairing and maintaining utilities.

Energy Grade Line – A line that represents the elevation of energy head of water flowing in a pipe, conduit or channel.

Engineer – A professional engineer registered in the State of Missouri.

Entrance, Commercial – A driveway providing ingress and egress for a commercial site.

Entrance, Residential – A driveway providing ingress and egress for a residential site.

Escrow – An agreement between the developer and the City of Wentzville whereby the developer establishes funds to cover the cost of completion of required on-site improvements as depicted upon approved construction improvement plans.

FEMA – Federal Emergency Management Agency

Fence, Sight Proof – A fence with an opaque value of seventy (70) percent or greater. Such structure may be a chain link fence in combination with slat or lattice materials.

Filtration – A process by which pollutants or pathogens are removed from stormwater by means of a porous media, such as sand, or a man-made filter.

Finished Grade – The final elevation of the ground surface after development.

Flood Insurance Floodway Maps – Current maps from the Federal Emergency Management Agency Flood Insurance Study.

Flood Insurance Study – The Official Report provided by the Federal Emergency Management Agency containing flood profiles; flood boundaries; floodway maps and the water surface elevation of the base flood.

Flood Plain – A geographic area susceptible to periodic inundation from the overflow of natural waterways during the base (100 year) flood.

Floodway – The area designated as Floodway on the Federal Emergency Management Agency Flood Boundary and Floodway Maps. It is derived by determining that portion of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.

Floodway Fringe – That area of the 100-year Flood Plain excluding the floodway is known as the floodway fringe. It is also that portion of the 100-year Flood Plain which can be developed without cumulatively raising the base flood elevation more than one foot.

Flowline – The low point (invert) in the cross section of a pipe or channel.

Force Main – A pressurized sewer carrying wastewater.

Foulwater Drops – A structure permitting sanitary flow to pass from an incoming pipe at a higher elevation to an outgoing pipe at a lower elevation.

Freeboard – The difference in elevation (expressed in feet) between the hydraulic grade line elevation and (1) the inlet sill elevation; or (2) the top of structure elevation; or (3) the top of channel bank elevation; or (4) the top of wall elevation.

Frontage – The edge of a lot bordering a street.

Full Median Opening - An opening in a non-traversable median that permits all movements, i.e., left-turns from the roadway, left-turns from an access connection or cross road and crossing movements from one side of the roadway to the other.

Functional Intersection Area - The distance traveled during the driver's perception-reaction time plus the distance to brake to a stop plus the distance for storing a queue of stopped vehicles.

Geotechnical Report – A report, signed and sealed by an engineer, used to determine extent of development and grading, slope stability in the form of maximum slopes, sink hole conditions, need for interceptor ditches and any items that may affect the extent of development and/or location of structures on the site.

Grade – The rate of deviation of the ground surface from the horizontal surface, expressed in percentages (i.e., 2%, 3%, etc.).

Grade Control – A weir, sill, dam, or other structure used to reduce steep channel grades or control erosion in incising channels.

Highway – Same as street.

House Lateral – Private sewer from building drain to the public sewer. This shall include the connection to the sewer.

Hydraulic Grade Line – A line coinciding with the level of flowing water at any given point along an open channel; or the level to which water would rise in a vertical tube connected to any point along a pipe or closed conduit flowing under pressure.

HS-10 – The live truck wheel loads as designated by the AASHTO Specifications.

HS-20 – The live truck wheel loads as designated by the AASHTO Specifications.

Impervious – The characteristic of a material that prevents the infiltration or passage of liquid through it. Examples of impervious surfaces include roads, streets, some parking lots, rooftops, and sidewalks.

Improvements – Street pavement, turning lanes, traffic signals, bridges and culverts, sidewalk pavement pedestrian way pavement, utilities, fire hydrants, storm sewers and roadside drainage ditches, erosion and siltation control, sanitary sewers, signs, monuments, landscaping, street lights, and other similar items.

Infiltration – The process by which rainfall or Stormwater runoff penetrates into soil and moves downward from the ground surface.

Inlet Time – The overland flow time for runoff to reach the inlet.

Intersection - A junction of two public roads.

Intersection Sight Distance - The distance required by a driver, traveling at a given speed approaching an intersection, to perceive the presence of potential conflicts and adjust their speed or come to a stop, as appropriate, to avoid a collision. It consists of the distance traveled during perception-reaction time plus the distance used while braking to adjust their speed or come to a stop.

Intrados – The inside top of the sewer pipe.

Irrevocable Letter of Credit – A commitment from an authorized lending institution to an approved escrow agent guaranteeing the availability of a sum of money sufficient in amount to cover the costs of construction and completion of required on-site and off-site improvements as depicted upon the approved improvement plans.

Land Surveyor – A professional land surveyor registered in the State of Missouri.

Large Vehicle - Any vehicle having more than two axles or dual wheels on any axle.

Lateral Sewer – A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it.

Left-turn lane, Left-turn bay - An auxiliary lane to permit a driver making a left-turn to clear the through traffic lane before decelerating to a stop.

License, Temporary Slope Construction – A grant by a property owner to the City for the purpose of making cuts, fills and sloping embankments, constructing driveways, providing working room and implementing any and all other related construction items in connection with the improvement.

Loading Space – A space within the main building or on the same lot providing for the standing, loading or unloading of trucks, which space shall have a minimum dimension of ten (10) by forty (40) feet and a vertical clearance of at least fourteen (14) feet. Each such designated space shall comply with the dimensional requirements set forth in section 405 of the Municipal Code. Off-Street Parking and Loading Spaces shall be located to avoid any maneuvering on public roadways.

Longitudinal Profile Survey – A profile of the channel surveyed along the flowline of a stream. A longitudinal profile is not a channel centerline profile and the two are not interchangeable.

Low Flow Channel – The portion of a stream channel that is maintained by the bank-full discharge. In a natural, two-stage channel, the low flow channel lies within a larger channel cross section containing the bank-full floodplains.

Low Sill – The lowest elevation of any opening in a building.

Main Sewer – The principal sewer to which branch sewers and sub-mains are tributary; also called trunk sewers.

Minimum Connection Spacing - The minimum distance between access connections on the same side of the roadway as measured from center-to-center of adjacent access connections.

MoDOT – Missouri Department of Transportation.

MoDNR – The Missouri Department of Natural Resources.

Monument – A marker to be made of materials and placed by a land surveyor at locations specified in Section 410.340 of the Municipal Code and/or as directed by the Department.

Monuments and Signs, Ornamental Entrance – A structure or device designed or intended to convey information to the public in written or pictorial form, and which identifies residential or non-residential subdivision and/or commercial developments.

MUTCD – Manual on Uniform Traffic Control Devices for Streets and Highways, U.S. Department of Transportation and the Federal Highway Administration, Washington, D.C., as amended.

"n" Value – A dimensionless coefficient used in the Manning's Equation to account for frictional losses in steady uniform flow.

Nonconforming Lot - A property that has frontage that is less than the access connection spacing due to topographic or other aloud conditions.

Normal Pool Elevation – The flowline elevation of the lowest control outlet for a pond or wetland.

On-Street Parking Space – A temporary storage area for a motor vehicle that is located on a dedicated street right-of-way.

Ordinance – Any ordinance duly adopted by the Board of Aldermen of the City of Wentzville.

Outfall - The point location or structure where wastewater or drainage discharges.

Parcel (Tract) of Land - A separately designated area of land delineated by identifiable legally recorded boundary lines.

Park - An area opens to the general public and reserved for recreational, educational or scenic purposes.

Parking Area - An area of land used or intended for off-street parking facilities for motor vehicles.

Parking Bay - A paved vehicle storage area directly adjacent to the access street or privately controlled pavement.

Parking Space - A durably paved, properly graded for drainage, usable space, enclosed in a main building or in an accessory building, or unenclosed, reserved for the temporary storage of one (1) vehicle and connected to a street, alley or other designated roadway by a surfaced aisle or driveway. Each such designated space shall comply with the dimensional requirements set forth in the City Code Title IV, Chapter 405, Article VII, Section 405.255i (Off-Street Parking and Loading Requirements).

Parkway - A road or roadway intended to be used primarily for passenger vehicles and developed with a park-like or scenic character, with recreational uses.

Pave (Pavement) - The act or result of applying a hard, water-tight material to any ground surface in such manner as to present a uniform surface over large areas.

Peak Hour Traffic - The 60-minute interval of highest traffic volumes on roadways within a study area and/or the 60-minute interval of highest traffic volumes of trips generated by a property.

Pedestrian Way - An easement or right-of-way designated to facilitate pedestrian access to adjacent streets and properties.

Perception - Reaction Time - The time needed by a driver to perceive a situation or condition plus the time to identify the specific situation or condition plus the time needed to evaluate and decide upon a specific course of action plus the time to initiate that action.

Permit - Permits as issued by the Department to include, but not limited to Storm Water Pollution Prevention Permits, Construction Permits, Blasting Permits and Utility Excavation Permits.

Person - Any individual, co-partnership, firm, association, company, or combination of individuals, of whatever form or character.

Plan, Concept - Drawing showing the site, internal circulation, adjacent public roads and commercial and residential entrances. Such plans must also show the dimensions and lane use of the existing public roadways.

Plan, Site - A drawing showing plan and section views of the existing conditions and proposed improvements.

Plans, Construction - Same as Plans, Improvement.

Plans, Improvement - The engineering drawings showing the construction details and the types of materials for the physical structures and facilities, excluding dwelling units, to be installed in conjunction with the development of the project.

Plat - A subdivision of land legally approved and recorded.

Pool – The topographical lows in a streambed produced by scour.

Pre-Developed Runoff Rate - The amount of flow from an existing site prior to new development or improvements as computed by the Rational Formula.

Prismatic Channel - A channel characterized by uniform cross sections and constant bottom slope.

Private Sewer - A sewer not accepted for public maintenance as determined by the reviewing agency.

Property Line - The legally recorded boundary of a lot, tract, or other parcel of land.

Public Sewer - A sewer which has been accepted for public maintenance as determined by the reviewing agency.

Public Utility Facility, Local - A public utility facility serving a local area only, such as an electric substation or a water or gas pumping or regulating station or a telephone switching center.

Radius of Curvature – The radius of an individual meander of a river or stream.

Reach - A distance, in pipe or channel, between two identified points.

Record Subdivision Plat - That plat containing the signature of the City Clerk which designates final approval and is recorded in the Office of the Recorder of Deeds of Saint Charles County.

Redevelopment – Removing an existing development or improvements and replacing with a new development or improvements.

Retention – Normally a basin used in the treatment and/or control of stormwater such that it is designed to hold water at all times, such as a lake. It is also used to delay and attenuate flows.

Revetment – Facing of stone or other material placed along the edge of a body of water to stabilize the bank and/or protect it from erosion.

Riffle – The topographical high areas in a streambed created by the accumulation of relatively coarse-grained sediment.

Riffle Spacing – A sequence defined as the beginning point of one riffle to the beginning of the next.

Right-of-way - A strip of land reserved or acquired by dedication, prescription, condemnation, gift, purchase, eminent domain or any other legal means, occupied or intended to be occupied by a street, sidewalk, railroad, utility, sewer, or other similar use.

Riparian Buffer – A vegetated area bordering a stream through which stormwater flows in a diffused manner, to prevent channelization of runoff and provide for the infiltration and filtering of stormwater. Riparian buffers are measured horizontally from the top of bank of a stream.

Riparian Corridor – The area bordering a stream generally comprised of trees and woody vegetation.

Road - The entire width and length of the right-of-way or the easement of a road, street, avenue or boulevard or similar item.

Roadway - That portion of a road intended for use by the general traveling public, typically delineated by curbs, edgelines, edge of pavement.

Roadway Right-of-Way Line - The boundary which divides a lot from a public or private roadway.

Sanitary Sewer – A sewer which carries wastewater.

Separate Sewer – A sewer intended to receive only wastewater or stormwater runoff.

Setback (Building Line) - The required minimum distance from a road, right-of-way or lot line that establishes the area within which a structure can be erected or placed, except as may be permitted in the Zoning Ordinance.

Sewer – A pipe or closed conduit carrying wastewater or stormwater.

Sidewalk - A paved area separate from the highway or roadway intended to be used by pedestrians.

Sight Triangle - specified 3-sided area, which should be clear of obstructions, with sides that follow along two adjacent intersection approaches that connect at a shared corner and connect to a third side placed across the corner. Distances along the triangles are based on drivers traveling at a given speed and the size of the intersection.

Sign, Guide - A sign identifying entrances, exits, aisles, ramps, and similar traffic-related information.

Signal Spacing - The distance between signalized access connections or intersections as measured center-to-center of the intersecting roadways.

Siltation Control - The installation of such devices as sediment ponds, bales of straw, siltation fencing, sodding or seeding and mulching, or other devices to prevent silting of abutting properties and roadway during the period of construction and up to and including such time as permanent ground cover is attained.

Sinkhole – a topographic depression with no natural surface drainage outlet.

Sinuosity – The ratio of channel length to valley length.

Slope - The rate of deviation of the ground surface from the horizontal surface, expressed in percentages or proportions (i.e., 3 horizontal: 1 vertical, 4 horizontal: 1 vertical, etc.).

Soils Report - See Geotechnical Report.

Springline – The line or plane in which an arch rises from its impost. In circular conduits, the horizontal plane through the midpoint of the section.

Standard Construction Details – Plans of structures or devices or construction details commonly used on City work and referred to on the plans or in the specifications.

Steady Flow – The quantity of water passing a cross section is constant, i.e., has patterns and magnitudes which so not vary with time.

Steep Grade - Roadway grades in excess of 6% or 8% as applicable to the street classification.

Stopping Sight Distance - The distance required by a driver, traveling at a given speed, to come to a stop. It consists of the distance traveled during perception-reaction time plus the distance used while braking to a stop.

Stormwater Detention – A stormwater runoff facility designed to detain (hold) stormwater temporarily during and immediately after a runoff event.

Stormwater Sewer – A sewer which carries surface runoff and subsurface waters.

Street - A public or private thoroughfare which affords the principal means of access to abutting property, including all facilities which normally occur within the right-of-way. The term shall also include such other designations as highway, thoroughfare, parkway, throughway, road, pike, avenue, boulevard, lane, place, court, but shall not include an alley or a pedestrian way. The pavement requirements for private streets shall be the same as public streets except that special roadway sections may be used for drainage and perpendicular parking.

Street, Access - A private thoroughfare or driveway which affords a means of access to parking areas and bays and to abutting buildings.

Street, Arterial - A major street so designated on the Highway System Plan adopted by the Commission, or otherwise designated by the Director of the Department of Highways and

Traffic, and utilized primarily for heavy volumes of traffic on a continuous route or for high vehicular speeds with intersections at grade.

Street, Collector - A secondary land service street that moves traffic from the arterial streets, and distributes traffic regionally, to the minor streets. Collector streets also may serve individual lots, parcels, and uses as a secondary or additional function.

Street, Creep - The lengthening or movement of concrete pavement due to cycles of contraction and expansion of individual slab sections.

Street, Cul-de-Sac - A short, independent, minor street terminating in a circular turnaround.

Street, Dead End (No Outlet) - A street having only one point of ingress and egress.

Street, Frontage or Service - A secondary street, generally parallel and adjacent to arterial streets and highways, which provides access to abutting properties and protection from through traffic by way of controlled access points along arterial streets or highways.

Street, Local Access - Same as Street, Minor.

Street, Loop - A short, independent, minor street which usually terminates along the same collector street of its origin.

Street, Minor - A land service facility for access to abutting properties. Minor streets serve the local neighborhood and are in the form of a cul-de-sac or loop street. Any combination of loop and cul-de-sac streets may be utilized without the streets being designated as collector streets provided such an arrangement serves the same function and the maximum fronting lots do not exceed the total allowed within the provisions of the Street Specifications Matrix set forth in Section 1005.180 of the Subdivision Ordinance.

Street, Multi-Family Access - A private way or driveway which affords a means of vehicular access to parking areas and bays and to abutting buildings in a multiple dwelling unit subdivision.

Street, Private - A privately maintained thoroughfare which affords the principal means of public access to abutting property and which is constructed within easements provided by adjacent property owners.

Street, Public - A street maintained by the Department.

Structure - Any assembly of material forming a construction for occupancy or use, excepting, however, utility poles and appurtenances thereto, underground distribution or collection pipes or cables, and underground or ground level appurtenances thereto.

Study Area (TIS study area) - An area within limits as defined by the City Engineer or City Public Works Director.

Study Horizon or Horizon year - The future year as defined by the City Engineer or City Public Works Director that the Traffic Impact Study should evaluate when analyzing the property's no-build condition (or other baseline alternative condition) and the build

condition. There can be more than one event horizon as determined by the City Engineer or City Public Works Director.

Subsequent Development – Adding to an existing development.

Substantial Completion of Development or Work –

a) In a project involving structures, the completion of the structures such that they may be placed into service.

b) In a project involving no structures or insignificant structures, the completion of grading.

Swale – A broad, shallow water course.

Time of Concentration – Consists of inlet time plus the travel time in the sewer or channel from the most remote point in the watershed to the point under consideration.

Title Company - A corporation qualified and acting under the Missouri Title Insurance Law or a corporation which is an issuing agency for an insurance company insuring land titles.

Title Page - Refer to Section 410.130 of The City of Wentzville Municipal Code entitled "Improvement Plans."

Thoroughfare Plan – A plan depicting the general alignment and nature of road improvements for existing and future classified roads on the Arterial and Collector Road Systems and listing of classification, minimum future pavement width and minimum right-of-way requirements for all classified roads.

Tract - An area or parcel of land which the developer intends to subdivide and improve, or to cause to be subdivided and improved, pursuant to the requirements of this criteria and applicable City of Wentzville ordinances.

Travel Time – The time it takes for the runoff to flow through the drainage system from one point of reference to the next point of reference.

Traveled way - That portion of a roadway for the movement of vehicles, exclusive of shoulders or auxiliary lanes.

Trunk Sewer – The principal sewer to which branch sewers and sub-trunks are tributary; also called main sewers.

Unclassified Road - All roads in the City of Wentzville which are not classified, typically a minor or local access street.

Uniform Flow – The flow in a channel, conduit or pipe, having a uniform cross section and velocity at every location within a given reach.

USGS – United States Geological Survey.

Utilities – Public service facilities for supplying gas, electricity, water, power, steam, cable T.V., telephone and telegraph communication, railway transportation, and the like. Sewers are not considered utilities.

Wastewater – The spent water of a community.

Watercourse – A stream of water or a natural channel through which water may flow.

Wetland – Lands where saturation with water is the dominant factor determining the nature of soil development and the types of flora and fauna inhabiting the land.

Zoning Ordinance – Title IV of the Municipal Code, as from time to time amended, which controls and regulates zoning for The City of Wentzville.

Chapter 2

Currently Not Being Used

3. Design Requirements for Sanitary Sewers

3.01 General

This section gives the minimum technical design requirements of the City for sanitary sewerage piping, pumping and treatment facilities. Adherence to these will expedite review and approval of plans. In general, the formulae presented herein for hydraulic design represent acceptable procedures not necessarily to the exclusion of other sound and technically supportive formulae. Any departure from these design requirements should be brought to the attention of the City and discussed before submission of plans for approval, and should be justified. All construction details pertaining to sanitary sewer improvements shall be prepared in accordance with the City of Wentzville Standard Specifications and Construction Details unless otherwise noted.

3.02 Regulations Governing the Use of Public and Private Sewerage Facilities

The following sections are summarized from the City of Wentzville Sewer Use Ordinance. The current Sewer Use Ordinance in effect shall be considered the governing document and should be consulted for elaboration. Requests for variances or clarification of these regulations should be addressed to the attention of the Director with information supporting the request.

3.02.01 Unlawful Discharges and Sewage Disposal

1. Discharges and deposits of any sewage, industrial wastes, garbage, polluted water or any other substance that constitutes a nuisance or hazard to the public health or welfare into any natural outlet, drainage channel, or watercourse, are prohibited.

2. No cesspool, septic tank or other facility intended or used for the disposal of sewage shall be installed except as hereinafter provided.

3.02.02 Public Sewer Availability

A public sanitary sewer shall be considered to be available if it is within two hundred (200) feet of any part of the property to be connected to the sewer. Under such conditions a direct connection must be made to the public sewer.

3.02.03 Prohibited Discharges and Waste Disposal Into Sanitary Sewers

1. Surface water, stormwater, groundwater, roof runoff, subsurface drainage, uncontaminated cooling water, unpolluted industrial process waters, shall not be discharged to a sanitary sewer.

2. No person shall deposit or throw into any sewer, or into any private drain connecting with a public sewer any waste, product or material of manufacture, rags or garbage which has not been properly shredded, or any substance which may constrict, cause a nuisance, dam or otherwise obstruct any sewer.

3. No gasoline service station, garage, car wash facility, refining plant, chemical plant, packing house, slaughter house, lard rendering establishment, dairy, steam plant, or any other establishment from which any substance would be discharged into the sewers which could tend to obstruct or damage the sewers, or cause a nuisance, or endanger the public health or safety, or endanger persons who might be in such sewers, shall be connected with any public sewer, or to any private sewer which discharges directly or indirectly into any public sewer. EXCEPTION would be through one or more City approved interceptors or traps. Any approved trap shall be maintained and operated in a manner satisfactory to the City, and the substance removed from such traps shall not be deposited in a way or place not previously approved by The City of Wentzville.

   Where grease, oil and grit interceptors, and other, preliminary treatment facilities are provided, they shall be maintained continuously in satisfactory and efficient operation by the owner at his expense. Such facilities shall be subject to inspection by the City at all times. Sampling "T-s or control manholes may be required that would be easily accessible by the City.

   If the substance discharged by any establishment is deemed harmful to the sewer, detrimental to the public health or safety, and dangerous to persons who may enter such sewers, the discharge from such establishment shall be entirely excluded from the sewer.

3.02.04 Wastes Having Excessive Biochemical Oxygen Demand (BOD_5), Suspended Solids, or Toxic Elements

If excessive BOD_5, suspended solids or toxic elements could occur and constitute a nuisance or adversely affect the operation of any existing or proposed sewage treatment plant or overload any sewage treatment plant owned or operated by the City, the owner shall provide, at his expense, such preliminary treatment as may be necessary to:

1. Control objectionable characteristics or constituents in such a manner as to not obstruct or interfere with the maintenance or operation of any public sewerage facility.

2. Control the quantities and rates of discharge of such waters or wastes. Plans, specifications, and other pertinent information relating to proposed preliminary treatment facilities shall be submitted for the approval of the City, and construction of such facilities shall not commence until such approval is granted in writing.

3.02.05 Measurements, Tests, and Analysis

The City shall be provided means to monitor the discharge into the public sewers of any waters or wastes discharging into sewer or any treatment facility maintained and operated by the City that contain any quantity of

substances having the characteristics described in Sections 3.02.03 or 3.02.04, or have an average daily flow greater than two percent (2%) of the average daily sewage capacity of the treatment facility. All discharges shall be subject to the analytical inspection and approval of the City.

Measurements, tests, and analyses of the characteristics of the water and wastes referred to in Sections 3.02.03 and 3.02.04 shall be determined in accordance with the current edition of "Standard Methods for Examination of Water and Wastewater" published jointly by the American, Public Health Association, the American Water Works Association and the Water Environment Federation. Other approved testing methods as specified by the Environmental Protection Agency in 40 CFE PART 136 may also be used. Additional methods of making measurements, tests or analyses of the characteristics of water or wastes may be required by the Director of Public Works, when, in the opinion of the Director, they are necessary.

All measurements, tests or analyses shall be upon suitable samples taken at the sampling "T" or control manhole. In the event no special manhole has been required, the control manhole shall be considered to be the downstream manhole in the public sewer nearest to the point at which the building or industrial connection is made. All non-residential facilities shall have a six (6) inch (minimum) diameter, straight "T" vent for taking samples. This "T" vent shall be located on the lateral line outside the building. The "T" placement shall be before the lateral connects to the public sewer and downstream from any grease traps, interceptors, or any other private wastewater treatment system.

3.02.06 Furnishing Records

It shall be the duty of every person, public utility, or institution holding a permit to operate a sewerage system or sewage treatment plant to furnish records as may be required by the City to ascertain compliance with the rules and regulations and ordinances of the City.

3.03 General Requirements of Sanitary Sewer Construction

All sanitary sewers shall meet the following general requirements:

3.03.01 Size and Shape

The minimum diameters of pipe for sanitary sewers shall be eight (8) inches. Sewers shall not decrease in size in the direction of the flow. Circular pipe sewers shall be used for all sizes of sanitary sewers. The minimum diameters of pipe for sanitary sewer laterals shall be six (6) inches.

3.03.02 Materials

All materials shall conform to The City of Wentzville Standard Specifications and Construction Details.

3.03.03 Bedding

The project Plans and Project Specifications shall indicate the specific type or types of bedding, cradling, or encasement required in the various parts of the sanitary sewer construction if different than the current City of Wentzville Standard Specifications and Construction Details.

Special provisions shall be made for pipes laid under or over fills or embankments in shallow or partial trenches either by specifying extra strength pipe for the additional loads due to differential settlement, or by special construction methods, including ninety (90) percent modified proctor compaction of fill, to prevent or to minimize such additional loads.

Compacted granular backfill shall be required in all trench excavation within public (or private) rights-of-way or areas where street rights-of-way are anticipated to be dedicated for public use. Under areas to be paved, the compacted granular backfill shall be placed to the sub-grade of the pavement. Under unpaved areas, the compacted granular backfill shall be placed to within two (2) feet of the finished surface.

Pipes having a cover of less than three (3) feet shall be encased in concrete, unless otherwise directed by the City.

If the storm and sanitary sewers are parallel and in the same trench, the upper pipe shall be placed on a shelf and the lower pipe shall be bedded in compacted granular fill to the flow line of the upper pipe.

3.03.04 Pipe or Conduit Under Streets and Pavements

Any pipe or conduit material beneath a highway, road, street, or pavement, or with reasonable probability of being so located, shall have ample strength for all vertical loads, including the live load required by the highway authority having jurisdiction, and in no case shall provide for less than an AASHTO HS-20 loading. For other locations, the minimum live load shall be the HS-10 loading. Special considerations may be required for adverse conditions. Granular backfill, consisting of 1” clean stone, shall be utilized in utility trenches for fill, up to the base of the pavement.

3.03.05 Joints

The joint type required for the type of pipe used and the application shall conform to the latest standards set forth in the City of Wentzville Standard Specifications and Construction Details or as approved by the Engineering Division.

3.03.06 Monolithic Structures

Monolithic reinforced concrete structures shall be designed structurally as continuous rigid units.

3.03.07 Alignment

Sanitary sewer alignments are normally limited by the available easements which in turn should reflect proper alignment requirements.

Sanitary sewers shall be aligned:

1. To be in straight line between structures for all pipe sewers thirty (30) inches in diameter and smaller.

2. To be parallel with or perpendicular to the centerline of straight streets unless otherwise unavoidable. Deviations may be made only with approval of the City.

3. To avoid meandering, off-setting and unnecessary angular changes.

4. To make angular changes in alignment in a manhole located at an angle point.

5. For sewers thirty-three (33) inches in diameter or larger, consideration may be given to the use of curvilinear alignment, on a case by case basis. However, curvilinear alignment of large diameter sanitary sewers will generally not be allowed. The design shall include the following:

   a. The alignment shall not exceed the manufacturer's maximum joint deflection limit, and shall have a minimum radius of ten times the pipe diameter
   b. Compression joints shall be specified on the plans
   c. Curves are to be simple that start and end at manholes
   d. Calculated velocity shall be equal or greater than 2 feet per second when flowing full

6. To avoid angular changes in direction greater than necessary and any exceeding ninety (90) degrees.

3.03.08 Location

Sanitary sewer locations are determined primarily by the requirements of service and purpose. It is also necessary to consider accessibility for construction and maintenance, site availability and competing uses, and effects of easements on private property.

Sanitary Sewers shall be located:

1. To serve all property conveniently and to best advantage.

2. In public streets, roads, alleys, rights-of-way, or in sewer easements dedicated to the City.

3. In easements on private property only when unavoidable.

4. On private property along property lines or immediately adjacent to public streets, avoiding crossing through the property.

5. At a sufficient distance from existing and/or proposed buildings (including footings) and underground utilities or other sewers to avoid encroachment and reduce construction hazards.

6. To avoid interference between house connections to foul water or sanitary sewers and stormwater sewers.

7. In unpaved or unimproved areas whenever possible.

8. To avoid, whenever possible, any locations known to be or probably to be beneath curbs, paving or other improvements particularly when laid parallel to centerlines.

9. To avoid sinkholes and creeks.

3.03.09 Flowline

The flowline of sanitary sewers shall meet the following requirements:

1. The flowline shall be straight or without gradient change between the inner walls of connected structures.

2. Gradient changes in successive reaches normally shall be consistent and regular, with small or insignificant differences in successive reaches. Gradient designations of less than the nearest 0.001 foot per foot, except under special circumstances and for larger sewers, shall be avoided.

3. Sewer depths shall be determined primarily by the requirements of pipe or conduit size, utility obstructions, required connection, future extensions, and adequate cover.

4. For sanitary, the hydraulic grade line shall not rise above the intrados of the pipe.

5. When the grade of a sewer is twenty (20) percent or greater, concrete collars are required. The table below indicates the maximum allowable spacing:

Slope	Max. Concrete Collar Spacing (feet)
20% to 35%	36
35% to 50%	24
>50%	12 or one per joint of pipe

For grades exceeding fifty (50) percent a special design and Project Specifications are required.

6. High Velocity Protection. The maximum permissible velocity at average daily flow shall be 15 feet per second. Drop manholes shall be provided to break the steep slopes to limit the velocities to 15 feet per second in the connecting sewer pipes between manholes. Where drop manholes are impracticable for reduction of velocity, the sewer shall be fitted with concrete collars at 15 foot intervals along the slope to limit movement of the pipe.

7. A 0.2' drop shall be provided from the incoming to outgoing flowline of manholes.

3.03.10 Manholes

Manholes provide access to sewers for purposes of inspection, maintenance and repair. They also serve as junction structures for connecting lines. Requirements of sewer maintenance determine the main characteristics of manholes.

1. Manholes shall be located at changes in direction, changes of pipe size, flowline gradient, and at junction points with connecting sewers.

   For sewers thirty-three (33) inches in diameter and larger, manholes shall be located on special structures, at junction points with other sewers, and at changes of size or gradient.

2. Spacing of manholes shall not exceed four hundred (400) feet for pipe sewers thirty-six (36) inches in diameter and smaller and five hundred (500) feet for pipe sewers forty-two (42) inches in diameter and larger, except under special approved conditions. Spacing shall be approximately equal, whenever possible.

3. At stream and channel crossings, manholes shall be located on both sides of the crossing at changes in pipe material. The manhole shall be located a minimum of twenty (20) feet from the top of the bank on both sides of the crossing.

4. All manholes on sanitary sewers that are built within the 100-year flood limits, in the Stormwater overland flow path, or in areas determined to be subject to flooding shall be provided with lock-type watertight manhole covers.

5. Manholes located on 8" sanitary sewers shall be 42" diameter, minimum size. Manholes located on 10" sanitary sewers and larger shall be 48" diameter, minimum size. Manholes having one (1) inside drop shall be 48" diameter, minimum size. Manholes having two (2) inside drops shall be 60" diameter, minimum size. Terminal manholes

that could facilitate a future extension of the sanitary system shall be 48" diameter manholes, minimum.

3.03.11 Sewage Treatment Facilities

New treatment plants will not be allowed.

3.04 Design Requirements

3.04.01 General

All Sanitary Sewers shall be so designed and constructed as to conform to these design requirements. Hydraulic Calculations shall be submitted when requested by the City or when pipes 12" and smaller in size have slopes exceeding 10% and when larger pipes have slopes exceeding 5%. As part of the hydraulic calculations, velocities shall be calculated for all pipes under these conditions. Calculations must include existing and ultimate upstream development conditions.

3.04.02 Gradients

The following minimum slopes of sanitary pipe sewers are those giving at least 3 feet per second velocities flowing full, based on Manning's formula using an "n" value of 0.013 unless otherwise directed by the City. Slopes greater than these minimums shall be used wherever possible.

Pipe Size	Minimum Slope in Ft. per 100 Ft. (% Grade)
8	1.0
10	0.6
12	0.6
15	0.4
18	0.3
21	0.3
24	0.2
27	0.2
30	0.2
36	0.1

Pipes larger than thirty-six (36) inches in diameter shall maintain a cleansing velocity of three (3) feet per second.

Sanitary Sewer laterals, which shall be a minimum size of 6", shall have a minimum slope of 2%. (2 feet per 100 feet)

3.04.03 Depth and Minimum Cover

The minimum depth of collecting and lateral sewers should be nine (9) feet below the finish street grade to flowline except where the topography indicates this depth is not necessary. Where the nine (9) feet depth is not required, the minimum vertical distance from the low point of a basement or low floor to the flowline of a sanitary sewer at the corresponding house connection shall be not less than the diameter of the sewer plus a vertical distance of two and one-half (2 l/2) feet. This minimum vertical distance shall be increased, if the length of the lateral requires, obtaining a minimum slope of two (2) percent for six (6) inch house laterals. These minimum depths will not apply to interceptor sewers in low areas whose only function is to carry off the accumulated flow to existing or proposed trunk sewers.

All collecting and outfall, sub-trunk and trunk line sewers in low areas in close proximity to natural watercourses shall be constructed at depths low enough to permit all proposed and existing connecting lateral sewers to make the channel crossing so as to have at least two (2) feet of cover over the top of the lateral pipe. All sanitary sewers shall have a minimum of two (2) feet of cover where crossing streams or channels. All sanitary sewers shall be laid deep enough to allow for future extension of the system to fully serve the watershed. The foregoing depth requirements may be modified in special cases when such modifications are feasible and will not jeopardize the design when considered as an integral part of an overall system. The City shall approve all modifications.

All sewer mains twenty (20) feet in depth or greater shall be C900 PVC, said pipe extending from Manhole to Manhole. All sewer laterals connected to C900 PVC main, shall also be of C900 PVC, extending up to the building line of the property being served

3.04.04 Flow Design

All lateral and sub-main or collecting sewers shall be designed on the basis of an average per capita use. In the case of industrial flow, when the rate and volume can be predetermined with a reasonable degree of accuracy, no dilutions or diminishing factor shall be applied against this flow in the outfall, sub-trunk or trunk sewers.

3.04.05 Sanitary Flow Table

	Flow (Gallons per day per capita)	Persons per unit
Single Family Homes	100	3.7
Apartment or Condominium		
(1 Bedroom)	100	2.0
(2 Bedroom)	100	3.0
(3 Bedroom)	100	3.7

The Population Equivalent (PE) shall be equal to 100 gallons per day per person. When flows are calculated from commercial or non-residential developments, the PE shall be calculated, along with the basis for same. Calculations shall be provided to the Engineering Division for review for all other types of establishments and uses. Flow quantities must be referenced from an acceptable industry standard or studies. All sewers, lift stations and force mains shall be designed for the peak flow rate using the peaking factor as calculated from the following formula:

$$\text{Peaking Factor} = \left(18 + \sqrt{\frac{PE}{1000}}\right) \div \left(4 + \sqrt{\frac{PE}{1000}}\right)$$

3.04.06 Infiltration

An additional amount of flow due to infiltration shall be evaluated. All sanitary sewers shall be limited to a maximum of 200 gallons per inch of diameter per day per mile of line, as required by MDNR Specifications, when tested by actual infiltration conditions. In addition, there shall be no visible leaks. All manholes on sanitary sewers that are built within the 100 year flood limits or in other areas determined to be subject to flooding shall be provided with lock type watertight manhole covers.

3.04.07 Special Situations and Design Requirements

1. Connections to Manholes

   a. Foulwater drops are required only for sewers containing sanitary flow and then only when it is necessary that sanitary flow enter a manhole at a height of two (2) feet or greater above its flowline. If an inside drop is to be used, a forty-eight (48) inch diameter manhole is required. If two inside drops are to be used, a sixty (60) inch diameter manhole is required. Sewer-lines shall not enter the manhole in the transition conical section, or through a joint. The slope on incoming pipes should be limited to a maximum one percent for inside drops. Manhole inverts should be shaped to assure proper flow through drop structures. All drop sewer lines are to be ductile iron for the first 20 feet upstream from the manhole.

   b. If it is necessary to enter a manhole with a force main this should be done within twelve (12) inches of the flowline of the manhole, and the manhole invert should be shaped to ensure proper flow through the structure.

      Consideration shall be given to the detention time of the sewage in the force main, and the potential detrimental effects of the release of hydrogen sulfide from the force main on the concrete structure of the manhole. The receiving manhole and

the next 2 downstream concrete manholes, at a minimum must be protected by the application of an epoxy coating.

c. The number of lines coming into one manhole should be kept to a minimum. A special detail may be required to assure the proper constructability and maintenance of the structure.

d. Pipes entering and exiting manholes at the flowline should project through the center of the structure and the manhole invert should be shaped to assure proper flow through the structure.

e. Private house lateral connections should be made to the main sewer, not to the manholes.

f. All connections to sanitary manholes are subject to City of Wentzville review and approval and will be made at the City's discretion.

g. Connections to existing structures may require rehabilitation or reconstruction of the structure being utilized. This work will be considered part of the project being proposed.

h. Connection to existing structures shall not be made to the surface of the existing bench. The bench must be chiseled out to make the new invert for connection.

2. Adjusting Manholes to Grade

When a project requires a manhole to be adjusted to grade, a maximum of twelve (12) inches of rise is allowed if not previously adjusted. Adjustments greater than twelve (12) inches, or lowering, will generally require rebuilding all or part of the manhole.

3. Swimming Pools

Swimming pool backwash connections to the sanitary sewer must not exceed fifty gallons per minute (50 gpm).

4. Channel Crossings

If a sanitary sewer must cross under a channel, the pipe must be concrete encased when cover is less than 3 feet. A manhole shall be provided on both sides of the crossing at changes of pipe materials at a minimum distance of twenty (20) feet from top of bank of both sides of the crossing.

Channel crossing shall not conflict with sewer outfalls, headwalls, manholes, gateboxes or other structures and shall not interfere with stream flood flows.

5. Private Force Main Connections

When site topography does not allow for gravity lateral service to the sanitary sewer, a private force main connection may be made. The City requires that a grinder pump or sewage ejector be used in these cases. As indicated above, in Section 3.04.07 1.b., the connection shall be made into a manhole, in accordance with the requirements set forth therein.

6. Storm Sewers Crossing Over Sanitary Sewers

When a storm pipe crosses over a sanitary sewer and the vertical clearance is less than two (2) feet, the sanitary sewer must be encased in concrete through the crossing and for ten (10) lineal feet each side of the crossing.

7. Location in Conjunction with Water Service

Sanitary sewers shall be at least ten (10) feet horizontally from any existing or proposed water main. On crossings, a minimum vertical clearance of eighteen (18) inches shall be provided between the outside of the water main and outside of the sanitary sewer. If these minimum clearances cannot be met, then the requirements set forth in the Standard Specifications shall be followed.

8. Abandonment of Sanitary Sewer Services

Sanitary sewer laterals, from buildings to be demolished, shall be plugged with concrete for their entire length, or removed. Portions of a lateral may be left in service if those portions of the lateral are to be continued in service to replacement buildings, and existing buildings which remain on the lateral. All laterals permanently abandoned shall be cut off and capped at the sewer main as directed by the City.

Sewer mains that are to be abandoned shall either be plugged with concrete for their entire length or removed. Manholes that are to be abandoned shall be plugged with either concrete or the bottoms broken out, with the inlet and outlet piping being plugged. The top section of the manhole, consisting of the cone section lid and cover are to be removed, and the void filled with 1” clean stone.

9. Oil/Gas Separators and Sand Filters

If required by the City, grease, oil and sand interceptors or traps shall be provided when such devices are necessary for the proper handling of liquid wastes containing grease or oil in excessive amounts or any flammable wastes, sand, or other harmful materials which can be trapped. Such interceptors or traps shall not be required for private dwelling units. Prior to the installation of any interceptor or trap,

drawings and specifications shall be submitted to the City for approval. All interceptors and traps shall be located so as to be readily accessible for cleaning and inspection.

Grease and oil interceptors or traps shall be constructed of impervious materials capable of withstanding sudden and extreme changes in temperature. All such devices shall be of substantial construction, water-tight, and equipped with easily removable covers which, when bolted in place, shall be gas tight and watertight, unless otherwise approved by the City.

All grease, oil and sand interceptors or traps shall be maintained in effective operation at all times by and at the expense of the user.

3.05 Sanitary Detention Requirements

3.05.01 Surcharged Sanitary Sewers

When it has been determined that the outfall sewer or the downstream system serving a proposed development is overcharged, the City may require the developer to provide special facilities that the City deems necessary. As an example, the downstream system may need to be upgraded in order to provide additional capacity, by the replacement of an inadequately sized pipe, by a pipe sized for the additional flows, or the construction of a pipe, located parallel to the pipe that is undersized.

In the design of such facilities, consideration should be given for the protection of structures and equipment against corrosive and/or explosive gasses that may result from the detention of sewage.

4. Design Requirements for Sewage Pumping Stations

4.01 General

This section gives the minimum technical design requirements for the City of Wentzville for sewage pumping stations.

To provide the most efficient, cost effective, reliable service to the customers of the City, sanitary sewage pump stations will only be considered where a thorough study of all alternatives clearly indicate a gravity collection and disposal system is not practical or feasible.

The following are the standard specifications for pump stations to be installed within the jurisdiction of the City of Wentzville. These specifications not only adhere to the guidelines and set out by the Missouri Department of Natural Resources but also incorporate the most cost effective and reliable design for maintenance and operation.

Failure of any particular equipment or installation design may, from time to time, dictate changes in the design specifications. It is the responsibility of the designing engineer to check with the Engineering Division before starting design work to ensure that the designer has the latest revisions.

4.02 Plan Review Procedure

The following material must be submitted to the Engineering Division for review of any proposed pump stations. See section 1.03.02 (2) for the required number of submittal documents.

4.02.01 Engineering report

All pump station plans shall be accompanied by an engineering report typed and bound in an 8 ½" x 11" booklet. The following information shall be included in the report:

1. Title Page
    a. Date
    b. The Developer/Owner
    c. Engineering firm preparing plans.
    d. Engineer's Seal
    e. City of Wentzville Project Number
2. Sewer System Information
    a. Introduction
        1) Type, location and size of development
        2) Number of and range in size of lots or buildings to be serviced.

b. Existing Sewer System

Location and type of gravity system the force main will discharge into.

c. Future of Sanitary Sewer Service

1) State whether the entire development will be serviced by the proposed phase or if several phases will be involved.

2) State the number of lots this phase will encompass initially and finally if future phases are to be constructed.

3) State whether other areas outside of the development may be tributary to the pump station.

3. Pump Station and Force Main Calculation

a. Population Equivalent

Nb = Number of specified types of buildings
Np = number of persons per unit = 3.7
PE = Population Equivalent – Nb x Np = 3.7 x Nb

b. Average Daily Flow (ADF)

F = Flow (See section 3.04.04 and 3.04.05)
I = Infiltration Flow from:

1) gravity system
2) 8 hour retention chambers
3) 12” piping from retention chambers to wet well

I = Piping diameter (in.) x piping length (miles x 200 gal./in.dia./mi,/day)

ADF (GPD) = F + I
ADF (GPM) = ADF (GPD) / 1440 (min./day)

c. Peak Daily Flow (PDF)

PDF (GPD) = Peaking Factor x ADF (GPD)
PDF (GPM) = Peaking Factor x ADF (GPD)

Peaking Factor – See section 3.04.05

d. Total Dynamic Head

1) Static Head (H_S)
E_h = Maximum force main elevation
E_1 = Wet well low water elevation (Pump Off)
H_S (feet) = E_h - E_1

2) Loss (L_f) due to friction in force main
Length = Total equivalent length of force main (feet)
L_f (feet) = Length x Friction Factor

3) Loss (L_s) from friction in the station piping
Length = Equivalent length of station piping (feet)
L_s (feet) = Length x Friction Factor

4) To Calculate the Friction Factors, use the Hazen and Williams formula with the following c-Factors:

For the design pump operating point:

Unlined iron or steel pipe:	C=100
All other pipe (including Plastic and lined DIP)	C=120

To ensure pump motor does not overload after initial installation:

Plastic Pipe and lined DIP	C=150
All other pipe	C=140

The operating point on submersible pump stations will be evaluated at low water cutoff.

Friction head loss per 100' pipe:

$$= 0.2083 \times (100/C)^{1.85} \times Q^{1.85} / d^{4.8655}$$

5) TDH (feet) = $H_s + L_f + L_s$

Plot a worst case TDH curve, using the lower C values above, and a best case TDH curve, using the higher C values above, on a manufacturer's pump performance curve sheet.

The Constant Speed Rating (CSR) or the pump's operating point is the point where the worst case TDH and the pump manufacturer's pump performance curve intersect.

Find where the best case TDH and the pump manufacturer's pump performance curves intersect and check the pump is not in an overload condition.

A minimum of four flow rates shall be used to plot each curve.

e. Eight Hour Storage Requirements
Volume of Retention Chambers (V_s) in gallons

V_s = ADF (GPD) ÷ 3 = Cylindrical volume of retention chamber pipe used

Note: Volume of inlet gravity lines or wet well shall not be included to size the eight-hour storage. Only volume of retention chambers shall be used.

f. Buoyancy Calculations

1) W_w = Weight of concrete wet well
W_f =Weight of concrete bottom slab
W_e = Weight of earth backfill on footing
$W_t = W_w + W_f + W_e$

2) W_s = Weight of displaced sewage

3) W_t = should be greater than W_s

4. Cycle Times

a. Volume (V_r) of water required to raise the level in the wet well for the primary pump to turn on:

1) Elevation difference (E5) between primary pump on elevation (E3) and pump off elevation (E4)

E5 (feet) E3 - E4

2) Volume (V_{pf}) of water per vertical foot in the wet well:

V_{pf} (gal./ft.) = A x 7.481 (gal./cu. Ft.)

A = the inside area of the wet well

3) V_r (gal.) = E5 x V_{pf}

b. Cycle time for ADF

1) Time (T_f) required for volume in wet well to reach Vr (Pump Off)

T_f (min.) = V_r / ADF (GPM)

2) Time (T_p) required for pump to return water level to the pump off elevation (Pump On)

T_p (min.) = V_r / (CSR - ADF)

3) Time (T_c) required for one complete cycle of a duplex pump station. (Should the pump station consist of 3 or more pumps, the multiplier shall be equal to the number of pumps included in the station.)

T_c (min.) = 2 x (T_f + T_p)

c. Cycle time for PDF

1) T_f (min.) = V_r / PDF (GPM)
2) T_p (min.) = V_r / (CRS - PDF)
3) T_c (min.) = 2 x (T_f + T_p)

5. Listing of results from the design calculations to be presented in the following order:

a. Number of lots or building
b. Population Equivalent
c. Average Daily Flow in GPM
d. Peak Daily Flow in GPM
e. The volume of the 8 hour retention chamber
f. Static Head
g. Total Dynamic Head
h. The pump selected (including type, size, Hp, RPM, phase and GPM)
i. Total cycle time for ADF
Number of Minutes ON (Pumping Time)
Number of Minutes OFF (Fill Time)
j. Total cycle time for PDF
Number of Minutes ON (Pumping Time)
Number of Minutes OFF (Fill Time)
k. Size and length of force main. (Actual inside diameter shall be used in calculations and not the nominal diameter of pipe.)
l. Velocity maintained in force main
m. Force Main Test Pressure
This figure is taken from the selected pump manufacturers' performance curve and is considered to be the maximum pump shut off head in PSI, plus 50 lbs. This figure shall also be clearly indicated on the force main profile sheet as:
"FORCE MAIN TEST PRESSURE".

6. The manufacturer's specifications for the pumps shall be included in the back of the report booklet. Selected items on the manufacturer's cut sheets shall be marked for ease of identification.

7. Pump performance curves shall be included with the proposed pump information. The C.S.R. rating for both pumps shall be plotted on the manufacturer's curve using a system head-capacity curve. A minimum of four random flow rates shall be used to plot each curve. Figures used to determine each point shall be listed.

8. Construction, Operation and Maintenance

   It is the responsibility of the Developer/Owner to construct the pump station according to the approved construction drawings and specifications included in this report. The Developer/Owner will furnish a 24-hour emergency telephone number in the event the station needs attention/repair before City acceptance.

4.02.02 Individual 24" x 36" design plan sheets of:

1. Pump station structure (1/2" = 1' scale)

2. Pump and valve chamber interior layout (1/2" = 1' scale)

3. Site plan (1/4" = 1' scale)

4. Force main plan and profile, with thrust block locations indicated on each sheet.

5. Gravity system plan and profile, with elevations for both the building lateral and the lowest finished floor connections being indicated on the profile sheet.

6. Detailed items such as: service panels, thrust blocks, alarm towers, etc.

4.02.03 Detail Drawings

A detailed plan and profile drawing of the pump station concrete structure shall be included in the submitted plans detailing:

1. The size and location of all gravity lines, discharge pipes, drain piping and electric passage openings.

2. Reinforcing bar

3. Floor, top and wall dimensions

4. Detail of the wet pit and valve pit hatch casting with the exact location of the hatches (for wet well hatch placement contact pump manufacturer).

5. All elevations of station piping passages

6. Structure elevations at the:

   a. Footing bottom
   b. Wet well flow line
   c. Valve chamber floor
   d. Structure top

7. On pre-cast stations, gravity lines must have their angles of entry included on the structure plans at their point of entry to the structure.

8. All pipes must enter the structure walls with a one foot minimum distance from the center line of the pipe to the face of the adjoining wall to allow for proper pipe gasket placement.

9. One detailed section joint shall be included on the structural sheet. Actual joint elevations shall be determined by the precast manufacturer.

10. A sectional view of the chamber tie walls detailing each wall as you are facing it from the pump chamber and valve chamber side.

11. To prevent the possibility of the valve chamber pulling the top section of the wet well off of the joint, a poured counter weight is required to offset the mechanical lever arm tipping force. The counter weight shall be monolithically poured at the bottom of the upper most wet well section opposite of the valve chamber tie wall. Size and weight of the counter weight shall be shown on the plans.

4.02.04 Structure Sheet

The purpose of this sheet is to provide an accurate, complete, non-cluttered structure sheet for the pre-cast company. All measurements and information needed to cast this structure should be included on this sheet. The pump, pipe, and electrical details shall not be displayed on this sheet. Information not pertinent to the structure should not be included. Structure plans shall be drawn to a ½" equals 1' scale on its own individual plan sheet.

4.02.05 Electrical Plans

1. Electrical Plans shall be submitted detailing all:

   a. Field and factory schematics and wiring diagrams
   b. Conduit and wire sizes
   c. Conduit layouts from:
      i. The electric service entrance to the control panel
      ii. Control panel to the valve vault

2. The following information shall be included on the plans:

    a. Date
    b. Project name
    c. Control panel job number
    d. All nameplate information of the installed pumps
    e. Complete bill of materials for all installed components

3. Plans shall also include all external devices interfaced into the control panel such as:

    a. Valve chamber pressure switches
    b. Floats
    c. SCADA telemetry
    d. Phase converters (when applicable)

4.02.06 Site Plans

A detailed pump station site plan, using a ¼" = 1' scale, shall be submitted along with the completed design plans. The site plan shall include the following:

1. All access roads, fencing and pavement surrounding the pump station.

2. Location of all sewer, water, storm and electric lines running to or through the pump station easement.

3. Location of all pump station appurtenances, such as, control panels, antenna poles, yard hydrants, boxes, phase converters (if applicable), etc. (Yard hydrants are to be located a minimum of 25 feet from the lift station wet well structure.)

4. Details on any proposed landscaping affecting the immediate area surrounding the pump station site.

5. Property information shall be shown on the site plan indicating:

    a. City/Pump Station ingress, egress and sewer easements.
    b. Adjacent private or common ground property lines.
    c. Utility Easements and Drainage Easements.

Plans submitted to the City that do not have required sheets and/or engineering booklet shall be returned to the designing engineer with a "request for missing material". No attempt will be made to review incomplete submittals.

Upon completion of the review by the appropriate City personnel, all comments will be forwarded to the designing engineer by the Engineering Division.

No construction approval of a portion of a sanitary sewer system, which requires a pump station, shall be given until construction approval of the pump station and force main has been made.

4.03 Testing and Acceptance Procedure

See Section 407 of the City of Wentzville Standard Specifications.

4.04 Pump Station Design Criteria

4.04.01 Structure Requirements

The following table shall be used for the pump station structure design in addition to those items listed below:

Structure Requirement	Standard Specification
Design of Concrete Structures	Sec. 401.2
Joining Chambers	Sec. 401.3
Access Hatches	Sec. 401.4
Access Openings	Sec. 401.5
Gravity Pipes	Sec. 401.6
Valve Chamber Floor	Sec. 401.7
Valve Supports	Sec. 401.8
Entrance Steps	Sec. 401.9
Sealing of Wet Well & Valve Chamber	Sec. 401.10

1. Retention Chamber

Eight-hour retention chambers are required method to allow gravity flows to continue without –

a. Bypass of sewage to the environment
b. Property damage/loss to the City customer
c. Creation of public health hazard

Retention chambers shall be sized based on the 8 hour ADF quantity. Eight-hour retention chambers allow for power outages, lightning strikes to mechanical and/or electrical equipment, mechanical breakdowns, vandalism, force main breaks, and the subsequent repairs necessary to put the station back into operation.

Lift Stations with flows exceeding 250,000 GPD will require eight-hour retention, or will be required to supply a secondary power source (generator or alternate power source) and four hour retention.

Both the pump chamber and the incoming gravity system are not to be considered for the retention calculations. Retention shall be installed below ground with an access manhole located at the

upstream end. The connection between the retention chamber and the wet well wall shall be made with a 12" ductile iron pipe. The retention tank must be a dedicated system; it may not be used as part of the gravity system. The retention tank and connecting line shall be laid with a minimum 1% slope. Note: the lowest development elevation must be above the elevation of the highest point of the retention chamber.

No more than 2 chambers 180' long, minimum of 6' diameter, maximum of 10' diameter, then two power sources or backup generator. As a minimum each retention chamber shall have a manhole, for entrance into the chamber and located on the end furthest from the lift station, as well as a 6" vent, located on the low end of the chamber. Retention chambers of 100' in length or greater requires two manholes.

2. Wet Well Chamber Sizing

The pump station wet well and valve chambers shall each be sized as noted for the following type of pump installations; access hatches will be correspondingly sized to the chosen structure size.

a. Two (2) grinder pumps
Valve chamber - 4' x 4' id. Access hatch 48" x 48"
Wet pit – 4' x 4' id. Access hatch 30" x 48"

b. Two 4" or (two) 6" pumps
Valve chamber - 6' x 6' id. Access hatch 72" x 72"
Wet pit – 6' x 6' id. Access hatch 48" x 72"

c. Two 8" pumps
Valve chamber - 7' x 7' id. Access hatch 84" x 84"
Wet pit – 7' x 7' id. Access hatch 60" x 84"

Any other configuration of number or size of pumps shall be reviewed by the Engineering Division on a case by case basis. In addition to the sizes listed above, a minimum clearance from the interior walls to the flanges of the piping shall be 6 inches. Consideration for additional spacing shall be given if a flow meter is required.

3. Incoming Manhole Placement

A manhole shall be placed on the gravity line a minimum of 20' and a maximum of 26' from the pump station structure.

4. Retention Chamber Placement

The 12" pipe joining the 8 hour retention chamber and the pump station shall be no less than 20' in length.

4.04.02 Piping and Valves

The following table shall be used for the pump station piping and valve design in addition to those items listed below:

Piping and Valves Requirement	Standard Specification
Discharge Riser Piping Material	Sec. 402.2
Force Main Material	Div. 300
Transition Piping	Sec. 402.4
Gate and Check Valves	Sec. 402.6
Valve Chamber Drain Valve	Sec. 402.7
Gravity Lines Entering the Station	Sec. 402.8
Retention Pipe	Sec. 402.9
Sealing of Wet Well & Valve Chamber	Sec. 402.10

1. Force Main Design Requirements

Force mains shall meet the following criteria:

a. Velocity – At design average daily flow, a cleansing velocity of at least two feet per second and at maximum eight feet per second shall be maintained.

b. Air Relief / Vacuum Valve – An automatic combination vacuum air relief valve shall be placed at high points in the force main to prevent air locking.

1) The valve shall be equipped with all backwash accessories.

2) The body of the ARV shall be supported to the wall of the structure by a 1-1/4” x 1-1/4” x 1/8” stainless steel angle bracket.

3) Conform with Section 301.3 of the City of Wentzville Standard Specifications and Construction Details.

c. Termination – Force mains shall discharge to the gravity sewer system at a point not more than one foot above the flow line of the receiving manhole. Inside drops will not be permitted. The force main discharge manhole shall be gasketed and sealed down with a locked down cover. The manhole in which the force main connects to, as well as the next two downstream manholes shall be epoxy coated.

d. Thrust Blocks – The force main shall be fitted at all bends with permanent thrust blocks, constructed to withstand the thrust developed under test pressure plus 50 psi. Thrust block locations shall be given on both plan and profile drawings. A standard thrust block detail shall be drawn on the pump station detail sheet.

e. Clean-Outs – The need for clean out on the force main shall be determined during plan review by the City. As a general guideline, clean-outs will not be required on force mains under 1800 feet in length.

2. Piping Design

The standard pump station piping arrangements called out in this design book have proven themselves to be of sound design in typical pump station installations. Special bracing or water hammer protection devices have not been included or called for. However, when the surrounding terrain or station site is such that extreme hydraulic conditions may be created, it is the responsibility of the designing engineer to anticipate such condition and design for the probability of excessive pressure, stress and/or movement in the piping system. The engineer shall be responsible for including whatever restraints, relief valves, or surge protection, deemed necessary for the protection of the valve and piping system.

4.04.03 Submersible Wastewater Pumps

Sewage pumps installed in the pumping station shall meet the following requirements;

1. General

Pump selection shall be based on the following minimum standards:

a. Single phase pumps are not acceptable.

b. Pumps less than 3 hp are not acceptable.

c. Non-clog pumps are the preferred type pump. Grinder pumps will only be considered when site conditions prove that non-clog type pumps will not perform adequately.

d. All pumps shall be designed to maintain a minimum force main velocity of 2 f.p.s. and a maximum main velocity of 8 f.p.s. for scouring purposes.

e. All pumps except where grinder pumps are used shall be capable of passing spheres of at least three inches (7.6 cm) in

diameter, pump suction and discharge piping shall be at least four inches (10.2 cm) in diameter.

f. Grinder Pump Application

1) The pump discharge pipe diameter shall be determined as follows:

Individual Pump Output	Pipe Diameter
50 GPM and Below	2”
51 to 80 GPM	3”
81 GPM and Above	4”

g. For stations with two pumps, the header and force main pipe diameter shall remain the same as the individual pump discharge pipe diameter.

h. For stations with three or more pumps, the header and force main shall be sized to produce a minimum flow of 2 fps and a maximum flow of 8 fps from the combined output of two pumps.

i. Pumps shall be as required by the City’s Standard Construction Specifications Section 403.

2. Pump Design

The pump(s) shall be capable of handling raw, unscreened sewage. The discharge connection elbow shall be permanently installed in the wet well along with the discharge piping. The pump(s) shall be automatically connected to the discharge connection elbow when lowered into place, and shall be easily removed for inspection or service. There shall be no need for personnel to enter the pump well. Sealing of the pumping unit to the discharge connection elbow shall be accomplished by a simple linear downward motion of the pump. A sliding guide bracket shall be an integral part of the pump unit. No portion of the pump shall bear directly on the floor of the sump. The pump, with its appurtenances and cable, shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet.

4.04.04 Interior

The following table shall be used for the pump station interior design:

Interior Requirement	Standard Specification
Slide Rails	Sec. 404.2
Lifting Chain	Sec. 404.3
Bolts	Sec. 404.4
Fasteners	Sec. 404.5
Floats and Settings	Sec. 404.6
Access Hatches	Sec. 404.7
Locking Hardware	Sec. 404.8
Pressure Sensor Units	Sec. 404.9
Intrinsic Barriers	Sec. 404.10
Pump Chamber Inspection	Sec. 404.11

4.04.05 Electrical

All electrical devices and installation of same shall comply with the specifications set forth in Division 400 Sanitary Sewage Pump Stations of the City of Wentzville Construction Specifications and City of Wentzville Standard Construction Specifications and Details.

1. Pump Control Panel

   The selected pump supplier shall be directly responsible for all panel fabrication and component installation. The pump control panel shall meet the specifications set forth in Division 400 Sanitary Sewage Pump Stations of the City of Wentzville Standard Construction Specifications and Details.

2. Three Phase Motors

   a. All pumps will operate using 480 VAC three phase power.

   b. Any site requiring a total three phase station load in excess of 50 HP will require Ameren-UE/Cuivre River supplied three-phase power.

   c. Any site requiring a total three-phase load less than 50 HP may use a phase converter design upon acceptance from the City. Allowance of such a System will depend on the cost analysis presented by the designer/owner. Allowance will be determined on a case-by-case basis. The Ameren-UE/Cuivre River Electric three-phase power is the preferred source.

3. Electrical Options

There are two possible avenues for the electrical distribution at the pump station. First, is the Ameren-UE/Cuivre River Electric supplied 3 phase source which is preferred and the other is the Ameren-UE/Cuivre River Electric supplied single-phase source. The following is a list of the basic electrical requirement for each.

a. THREE PHASE SOURCE OPTION

1) City will provide generic electrical drawings for three-phase source.

2) City will provide a control program for starter/soft starter operation.

b. SINGLE PHASE (INVERTOR) SOURCE OPTION

1) City will provide generic electrical drawings for single-phase source.

2) Contractor will be required to provide a single phase shielded step up transformer (240/480). It should be capable of supplying 1.5 times the total pump load requirement.

4. Ameren-UE/Cuivre River Electric 3 Phase Supply Control Option

Magnetic across the line horsepower rated motor starters shall be provided per Division 400 of the Standard Construction Specifications and Details. Pumps 20 HP and larger shall be supplied with soft starters and or VFD's with bypass contactors.

5. Phase Converter Option

Because of the higher probability of electrical failure from using a phase converter, this type of system shall only be considered after investigating the feasibility of having three-phase power brought onto the job site. Ameren-UE/Cuivre River Electric supplied three phase power shall be used unless installation cost justified the installation cost of a converter. If a converter is to be used, submitted plans shall detail the converter installation. All phase converter installations shall meet the following requirements:

a. Singe phase 480 VAC shall be run to the station if available. Single phase 240 VAC shall be accepted. It shall be stepped up to single phase 480 VAC through a shielded, isolated, power transformer sized to handle 1.5 times the total pump load requirement.

b. The converter shall be a variable frequency drive unit set up to run at 100% speed. The converter shall be derated to account for the single-phase power supplied to the unit. Converter shall have EMI/RFI filtering built in to the front end to inhibit harmonic interference. It shall be programmed and controlled from a keypad/display unit. The following functions will be available:

1) Local/Manual/Remote with Start/Stop keypad pushbuttons.
2) Keypad and hardwired reset functions.
3) Hardwired input for external failure points.
4) Hardwired remote start/stop through a single contact.
5) Ramp up, ramp down settable 0-30 seconds.
6) Status display.
7) Under voltage protection.
8) Over current protection.
9) Ground fault protection.
10) Failure log.
11) Hardwired run and failure output contacts.

See Section 405.5 of the City of Wentzville Standard Specifications

6. Station Interior Wiring, See Section 405.5 of the City of Wentzville Standard Specifications.

7. Check Valve Pressure Switch Wiring, See Section 405.6 of the City of Wentzville Standard Specifications.

8. Field Wiring Specifications, See Section 405.7 of the City of Wentzville Standard Specifications.

9. Conduit Specifications, See Section 405.8 of the City of Wentzville Standard Specifications.

10. Control Panel Mounting, See Section 405.9 of the City of Wentzville Standard Specifications.

4.04.06 Alarm System

The following specifications shall be used for installation of the pump station alarm system:

1. SYSTEM REQUIREMENTS

a. Each pump station shall have a Motorola MOSCAD-ACE RTU conforming to the City's existing system as specified in

Division 400 of the Standard Construction Specifications and Details.

b. The City's system utilizes a Motorola MOSCAD Central Station Transceiver for interrogation and acknowledgement of alarms.

c. All hardware components and software/integration into the existing SCADA system by the City's Systems Integrator for the RTU shall be provided by the Developer for Contractor installation. Contractor will install and terminate the RTU per the contract drawings. The RTU shall not be energized by the Contractor. RTU CONFIGURATION, programming and startup shall be by the City's Systems Integrator.

Acceptable Manufacturer: Motorola

d. Smaller stations require the MOSCAD SCADA Unit to perform alarming functions for the float-only control system. Larger stations require the MOSCAD to perform all local control and alarming functions and will backup to a hardwired float system and require coordination with the City and City's Systems Integrator before station is approved for design or implementation. Both require integration with the City's existing SCADA system with the City's Systems Integrator.

4.04.07 Paving, Fencing and Other Requirements

The following table shall be used for the pump station site design:

Site Requirement	Standard Specification
Paving	Sec. 406.2
Fencing	Sec. 406.3
Entrance Road Barrier	Sec. 406.4
Yard Hydrants	Sec. 406.5

4.04.08 Site Details

1. Temporary Erosion Control

Surface water drainage must be diverted away from the pump station site to prevent mud and debris from washing over the paved station area until such time as the surrounding vegetation has sufficiently established itself to prevent erosion.

2. Final Grading and Seeding

All ground surrounding the lift station must be graded, seeded and retained in such a manner so as to prevent ground erosion over the

station site or entrance road. Final acceptance of the lift station will not be given until an effective erosion control has been demonstrated.

3. Landscaping

Where applicable, all ground surrounding the lift station shall include the planting of trees and shrubs in sufficient density to screen the presence of the lift station. Shrubs and plantings shall be in accordance with Section 807 of the Standard Specifications and Construction Details.

3. Water Service

A one-inch tap/water yard hydrant/meter setup shall be provided, with yard hydrant located a minimum of 25 feet from the wet well.

4.05

4.05 Standard Construction Details

Standard details for construction of sewage pumping stations can be found in The City of Wentzville Standard Specifications and Construction Details.

5. Design Requirements for Potable Water Distribution Facilities

5.01 General

This section gives the minimum technical design requirements of the City for water distribution facilities. Adherence to these will expedite review and approval of plans. All construction details pertaining to water distribution improvements shall be prepared in accordance with the City of Wentzville Standard Construction Specifications unless otherwise noted.

5.02 General Requirements for Potable Water Main Construction

5.02.01 Size and Shape

All water mains shall be eight (8) inches or larger, except the last three hundred (300) feet on cul-de-sacs which shall be six (6) inch.

Prior to sizing water mains for a development, a fire flow test shall be conducted by the developer. The test, conducted in cooperation with the City's Water Department, shall include a minimum of one residual hydrant and one flow hydrant. The elevations of the hydrants, including the static pressure taken from both hydrants, and the residual pressure from the residual hydrant and the flow, in gpm, from the flow hydrant shall be recorded. A report of this test should be furnished to the Division.

All water mains shall be sized in accordance with a hydraulic analysis based on flow demands and pressure requirements. Normally in residential areas the design should be for a minimum flow of 1,000 gallons per minute, and in commercial areas the minimum flow should 1,500 gallons per minute. When fire flow requirements are established by the building sprinkler system, that flow should be designed so that the City's distribution system will not drop below 20 psi anywhere in it's system. The system shall be designed to maintain a minimum pressure of 35 psi at ground level at all points in the distribution system under all conditions of design flow not including fire flow. The normal working pressure in the distribution system should be approximately 60 psi.

5.02.02 Materials

All materials shall conform to The City of Wentzville Standard Specifications and Construction Details.

5.02.03 Bedding

The project Plans and Project Specifications shall indicate the specific type or types of bedding, cradling, or encasement required in the various parts of the water main construction if different than the current City of Wentzville Standard Specifications and Construction Details.

Special provisions shall be made for pipes laid under or over fills or embankments in shallow or partial trenches either by specifying extra

strength pipe for the additional loads due to differential settlement, or by special construction methods, including ninety (90) percent modified proctor compaction of fill, to prevent or to minimize such additional loads.

Compacted granular backfill shall be required in all trench excavation within public (or private) rights-of-way or areas where street rights-of-way are anticipated to be dedicated for public use. Under areas to be paved, the compacted granular backfill shall be placed to the sub grade of the pavement. Under unpaved areas, the compacted granular backfill shall be placed to within two (2) feet of the finished surface.

Pipes having a cover of less than three (3) feet shall be encased in concrete, unless otherwise directed by the City.

5.02.04 Pipe or Conduit Under Streets or Pavement

Any pipe or conduit material beneath a highway, road, street, or pavement, or with reasonable probability of being so located, shall have ample strength for all vertical loads, including the live load required by the highway authority having jurisdiction, and in no case shall provide for less than an AASHTO HS-20 loading. For other locations, the minimum live load shall be the HS-10 loading. Special considerations may be required for adverse conditions.

5.02.05 Alignment

All water mains are to be installed in accordance with the alignment shown on the approved plans. Pipe shall generally be straight between bends and bent to the radius indicated on the plans. No 90 degree bends shall be allowed. C906 Poly pipe may be bent according to manufacturer's specifications.

Water mains shall also be aligned so as to allow for future extensions of the water system. Water main stubs shall be provided to the property or phase line as directed by the Engineering Division at locations necessary for future extensions of the water system.

5.02.06 Location

Water main locations are determined primarily by the requirements of service and purpose. It is also necessary to consider accessibility for construction and maintenance, site availability and competing uses, and effects of easements on private property.

Water mains shall be located:

1. Typically 5' behind the curb in new construction so as not to interfere with other utilities. See Standard Construction Detail 502.01.

2. To serve all property conveniently and to best advantage.

3. In public streets, roads, alleys, rights-of-way, or in sewer easements dedicated to the City.

4. In easements on private property only when unavoidable.

5. At a sufficient distance from existing and/or proposed buildings (including footings) and underground utilities or other sewers to avoid encroachment and reduce construction hazards.

6. To avoid conflicts with the depth or horizontal location of existing and proposed sanitary and storm sewers including house laterals.

7. In unpaved or unimproved areas whenever possible.

8. To avoid, whenever possible, any locations known to be or probably to be beneath curbs, paving or other improvements particularly when laid parallel to centerlines.

5.02.07 Fire Hydrants

The location of fire hydrants is determined by the Engineering Division in conjunction with the Wentzville Fire Protection District and in compliance with the standards and specifications for fire protection as established by the Insurance Services Office (ISO).

Generally, fire hydrants shall be required every five hundred (500) feet for residential projects and three hundred (300) feet for commercial projects. Elsewhere fire hydrants shall be located at a separation of 1200 feet. Fire hydrants shall also be required at the terminal end of water main installations. Flushing hydrants will not be allowed. A fire hydrant is required to be located within a 150 foot radius of a building's Fire Department Connection. All fire hydrants shall conform to the City of Wentzville Standard Specification and Construction Details.

When fire hydrant installations have a greater than normal exposure to damage due to vehicular traffic (parking lot installations, unusual driving situation, etc.), the engineer may require hydrant protection using steel pipe bollards.

5.02.08 Abandoned Wells

All wells abandoned shall require filing of a well abandonment form with the Missouri Department of Natural Resources.

5.02.09 Sanitary Sewers or Storm Sewers Crossing over Water Main

Water mains shall be separated from storm and sanitary sewers in accordance with the requirement contained in the City's Standard Specifications, and Standard Details covering.

5.02.10 Cover

All water mains should have a minimum cover of 42" above the pipe, and 42" from the outside of the pipe to exposed air below the pipe. Cover less than this shall require specific approval from the Division.

5.02.11 Air Release Valves

Air release valves shall be located at high points in water mains where air can accumulate. Provisions shall be made to remove the air by means of manually operated hydrants or automatic air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur. In general, ARVs are not required on distribution mains being sized at 8" or less, but should be on transmission mains of 12" or larger sizes.

5.02.12 Valves

Sufficient valves shall be provided on water mains so that inconvenience and sanitary hazards to customers will be minimized during repairs. Valves should be located at not more than 500 foot intervals in commercial districts and at not more than one block (or 800 foot) intervals in residential or other districts. Valves shall be located as designated by the Engineering Division at street, bridge, railroad, waterway crossings, dead ends, and at all fire hydrants.

Location: Valves shall be installed at the intersection of two water mains, or a water main and a hydrant. Maximum separation between valves along a transmission water main shall be 1000 feet. Larger transmission mains should have valves placed so as to allow for isolation of breaks, and so as to reduce the number of customers that would be shut off when the main is shut down for maintenance or operational purposes. The Division shall be the sole judge as to the needed location of valves on large transmission main.

The number of valves at a branch fitting shall be determined as described as follows and as required by the City Engineer:

(1) At a cross fitting with only one direction supplying from the water source, a minimum of three valves shall be installed, one on each of the "dead-end" directions.

(2) At a tee fitting with only one direction supplying from the water source, a minimum of two valves shall be installed, one on each of the "dead-end" directions.

(3) At a tee fitting with two directions supplying from the water source, a minimum of two valves shall be installed.

(4) At locations where the water main has been stubbed for future extension, a valve shall be placed such that no service will be interrupted by the future extension.

5.03 Water Taps, Service Lines, and Meters

1. All residential service connections are to be double setups, unless approved by the Engineering Division. This setup should be located on the property line. Each service connection shall be individually metered.

2. All residential service lines for under streets are to have a 2" PVC casing installed, at a minimum of 30" depth.

3. The following supplies will be issued by the City of Wentzville, for ¾" through 2":

   a. Saddle & Corp
   b. Setter w/ compression ends
   c. Meter
   d. Meter Box
   e. Frame & Cover
   f. Y Branch (for double setter if required)

4. For 3" and larger meters, the City will only issue the meter. All fittings, valves, vault and lid shall be furnished in accordance with the City's Standard Specifications.

5. The City of Wentzville Water Department supports the following water meter sizes. Water meters and service sizes should be indicated appropriately. For residential subdivisions, the taps should be a minimum of 1" for a double ¾" meter set-up.

   ¾", 1" & 2" – Standard meter required

   3" – Compound Meter required, installed in Concrete Vault.

   4", 6", 8", 10", & 12" – Mag meter required, installed in Concrete Vault.

5.04 Irrigation Requirements

The following requirements shall be met for installing another meter on the homeowner's side of the meter for the purpose of monitoring water used by an irrigation system:

1. Required to tee into the water service after the existing water meter.

2. Set another meter setter box, frame and cover in the easement area.

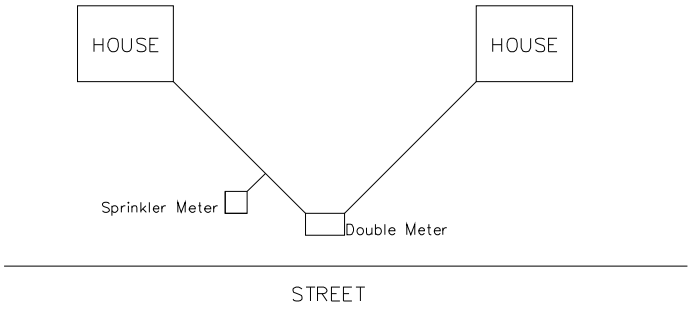
3. Meter, setter, box, frame and cover must be purchased from the City.

4. Inspection is required. A 24-hour notice is required for supply pickup and inspection.

5. A State approved backflow device will be required for all irrigation systems. A test report is due within 30 days of installation. Forward copy to Wentzville Public Works, 200 E. Fourth St., Wentzville, MO 63385.

6. The City will maintain the meter setter, box, frame and cover after installation.

7. An annual test report from *Certified Inspector for Backflow is required.*



5.05 Fire Hydrant Water Usage

Water usage from fire hydrants shall meet the following requirements:

1. Hydrant meters may be checked out with a deposit. The check will be deposited in the City's account. When the meter is returned, the deposit will be refunded. Call 636-327-5102 for water rate and meter deposit amount.

2. Charges for use of a hydrant meter are as follows:

   a. A monthly rental fee shall be charged. A reading will be taken on the tenth (10^{th}) of each month. The renter is responsible for arranging for hydrant meter reading, either by bringing the meter to the Public Works Office or contacting Public Works at 636-327-5102 or 636-332-5102.

   b. Water usage shall be charged at the current rate plus applicable taxes.

3. A backflow device is required to be used at all times. See Standard Detail 505.01 for typical setup.

4. Daily tags can be purchased from the Public Works office in lieu of use of a hydrant meter. If use of a hydrant lasts more than five (5) days, use of a hydrant meter is required.

   a. One day tags for washing streets, construction site and sod watering…… Issued for daily use, Monday through Friday, 8:00 a.m. – 5:00 p.m.
   b. One day tags for jetting…….……. Issued for daily use, Monday through Friday, 8:00 a.m. – 5:00 p.m.

For the current rates for hydrant meters, water usage and daily tags, contact the Public Works office at 636-327-5102.

6. Design Requirements for Storm Drainage Facilities

6.01 General

6.01.01 Introduction and Mission Statement

The mission of these stormwater design criteria is to:

- Protect property and infrastructure
- Prevent environmental degradation
- Protect natural waterways
- Accommodate growth by offering a variety of design tools
- Meet the City's State and Federal regulation requirements
- Achieve this mission in a cost effective manner to the City

The City of Wentzville recognizes that natural waterways are an integral part of our stormwater conveyance system. Therefore, a major component of the stormwater design criteria is to use stormwater best management practices (BMP) in each development to more closely imitate natural hydrologic function. By doing so, we are delivering cleaner stormwater in a natural flow regime to our receiving natural channels.

Portions of this criterion have been adapted from the Metropolitan St. Louis Sewer District, "Rules, Regulations, and Engineering Design Requirements for Sanitary Sewer and Stormwater Drainage Facilities" February 2006 manual.

The criteria set forth in this document are minimum standards and design professionals are encouraged to provide stormwater system designs that go beyond these standards.

6.01.02 Companion Documents

The following documents have been included in these criteria by reference:

- The Municipal Code of the City of Wentzville (latest revision)
- City of Wentzville Construction Specifications and Standard Details (latest revision)
- Maryland Stormwater Design Manual, Volume I and II (latest revision)
- City of Wentzville Comprehensive Plan

Each document has requirements pertaining to development and contains information regarding stormwater systems. The designer is expected to understand and follow these documents as applicable.

6.01.03 Construction Alternatives

This section gives the minimum technical design requirements of the City of Wentzville storm water drainage facilities. In general, the methods presented herein for stormwater design represent acceptable procedures, not necessarily to the exclusion of other sound and technically supportive methods. Any departure from these design requirements should be discussed before submission of plans for approval and should be justified.

Variance to these requirements will NOT be entertained unless the reasons for doing so can be shown to enhance the stated mission of these criteria.

6.01.04 Escrow

Escrow release associated with stormwater facilities shall conform to Section 9 of this design criteria manual.

6.01.05 Quick Reference Guide

Following is a quick reference guide to the performance criteria included in this section. Section 6 must be read in its entirety to fully understand these criteria.

6.01.06 Quick Reference Guide

Facility Type	Design Storm	Tc	Accepted Methodology for Peak Flow or Volume Calculation	Freeboard, Ponding Limits and Other Requirements	Design Criteria Section
Enclosed Systems					6.02
Street Gutters, Curb and Area Inlets	15 year	20 min	Modified Rational Equation	8' maximum spread	6.02.02
Storm Sewers	15 year	20 min	Modified Rational Equation	3' maximum head; 6" freeboard to inlet sill, 1' freeboard to top of manhole	6.02.03
Emergency Relief System	100-yr, 20-min. with design system blocked	Compute	Modified Rational Equation	Low sill of any adjacent structure shall be 6" above	6.02.04
Engineered Channels					6.03
Engineered Channels (DA < 20 acres and Tc ≤ 20 min)	15-yr with 100-yr, 24-hr check	20 min	Modified Rational Equation for 15-yr, NRCS Unit Hydrograph for 100-yr	Design - 6 inches to top of bank.	6.03
Engineered Channels (DA ≥ 20 acres or Tc > 20 min)	15-yr, 24-hr with 100-yr, 24-hr check	Compute	NRCS Unit Hydrograph	Check - 1-foot to low sill of adjacent structure.	6.03
Culverts, Bridges and Natural Channel Crossings					6.04
Culverts - Under driveways along roadside ditches	15 year	20 min	Modified Rational Equation	1-foot to edge of pavement	6.04.03
Culverts - In Natural Channels	Low Flow: 1-yr, 24-hr Full Capacity: 100-yr, 24-hr	Compute	NRCS Unit Hydrograph	1-foot to edge of pavement	6.04.04
Bridges	Low Flow: 1-yr, 24-hr Full Capacity: 100-yr, 24-hr	Compute	NRCS Unit Hydrograph	1-foot to bottom chord	6.04.05
Grade Controls	Rock size: 100-yr, 24-hr Height of rock to top of bank or 10-yr, 24-hr elevation	Compute	NRCS Unit Hydrograph		6.04.07
Detention and Water Quality					6.05
Water Quality Volume WQ_v	1.14 inches	NA	$WQ_v = [(P/12)(R_v)(A*43,560)]$	BMP to treat	6.05.03.2
Channel Protection Volume Cp_v	1 year, 24 hour	Compute	NRCS Unit Hydrograph	24-hour extended detention	6.05.03.3
Flood Protection Qp_2 and Qp_{25}	2-yr, 24-hr and 25-yr, 24-hr	Compute	NRCS Unit Hydrograph	Proposed, routed peak flow ≤ existing peak flow unless allowable release rate has been established for the watershed.	6.05.03.4
Limits of Maximum Ponding	100 year, 24 hour with lower outlets blocked	Compute	NRCS Unit Hydrograph	Ponds: 30' horizontal and 2' vertical distance to low sill of any building. Parking lots: 10' horizontal and 1' vertical distance to low sill elevations. 1' freeboard to top of the basin.	6.05.04

Rainfall Data (Rainfall Frequency Atlas of the Midwest, Bulletin 71)

Design Storm	Rainfall (inches)	Design Storm	Rainfall (inches)
1 year, 24 hour	2.50	25-year, 24 hour	5.60
2 year, 24 hour	3.10	50-year, 24 hour	6.38
10 year, 24 hour	4.64	100 year, 24 hour	7.21
15 year, 24 hour	5.03		

6.01.06 Flow Quantities

1. Modified Rational Method

Flow quantities for street gutters, inlets and pipe systems shall be calculated by the Modified Rational Method in which:

$$Q = API$$

where:

Q = runoff in cubic feet per second
A = tributary area in acres.
I = Average intensity of rainfall (inches per hour) for a given period and a given frequency.
P = runoff factor based on runoff from pervious and impervious surfaces.

P (Runoff Factors) for various impervious conditions are shown in Table 6-1.

PI values for various impervious conditions are shown in Tables 6-2, 6-3 and 6-4.

a. Impervious Percentages and Land Use

Minimum impervious percentages to be used are as follows:

1) For manufacturing and industrial areas, 100% *

2) For business and commercial areas, 100% *

3) For residential areas, including all areas for roofs of dwellings and garages; for driveways, streets, and paved areas; for public and private sidewalks; with adequate allowance in area for expected or contingent increases in imperviousness:

In apartment, condominium and multiple dwelling areas:	75%*
In single family areas:	
1/4 Acre or less	50%
1/4 Acre to 1/2 Acre	40%
1/2 Acre to One Acre	35%
One Acre or larger	Calculate Impervious Percentage*
Playgrounds (non-paved)	20-35%*

4) For small, non-perpetual charter cemeteries 30%

5) For parks and large perpetual charter cemeteries 5%

*__NOTE__: Drainage areas may be broken into component areas, with the appropriate run-off factor applied to each component, i.e.; a proposed development may show 100% impervious for paved areas and 5% impervious for grassed areas.

The design engineer shall provide adequate detailed computations for any proposed, expected or contingent increases in imperviousness and shall make adequate allowances for changes in zoning use. If consideration is to be given to any other value than the above for such development, the request must be made at the beginning of the project, must be reasonable, fully supported, and adequately presented, and must be approved in writing before its use is permitted.

Although areas generally will be developed in accordance with current zoning requirements, recognition must be given to the fact that zoning ordinances can be amended to change the currently proposed types of development, and any existing use. Under these circumstances the possibility and the probability of residential areas having lot sizes changed or re-zoned to business, commercial, or light manufacturing uses shall be given careful consideration.

b. Limitations of the Modified Rational Method

The Modified Rational Method is only valid if the time of concentration is less than twenty (20) minutes and the tributary area is less than twenty (20) acres. If the time of concentration or acreage limit is exceeded for a drainage structure, the NRCS Unit Hydrograph method shall be used to calculate peak flow rates. See Section 2, below for more information on the NRCS Unit Hydrograph method.

2. NRCS Unit Hydrograph Method

Flow quantities for engineered channels, culverts, bridges, detention, and channel protection volume shall be determined by using NRCS Unit Hydrograph methodology. The hydrograph shall be developed based on the actual flow and timing characteristics upstream of the design point. The rainfall distribution shall be Type II. The rainfall quantities to be used are from the Rainfall Frequency Atlas of the Midwest, Bulletin 71, developed by the Midwest Climate Center and Illinois State Water Survey. For use in the modeling of the 24 year storm, the applicable rainfall quantities shall be as follows: 1-year = 2.50 inches; 2-year = 3.10 inches; 10 year = 4.64 inches; 15 year = 5.03 inches; 25 year = 5.60 inches; 50 year = 6.38 inches; 100 year = 7.21 inches.

Applicable NRCS Curve Numbers are shown in Table 6-5

6.02 Enclosed Systems

6.02.01 General

1. Design Frequencies

   In the design of local storm sewer systems, a fifteen (15) year rainfall frequency and a twenty (20) minute time of concentration shall be used. Figure 6-1 gives rainfall curves for 2, 5, 10, 15, 20 and 100 year frequencies.

2. Flow Quantities

   Flow quantities for street gutters, inlets, and pipe systems shall be calculated by the Modified Rational Method as described in Section 6.01.07, sub-section 1.

3. Use of Existing Systems

   Use of existing on site drainage facilities is allowed if the existing system meets the following requirements:

   a. The existing system is in sound structural condition as determined by the City.

   b. The existing system hydraulic capacity is equal to or greater than the capacity required by these criteria.

   c. Easements exist or are dedicated to allow operation and maintenance.

   d. Connections to existing structures may require rehabilitation or reconstruction of the structure being utilized. This work will be considered part of the project being proposed.

4. Off Site Flow Calculations

   Off site flows for enclosed systems shall be calculated using the design criteria presented herein. Off site drainage shall be calculated assuming the future built out land use condition per the City of Wentzville Comprehensive Plan.

6.02.02 Street Gutters, Curb and Area Inlets

1. General

   a. Street gutters, inlets, and sumps shall conform to the City of Wentzville Standard Specifications and Construction Details (latest revision).

   b. Grated inlets are not allowed for public systems.

   c. Inlets shall be located in a sump such that the inlet face is 2 feet 6 inches behind the back of the roadway curb. The sump shall begin 2

feet in front of the back of curb. The top elevation of the stone shall remain 3 inches above the top of rolled curb and level with the top of mountable curb.

d. Curb inlets placed at street intersections or near driveways shall be placed such that no part of the inlet structure or sump is within the curb rounding or curb ramps.

2. Inlet Design Method

a. For inlets located on a roadway profile grade of 6% or less, use Figure 6-3 to calculate inlet capacity. Figure 6-3 shows inlet capacity/maximum gutter capacity with a given gutter line grade and flow.

b. For inlets located on a roadway profile grade greater than 6%, a double inlet shall be used. Use Figure 6-3A to calculate inlet capacity. Figure 6-3A shows inlet capacity with a given gutter line grade and flow.

c. Six (6) inch open throat inlets shall be used at all times.

d. Area (or yard) inlets capacity shall be a maximum of 3 cfs per side for a single inlet with a maximum capacity of 8 cfs per single inlet.

e. Area inlets in residential yards shall be spaced so that the length of the drainage path is no greater than 300 feet and the surface flow is no greater than 3 cfs in any swale, unless part of a workable, recognized and approved BMP or as part of an Environmentally-Sensitive Development as defined in Section 6.08.06.

f. Inlet capacity shall not be less than the quantity flow tributary to the inlet.

g. Inlets at low points (sag vertical curves) shall be sized so that the maximum ponding spread during the design storm (encroachment into the driving lane) shall not exceed 8’ measured from back of curb.

6.02.03 Storm Sewers

All storm sewers shall meet the following general requirements:

1. Size and Shape

The minimum diameter of pipe for stormwater shall be twelve (12) inches. Sewers shall not decrease in size in the direction of the flow unless approved by the Engineering Division. Circular pipe sewers are preferred for stormwater sewers, although rectangular or elliptical conduits may be used with special permission.

2. Materials

All materials shall conform to the City of Wentzville Standard Specifications and Construction Details (latest revision).

3. Bedding, Cradling and Encasement

   a. Bedding, cradling and encasement shall be per the City of Wentzville Standard Specifications and Construction Details.

   b. A special design including a concrete cradle is required when the grade of a sewer is twenty (20) percent or greater. Maximum pipe slope is 45%.

   c. Pipes shall have a minimum cover of three (3) feet and a maximum cover of fifteen (15) feet unless otherwise directed by the Engineering Division.

   d. When the storm and sanitary sewers are parallel and in the same trench, the upper pipe shall be placed on a shelf and the lower pipe shall be bedded in compacted granular fill or concrete encased to the flow line of the upper pipe.

4. Pipe or Conduit Under Streets and Pavements

   Reinforced Concrete pipe shall be Class III, minimum. Any pipe or conduit material beneath a highway, road, street, or pavement, or with reasonable probability of being so located, shall have ample strength for all vertical loads, including the live load required by the highway authority having jurisdiction, and in no case shall provide for less than an AASHTO HS-20 loading. For other locations, the minimum live load shall be the HS-10 loading. Special considerations may be required for adverse conditions.

5. Monolithic Structures

   Monolithic reinforced concrete structures shall be designed structurally as continuous rigid units. As much concrete as is practical shall be poured in one single operation with the reinforcing steel not terminated at the ends of a member but carried over at the joints into adjacent members.

6. Alignment

   Sewer alignments are normally limited by the available easements, which in turn shall reflect proper alignment requirements. Since changes in alignment affect certain hydraulic losses, care in selecting possible alignments can minimize such losses and use available head to the best advantage. Sewers shall be aligned:

   a. To be in a straight line between structures, such as manholes, inlets, inlet manholes and junction chambers, for all pipe sewers thirty (30) inches in diameter and smaller.

   b. To be parallel with or perpendicular to the centerlines of straight streets and straight property lines unless otherwise unavoidable. Deviations may be made only with approval of the Engineering Division.

   c. To avoid meandering, offsetting and unnecessary angular changes.

d. To make angular changes in alignment for sewers, locate a manhole or junction chamber at the angle point.

e. For sewers greater than thirty (30) inches in diameter, angular changes can be made by a uniform curve between two tangents. Curves shall have a minimum radius of ten times the pipe diameter.

f. To avoid angular changes in direction greater than necessary and any exceeding ninety (90) degrees.

g. To allow for connection of future storm sewers (for pipes collecting offsite flow). Storm sewers which have discharge that flows onto a proposed site and storm sewer discharges from a project site shall have the enclosed storm sewer systems connected as directed by the Engineering Division.

7. Location

Storm sewer locations are determined primarily by the requirements of service and purpose. It is also necessary to consider accessibility or construction and maintenance, site availability and competing uses, and effects of easements on private property. Storm sewers shall be located:

a. To serve all property conveniently and to best advantage.

b. In public streets, roads, alleys, rights-of-way, or in sewer easements on private property dedicated to the City of Wentzville.

c. On private property immediately adjacent to and in alignment with property lines or immediately adjacent to public streets, avoiding diagonal crossing through the central areas of the property. Single inlets and manholes shall be centered at 2.5 feet from side or rear property lines, fully within a single property to facilitate fencing.

d. At a sufficient distance from existing and proposed buildings including footings and underground utilities or other sewers to avoid encroachments and reduce construction hazards.

e. To avoid interference between other stormwater sewers and house connections to sanitary sewers.

f. In unpaved or unimproved areas whenever possible.

g. To avoid, whenever possible, any locations known to be beneath curbs, paving or other improvements particularly when laid parallel to centerlines.

h. To avoid sinkhole areas..

i. Crossing perpendicular to street, unless otherwise unavoidable.

8. Flowline

The flowline of storm sewers shall meet the following requirements:

a. The flowline shall be straight or without gradient change between connected structures.

b. Gradient changes in successive reaches normally shall be consistent and regular. Gradient designations less than the nearest 0.001 foot per foot, except under special circumstances and for larger sewers, shall be avoided.

c. Sewer depths shall be determined primarily by the requirements of pipe or conduit size, utility obstructions, required connections, future extensions and adequate cover.

d. Stormwater pipes discharging into lakes shall have the discharge flowline a minimum of three feet above the lake bottom at the discharge point or no higher than the normal pool elevation.

e. For sewers with a design grade less than one (1) percent, field verification of the sewer grade will be required for each installed reach of sewer, prior to any surface restoration or installation of any surface improvements.

f. See Section 6.02.06 for information regarding construction tolerances and As-Built Certification for Storm Sewer Facilities.

9. Manholes

Manholes provide access to sewers for purposes of inspection, maintenance and repair. They also serve as junction structures for lines and as entry points for flow. Requirements of sewer maintenance determine the main characteristics of manholes.

a. For sewers thirty (30) inches in diameter or smaller, manholes shall be located at changes in direction; changes in size of pipe; changes in flowline gradient of pipes, and at junction points with sewers and inlet lines.

b. For sewers greater than thirty (30) inches in diameter, manholes shall be located on special structures at junction points with other sewers and at changes of size, alignment change and gradient. A manhole shall be located at one end of a short curve and at each end of a long curve.

c. Spacing of manholes shall not exceed four hundred (400) feet for pipe sewers thirty (30) inches in diameter and smaller; five hundred (500) feet for pipe sewers greater than thirty (30) inches in diameter, except under special approved conditions. Spacing shall be approximately equal, whenever possible.

d. When stormwater is permitted to drop into a manhole from lines twenty-one (21) inches or larger, the manhole bottom and walls below the top of such lines shall be of reinforced concrete.

e. Manholes shall not be installed in streets, driveways and sidewalks. Single inlets and manholes shall be centered 2.5 feet from side or rear property lines, fully within a single property to facilitate fencing.

f. When a project requires a manhole to be adjusted to grade a maximum of twelve (12) inches of rise is allowed if not previously adjusted. When adjustments to raise or lower a manhole are required, the method of adjustment must be stated on the project plans and approved by the Engineering Division.

10. Hydraulic Grade Line for Closed Conduits

a. Computation Methods

The hydraulic grade line is a line coinciding with (a) the level of flowing water at any given point along an open channel, or (b) the level to which water would rise in a vertical tube connected to any point along a pipe or closed conduit flowing under pressure.

The beginning point for hydraulic grade line computations for storm sewers shall be at least the higher of the elevations listed in Section 6.02.03, sub-section 11.

The hydraulic grade line shall be computed to show its elevation at all structures and junction points of flow in pipes, conduits and open channels, and shall provide for the losses and the differences in elevations as required below. Since it is based on design flow in a given size of pipe or conduit or channel, it is of importance in determining minimum sizes of pipes within narrow limits. Sizes larger than the required minimum generally provide extra capacity, however consideration must still be given to the respective pipe system losses.

There are several methods of calculating "losses" in storm sewer design. The following procedures are presented for the engineer's information and consideration.

It is expected that the design will recognize the reality of such "losses" occurring and make such allowances as good engineering judgment requires.

1) Friction Loss

The hydraulic grade line is affected by friction loss and by velocity head transformations and losses. Friction loss is the head required to maintain the required flow in a straight alignment against frictional resistance because of pipe or channel roughness. It is determined by the equation:

$$h_f = L \times S_h,$$

Where:

- h_f = difference in water surface elevation, or head in feet in length L
- L = length in feet of pipe or channel
- S_h = hydraulic slope required for a pipe of given diameter or channel of given cross-section and for a given roughness "n", expressed as feet of slope per foot of length.

From Manning's formula: $S_h = [V\ n\ /(1.486\ R^{0.667})]^2$

Where:

- R = hydraulic radius of pipe, conduit or channel (feet) (Ratio of flow area/wetted perimeter)
- V = velocity of flow in feet per second (fps)
- n = Manning's value for coefficient of roughness

Use:

- n = .013 for pipes of concrete, vitrified clay, and PVC pipe
- n = .012 for formed monolithic concrete, i.e., vertical wall channels, box culverts, and for R.C.P. over 48” in diameter
- n = .015 for concrete lining in ditch or channel inverts and trapezoidal channels
- n = .020 for grouted riprap lining on ditch or channel side slopes
- n = .033 for gabion walled channels

Note:

"n" will have a weighted value for composite lined channels.

"n" values for unlined channels to be determined on an individual basis.

2) Curve Loss

Curve loss in pipe flow is the additional head required to maintain the required flow because of curved alignment, and is in addition to the friction loss of an equal length of straight alignment. It shall be determined from Figure 6-2, which includes an example.

3) Entrance Loss at Terminal Inlets

Entrance loss is the additional head required to maintain the required flow because of resistance at the entrance. The entrance loss at a terminal inlet is calculated by the formula:

$$H_{ti} = (V^2/2g)$$

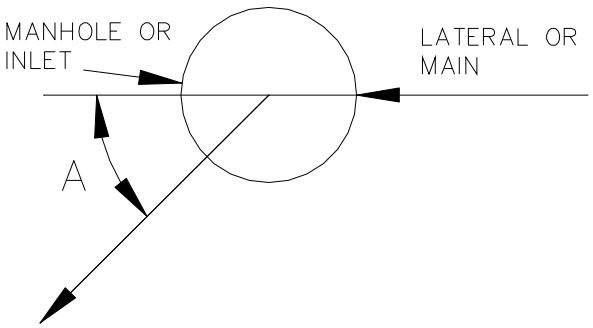
Where: V = Velocity in flow of outgoing pipe
g = Acceleration of gravity (32.2 Ft/Sec/Sec)

4) Turn Loss

Head losses in structures due to change in direction of flow (turns) in a structure, will be determined in accordance with the following:

Change in Direction of Flow (A)	Multiplier of Velocity Head of Water Being Turned (K)
90 Deg.	0.7
60 Deg.	0.55
45 Deg.	0.47
30 Deg.	0.35
15 Deg.	0.18
0 Deg.	0.0
Other Angles	By Interpolation

Diagram:



Formula: $H_L = K(V_L)^2/2g$

Where:

H_L = Feet of head lost in manhole due to change in direction of lateral flow
V_L = Velocity of flow in lateral in ft/sec
g = Acceleration of gravity (32.2 ft/sec/sec)
K = Multiplier of velocity head of water being turned

5) Junction Chamber Loss

A sewer junction occurs for large pipes or conduits too large to be brought together in the usual forty two (42) inch diameter manhole or inlet where one or more branch sewers enter a main sewer. Allowances shall be made for head loss due to curvature of the paths and due to impact at the converging streams.

Losses in a junction chamber for combining large flows shall be minimized by setting flowline elevations so that pipe centerlines (springlines), will be approximately in the same planes.

At junction points for combining large storm flows, a manhole with a slotted cover shall be provided.

A computation method for determining junction chamber losses is presented below:

$H_j = \Delta y + V_{h1} - V_{h2}$

Where:

H_j = Junction chamber loss (ft)
V_{h1} = Upstream velocity head
V_{h2} = Downstream velocity head
Δy = Change in hydraulic grade line through the junction in feet

Where:

$$\Delta y = \frac{[(Q_2V_2) - ((Q_1V_1) + \{(Q_3V_3\text{Cos }\Theta_3) + (Q_nV_n\text{Cos }\Theta_n)\})]}{0.5(A_1 + A_2)g}$$

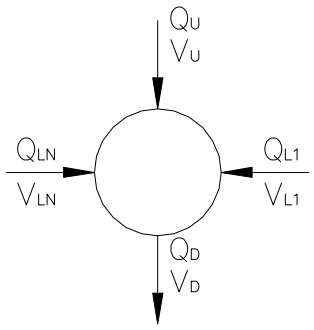
Where:

Q_2 = Discharge in cubic feet per second (cfs) at the existing conduit
V_2 = Velocity in feet per second (fps) at the existing conduit
A_2 = Cross sectional area of flow in sq. ft. for the existing conduit
Q_1 = Discharge in cfs for the incoming pipe (main flow)

V_1 = Velocity in fps for the incoming pipe (main flow)
A_1 = Cross sectional area of flow in sq. ft. for the incoming pipe (main flow)
Q_3, Q_n = Discharge (s) in cfs for the branch lateral (s)
V_3, V_n = Velocity (ies) in fps for the branch lateral (s)
Θ_3, Θ_n = The angle between the axes of the exiting pipe and the branch lateral (s)
g = Acceleration of gravity (32.2 ft/sec/sec)
Θ = Is the angle between the axes of the outfall and the incoming laterals

6) Losses at Junctions of Several Flows in Manholes and/or Inlets

The computation of losses in a manhole, inlet or inlet manhole with several flows entering the structure shall utilize the principle of the conservation of energy. This involves both the elevation of water surface and momentum (mass times the velocity head). Thus, at a structure (manhole, inlet or inlet manhole) with laterals, the sum of the energy content for inflows is equal to the sum of the energy content of the outflows plus the additional energy required by the turbulence of the flows passing through the structure.



The upstream hydraulic grade line may be calculated as follows:

$$H_U = [V_D^2/2g] - [(Q_U/Q_D)(1-K)(V_U^2/2g)] - [(Q_{L1}/Q_D)(1-K)(V_{L1}^2/2g)] + [(Q_{LN}/Q_D)(1-K)(V_{LN}^2/2g)] + H_D$$

Where:

H_U = Upstream hydraulic grade line in feet
Q_U = Upstream main line discharge in cubic feet per second
Q_D = Downstream main line discharge in cubic feet per second
Q_{L1}, Q_N = Lateral discharges in cubic feet per second
V_U = Upstream main line velocity in feet per second
V_D = Downstream main line velocity in feet per second
V_{L1}, V_N = Lateral velocities in feet per second
H_D = Downstream hydraulic grade line in feet
K = Multiplier of velocity of water being turned
g = Acceleration of gravity (32.2 ft/sec/sec)

The above equation does not apply when two (2) almost equal and opposing flows, each perpendicular to the downstream pipe, meet and no other flows exist in the structure. In this case the head loss is considered as the total velocity head of the downstream discharge.

7) Transition Loss

The relative importance of the transition loss is dependent on the velocity head of the flow. If the velocity and velocity head of the flow are quite low, the transition losses cannot be very great. However, even small losses may be significant in flat terrain. The sewer design shall provide for the consideration of the necessary transitions and resulting energy losses. The possibility of objectionable deposits is to be considered in the design of transitions.

For design purposes it shall be assumed that the energy loss and changes in depth, velocity and invert elevation, if any, occur at the center of the transition. These changes shall be distributed throughout the length of the transition in actual detailing. The designer shall carry the energy head, piezometric head (depth in an open channel), and invert as elevations, and work from the energy grade line.

Transitions in small sewers may be confined within a manhole. Special structures maybe required for larger sewers. If a sewer is flowing surcharged, the form and friction losses are independent of the invert slope; therefore, the transition may vary at the slopes of the adjacent conduits. The energy loss in a transition shall be expressed as a coefficient multiplied by the change in velocity head ($\Delta V^2/2g$) in which ΔV is the change in velocity before and after the transition. The coefficient may vary from zero to one, depending on the design of the transition.

If the areas before and after a transition are known, it is often convenient to express the transition loss in terms of the area ratios and either the velocity upstream or downstream.

For an expansion:

$$H_L = K\,(V_1-V_2)^2/2g \approx [K\,(V_1)^2/2g]\,[1 - (A_1/A_2)]^2$$

in which H_L is the energy loss; K is a coefficient equal to 1.0 for a sudden expansion and approximately 0.2 for a well-designed transition and the subscripts 1 and 2 denote the upstream and downstream sections, respectively, i.e., A_1 = Area Before Transition and A_2 = Area After Transition.

For a contraction:

$H_L = [K (V_2)^2 /2g] [(1/C_C)-1]^2 \approx [K (V_2)^2 /2g] [1 - (A_2/A_1)]^2$

in which K is a coefficient equal to 0.5 for a well-designed transition, C_C is a coefficient of contraction, and the other terms and subscripts are similar to the previous equation. Losses in closed conduits of constant area are expressed in terms of $(V^2/2g)$.

The above equations may be applied to approximate the energy loss through a manhole for a circular pipe flowing full. If the invert is fully developed, that is, semi-circular on the bottom and vertical on the sides from one-half depth up to the top of the pipe, for the expansion $(A_1/A_2) = 0.88$, and for the contraction $(A_2/A_1) = 0.88$. The expansion is sudden; therefore, K = 1. The contraction may be rounded if the downstream pipe has a bell or socket. In this case, K may be assumed to be 0.2.

The expansion energy loss is 0.014 $[(V_1^2) /2g]$ and the contraction energy loss is 0.010 $[(V_2^2)/2g]$. If the invert is fully developed, the manhole loss is small, but if the invert is only developed for one-half of the depth, or not at all, the losses will be of considerable magnitude.

11. Hydraulic Grade Line Limits

The hydraulic grade line shall not rise above the following limits as determined by flow quantities calculated per Section 6.01.07, sub-section 1 and hydraulic grade lines calculated per Section 6.02.03, sub-section 10.

a. The hydraulic grade line at any inlet shall not be higher than six (6) inches below the inlet sill. The hydraulic grade line at any storm manhole shall be no higher than one (1) foot below the top.

b. The beginning point for the hydraulic grade line computations shall be the higher elevation as determined below:

   1) For connection to existing pipe system:

      i. Top of pipe intrados of one reach downstream of the connection point of the existing system; or

      ii. The hydraulic grade line computed for the existing system.

   2) For connection to channels or ditches:

      Top of pipe intrados of the proposed pipe, or the hydraulic grade line computed for the channel or ditch as approved by the Engineering Division.

c. The minimum depth of a terminal inlet or manhole is four (4) feet from the top of the inlet to the flowline of the outlet or inlet pipe. Greater

depth shall be used for intermediate inlets or manholes if necessary for the required depth of the hydraulic grade line. (See 6.02.03, sub-section 3.c. for requirements for concrete encasement.)

12. Outlet Erosion Protection

a. Outlet velocities from closed conduits shall not exceed 5 f.p.s. for the design storm. Erosion protection shall be required at outlets.

b. At no time shall outfalls discharge into an area with an average slope greater than 2% from receiving natural channel flowline elevation to the outfall flowline elevation.

c. Primary outfalls are those where the entire upstream channel is replaced by an enclosed system or constructed channel.

1) For primary outfalls, flow shall be discharged in line with the direction of the downstream channel segment.

2) A riprap apron shall be installed downstream of the outlet and a grade control provided to prevent undermining of the outfall by potential future head cuts. See Section 6.04.07 for more information on grade controls and Section 6.04.03, sub-section 7 for more information on riprap aprons.

3) The alignment and location of the outfall and associated riprap apron and grade control shall make a smooth transition into the downstream channel.

4) If the primary outfall is near the confluence with a larger natural channel, the outfall disturbance limit (limit of downstream grade control) shall be a minimum of ten channel widths (smaller channel) from the confluence, or to the edge of the larger natural channels riparian buffer, whichever is greater.

d. Lateral outfalls are outfalls that discharge at the banks of a natural channel.

1) Lateral outfalls shall be located to enter from the outside of a bend, and shall not enter from the inside of a bend.

2) Outfall pipes shall be oriented perpendicular to the flow of the natural channel with the outfall invert at the natural channel flowline.

3) Lateral outfalls shall be flush with or setback from the bank. The disturbed bank shall be shaped to provide a smooth transition from undisturbed to disturbed natural channel bank and protected with armor and vegetation (preferred).

4) If the outfall is on an existing riffle, the riffle shall be replaced with a grade control. If the outfall is in an existing pool, the next

downstream riffle shall be replaced with a grade control. See Section 6.04.07 for more information on grade controls.

5) All lateral outfalls shall include a concrete toe wall. Toe wall shall be a minimum of 30" below the channel flowline.

6.02.04 Emergency Relief System

The design components of the drainage system include the inlets, pipe, storm sewers, and improved and unimproved channels that function during typical rainfall events. The Emergency Relief System (ERS) comprises the major overland flow routes such as yard swales, streets, floodplains, detention basins, and natural overflow and ponding areas. The purpose of the emergency relief system is to provide a drainage path to safely pass flows that cannot be accommodated by the piped system without causing flooding of adjacent structures, or street ponding depth that restricts emergency access or property ingress/egress.

1. Provide an ERS that generally begins at the most upstream intake structure to convey flows when the piped system is blocked. The ERS shall be directed to a point of discharge at a detention facility, or as otherwise approved by the City. The ERS may include Critical and Non-Critical Components as defined herein.
   a. Non-Critical Component – A portion of the ERS that is unobstructed downstream and outside the influence of ponding.
   b. Critical Component – A portion of the ERS that is obstructed downstream causing ponding for the design event that, if not properly graded, could cause structural flooding or restrict property ingress/egress.

2. The capacity of the ERS shall be verified with hydraulic calculations using the following criteria:

   a. The ERS shall be designed for the 100-year, 20-minute storm event, assuming the piped system is blocked. The Modified Rational method shall be used to calculate the peak flow rate. See Section 6.01.06 for more information.

   b. The maximum peak flow rate through an ERS for the 100-year, 20-minute storm event, assuming the piped system is blocked, shall be 50 cubic feet per second (CFS) unless otherwise approved by the City.

   c. The maximum water surface elevation for improved open channel flow shall be one (1) foot.

   d. The ERS ponding depth in residential yards shall be 18 inches or less for public safety and nine (9) inches or less in streets and parking areas at the lowest gutter elevation for emergency access and property ingress/egress. Modifications to typical street cross-sections may be considered to achieve conformance with this criterion.

e. Low sill elevation of structures and any openings (i.e. egress windows, window wells, walkouts, etc.) adjacent to the ERS shall be established at a minimum of 6 inches above the 100-year high water elevation.

f. Where the topography will not allow for an emergency relief path or as otherwise approved in lieu of an emergency relief path, pipe and intake capacity of the piped system shall be designed for the 100-year, 20-minute event. Additionally, the minimum pipe size shall be thirty-six (36) inches in diameter.

3. The following is the minimum design information that shall be included on the improvement plans:

a. The ERS shall be designated on the drainage area map and on the grading plan from the first upstream intake structure to the point of discharge. All critical and non-critical components of the ERS shall be labeled.

b. Non-Critical Components of the ERS shall be identified on the plans with a general flow path provided.

c. Critical Components of the ERS shall be identified on the plans with cross-sections and calculations provided demonstrating compliance with the design criteria noted listed in Section 6.02.04.2.

d. For where an open channel is part of the ERS, provide the following information (table preferred):
   i. Finish grade elevations of property lines
   ii. the highest midpoint in between property corners for side yard ERS
   iii. Minimum low sill elevation for each lot along the ERS

e. For where a piped system is part of the ERS, provide the following information (table preferred):
   i. 100 year 20 minute flows for each drainage area to the ERS
   ii. Capacity of intake structures for the 100-year 20-minute event
   iii. Capacity of the piped system for the 100-year 20-minute event
   iv. Ponding depths in conformance with Section 6.02.04.2.d.

4. At a minimum, a 10-foot wide drainage easement shall be established over the ERS on the record plat. Provide additional easement width as required to accommodate the ERS.

5. All foundation opening elevations shall be clearly documented on the Building Permit Application Submittal.

6. Temporary and final occupancy permits will not be issued until structures, grading and drainage are verified to be in accordance with this section.

a. All lots adjacent to Non-Critical Components of the ERS shall be visually verified by the City for conformance with the ERS criteria and improvement plans prior to final occupancy.

b. All lots adjacent to Critical Components of the ERS shall be verified for construction in accordance with the improvement plans by a survey signed and sealed by a Professional Land Surveyor prior to temporary occupancy.

c. If during the verification process it is determined that the ERS component may not be constructed in accordance with the improvement plans, the builder shall either:

   i. Provide an Engineer Certification signed and sealed by the professional engineer. The Engineer Certification shall demonstrate through hydraulic calculations that the ERS has been verified to suffice the criteria in Section 6.02.04.2 as constructed.
   ii. Ensure the grades and elevations follow the improvement plans and provide elevation verification by a Professional Land Survey demonstrating conformance to the improvement plans.

d. The next permit inspection shall not be authorized by the Building Official without verification.

6.02.05 Sinkhole Areas

1. Sinkhole Report

Where improvements are proposed in any area identified as sinkhole areas, a sinkhole report will be required. This report is to be prepared by a Professional Engineer, registered in the State of Missouri, with demonstrated expertise in geotechnical engineering, and shall bear his or her seal.

The sinkhole report shall verify the adaptability of grading and improvements with the soil and geologic conditions available in the sinkhole areas. Sinkhole(s) shall be inspected to determine its functional capabilities with regard to handling drainage.

The report shall contain provisions for the sinkholes to be utilized as follows:

a. All sinkhole crevices shall be located on the plan. Functioning sinkholes may be utilized as a point of drainage discharge by a standard drainage structure with a properly sized outfall pipe provided to an adequate natural discharge point, such as a ditch, creek, river, etc.

b. Non-functioning sinkholes and sinkholes under a proposed building may be capped.

c. If development affects sinkholes, they may be left in their natural state; however they will still require a properly sized outfall pipe to an adequate natural discharge point.

d. An emergency relief path shall be required for all sinkholes assuming the outfall pipe and sinkhole become blocked.

Where the topography will not allow for an emergency relief path:

1) The storm sewer shall be designed for the 100-year, 24-hour storm; and

2) If this storm pipe is smaller than thirty-six (36) inches in diameter, a designated ponding area shall be identified, assuming the pipe is blocked; and

3) Ponding areas shall be based on the 100-year, 24-hour storm; and

4) The low sill of all structures adjacent to the ponding area shall be a minimum of 6 inches above the 100-year high-water elevation and in compliance with Section 6.02.04.

2. Procedure for Utilization of Sinkholes

a. Excavation. Prior to filling operations in the vicinity of a sinkhole, the earth in the bottom of the depression will be excavated to expose the fissure(s) in the bedrock. The length of fissure exposed will vary, but must include all unfilled voids or fissure widths greater than one-half (1/2) inch maximum dimensions which are not filled with plastic clay.

b. Closing Fissures. The fissure or void will be exposed until bedrock in its natural attitude is encountered. The rock will be cleaned of loose material and the fissures will be hand-packed with quarry-run rock of sufficient size to prevent entry of this rock into the fissures, and all the voids between this hand-packed quarry-run rock filled with smaller rock so as to prevent the overlying material's entry into the fissures. For a large opening, a structural (concrete) dome will be constructed with vents to permit the flow of groundwater.

c. Placing Filter Material. Material of various gradations, as approved, will be placed on top of the hand-packed rock with careful attention paid to the minimum thicknesses. The filter material must permit either upward or downward flow without loss of the overlying material.

The fill placed over the granular filter may include granular material consisting of clean (no screenings) crushed limestone with 10 inch maximum size and one inch minimum size or an earth fill compacted to a minimum density of 90 percent modified Proctor as determined by ASTM D-1557.

d. Supervision. Periodic supervision of the cleaning of the rock fissures must be furnished by the Engineer who prepared the Soil Report. Closing of the rock fissures will not begin until the cleaning has been inspected and approved by that Engineer.

During the placement and compaction of earth fill over the filter, supervision by the Engineer shall be continuous. Earth fill densities will be determined during the placement and compaction of the fill in sufficient number to insure compliance with the specification. The

Engineer is responsible for the quality of the work and to verify that the specifications are met.

6.02.06 As-Built Certification for Storm Sewer Facilities

An as-built survey is required for all storm sewer facilities. The design engineer shall submit the Professional Engineer's Construction/As-Built Certification for Sanitary and Storm Sewers as required in Section 11.

The City may require the submittal of revised hydraulic calculations for any sewer reach having an as-built grade flatter than the design grade by more than 0.1 percent. Based on a review of this hydraulic information, the City may require the removal and replacement of any portion of the sewer required to ensure sufficient hydraulic capacity of the system.

6.03 Engineered Channels

6.03.01 General

Engineered Channels shall be defined as:

- Any created open channels,
- Swales, defined as broad shallow grass or rock lined ditches with non-erosive slopes that convey stormwater in between structures or across property,
- Roadside swales (roadside swales shall only be allowed for R-1A, Agricultural and industrial developments, as approved by the City),
- Modified existing open channels where a riparian corridor buffer does not exist or that do not otherwise meet the definition of a Natural Channel (See section 6.04.01).

6.03.02 Design

- Engineered channels shall be designed for the 15-yr, 20-min storm.
- The 100-yr, 24-hr storm shall be evaluated for freeboard requirements as described in Section 6.02.04 and 6.03.05.
- All residential side and rear yard swales, shall have a slope of 2% or greater to facilitate adequate drainage. Hydraulic computations are not required unless the swale is part of the emergency relief path. Elevations shall be provided at property lines and halfway in between property lines.
- Sheet flow over terraces with slopes five feet in height or greater shall not exceed three (3) cubic feet per second (cfs). Engineered channels shall be provided to collect the flow at the top of the terrace and carry it to a drainage structure. Total accumulation inside engineered channels shall be a maximum of three (3) cfs.

6.03.03 Flow quantities

- The design flow to engineered channels shall be calculated in accordance with Section 6.01.07, sub-section 1.
- The NRCS Unit Hydrograph method shall be used to calculate the 100-yr, 24-hr peak flow. See Section 6.01.07, sub-section 2. for more information on the NRCS Unit Hydrograph method.

6.03.04 Computation Methods

Engineered channels under uniform flow shall be evaluated using Manning's Equation:

$$Q = \frac{1.486}{n} A \cdot R^{2/3} S^{1/2}$$ where:

Q = Discharge in cubic feet per second
A = Cross sectional area of flow in square feet
n = Roughness Coefficient (see Table 6-6)

R = Hydraulic radius $R = \frac{A}{P}$ in feet

S = Slope in feet per foot

P = Wetted perimeter in feet

Engineered channels subject to backwater shall be evaluated using the direct step method for prismatic channels or the standard step method for non-uniform channels. The use of the HEC-RAS program, developed by the U.S. Army Corps of Engineers, is recommended for standard step calculations. (Available from http://www.hec.usace.army.mil/software/hec-ras).

6.03.05 Freeboard

The low exterior sill or low opening elevation of adjacent structures and/or edge of pavement for roadside swales shall be 1 foot above the 100 year, 24 hour return frequency stormwater surface elevation.

6.03.06 Size and Shape

Open channels shall not decrease in size in the direction of flow. Side slopes shall not be steeper than:

- 3 horizontal to 1 vertical (3H:1V).
- Side slopes may need to be flatter than 3H:1V, if necessary to stabilize slopes.

6.03.07 Drop Structures

Drop structures made of rock, concrete or other material are allowed intermittently in engineered channels only as approved by the City. The maximum allowable drop for a rock drop structures shall not exceed ½ the diameter of the rock used.

6.03.08 Materials

The design of the lining material shall protect the channel for heights up to the 15-year, 20-minute design storm, with material designed to withstand a flow up to the 100-year, 24-hour storm event. Channels may be lined with appropriate vegetation, riprap, and articulated concrete or other approved material. The City shall have the right to approve or disapprove any channel material. Swales used as BMPs shall be appropriately vegetated and maintained, or otherwise stabilized in an approved manner.

6.03.09 Channel Lining Height

Minimum lining height shall be the selected design storm water profile plus at least 6 inches.

Channel lining height on the outside bend of curves shall be increased by:

$y = \frac{D}{4}$ where:

y = Increased vertical height of lining in feet
D = Depth of design flow in feet

Increased lining height shall be transitioned from *y* to zero feet over a minimum of:

30**y* feet downstream from the point of tangency (P.T.).

10**y* feet upstream from the point of curvature (P.C.).

6.03.10 Location and Easements

1. Engineered Channels shall be located
    a. In permanent easements dedicated to the City.
    b. Along property lines or immediately adjacent to public streets, avoiding crossings through the property.
    c. At a sufficient distance from existing and proposed buildings and underground utilities or sewers to avoid future problems of flooding or erosion.
    d. To avoid interference between stormwater sewers and house connections to sanitary sewers.

2. Roadside swales located in the street right-of-way do not require an easement. Otherwise, roadside swales shall have a dedicated easement from the street right-of-way extending to five feet outside of the top of the outside bank of the swale.

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6.03.11 Alignment Changes

Alignment changes shall be achieved by curves having a minimum radius of:

$$R = \frac{V^2 \cdot W}{8D}$$ where:

R = Minimum radius on centerline in feet
V = Design velocity of flow in feet per second
W = Width of channel at water surface in feet
D =Depth of flow in feet

6.03.12 Hydraulic Jump

When flow changes from the supercritical to subcritical state, a hydraulic jump may occur. A study should be made on the height and location of the jump, and for discharges less than the design discharge, to ensure adequate wall heights extend over the full ranges of discharge.

6.03.13 Erosion Protection

If erosive energy exists at the termination point of an engineered channel, erosion protection is required to dissipate the energy to a non-erosive level. See Section 6.04.03, sub-section 7 for information on energy dissipation structures.

6.04 Culverts, Bridges and Natural Channel Crossings

6.04.01 General

Natural Channels are defined as natural watercourses that are protected under the City of Wentzville Municipal Code, Title IV, Regulation for the Protection of Natural Watercourses, Ordinance #2863. In general, natural channels are channels protected by riparian corridor buffers. Buffers are as identified by the City or required because the channel is determined to be jurisdictional waters of the United States by the U. S. Army Corps of Engineers.

This section sets forth requirements for management and maintenance of riparian buffers during the allowable construction and alteration activities within the buffers as presented in Title IV, Article IV.

6.04.02 Channel Assessment and Channel Condition Scoring Matrix

If construction is proposed within a natural channel's riparian corridor buffer for a culvert, bridge or other natural channel crossing, the channel shall be assessed. The assessment has 4 components as follows, which are described in detail in this section:

1) Longitudinal Profile and Channel Cross Section Survey
2) Channel Condition Scoring Matrix, which rates the condition of 15 natural channel parameters
3) Bank-Full, Plan-Form Ratios and Critical Shear Stress Calculations
4) Natural Channel Plan, Profile and Section Exhibits

The channel assessment and Channel Condition Scoring Matrix provides a framework for engineers to gather natural channel data needed to develop a general indication of the natural channel's condition and to guide design.

1. Longitudinal Channel Profile and Channel Cross Section Survey

   a. Longitudinal Channel Profile Survey

      The longitudinal profile survey is a detailed string of survey shots of the channel bottom to define the pools and riffles in profile and the low flow channel sinuosity in plan. The profile survey shall include as many survey shots as necessary to clearly define every pool and riffle. In segments where the channel is flat and apparently without pools and riffles, a minimum of one shot shall be taken every 20 feet at the lowest point in the channel. The minimum length of profile survey shall be as follows (centered at the proposed crossing):

Buffer Width	Minimum Profile Survey Length
25	500
50	1,000
100	2,000

Plan Profile sheets of the profile survey shall be created per the Natural Channel Plan, Profile and Section Exhibits requirements of sub-section 4.

b. Channel Cross Section Survey

A minimum of 4 channel cross sections shall be surveyed. All channel cross sections shall be located on riffles and/or at any significant change in section area. Minimum spacing between sections shall be no greater than 4 times the buffer width as follows:

Buffer Width	Minimum Cross Section Spacing
25	100
50	200
100	400

The cross sections shall be plotted to an appropriate scale per the Natural Channel Plan, Profile and Section Exhibits requirements of sub-section 4.

2. Channel Condition Scoring Matrix

The length of channel surveyed shall be walked for the purpose of completing the Channel Condition Scoring Matrix (Form 6-1) and photographing existing conditions. The matrix includes 15 parameters, 12 of which can be determined during the field visit. The remaining 3 parameters will be determined using survey done as part of the Natural Channel Plan, Profile and Section Exhibits described in sub-section 4 and calculations as described in sub-section 3. The parameters are described in Form 6-1.

Two photographs shall be taken at each cross section location and at each proposed crossing location, one facing upstream and one facing downstream. This will produce a minimum of 8 photographs.

The Channel Condition rating shall be used as follows:

a. A rating of under 12 indicates a natural channel of moderate stability, therefore the criteria outlined in this section for culverts, bridges and other natural channel crossings shall be followed, at a minimum.

b. A rating between 12 and 18 indicates that special measures may be necessary, at the discretion of the City, to address those issues rated as poor in the assessment.

c. A rating greater than 18 indicates a natural channel with significant system-wide instability. The design of culverts, bridges and other channel crossings in unstable natural channels shall include a detailed fluvial geomorphic study. A firm with demonstrated expertise in river engineering and fluvial geomorphology shall perform the study and make recommendations.

3. Bank-full, Plan-Form Ratios, and Critical Shear Stress Calculations

Using the survey, data collected during the field visit and other available information, the following shall be calculated:

a. Bank-full Discharge, Width, and Depth

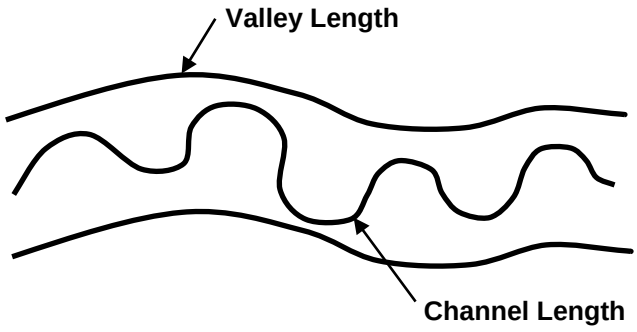
b. The bank-full discharge shall be estimated as the 1-yr, 24-hour storm using the NRCS Unit Hydrograph method. See Section 6.01.07, sub-section 2. for more information on calculating the discharge using the NRCS Unit Hydrograph method.

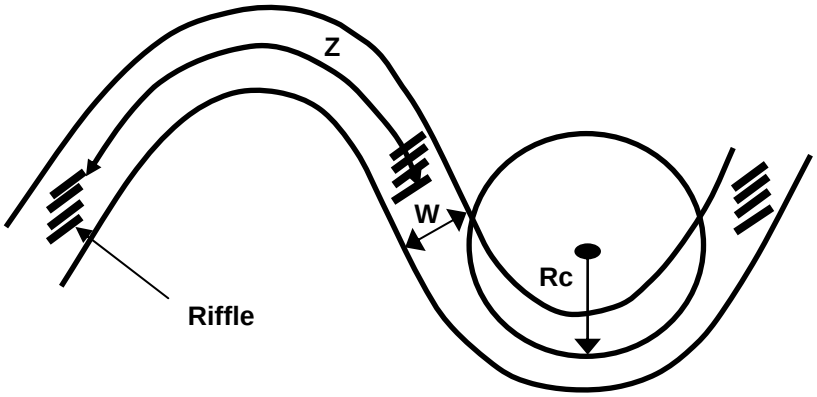
The bank-full depth and width shall be the depth and width of the bank-full discharge in the existing channel as calculated by Manning's Equation. See Section 6.03.04 for more information on Manning's Equation.

c. Plan-Form Ratios

The following ratios shall be calculated, and those that lie outside the typical range shall be noted. See the definition sketches below for plan-form terminology.

Ratio	Typical Range
Sinuosity (channel length / valley length)	1.1 to 1.5
Radius of curvature / Bank-full width	2 to 5
Riffle Spacing / Bank-full width	5 to 7





Rc = radius of curvature
W = bank-full width
Z = riffle spacing

d. Critical Shear Stress Analysis

The type of rock and/or soil exposed in the bed and banks shall be identified at each riffle. Bank soils shall be reported by Uniform Soil Classification using the visual-manual procedures (ASTM D 2488-00). The median (D_{50}) particle size shall be determined visually for each reach where the bed material changes. A shear stress ratio shall be calculated for each location based on the applied shear at bank-full flow divided by the critical shear of the D_{50} particle in the riffle, using methods and tables described below.

The average applied shear stress (τ_o) shall be calculated from the hydraulic data as follows:

$$\tau_o = \gamma RS$$

where: γ is the specific weight of water (62.4 pcf),

R is the hydraulic radius at bank-full flow, and

S is the water surface slope (in ft/ft) along the main channel bank-full flow, averaged over several bends in the area of the intervention.

The critical shear stress, τ_c, is that at which particles in the bed or bank are entrained and scour ensues.

Critical shear stresses are listed in Table 6-7. This table presents critical shear for sediment-laden water and where noted, clear water. The user must exercise judgment as to future conditions. Clear water values are only applicable below a heavily piped area, concrete channels designed to contain the future flows or immediately below a managed detention pond.

The ratio of average boundary stress to critical stress is the shear stress ratio:

shear stress ratio = τ_o / τ_c

If bed and bank materials are different, then the shear stress ratio should be calculated for each.

If the shear stress ratio of either streambed or bank is greater than one, the channel is prone to near-term adjustment and any interventions should be designed to prevent accelerated erosion. If the bed consists of rock, then the shear stress ratio is not applicable, unless the rock is prone to fracturing, slaking, or break-up, in which case the median size of particle should be used for calculation of the ratio.

4. Natural Channel Plan, Profile and Section Exhibits

A plan and profile sheet(s) and cross section sheets of the longitudinal profile and channel cross section surveys shall be plotted to an appropriate scale. The project name and the City of Wentzville Engineering Project Number shall appear in the lower right corner of the sheets. Example Natural Channel Plan, Profile and Section Exhibits are shown in Figures 6-4A and 6-4B.

a. The following items shall be shown and clearly labeled in the plan view:

1) Stationed longitudinal profile survey
2) Ground contours (if available). Aerial photographs or planning-level aerial survey may be used.
3) Riparian buffer limit along each bank.
4) Location of the proposed construction within the buffer.
5) Locations of differing bed and bank soil or rock materials. Indicate the D_{50} of the material as determined during the field visit.
6) Using the plan form of the longitudinal profile survey, draw circles to closely fit the stream meanders. Label the radius of curvature for each bend.
7) Locations of photographs. These photographs shall be printed (maximum of 4 photos per 8 ½ x 11 sheet) and submitted with the Exhibit.
8) North arrow and scale

b. The following items shall be shown and clearly labeled in the profile view:

1) Stationed profile survey
2) Hydraulic Grade Line (HGL) of the 1-yr, 24-hour storm.
3) Average channel slope(s) including any major changes in overall slope (use top of riffle to top of riffle to determine slopes).
4) Label the spacing between riffles.
5) Vertical and horizontal scale

c. The following items shall be shown and clearly labeled on the cross sections:

1) Cross section station
2) Draw and label the calculated bank-full depth and width
3) Vertical and horizontal scale

6.04.03 Culverts - General

1. Design Frequencies

Culverts shall be designed to have capacity for the following storm events:

a. Culverts for driveways crossing roadside ditches – 15-yr, 20-minute storm

b. All other culverts – 100-yr, 24-hr storm

2. Flow quantities

a. The 15-yr, 20-minute storm flow shall be calculated using the Modified Rational Method, as described in Section 6.01.07, sub-section 1.

b. The 100-yr, 24-hr storm flow shall be calculated using the NRCS Unit Hydrograph Method, as described in Section 6.01.07, sub-section 2.

3. Freeboard Requirements

There shall be a minimum of 1 foot of freeboard from the design storm hydraulic grade line to the edge of pavement. The requirements for the 100-yr overland flow path shall be as described in Section 6.02.04.

4. Materials

All culverts within the public right of way shall be reinforced concrete as approved by the City.

5. Computation Methods

Culverts are classified as having either inlet or outlet control. Either the inlet opening (inlet control), or friction loss within the culvert and/or backwater from the downstream system (outlet control) will control the discharge capacity. Culverts must be analyzed for both types of flow. Whichever produces the highest headwater depth must be used.

a. Inlet Control - Inlet control occurs when the culvert is hydraulically short (when the culvert is not flowing full) and steep. The flow regime at the entrance is critical as the water falls over the brink (water passes from subcritical to supercritical flow). If the tail water covers the culvert completely (i.e., a submerged exit), the culvert will be full at that point, even though the inlet control forces the culvert to be only partially full at the inlet.

   Design variables for culverts operating under entrance control shall be determined from Figures 6-5A through 6-5E.

b. Outlet Control - If the flow in a culvert is full for its entire length, then the flow is said to be under outlet control. The discharge will be a function of the differences in tail water and headwater levels, as well as the flow resistance along the barrel length.

   Design variables for culverts operating under outlet control shall be determined from Figures 6-6A through 6-6C.

c. Tail water conditions for culverts shall be calculated using the Manning's Equation for channels under uniform flow. Channels subject to backwater shall be evaluated using the direct-step method for prismatic channels or the standard-step method for non-uniform channels. The use of the HEC-RAS program, developed by the U.S. Army Corps of Engineers, is recommended for standard step calculations.

d. HEC-RAS software, developed by the U.S. Army Corps of Engineers, may also be used for culvert analysis.

e. More information can be found at the Federal Highway Administration website (http://www.fhwa.dot.gov/engineering/hydraulics/culverthyd/index.cfm) including applicable design manuals, reports, and FHWA hydraulic engineering software, FHWA Culvert Analysis, and HDS 5 Hydraulic Design of Highway Culverts.

6. Entrances and Headwalls – Headwalls and wingwalls are required at the entrance and exits of all box culverts. Flared end sections are required, at a minimum, at the entrance and exits of pipe culverts.

7. Energy Dissipation

   a. The outfall of all culverts and engineered channels shall include energy dissipation sufficient to transition outlet flows to velocities and applied shear stresses consistent with the normal flow conditions in the receiving channel, up to the design storm of 15-year, 20-minutes for driveway culverts or 100-year, 24-hours for all other culverts.

b. Examples of energy dissipating structures are:
   - Riprap Aprons
   - Stilling Basins
   - Hydraulic Jump Basins
   - Impact Baffle Basins
   - Plunge Pool and Plunge Basin
   - Slotted-Grating or Slotted Bucket Dissipaters

   The suitability of each method is site dependent. The FHWA computer program HY8 Energy (downloadable free from the FHWA hydraulics website) lists methods and applicability. Energy dissipaters shall be designed according to the criteria and procedures defined in professionally acceptable references. All references used shall be appropriately documented, and referenced, and tables or graphs copied into the report. Several such references include:

1) United States. Department of the Interior. Bureau of Reclamation. Design of Small Dams. 1987 ed. Denver: GPO, 1987.

2) United States. Department of the Interior. Bureau of Reclamation. A Water Resource Technical Publication. Engineering Monograph No. 25. Hydraulic Design of Stilling Basins and Energy Dissipaters. 1978 ed. GPO, 1978.

3) Federal Highway Administration (FHWA), 1983. Hydraulic Design of Energy Dissipaters for Culverts and Channels, Hydraulic Engineering Circular (HEC) No. 14, along with HY8 Energy design software.

4) US Army Corps of Engineers, 1994. Hydraulic Design of Flood Control Channels, US Army Corps of Engineers Engineer Manual EM 1110-2-1601.

5) Bridge Scour and Stream Instability Countermeasures Experience, Selection, and Design Guidance (Latest Edition), National Highway Institute, HEC No. 23.

6) River Engineering for Highway Encroachments, Highways in the River Environment, U.S. Department of Transportation, Federal Highway Administration, Publication No. FHWA NHI 01-004, December 2001.

6.04.04 Culverts in Natural Channels

1. Low Flow Design:

   a. The upstream culvert flow line shall match the natural channel flowline at the upstream limit.

   b. The culvert low flow barrel shall be designed to convey the 1 year, 24 hour storm at a depth equal to the 1 year, 24 hour flow depth in the undisturbed natural channel immediately upstream of the culvert entrance.

2. 100 year, 24 hour storm Capacity Design:

   The remaining capacity necessary for the 100 year, 24 hour storm shall be provided above the hydraulic elevation of the 1 year, 24 hour storm. In other words, the flow line of the overflow barrels shall be at the water surface elevation of the 1 year, 24 hour storm.

3. Natural channel interventions and structures shall be included upstream and downstream of the culvert as needed such that the post construction energy grade line (EGL) and hydraulic grade line (HGL) for the 1 year, 24 hour storm flow match the natural channel EGL and HGL at the limits of disturbance.

   a. At a minimum, there shall be a grade control at the upstream and downstream limits of disturbance as the final transition from the construction area to a natural channel.

   b. A stilling basin is typically required at the culvert outfall to eliminate erosive energy created by the culvert.

4. Realignment of channels to accommodate culverts shall be avoided or minimized as much as possible.

6.04.05 Bridges

1. Design Frequencies

   Bridges shall be designed to have capacity for the following storm events:

   a. Low-flow channel: 1-yr, 24-hr storm
   b. 100-yr, 24-hr storm

2. Flow quantities

   The 1-yr and 100-yr, 24-hr storm flows shall be calculated using the NRCS Unit Hydrograph Method, as described in Section 6.01.07, sub-section 2.

3. Low Flow Channel Design

   For a bridge over an undisturbed channel, the existing low flow channel depth, width, slope and roughness shall be maintained or re-established through the bridge opening.

   If the bridge is to replace an existing culvert or bridge, the section under the bridge shall have a 2-stage channel shape such that the proposed 1 year, 24 hour flow depth and velocity in the new channel is equal to the 1 year, 24 hour flow depth and velocity in the undisturbed natural channel immediately upstream of the bridge.

4. Freeboard Requirements

   The lowest point of the bridge superstructure shall have a freeboard clearance of 1 foot for the 100 year frequency.

5. Waterway Alignment

   The bridged waterway will be aligned to result in the least obstruction to stream-flow, except that for natural channels consideration will be given to future realignment and improvement of the channel.

6. Computation Methods

   Hydraulic calculations for natural channels shall be done using the standard-step backwater method. Major stream obstructions, such as bridges can cause significant energy loss. In these cases, the energy equation does not apply and the momentum equation shall be used. The use of the HEC-RAS program, developed by the U.S. Army Corps of Engineers, is recommended for these calculations.

7. Natural channel interventions and structures shall be included upstream and downstream of the bridge as needed such that the post construction energy grade line (EGL) and hydraulic grade line (HGL) for the 1 year, 24 hour storm flows matched the natural channel EGL and HGL at the limits of disturbance.

   At a minimum, there shall be a grade control at the upstream and downstream limits of disturbance as the final transition from the construction area to a natural channel.

8. Erosion Protection

   To preclude failure by scouring, abutment and pier footings will usually be placed either to a depth of not less than five (5) feet below the anticipated depth of scour, or on firm rock if such is encountered at a higher elevation. Large multi-span structures crossing alluvial natural channels may require extensive pile foundations. To protect the channel, revetments on the channel sides (above the low flow channel) consisting of concrete, rock blanket, articulated concrete block, or others as approved by the City, should be placed as required. The governing authority should be contacted regarding their design requirements.

6.04.06 Below Grade Natural Channel Crossings

1. Below grade natural channel crossings primarily include utility pipelines.

2. Crossing at a riffle. Crossing at the upstream end of an existing riffle is preferred. A grade control structure shall be constructed at the riffle. The grade control shall be constructed in addition to and immediately downstream of the utility line.

3. Crossing at a pool. If the crossing is in a pool or otherwise not in the upper portion of an existing riffle, a grade control structure shall be constructed at the next downstream riffle. Crossings under pools should not be armored directly, but are protected by a downstream grade control. The existing pool depth and location shall be maintained (i.e. the pool shall not be filled).

4. The proposed channel shape at the crossing shall match the existing channel shape. Natural channel banks shall be repaired using vegetative methods whenever possible and the hydraulic roughness of the repaired natural channel bank should match that of the undisturbed natural channel banks.

6.04.07 Grade Control

1. Design Frequencies

   Grade controls shall be designed to provide channel protection for the following storm events:

   a. The grade control rock shall extend to the top of bank on both sides, or to the depth of the 10-year, 24-hour storm, whichever is greater.

   b. The grade control rock shall be sized for the 100-yr, 24-hr storm.

2. Grade controls shall be placed on existing riffles or otherwise in locations where the streambed profile will support the creation or continuance of a riffle. The flowline of the grade control shall match the existing riffle flowline.

3. Grade control geometry:

   a. Plan form - Grade controls shall be shaped in plan form to focus the flow to the center of the channel. This will produce a crescent or V-shaped grade control with the apex of the crescent or V at the upstream limit of the grade control.

   b. Profile – The upstream limit of the grade control shall start at the upstream limit of the riffle and extend to a point below the crest elevation of the next downstream riffle. The grade control profile slope shall match the existing riffle slope.

   c. Cross Section – The grade control cross section shall extend to the top of bank on both sides or to the depth of a 10-year, 24-hour storm. The grade control shall not be flat across the bottom of the channel, it shall have a well-defined low point located at the center of the channel.

   d. Grade Control Rock – Rock shall be hard, durable, angular in shape and not elongated. Rock shall be well graded. Shotrock with sufficient fines to fill voids may be used. The use of filter fabric and uniform gradations of stone are discouraged in natural channel beds.

e. Grade Control Rock Sizing and Gradation – Structures shall be constructed from rock sized using one of the following approved methods:

1) US Army Corps of Engineers, 1994. Hydraulic Design of Flood Control Channels, USACE Engineer Manual EM 1110-2-1601.

2) US Bureau of Reclamation, Peterka, A. J., 1958. Hydraulic Design of Stilling Basins and Energy Dissipators, US Bureau of Reclamation, Engineering Monograph No 25.

3) The American Society of Civil Engineers, Vanoni, V. A. (ed.) 1977. Sedimentation Engineering, ASCE Manuals and Reports on Engineering Practice – No 54, ASCE, New York, New York.

4) HEC-11, US Federal Highway Administration, 1989. Design of Riprap Revetment, Hydraulic Engineering Circular, No 11.

5) Others as approved by the City.

f. Grade Control Depth - The depth of grade controls shall be a minimum of 1.5 times the largest rock size in the gradation.

4. Where natural channel slope is less than 2%, the ramp-style grade control structure detailed in Figure 6-7 is recommended.

5. Where grades are in excess of 2%, low-drop structures should be used.

6. Alternate styles of grade control are allowed as approved by the City. For example, a hard-bottomed culvert may have profile grade controlling properties that may be acceptable to the City.

7. If, in the opinion of the design engineer, a grade control causes the development to require an Individual 404 Permit, and there is an alternative that meets the goals of the grade control requirements, the engineer may submit the alternative to the Engineering Department for review.

6.04.08 Bank stabilization in Disturbed Areas

1. Disturbed banks shall be stabilized.

2. Banks shall be stabilized using materials and shapes that closely match the natural channel materials and shapes as much as practicable.

3. Bank stabilization must provide both geotechnical stability and protection from erosive stream forces.

4. Bank stabilization materials and techniques include, but are not limited to:

a. Rock revetment – Rock shall be hard, durable, angular in shape and not elongated. Rock shall be sized for the 100-year, 24-hour storm per USACE, USBR, ASCE, FHWA HEC-11 methods, or others as approved

by the City. See Section 6.04.07, sub-section 3.e, for more information on rock sizing. Rock shall be well graded. Shotrock with sufficient fines to fill voids may be used. The use of filter fabric and uniform gradations of stone are discouraged in natural channel beds. The depth of rock revetments shall be a minimum of 1.5 times the largest rock size in the gradation.

b. Articulated Concrete Block (ACB).

c. Modular Block Retaining Walls

d. Bio-engineered revetments – Soil bioengineering involves the use of living vegetation in combination with soil reinforcing agents such as geogrids to provide bank stabilization.

e. Composite revetments - Composite revetments are a combination of techniques. For example, vegetated rock, vegetated ACB, etc.

f. Vegetation shall be appropriate to local conditions and shall be native Missouri riparian species. Planting plans and palettes shall be prepared by an experienced professional with a degree or certification that qualifies them to develop the planting palettes and plans.

6.05 Detention and Water Quality

6.05.01 General

1. All projects shall be submitted to the City for review and approval.

2. Detention and water quality facilities shall be provided and designed in accordance with the requirements of this section.

6.05.02 When Required

1. Stormwater detention and water quality requirements shall be evaluated for all projects. Specifically, stormwater detention and water quality shall be required for projects as outlined below:

   a. Water quality treatment is required for all development projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan or development, as follows.

      i. For all new development projects, controls shall be designed and implemented to prevent or minimize water quality impacts to the maximum extent practicable. This includes assessment of site characteristics at the beginning of design with the goal of protecting sensitive areas, minimizing the creation of stormwater pollution, and utilizing Best Management Practices that effectively remove stormwater

pollution. This can be achieved by reasonably mimicking pre-construction runoff conditions, such as reducing runoff volume through infiltration, evapotranspiration and/or rainwater harvesting or reuse.

ii. For all redevelopment projects, water quality strategies and technologies, including those that reduce runoff volume, shall be effectively used to the maximum extent practicable.

iii. The existence of downstream stormwater problems may require water quality treatment, regardless of disturbance size, at the discretion of the City.

b. Channel protection and flood protection are required as follows. The differential runoff is calculated by the Modified Rational Method per Section 6.01.07, sub-section 1.

i. Channel protection and flood protection is required for all projects which have a differential runoff of 2 cfs or more for the 15-year, 20-minute event.

ii. Subsequent development of sites without prior stormwater detention that have a cumulative differential runoff since January 1, 2007 that equals 2 cfs or more require channel and flood protection.

iii. Redevelopments and subsequent development with prior stormwater detention are exempt from providing additional channel protection and flood protection for the existing runoff. These projects are only required to provide channel and flood protection for the increase in runoff. When existing stormwater management facilities will be used to accommodate the increase in runoff from subsequent development or redevelopment, the facilities shall be retrofitted to meet the current stormwater management requirements for the additional runoff.

iv. The existence of downstream stormwater problems may require subsequent development or redevelopment projects to provide additional detention, regardless of differential runoff at the discretion of the City.

6.05.03 Stormwater Detention and Water Quality Sizing Criteria

1. General

This section presents the sizing criteria for stormwater facilities to meet pollutant removal goals, reduce channel erosion, prevent flooding, and pass extreme floods. A very brief summary is listed below.

SUMMARY OF THE KEY COMPONENTS AND STORMWATER CRITERIA

Stormwater Volume	**General Criteria and Calculation Method**
Water Quality Volume (WQ_v) (ft^3)	WQ_v shall be treated using one of the allowable BMPs. **$WQ_v = [(P/12)(R_v)(A*43,560)]$** P = rainfall depth = 1.14in R_v = volumetric runoff coefficient A = area in acres
Channel Protection Storage Volume (Cp_v)	Cp_v = 24 hour extended detention of post-developed one-year, 24 hour storm event
Flood Protection Volume (Qp_2 & Qp_{25})	The post-developed routed peak flow from the site may not exceed the existing routed peak flow for the 2-year and 25-year, 24-hour events, or the allowable release rates for applicable watersheds. Calculated using NRCS unit hydrograph method routed through the detention basin(s).

Subtraction for Non-structural Practices: When non-structural practices are employed in the site design, the WQ_v volume and to a lesser extent the Cp_v and Q_p can be reduced in accordance with the conditions outlined in Section 6.05.07 and 6.08.

The following sub-sections provide more expanded information, directories, explanations and resource references.

2. Water Quality Volume (WQ_v)

a. WQ_v is the storage needed to capture and treat the runoff from 90% of the recorded daily rainfall events. In numerical terms, it is equivalent to 1.14 inches of rainfall multiplied by the volumetric runoff coefficient (R_v) and site area. The WQ_v is directly related to the amount of impervious cover created at a site. A minimum WQ_v of 0.2 inches per acre shall be met at all sites where WQ_v is required. The following equations are used to determine WQ_v:

$$WQ_v = [(P/12)(R_v)(A*43,560)]$$

Where:
WQ_v = water quality volume (in ft^3)
P = 1.14 inches of rainfall
$R_v = 0.05 + 0.009 (I)$

I = percent impervious cover (in percent.
Eg 100% = 100, 75%=75,…). See table below for minimum impervious percentages.
A =area in acres

b. Percent Impervious Cover (I) can be calculated by breaking drainage areas into component areas, with the appropriate percent impervious applied to each component, i.e.; a proposed development may show 100% impervious for paved areas and 5% impervious for grassed areas and producing a weighted average.

If a weighted average is not calculated, the minimum I to be used is as follows:

For manufacturing and industrial areas	100%
For business and commercial areas	100%
For residential areas, including all areas for roofs of dwellings and garages; for driveways, streets, and paved areas; for public and private sidewalks; with adequate allowance in area for expected or contingent increases in imperviousness:	
In apartment, condominium and multiple dwelling areas:	75%
In single family areas:	
1/4 Acre or less	50%
1/4 Acre to 1/2 Acre	40%
1/2 Acre to One Acre	35%
One Acre or larger	Calculate Impervious Percentage
Playgrounds (non-paved)	20-35%
For small, non-perpetual charter cemeteries	30%
For parks and large perpetual charter cemeteries	5%

c. As a basis for determining water quality treatment volume the following assumptions may be made:

1) The water quality volume WQ_v for offsite areas is not required if the offsite flows bypass the water quality facilities. If offsite runoff flows into a water quality facility, the WQ_v calculation must include the offsite area. Offsite areas are defined as those areas that are not a part of the proposed development but produce runoff that flows to the proposed development.

2) Measuring Impervious Cover: The measured area of a site plan that does not have vegetative or permeable cover shall be considered total impervious cover.

3) Multiple Drainage Areas: When a project contains or is divided by multiple drainage areas, the entire WQ_v shall be addressed for each drainage area within that drainage area (i.e. you cannot increase the WQ_v in one BMP to compensate for no or reduced WQ_v in another). The City may waive this requirement for extreme situations in remote lots. However, the sum of these waived areas may not exceed 5% of the total disturbed area (not including common ground or conservation easements) of the proposed development.

4) BMP Treatment: The final WQ_v shall be treated by an acceptable BMP(s) from the list presented in Section 6.05.06.

5) Extended Detention (ED) for Water Quality Volume: The water quality requirements can be met by providing 24-hour extended detention of **up to half** of the water quality volume (WQ_v) in conjunction with a stormwater pond or wetland system. If the same pond or wetland is used for the Cp_v, the ED portion of the WQ_v may be included when routing the Cp_v.

6) All water quality facilities shall include a separate landscaping plan prepared by an experienced professional with a degree or certification that qualifies them to develop the planting palettes and plans.

7) Water quality portions of a BMP may not serve as a sediment control device during the site construction phase. In addition, the erosion and sediment control plan for the site must clearly indicate how sediment will be prevented from entering the BMP.

3. Channel Protection Storage Volume Requirements (Cp_v)

a. To protect channels from erosion, a 24-hour extended detention of the 1-year, 24-hour storm event shall be provided. The rationale for this criterion is that runoff will be stored and released in such a gradual manner that critical erosive velocity during bankfull and near-bankfull events will seldom be exceeded in downstream channels. A detention pond or underground vault is normally needed to meet the Cp_v requirement (and subsequent flood protection criteria Qp_2 and Qp_{25}).

b. As a Basis for determining Channel Protection Storage Volume the following assumptions may be made:

1) NRCS Unit Hydrograph method shall be used for determining peak discharge rates.

2) The rainfall depth for the one-year, 24-hour storm event is 2.50 inches. Use Type II rainfall distribution.

3) The length of overland sheet flow used in time of concentration (t_c) calculations is limited to no more than 100 feet for post project conditions.

4) The 24-hour extended detention is defined as providing a 24-hour detention lag time (T) for the one-year storm. The lag time is defined as the interval between the center of mass of the inflow hydrograph and the center of mass of the outflow hydrograph. The lag time and Cp_v orifice diameter shall be determined by use of pond routing software as indicated in Section 6.05.03.4.b.6. The method for computing Cp_v as outlined in Maryland Stormwater Design Manual, Appendix D.11 will not be accepted.

5) Cp_v is not required at sites where the one-year post development peak discharge is less than or equal to 2.0 cfs for the entire site.

6) A Cp_v orifice diameter of less than 1 ½" is not allowed. Cp_v orifice diameters greater than 3" require an acceptable external hood that extends above/below it such as screens, baffles, or as approved by the City Engineer. A Cp_v orifice diameter between 1 ½" and 3" will require internal orifice protection as approved by the City Engineer. An internal orifice protection may include an over-perforated vertical stand pipe with ½ inch orifices or slots that are protected by wire cloth and a stone filtering jacket. A schematic design of an acceptable internal orifice protection is provided in Detail No. 3 of Appendix D-8 of the Maryland Stormwater Design Manual.)

   The preferred method is a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation.

   Alternative methods are to employ a broad crested rectangular, V-notch, or proportional weir, protected by a half-round pipe or similar device that extends at least 12 inches below the normal pool. (See Detail No. 7 of Appendix D-8 of the Maryland Stormwater Design Manual.) No steel, galvanized steel, or corrugated metal pipe will be allowed.

   The use of horizontal perforated pipe protected by geotextile and gravel is not recommended.

   Vertical pipes may be used as an alternative if a permanent pool is present.

7) Multiple Drainage Areas: When a project contains or is divided by multiple drainage areas, the entire Cp_v shall be addressed for each drainage area within that drainage area. You cannot increase the Cp_v in one facility to compensate for no or reduced Cp_v in another, except in the following areas:
   1. Where the WQ_v is treated by widening the riparian buffer as described in Section 6.05.06
   2. Where a Sheet Flow to Buffer non-structural BMP credit for WQ_v is used as described in Section 6.05.07
   3. Where the WQ_v requirement has been waived under Section 6.05.03, sub-section 2.c.3.

8) Extended detention storage provided for the Cp_v does not fully meet the WQ_v requirement (that is Cp_v and WQ_v should be treated separately).

9) The stormwater storage needed for Cp_v may be provided above the WQ_v storage in stormwater ponds and wetlands; thereby meeting all storage criteria in a single facility with appropriate hydraulic control structures for each storage requirement.

10) Infiltration is not recommended for Cp_v control because of large storage requirements. If proven effective, appropriate and desirable however, in some rare situations it may be permissible.

4. Flood Protection Volume Requirement (Qp_2 & Qp_{25})

a. To protect downstream areas from flooding stormwater shall be detained on site or offsite as approved and released at a rate not to exceed the existing peak flow for the 2-year and 25-year 24-hour events, or the allowable release rates for applicable watersheds as determined by the City.

Note that stormwater pipes, downstream from the control structure, shall be sized to carry the runoff from the 15-year 20-minute design storm for the total tributary upstream watershed. No reduction in outfall pipe size shall be permitted because of detention.

b. As a Basis for Determining the Flood Protection Volume the following assumptions may be made:

1) The 2-year and 25-year, 24-hour inflow hydrographs shall be determined by using NRCS Unit Hydrograph method as described in Section 6.01.07, sub-section 2.

2) The volume of detention may be provided through permanent detention facilities such as dry basins or ponds, permanent ponds or lakes, underground storage facilities or in parking lots. The engineer shall make every effort to locate the detention facility at or near the lowest point of the project such that all of the onsite runoff will be directed into the detention facility. Multiple use of detention basins is encouraged. Multiple use may include parking lots, ball fields, tennis courts, play grounds and picnic areas.

3) Flows from offsite, upstream areas should be bypassed around the detention facility to ensure that the proposed detention facility will function as designed and will provide effective control of downstream flows with development in place. If offsite flows are directed into a detention facility, the allowable release rates shall not be modified. The bypass system shall be designed for the 100-year, 24-hour storm using future developed conditions.

4) Detention basin volume will be based on routing the post-developed 2-year and 25-year, 24-hour inflow hydrographs through the

detention facility while satisfying the appropriate allowable release rate. The routing computations shall be based on an application of the continuity principle, (i.e., level pool routing).

5) Multiple Drainage Areas: When a project contains or is divided by multiple drainage areas, the Qp_2 & Qp_{25} may be addressed for the entire site in one basin for the entire site, as long as all areas are tributary to the same stream. This does not alleviate the need to provide WQ_v (BMPs) and/or Cp_v for each separate discharge point.

6) Pond routing shall be modeled using a nationally recognized computer program using industry standard methodologies, including, but not limited to:
    1. Pondpack by Haested
    2. Hydraflow Hydrographs by Autodesk
    3. HEC-HMS by the U.S. Corps of Engineers
    4. Others as approved by the City

6.05.04 Limits of Maximum Ponding

1. The maximum ponding elevation shall be calculated based on a routing of the 100-year, 24-hour event assuming all outlet weirs and orifices are blocked, except for the highest overflow structure. The routing shall begin assuming water is ponded to the overflow structure's sill.

2. The limits of maximum ponding in dry basins or ponds and permanent lakes or ponds shall not be closer than thirty (30) feet horizontally to any building, and not less than two (2) feet vertically below the lowest sill elevation of any building.

3. The limits of maximum ponding in parking lots shall not be closer than ten (10) feet horizontally from any building and not less than (1) foot vertically below the lowest sill elevation of any building

4. A minimum of one (1) foot of freeboard shall be provided from the top of the basin to the maximum ponding elevation.

6.05.05 General Stormwater Basin Design Requirements

1. Underground Basins Special Requirements:

    a. Adequate access for basin maintenance and inspection shall be provided. A means of visual inspection from the ground surface of the low flow device, overflow weir, and outlet structure is necessary. Access shall also be provided to allow for cleaning of the low flow device from the ground surface.

    b. The basin should have sufficient volume and spillway capacity to pass/contain the 100-year 24-hour event with the low flow outlet blocked. The routing shall begin assuming water is ponded to the overflow structure's sill. In some situations it may be desirable to have control structures with at least 2 outlet openings, one above the other.

c. Underground basins shall be acceptable for non-residential projects only. Upon City approval, underground basins may be allowed on condominium or apartment projects if maintenance is provided by a management company.

d. Provide immediate manhole access from ground surface for both sides of the low flow device. Also provide a manhole at upstream end of underground basins, for access, inspection, to facilitate maintenance, and air release.

e. Adequate flowline spot elevations, sections and profiles including pipe length and slope shall be labeled to define basin and pipe geometry.

2. For detention ponds that do not contain water quality features, all ends of pipes discharging into a dry basin shall be connected with the low flow pipe or control structure, by means of a permeable swale. The swale shall have a minimum 4:1 lateral (25%) slope to the center, a minimum 1.0% longitudinal slope to ensure positive drainage and a maximum 2.0% longitudinal slope. Swales shall be a minimum of six (6) inches deep and four (4) feet wide or shall match the capacity of the low flow outlet works, whichever results in the greater capacity. The bottom of the basin shall be sloped a minimum of two percent (2%) towards the edge of the swale.

   No concrete swales will be allowed unless approved by the City.

   Permanent erosion control protection must be provided at the ends of discharging pipes into the pond to protect against the 15 year – 20 minute storm event.

3. See Section 6.02.03, sub-section 12 for erosion protection criteria for outflow pipes.

4. Railroad tie walls cannot be used.

5. Permanent detention ponds or lakes are to be designed to minimize fluctuating lake levels. Maximum fluctuation from the permanent pool elevation to the maximum ponding elevation shall be six (6) feet.

6. The maximum side slopes for dry basins or ponds, and the fluctuating area of permanent ponds or lakes shall be 3:1 (three feet horizontal, one foot vertical) without fencing.

7. Dry basins or ponds and the fluctuating areas of permanent ponds or lakes are to be appropriately vegetated to the maximum high water elevation. Areas above that elevation shall be appropriately stabilized and vegetated. Sod and mowing above that elevation may be approved and is required for dam embankment slopes and downstream toe areas for wet basins where riprap is not appropriate. All vegetation shall be approved by the City.

8. Control structures and overflow structures are to be reinforced concrete, including precast.

9. Accepted materials for use in baffles, grates, screens, hoods and pipe, which is normally submerged or is located in a normally wet environment shall be composed of aluminum, stainless steel, concrete, or other like material that is not subject to corrosion. Galvanized or coated steel is not acceptable. HDPE is not allowed for inlet or outlet piping in detention basins.

10. The outflow pipe shall be sized for the developed flow rate.

11. In basins with concrete walls or riprap covered slopes, provisions should be made for mowing equipment to reach the bottom (ramps, etc.).

12. Maximum Depths:

    a. The maximum depth of water in a dry detention basin shall not exceed ten (10) feet. The design of detention basin embankment must be sealed and certified by a Professional Engineer registered in the State of Missouri with demonstrated expertise in geotechnical engineering.

    b. Parking lots used for automobiles shall have a maximum depth of eight (8) inches of water.

    c. Parking lots used for trucks or truck trailers shall have a maximum ponding depth of water of twelve (12) inches.

13. Detention Basin Fencing

    A four (4) foot (minimum height) approved fence shall be provided around the perimeter of any basin where the side slopes exceed 3H:1V. Fencing such as post and rail, or fencing which prevents easy observation of detention basin, such as tall privacy fencing, should not be used.

14. Detention Basin Elevation

    a. If the detention basin discharges to a piped sewer system, no detention volume may be calculated below the 15-year, 20-minute hydraulic elevation of the receiving storm system.

    b. If the detention basin discharges to an open channel, or to a piped sewer system affected by flood levels in a nearby downstream open channel, then the low elevation of the detention storage shall be above the 100-year flood elevation in the open channel as established by the FEMA Flood Insurance Study.

6.05.06 Acceptable Urban BMP Options

1. This section sets forth six acceptable groups of BMPs that can be used to meet the Water Quality volume criteria (WQ_v). The design and selection of these BMPs shall generally conform to the criteria contained in the Maryland Stormwater Design Manual, Volumes I & II (latest revision), as prepared by the Center for Watershed Protection and the State of Maryland

Department of the Environment (MDE). The Manual can be purchased through MDE's website. A simple search for Maryland Stormwater Design Manual will provide a direct link. Performance criteria adapted from the Maryland Stormwater Design Manual are provided in Section 6.07.

Acceptable uses of the BMPs are summarized in Table 6-8 and Physical Feasibility Factors are summarized in Table 6-9.

a. The acceptable BMP designs are assigned into six general categories for stormwater quality control (WQ_v):

   BMP Group 1 Stormwater Ponds
   BMP Group 2 Stormwater Wetlands
   BMP Group 3 Infiltration Practices
   BMP Group 4 Filtering Practices
   BMP Group 5 Open Channel Practices
   BMP Group 6 Riparian Buffer Widening

b. A combination of BMPs and/or credits is normally required at most development sites to meet all three stormwater sizing criteria.

c. New structural BMP designs are continually being developed, including many proprietary designs. To be considered an effective BMP for stand-alone treatment of WQ_v, current or new BMP design variants cannot be accepted for inclusion on the list until independent pollutant removal performance and monitoring data determine that they can meet the following:
   1) Capturing and treating the required water quality volume (WQ_v)
   2) Reducing the average total load of total suspended solids (TSS) by 80%, and
   3) Having an acceptable longevity rate in the field

   The City only allows proprietary BMPs found on the Metropolitan St. Louis Sewer District's Approved Products and Suppliers: Structural Proprietary BMPs.

<u>BMP Group 1. Stormwater Ponds</u>

a. Practices that have a combination of permanent pool, extended detention or shallow wetland equivalent to the entire WQ_vs include:

   P-1 Micropool extended detention pond
   P-2 Wet pond
   P-3 Wet extended detention (ED) pond
   P-4 Multiple pond system
   P-5 Pocket Ponds

BMP Group 2. Stormwater Wetlands

a. Practices that include significant shallow wetland areas to treat urban stormwater but often may also incorporate small permanent pools and/or extended detention storage to achieve the full WQ_v include (Modification of existing wetland areas will require a Corps 404 permit):

W-1	Shallow wetland
W-2	ED shallow wetland
W-3	Pond/wetland system
W-4	Pocket wetland

b. Wetlands may be used for Cpv and WQv, but shall not be used for control of the flood protection volume.

c. Wetlands shall be designed by a professional with a degree or certification that qualifies them to design wetlands.

BMP Group 3. Infiltration Practices

a. Practices that capture and temporarily store the WQ_v before allowing it to infiltrate into the soil over a two day period include:

I-1	infiltration trench
I-2	infiltration basin

b. Infiltration practices will be allowed on sites where it is proven that infiltration will work to the satisfaction of the City. This must be supported by a soils report.

BMP Group 4. Filtering Practices

a. Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media are considered to be filtering practices. Filtered runoff may be collected and returned to the conveyance system. Design variants include:

F-1	Surface sand filter
F-2	Underground sand filter*
F-3	Perimeter sand filter
F-4	Organic filter
F-5	Pocket sand filter
F-6	Bioretention**

*not allowed on residential projects
**may also be used for infiltration

b. A maintenance agreement and maintenance schedule shall be required.

BMP Group 5. Open Channel Practices

a. Vegetated open channels that are explicitly designed to capture and treat the full WQ_v within the dry or wet cells formed by checkdams or other means include:

O-1	Dry swale
O-2	Wet swale

b. Open channel practices shall be designed with the proper plantings. They are not allowed on single-family residential projects with the exception that dry swales will be allowed on common ground. Upon City approval, open channel practices may be allowed on condominium or apartment projects if maintenance is provided by a management company.
c. An open channel practices BMP is different than engineered channels used for stormwater conveyance. See Section 6.03 for engineered channel design criteria.

BMP Group 6. Riparian Buffer Widening

This BMP shall be used only with the approval of the City and shall generally meet the following:

a. Riparian buffer widening is applicable for residential developments only.

b. Riparian buffer widening shall not be used for roadway drainage.

c. Riparian buffer widening may be approved if the development meets ALL of the following criteria:

1) The development is contiguous to an existing riparian buffer as described in the City of Wentzville Municipal Code, Ordinance #2863 Regulation for the Protection of Natural Watercourses.

2) Topography is such that stormwater runoff cannot gravity flow to a BMP.

3) Stormwater runoff from the area sheet flows directly into the existing riparian buffer and does not cross an impervious area.

4) Stormwater runoff from the area does not cross from one property onto another before entering the riparian buffer.

d. If approved, the WQ_v can be met by:

1) Widening the existing riparian buffer by a minimum of 25 feet per effected side as measured from the edge of the existing buffer away from the channel.

2) The widened riparian buffer shall meet all the requirements of the existing riparian buffer.

3) The new buffer width shall be platted as a riparian buffer conservation easement granted to the City and shall be in common ground.

4) If approved, the channel protection (Cpv) and the flood protection volumes (Qp2 and Qp25) shall be accommodated elsewhere in the development.

2. Additional resources for BMP design

In addition to the Maryland Stormwater Design Manual, the following resources may be useful to the design engineer:

a. Georgia Stormwater Management Manual, Volume 2 Technical Handbook, Chapter 3 and Appendixes D and E (latest revision) http://www.georgiastormwater.com

b. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring, Federal Highway Administration Publication No. FHWA-EP-00-002, http://www.fhwa.dot.gov/environment/ultraurb

6.05.07 Non-structural BMP Credits

Non-structural BMPs are increasingly recognized as a critical feature of stormwater BMP plans, particularly with respect to site design. In most cases, non-structural BMPs will be combined with structural BMPs to meet all stormwater volume requirements. The key benefit of non-structural BMPs is that they can reduce the generation of stormwater from the development, thereby reducing the size and cost of structural BMPs. In addition, they can provide partial removal of many pollutants. The non-structural BMPs have been classified into seven broad categories. To promote greater use of non-structural BMPs, a series of credits and incentives are provided for developments that use these progressive site planning techniques. For a complete description of the credits and how to determine if a credit is applicable, see Section 6.08, which has been adapted from Chapter 5 of the Maryland Stormwater Design Manual, Volume I, most current edition.

1. Natural area conservation
2. Disconnection of rooftop runoff (only available for R-1A, commercial and industrial zones)
3. Disconnection of non-rooftop impervious area
4. Sheet flow to buffer
5. Open channel use
6. Environmentally sensitive development
7. Impervious cover reduction – This is not a credit, per se, but is a means of reducing the WQ_v.

6.05.08 Easements Required

The detention basin and BMPs in non-residential developments shall be located in easements per Section 8. Detention basin and BMPs in residential developments shall be located in easements on common ground, except for BMPs treating

stormwater from an individual lot in a development satisfying Credit 6: Environmentally Sensitive Development Credit, which may be located in an easement in that individual lot. Variances to allow BMP placement in easements on private property will be considered. Justification must be provided for consideration.

6.05.09 Maintenance Agreement

Prior to plan approval the property owner(s) of the detention basin and BMP site(s) shall execute a City Maintenance Agreement for the BMPs and the detention basin or pond to insure the BMPs and the detention area will be kept in working order, to the satisfaction of the City. The City will not be responsible for maintenance of detention basins or BMPs.

The Maintenance Agreement shall include the Detention and BMP Operation and Maintenance Plan by reference (see Section 6.06.02 for more information regarding the Detention and BMP Operation and Maintenance Plan).

6.05.10 As-Built Certification for Detention/BMP Facilities

An as-built survey is required for all detention/BMP facilities. The design engineer shall submit the Professional Engineer's Construction/As-Built Certification for Detention/BMP Facilities as required in Section 11.

Grading tolerances should be kept at ±0.1 foot. In the event that the tolerance requirement is not met, the design engineer shall prepare and submit a revised Detention and BMP Design Report to demonstrate that the system still meets the performance requirements of these criteria.

6.05.11 Dam Permit Requirements

Dams with a height of thirty-five (35) feet, *from the upstream toe to the top of dam,* or greater will require approval from the Missouri Department of Natural Resources.

6.06 Stormwater Design Submittal Requirements

6.06.01 Construction Plans

Stormwater structures and features shall be shown in the project construction plans to the extent necessary to fully describe the design intent and adherence to these criteria. At a minimum, the construction plans shall include all information required in Chapter 1. General Instructions.

6.06.02 Stormwater Design Report

1. The engineer shall submit two copies of the Stormwater Design Report.

2. The Stormwater Design Report shall be signed, dated and sealed by the Missouri Professional Engineer who is responsible for its preparation. If the report is prepared by another person, a note on the cover shall state the

preparer's name and that he or she is under the direct supervision of the Missouri Professional Engineer who's seal is shown.

3. The Stormwater Design Report shall be bound with each section separated by a labeled tab.

4. The Stormwater Design Report shall at a minimum contain the following:

   a. Table of Contents

   b. Soils data for the site used to determine curve numbers and infiltration rates (if applicable).

   c. City of Wentzville Stormwater Design Summary (Form 6-2)

   d. A City of Wentzville Discharge Summary (Form 6-3) shall be completed for every discharge location leaving the site.

   e. Detention, channel protection and water quality BMP design calculations, including but not limited to:

      1) A City of Wentzville Detention and BMP Summary (Form 6-4) shall be completed for the entire site.

      2) A City of Wentzville Water Quality (BMP) Design Summary (Form 6-5) shall be completed for each BMP facility.

      3) A City of Wentzville Detention/Retention Pond Design Summary (Form 6-6) shall be completed for each detention facility.

      4) Storm routing calculations for all storm frequencies including time, inflow, outflow and elevation.

      5) Calculations to demonstrate 24-hour draw down for Cpv and ED portion of WQv (if applicable).

      6) Elevation vs Discharge tables or curves for each basin for 1-yr, 2-yr and 25-yr, 24-hour design storms.

      7) Elevation vs Storage tables or curves for each basin for 1-yr, 2-yr and 25-yr, 24-hour design storms.

      8) Hydraulic grade line computations for pipes entering and leaving the basin(s) for 1-yr, 2-yr and 25-yr, 24-hour design storms and the 15-yr, 20-minute design storm.

      9) If the embankment contains fill material a geotechnical report may be required.

      10) Existing Drainage Area Map plotted to a readable scale

i. City of Wentzville Engineering Project Number in the lower right corner
ii. Existing contours (2' intervals for residential projects, 1' intervals for commercial projects)
iii. Existing drainage areas
iv. For each drainage area, label: Area, CN, Flow Path, Tc and Q1, Q2 and Q25
v. North arrow.
vi. Graphic scale

11) Detention Basin and BMP Drainage Area Map plotted to a readable scale

i. City of Wentzville Engineering Project Number in the lower right corner.
ii. Proposed contours (2' intervals for residential projects, 1' intervals for commercial projects)
iii. Drainage areas to each detention basin and BMP
iv. For each drainage area, label: Area, CN, Flow Path, Tc and Q_1, Q_2, Q_{25} and WQ_v
v. Calculated routed flow from each drainage basin and BMP outlet.
vi. North arrow.
vii. Graphic scale.

12) Structural calculations for the outlet control structures (if required).

13) Cross sections defining the size, shape and depth of the detention basin(s) and other BMP features. At a minimum, three sections, one at each end and one in the middle of the basin will be required.

14) Detention and BMP Operation and Maintenance Plan

A Detention and BMP Operation and Maintenance Plan shall be submitted for approval. Detention and BMP Operation and Maintenance Plans shall include:

i. The person(s) or organization(s) responsible for maintenance (subdivision trustees, property owner, etc,)
ii. Drawing and description of the Detention or BMP facility(s) including all components integral to the operation of the facility.
iii. Routine seasonal and annual inspection procedures (such as plantings, replacing mulch)
iv. Routine seasonal and annual maintenance procedures
v. Non-routine maintenance procedures (less frequent and generally more expensive such as pond dredging or major repairs to structures)
vi. Repair procedures
vii. Inspection and maintenance logs and record keeping procedures to track and record compliance with the Operation and Maintenance Plan. These records shall be available upon request of the City.

In addition to the Maryland Stormwater Design Manual, the following resources may be useful in developing the Operation and Maintenance Plan:

i. Georgia Stormwater Management Manual, Volume 2 Technical Handbook, Chapter 3 and Appendix E (latest revision) http://www.georgiastormwater.com
ii. Stormwater Manager's Resource Center webpage http://www.stormwatercenter.net/. Go to Program Resources => STP Maintenance
iii. Contra Costa Clean Water Program: Stormwater Quality Requirements for Development Applications, Stormwater C.3 Guidebook, 3rd Edition, October, 2006 http://www.ci.concord.ca.us/pw/stormwater/stormwaterC3guidebook3rd.pdf. Appendix F contains a step-by-step guide to preparing an Operation and Maintenance Plan

f. Enclosed system design calculations, including but not limited to:

1) Calculation of the 15-yr, 20-min design flow to every inlet

2) Calculation of the 15-yr, 20-min flow in every pipe reach

3) Hydraulic grade line calculations for the 15-yr, 20-min design storm in all pipes including head loss

4) Calculations for all pipe outfalls including outlet velocity

5) Overland flow path calculations including the 100-yr, 24-hr flow quantity and high-water elevation at critical sections

6) Enclosed system drainage area map

i. City of Wentzville Engineering Project Number in the lower right corner.
ii. Proposed contours (2' intervals for residential projects, 1' intervals for commercial projects)
iii. For each inlet label tributary area, PI factor and flow.
iv. For each pipe reach, label accumulative flow.
v. 100 year 24 hour overland flow path, showing width and depth of flow.
vi. North arrow.
vii. Graphic scale.

g. Engineered channel design calculations, including but not limited to:

1) Calculation of 15-yr, 20-min and 100-yr, 24-hr design storms to all open channels

2) Hydraulic calculations for engineered channels including depth, velocity and boundary shear for the 15-yr, 20-min design storm and

the depth for the 100-yr, 24-hr design storm at critical locations. Include backwater calculations as applicable.

3) Engineered channel lining calculations including sizing of rock and permissible shear stress of lining materials as applicable

4) Energy dissipation calculations for all engineered channel outfalls including outlet velocity and rock sizing for the 100-yr, 24-hr flow in the receiving channel.

h. Culvert design calculations, including but not limited to:

1) Calculation of the 15-yr, 20-min design storm flow to roadside swale culverts, 100-yr, 24-hr storm flow to other culverts

2) Calculation of the 1-yr, 24-hr storm flow at the culvert location for culverts in natural channels

3) Calculation of the depth of the 1-yr, 24-hr flow in the natural channel and in the culvert low flow barrel.

4) Hydraulic calculations for culverts including inlet and outlet control, headwater and tailwater depth and outlet velocity for the 1-yr, 24-hour, 15-yr, 20-min and/or 100-yr, 24-hr design storms as applicable

5) Energy dissipation calculations for all culvert outfalls including outlet velocity and rock sizing for the design storm of 15-year, 20-minutes for driveway culverts or 100-year, 24-hours for all other culverts

i. Bridge design calculations, including but not limited to:

1) Calculation of the 1-yr, 24-hr and 100-yr, 24-hr design storm flows

2) Existing condition HEC-RAS input and output including:

i. Plan view with cross section locations
ii. Cross sections showing HGL and EGL for all storm events
iii. Profile view with HGL and EGL for all storm events
iv. Output table including flow, velocity, channel shear and HGL and EGL elevation for all storm events

3) Proposed condition HEC-RAS input and output including:

i. Plan view with cross section locations
ii. Cross sections showing HGL and EGL for all storm events
iii. Profile view with HGL and EGL for all storm events
iv. Output table including flow, velocity, channel shear and HGL and EGL elevation for all storm events

j. Natural channel crossing design calculations, including but not limited to:

1) Channel Condition Scoring Matrix (Form 6-1)

2) Bank-full and critical shear stress calculations, including:

   i. Bank-full discharge for the 1-yr, 24-hr storm event
   ii. Bank-full width and depth calculations
   iii. Critical shear stress ratio calculations

3) Natural Channel Plan, Profile and Section Exhibits

4) Calculations for the existing and proposed HGL and EGL a sufficient distance upstream and downstream to show where existing and proposed converge for the 1-yr, 24-hour and 15-yr, 20-min design storms

5) Grade control rock sizing for the 100-yr, 24-hr storm flow

6.07 Performance Criteria for Urban BMP Design, from the Maryland Stormwater Design Manual, Chapter 3.0

Note: The text from this section has been adapted from the *Maryland Stormwater Design Manual, Volumes I & II (2000)* [(1)]. Adaptations have been made for local natural conditions and criteria. Additional adaptations may be necessary but shall be as approved by the City.

(1) Schueler, T. and Claytor, R. 2000. *2000 Maryland Stormwater Design Manual Volumes 1&2*. Prepared for the Maryland Department of the Environment Water Management Administration. Center for Watershed Protection. Ellicott City, MD.

Performance Criteria for Urban BMP Design

This section outlines performance criteria for five groups of structural water quality stormwater BMPs that include ponds, wetlands, infiltration practices, filtering systems and open channels.

Each set of BMP performance criteria, in turn, is based on six factors:

- General Feasibility
- Conveyance
- Pretreatment
- Treatment/Geometry
- Environmental/Landscaping
- Maintenance

IMPORTANT NOTE: The criteria represent a set of conditions that ensure an effective and durable BMP. In this section, *mandatory* performance criteria are distinguished from suggested design criteria (the former is required at all sites, while the latter are only recommended for most sites and conditions). Thus, in the text, mandatory performance criteria are indicated by *italics*, whereas suggested design criteria are shown in normal typeface.

6.07.01 Stormwater Ponds

Definition: Practices that have a permanent pool, or a combination of a permanent pool, extended detention or shallow wetland with a permanent pool equivalent to the entire WQ_v. Design variants include:

- P-1 micropool extended detention pond (Figure 6.07.01)
- P-2 wet pond (Figure 6.07.02)
- P-3 wet extended detention pond (Figure 6.07.03)
- P-4 multiple pond system (Figure 6.07.04)
- P-5 "pocket" pond (Figure 6.07.05)

The term "pocket" refers to a pond or wetland that has such a small contributing drainage area that little or no baseflow is available to sustain water elevations during dry weather. Instead, water elevations are heavily influenced and, in some cases, maintained by a locally high water table.

Dry extended detention ponds that have no permanent pool are not considered an acceptable option for meeting WQ_v.

Stormwater ponds may also provide storage for the Cp_v, Qp_2 and/or Qp_{25} above the WQ_v storage elevation.

1. Pond Feasibility Criteria

Stormwater ponds shall have a minimum contributing drainage area of ten acres or more (25 or more are preferred)*, unless groundwater is confirmed as the primary water source (e.g., pocket pond) or a water balance is performed to demonstrate that a stormwater pond can withstand a thirty day drought at summer evaporation rates without completely drawing down.* See Section 6.07.02 for a shortcut assessment method for determining the adequacy of water balance.

The drainage area must be free of sources of pollution or contamination.

Stormwater ponds cannot be located within jurisdictional waters, including wetlands, without obtaining a Section 404 permit under the Clean Water Act and a 401 Water Quality Certification from the Missouri Department of Natural Resources.

Stormwater ponds shall conform to the following minimum design and construction criteria:

1) *design for a stable outfall using the 100 year design storm (or two year design storm if the pond is an off-line structure that only provides WQ_v storage).*
2) *dams shall meet all appropriate local and state dam safety regulations,*
3) *principal spillway/riser shall provide anti-floatation, anti-vortex, and trash-rack designs.*
4) *one (1) foot of freeboard shall be provided above the maximum high water elevation.*
5) *woody vegetation is prohibited in the immediate embankment area.*

A pond structure requires review and approval by the Missouri Department of Natural Resources if the proposed embankment is greater than thirty-five feet in height from the upstream toe to the top of dam.

2. Pond Conveyance Criteria

When reinforced concrete pipe is used for the principal spillway to increase its longevity, "O-ring" gaskets (ASTM C361) should be used to create watertight joints and should be inspected during installation.

Inlet Protection

Inlet pipes to the pond should not be fully submerged at normal pool.

A forebay shall be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond.

Adequate Outfall Protection

See Section 6.02.03, sub-section 12 for erosion protection criteria for outflow pipes

Pond Liners

When a pond is located in karst topography, gravelly sands or fractured bedrock, a liner may be needed to sustain a permanent pool of water. If geotechnical tests confirm the need for a liner, acceptable options include: (a) 6 to 12 inches of clay soil (minimum 15% passing the #200 sieve and a minimum permeability of 1×10^{-5} cm/sec), (b) a 30 ml poly-liner, (c) bentonite, or (d) other suitable materials approved by the appropriate review authority.

3. Pond Pretreatment Criteria

Forebay

Each pond shall have a forebay or equivalent upstream pretreatment to trap sediment and trash at all basin inlets. The forebay shall consist of a separate cell, formed by an acceptable barrier.

The forebay shall be sized to contain 0.1 inches per impervious acre of contributing drainage. The forebay storage volume counts toward the total WQ_v requirement. Exit velocities from the forebay shall be non-erosive. If elevated above the normal pool, the forebay shall be designed to drain the storage volume within 48 hours.

Direct maintenance access for appropriate equipment shall be provided to the forebay.

The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.

A fixed vertical sediment depth marker should be installed in the forebay to measure sediment deposition over time.

4. Pond Treatment Criteria

Minimum Water Quality Volume (WQ_v)

Ponds shall be designed to capture the computed WQ_v through any combination of permanent pool, extended detention (ED) or wetland.

It is generally desirable to provide water quality treatment off-line when topography, head and space permit (e.g., apart from stormwater quantity storage).

Water quality storage can be provided in multiple cells. Performance is enhanced when multiple treatment pathways are provided by using multiple cells, longer flow paths, high surface area to volume ratios, complex micro topography, and/or redundant treatment methods (combinations of pool, ED, and wetland).

If ED is provided in a pond, storage for Cp_v and WQ_v shall be computed and routed separately (e.g., the WQ_v requirement cannot be met simply by providing Cp_v storage for the one year storm).

Minimum Pond Geometry

Flowpaths from inflow points to outlets shall be maximized. Flowpaths of 1.5:1 (length relative to width) and irregular shapes are recommended. Cattails and algae growth can become a nuisance in shallow water depths, typically three feet and less. *Therefore, stormwater ponds shall have a minimum overall depth of four feet,* greater is recommended.

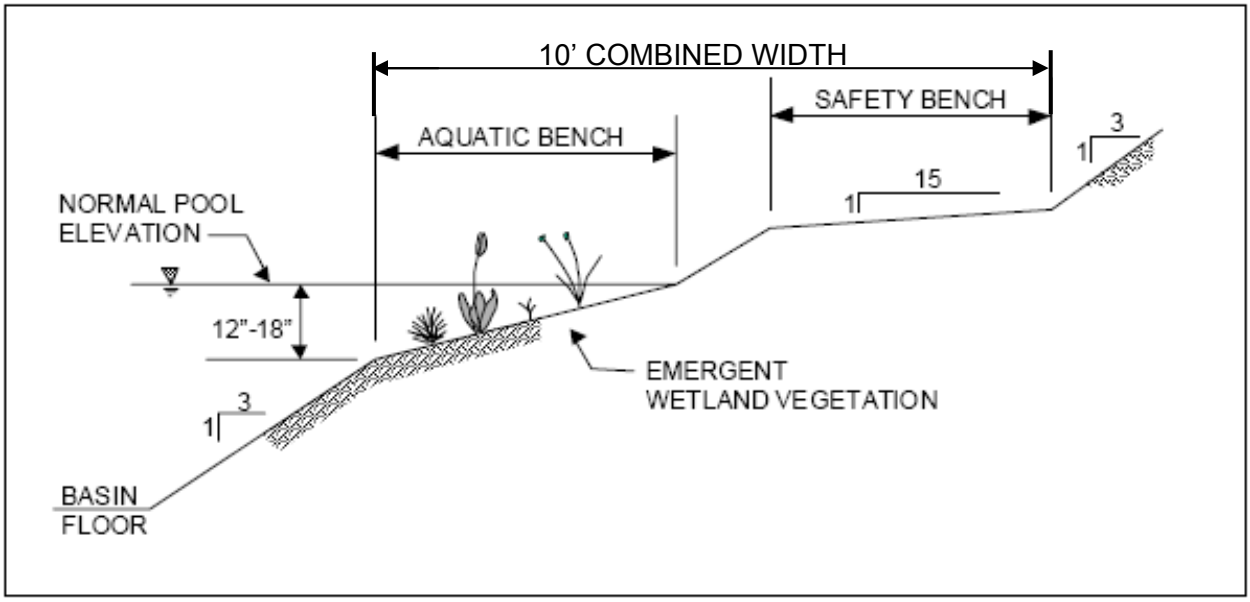
5. Pond Landscaping Criteria

Pond Benches

The perimeter of all deep permanent pool areas (four feet or greater in depth) shall be surrounded by two benches with a combined minimum width of 10 feet:

- *A safety bench that extends outward from the normal water edge to the toe of the pond side slope. The maximum slope of the safety bench shall be 6%.*
- *An aquatic bench that extends inward from the normal shoreline and has a maximum depth of eighteen (18) inches below the normal pool water surface elevation. An aquatic bench is not required in forebays.*

The combined minimum width of 10-feet may be mostly safety bench, mostly aquatic bench, or both benches in equal widths. An irregular shape with undulating benches to achieve a more natural aesthetic is recommended. See the following diagram for guidance.



Landscaping Plan

A landscaping plan for a stormwater pond and its buffer shall be prepared to indicate how aquatic and terrestrial areas will be vegetatively stabilized and established. Landscaping guidance for stormwater ponds is provided in MSD Landscape Guide for Stormwater Best Management Practice Design for species selection guide. Where pond is readily visible to the public, plantings shall be grouped by species to emphasis intentionality of the pond landscaping.

Wherever possible, wetland plants should be encouraged in a pond design, either along the aquatic bench (fringe wetlands), the safety bench and side slopes (emergent wetlands) or within shallow areas of the pool itself.

The best elevations for establishing wetland plants, either through transplantation or volunteer colonization, are within six inches (plus or minus) of the normal pool.

The soils of a pond buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils is so great that it effectively prevents root penetration, and therefore, may lead to premature mortality or loss of vigor. Consequently, it is advisable to excavate large and deep holes around the proposed planting sites, and backfill these with uncompacted topsoil.

As a rule of thumb, planting holes should be at least six inches larger than the diameter of the rootball (of balled and burlap stock), and three inches wider for container grown stock. This practice should enable the stock to develop unconfined root systems. Avoid species that require full shade, are susceptible to winterkill, or are prone to wind damage. Extra mulching around the base of the tree or shrub is strongly recommended as a means of conserving moisture and suppressing weeds.

Pond Buffers and Setbacks

A pond buffer should be provided that extends 25 feet outward from the maximum water surface elevation of the pond. The pond buffer should be contiguous with other buffer areas

that are required by existing regulations (e.g., stream buffers). An additional setback may be provided to permanent structures.

Existing trees should be preserved in the buffer area during construction. It is desirable to locate forest conservation areas adjacent to ponds. To discourage resident geese populations, the buffer can be planted with trees, shrubs and native ground covers.

Woody vegetation may not be planted on nor allowed to grow within 15 feet of the toe of the embankment and 25 feet of the principal spillway structure.

Annual mowing of the pond buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or forest.

6. Pond Maintenance Criteria

Maintenance Measures

Maintenance responsibility for a pond and its buffer shall be vested with a responsible party by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.

The principal spillway shall be equipped with a trash rack that provides access for maintenance.

If a minimum 50% vegetative coverage is not achieved in the planted areas after the second growing season, reinforcement plantings shall be required.

Sediment removal in the forebay shall occur when 50% of the total forebay capacity has been lost.

Sediments excavated from stormwater ponds that do not receive runoff from designated hotspots are not considered toxic or hazardous material and can be safely disposed by either land application or land filling. Sediment testing may be required prior to sediment disposal when a hotspot land use is present.

Sediment removed from stormwater ponds should be disposed of according to current erosion and sediment control regulations.

Maintenance Access

A maintenance right of way or easement shall extend to a pond from a public or private road.

Maintenance access should be at least 12 feet wide; having a maximum slope of no more than 15%; and be appropriately stabilized to withstand maintenance equipment and vehicles.

The maintenance access should extend to the forebay, safety bench, riser, and outlet and be designed to allow vehicles to turn around.

Non-clogging Low Flow (Cp_v) Orifice

The low flow orifice shall be sized and protected from clogging in accordance with Section 6.05.03.3.b.4.

Outlet Structure

The outlet structure shall be located within the embankment for maintenance access, safety and aesthetics.

Access to the outlet structure is to be provided by lockable manhole covers and manhole steps within easy reach of valves and other controls. Outlet structure openings should be fenced with pipe or rebar to prevent trash accumulation.

Safety Features

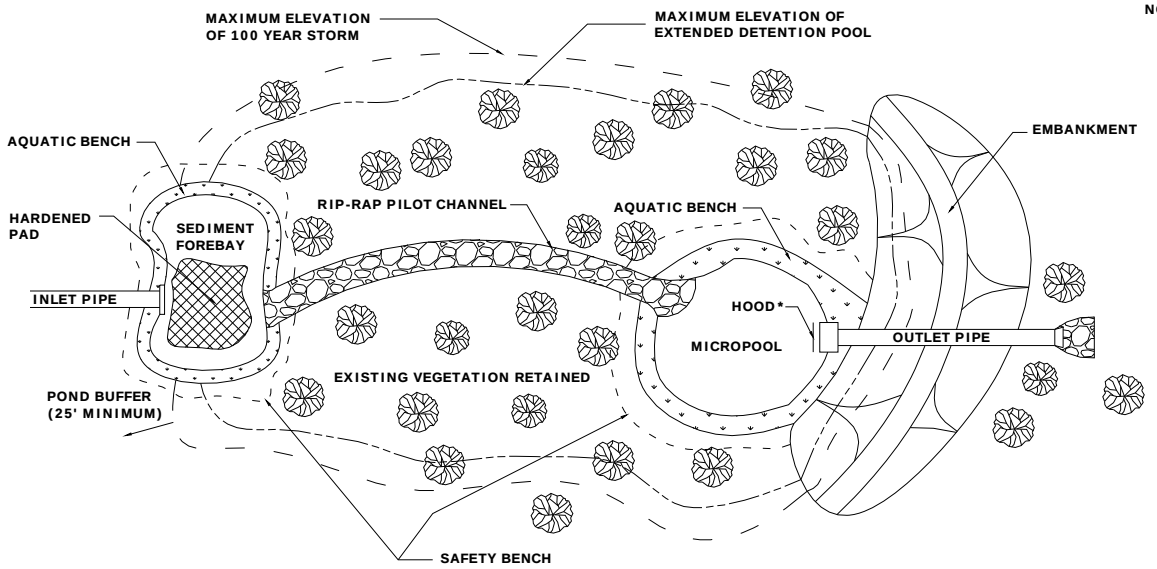
Internal side slopes to the pond should not exceed 3:1 (h:v) and shall terminate on a safety bench. Both the safety bench and the aquatic bench may be landscaped to prevent access to the pool.

Riser openings shall not permit unauthorized access. Riser tops that are four feet or greater above the ground shall include railings for safety. Endwalls above pipe outfalls greater than 48 inches in diameter shall be fenced to prevent injury.

Warning signs prohibiting swimming and skating may be posted.

P-1	**Figure 6.07.01** Example of "Micropool" Extended Detention Pond	P-1

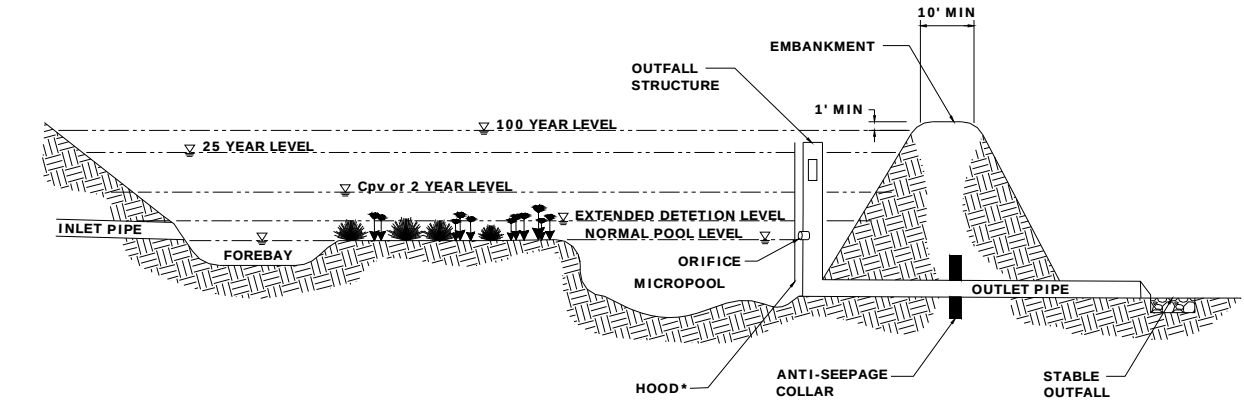
NOT TO SCALE



ADEQUATE ACCESS FOR BASIN MAINTENANCE AND INSPECTION SHALL BE PROVIDED.

PLAN VIEW

NOT TO SCALE



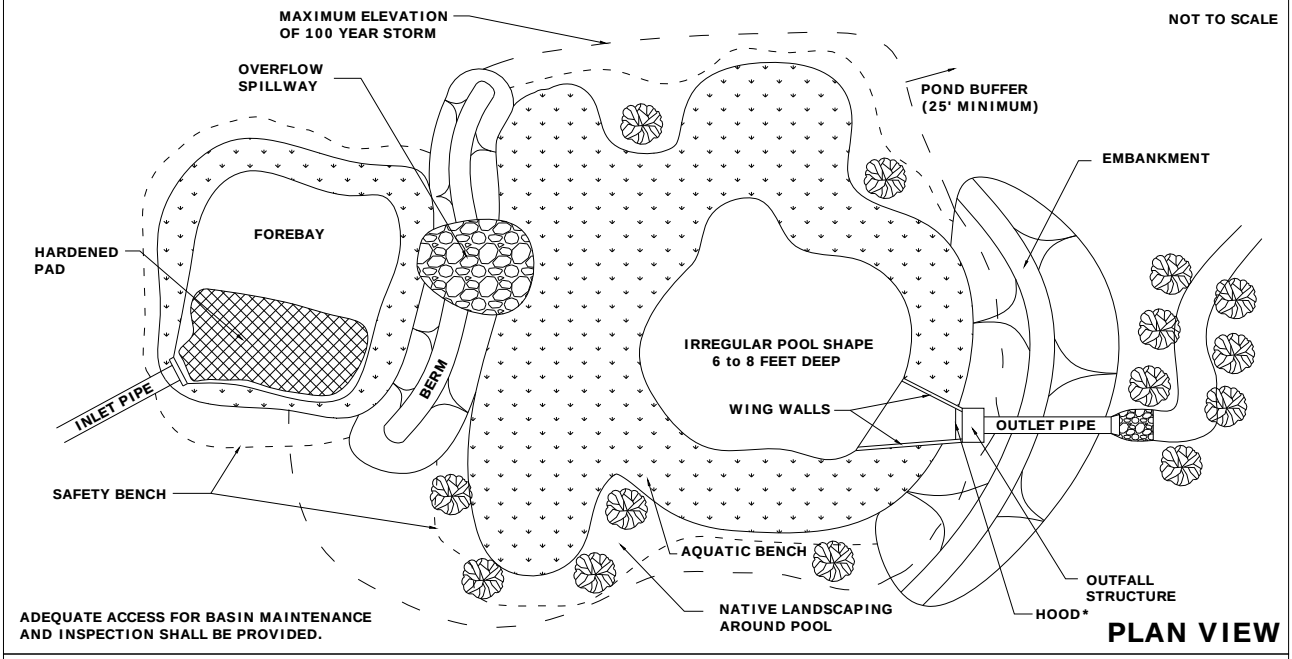
*HOOD TO BE PROVIDED FOR ANY ORIFICE 8 INCHES IN DIAMETER/MAXIMUM DIMENSION AND SMALLER

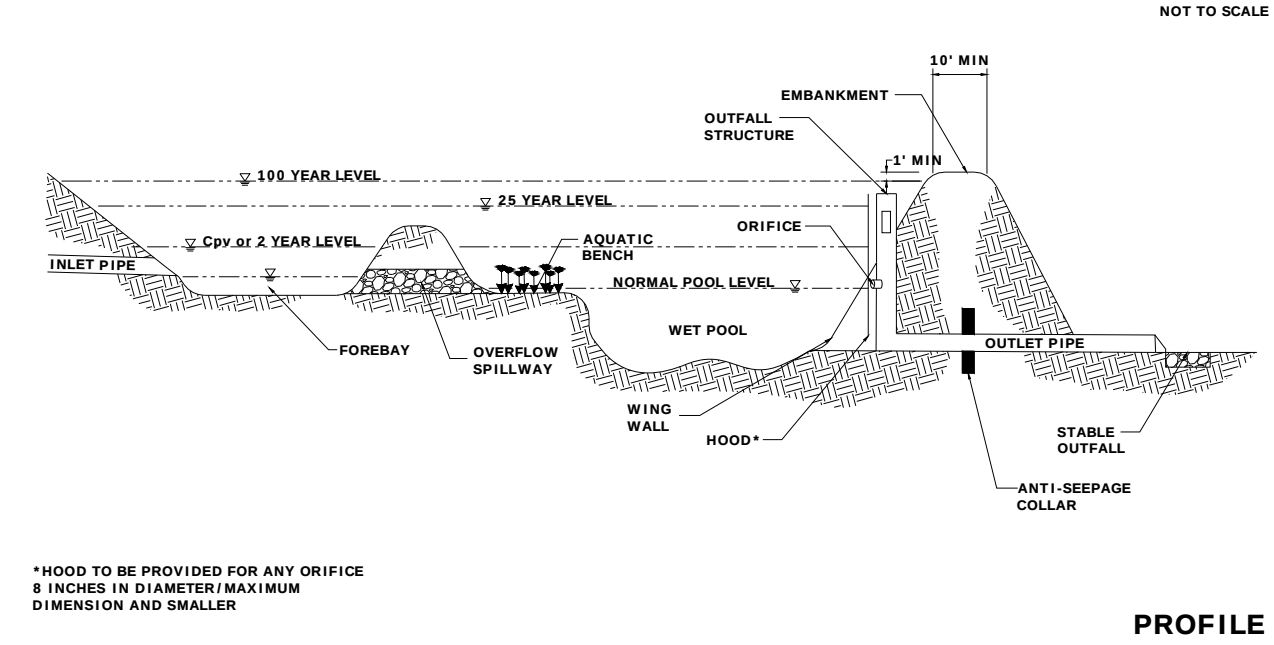
PROFILE

A micropool is provided in an extended detention pond to prevent resuspension of previously settled sediments and prevent clogging of the low flow orifice.

This example does not constitute a design and is for illustrative purposes only.

P-2	**Figure 6.07.02** Example of Wet Pond	P-2

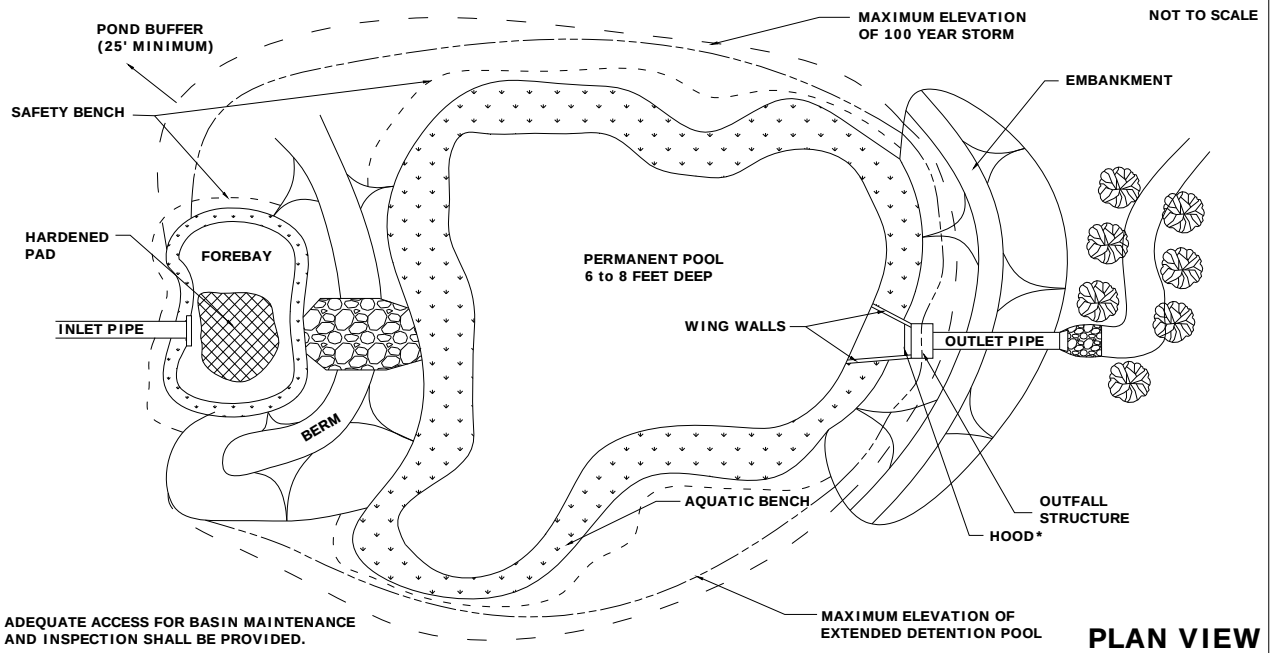


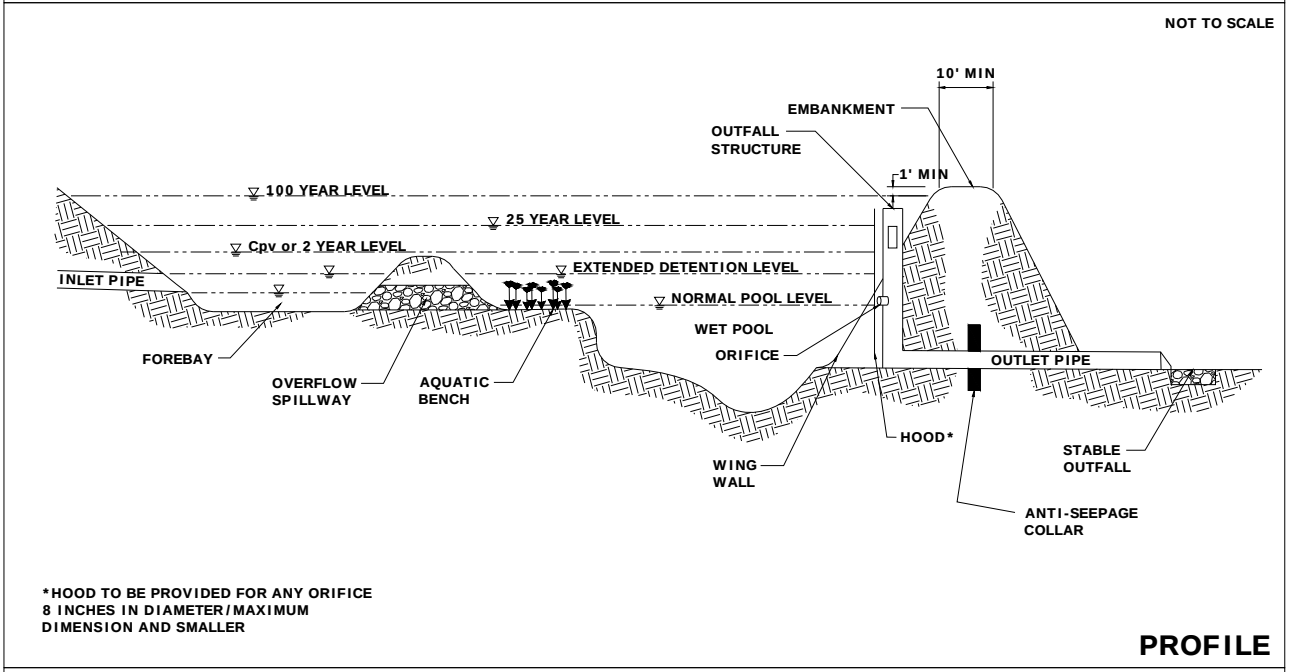


A wet pond provides all of water quality volume storage in a permanent pool.

This example does not constitute a design and is for illustrative purposes only.

P-3	**Figure 6.07.03** Example of Wet Extended Detention Pond	P-3

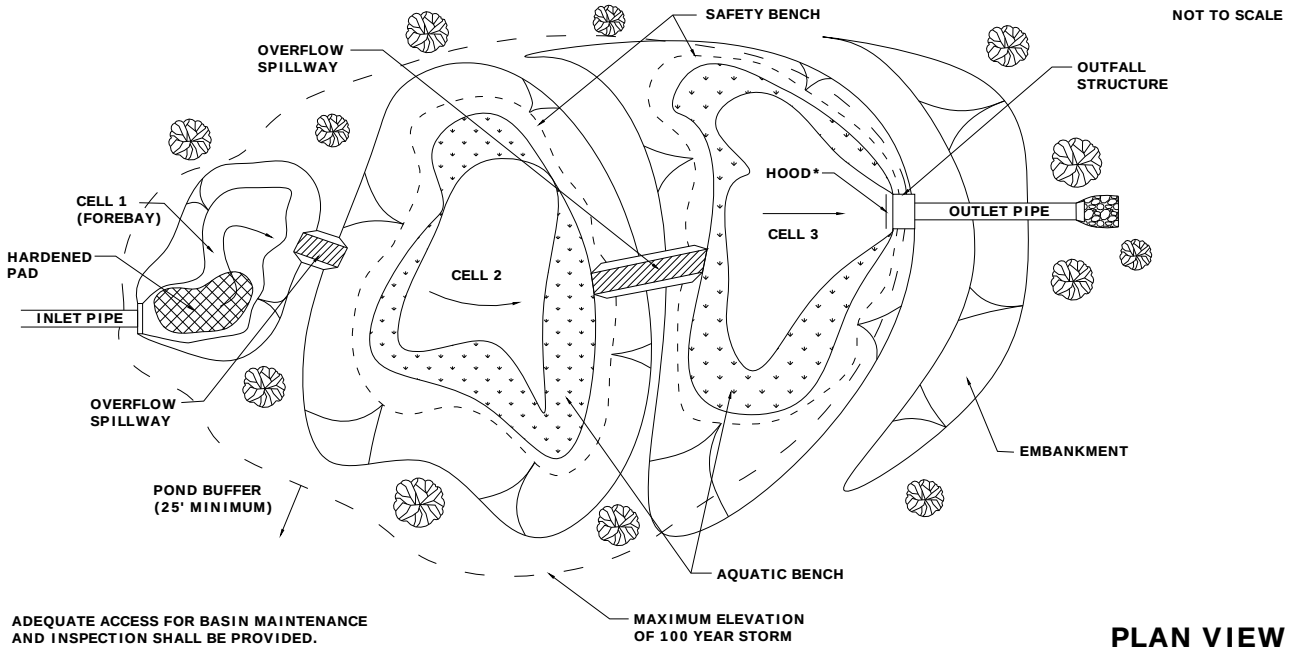


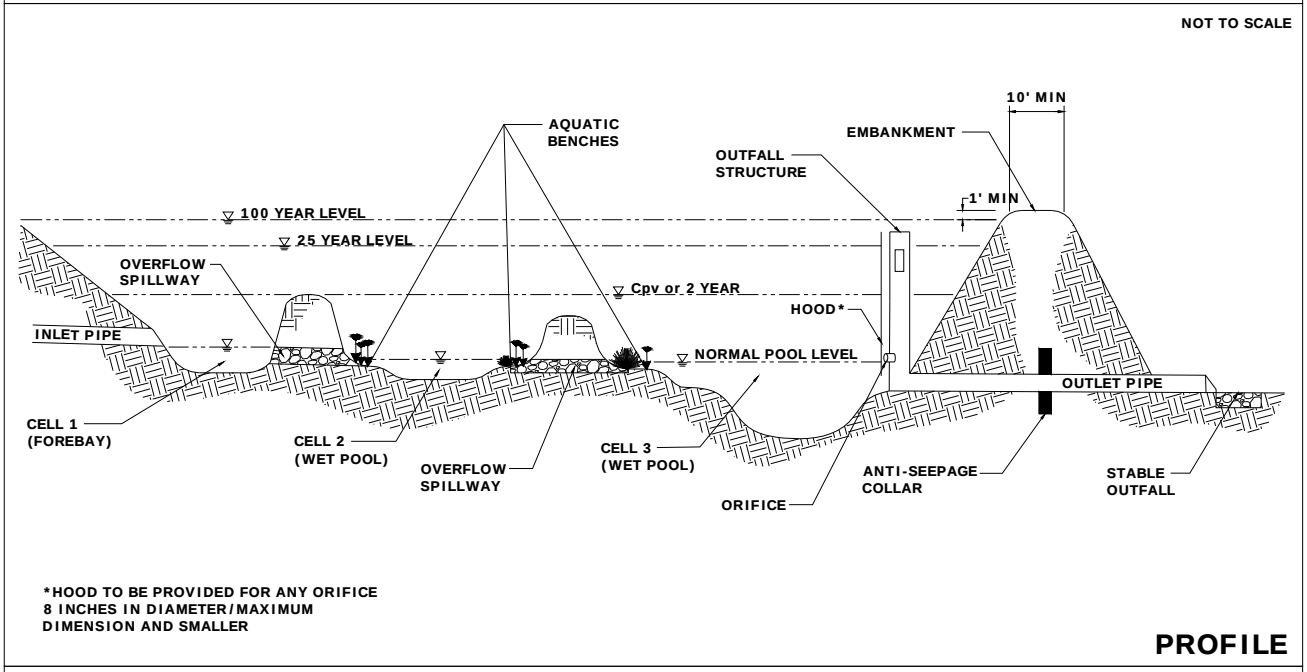


The wet extended detention pond provides water quality storage through a combination of permanent pool and extended detention storage.

This example does not constitute a design and is for illustrative purposes only.

P-4	**Figure 6.07.04** Example of Multiple Pond System	P-4



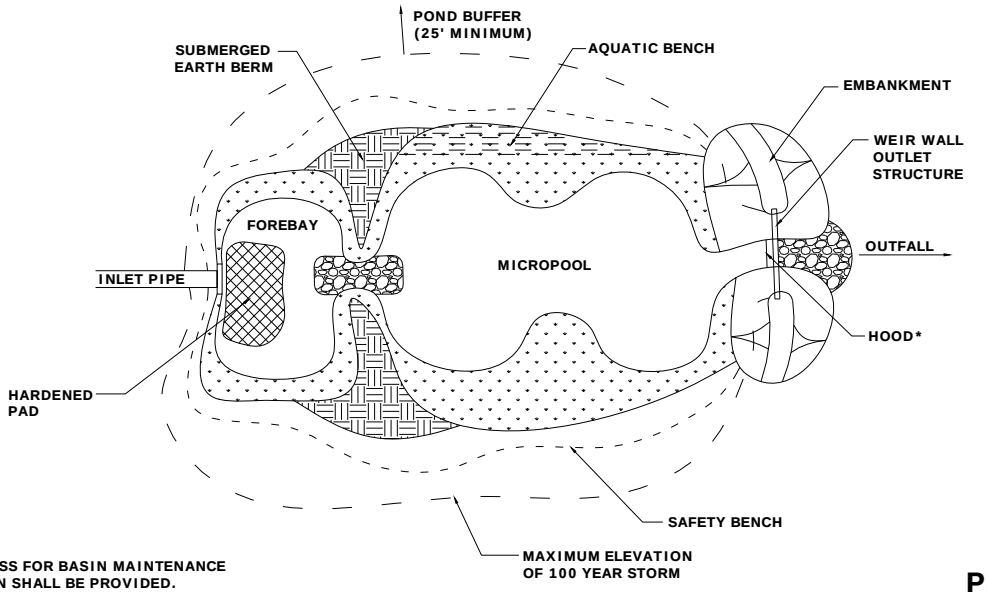


Multiple pond system provides WQv storage in two or more cells that create longer pullutant removal pathways.

This example does not constitute a design and is for illustrative purposes only.

P-5	**Figure 6.07.05** Example of "Pocket" Pond	P-5

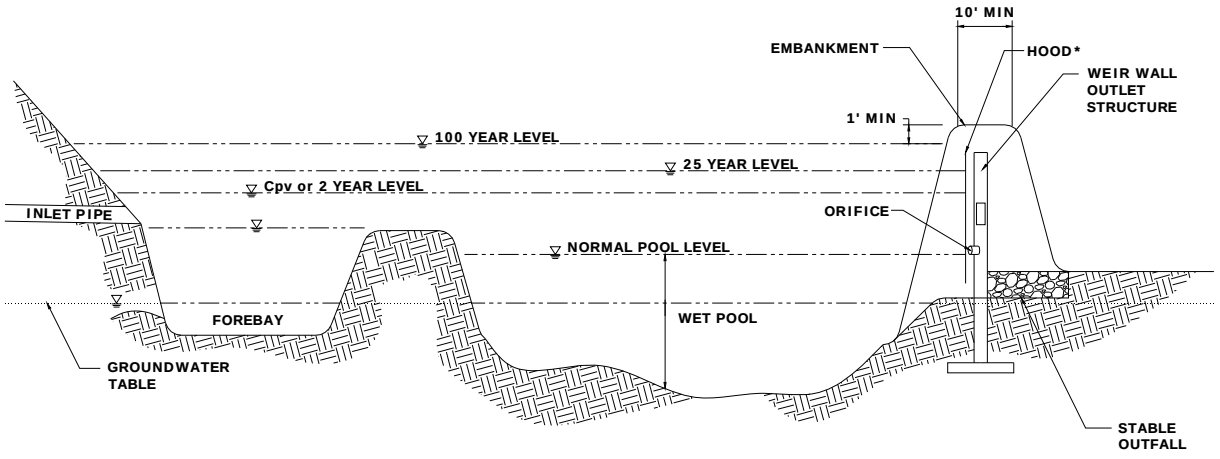
NOT TO SCALE



ADEQUATE ACCESS FOR BASIN MAINTENANCE AND INSPECTION SHALL BE PROVIDED.

PLAN VIEW

NOT TO SCALE



*HOOD TO BE PROVIDED FOR ANY ORIFICE 8 INCHES IN DIAMETER/MAXIMUM DIMENSION AND SMALLER

PROFILE

A high water table or groundwater interception maintains permanent pool level in a pocket pond. However, excavation to groundwater interception should be avoided where the land uses draining to the pond may contaminate drinking water supplies.

This example does not constitute a design and is for illustrative purposes only.

6.07.02 Stormwater Wetlands

Definition: Practices that create shallow wetland areas to treat urban stormwater and often incorporate small permanent pools and/or extended detention storage to achieve the full WQ_v. Design variants include:

- W-1 shallow wetland (Figure 6.07.06)
- W-2 ED shallow wetland (Figure 6.07.07)
- W-3 pond/wetland system (Figure 6.07.08)
- W-4 "pocket" wetland (Figure 6.07.09)

Stormwater wetlands may also provide Cp_v and Q_p storage above the WQ_v storage.

IMPORTANT NOTE:

Except for specific minimum contributing drainage area, all of the pond performance criteria presented in section 6.07.01 also apply to the design of stormwater wetlands. Additional criteria that govern the geometry and establishment of created wetlands are presented in this section.

1. Wetland Feasibility Criteria

   A water balance must be performed to demonstrate that a stormwater wetland can withstand a thirty day drought at summer evaporation rates without completely drawing down. See Section 7 below for a shortcut assessment method for determining the adequacy of water balance.

   Stormwater wetlands cannot be located within jurisdictional waters, including wetlands, without obtaining a Section 404 permit under the Clean Water Act and a 401 Water Quality Certification from the Missouri Department of Natural Resources.

2. Wetland Conveyance Criteria

   Flow paths from inflow points to outflow points within stormwater wetlands shall be maximized. Flow paths of 1.5:1 (length relative to width) and irregular shapes are recommended. These paths may be achieved by constructing internal berms (e.g., high marsh wedges or rock filter cells). Micro topography is encouraged to enhance wetland diversity.

3. Wetland Pretreatment Criteria

   Sediment regulation is critical to sustaining stormwater wetlands. Consequently, *a forebay shall be located at the inlet and a micropool shall be located at the outlet.* Forebays are designed in the same manner as ponds (see Section 6.07.01, sub-section 3). A micropool is a three to six foot deep pool used to protect the low flow pipe from clogging and prevent sediment resuspension.

4. Wetland Treatment Criteria

The surface area of the entire stormwater wetland shall be at least one percent of the total drainage area to the facility (1.5% for the shallow marsh design).

At least 25% of the total WQ_v shall be in deepwater zones with a minimum depth of four feet (the forebay and micropool may meet this criteria).

A minimum of 35% of the total surface area shall have a depth of six inches or less and at least 65% of the total surface area shall be shallower than 18 inches.

The bed of the wetland should be graded to create a maximum internal flowpath and microtopography.

If extended detention is utilized in a stormwater wetland, the ED volume shall not comprise more than 50% of the total wetland design, and the maximum water surface elevation shall not extend more than three feet above the normal pool. Q_p and/or Cp_v storage can be provided above the maximum WQ_v elevation within the wetland.

To promote greater nitrogen removal, rock beds may be used as a medium for the growth of wetland plants. The rock should be one to three inches in diameter and placed up to the normal pool elevation. Rock beds should also be open to flow-through from either direction.

5. Wetland Landscaping Criteria

A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of pondscaping zones, selection of corresponding plant species, planting configuration, and sequence for preparing wetland bed (including soil amendments, if needed).

Structures such as fascines, coconut rolls, or straw bales can be used to create shallow marsh cells in high energy areas of the stormwater wetland.

The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the wetland and buffers.

A wetland buffer may extend 25 feet outward from the maximum water surface elevation with an additional 15 foot setback to structures.

<u>Wetland Establishment Guidance</u>

Stormwater wetlands shall be designed by a professional with a degree or certification that qualifies them to design wetlands. This section is included for informational purposes only.

The most common and reliable technique for establishing an emergent wetland community in a stormwater wetland is to transplant nursery stock obtained from local nurseries. The following guidance is suggested when transplants are used to establish a wetland.

Transplanting is preferred in the spring to early summer. Planting after these dates is not recommended, as the wetland plants need a full growing season to build the root reserves needed to get through the winter. Plants may need to be ordered at least three months in advance to ensure the availability of the desired species.

The optimal depth requirements for several common species of emergent wetland plants are often six inches of water or less.

To add diversity to the wetland, 5 to 7 species of emergent wetland plants should be used, drawn from the suggested species listed in MSD Landscape Guide for Stormwater Best Management Practice Design.

The wetland area should be sub-divided into separate planting zones of more or less constant depth. Approximately half the wetland surface area should be planted. One plant species should be planted within each flagged planting zone, based on their approximate depth requirements. Plants should be installed in clumps with individual plants located an average of 18 inches on center within each clump. Individual plants should be spaced a no closer than 12 inches to 24 inches on center.

Post-nursery care of wetland plants is very important in the interval between delivery of the plants and their subsequent installation, as they are prone to desiccation. Stock should be frequently watered and shaded while on-site.

A wet hydroseed mix should be used to establish permanent vegetative cover in the buffer outside of the permanent pool. For rapid germination, scarify the soil to ½ inch prior to hydroseeding. Alternatively, red fescue or annual rye can be used as a temporary cover for the wet species.

Because most stormwater wetlands are excavated to deep sub-soils, they often lack the nutrients and organic matter needed to support vigorous growth of wetland plants. At these sites, three to six inches of topsoil or wetland mulch should be added to all depth zones in the wetland from one foot below the normal pool to six inches above. Wetland mulch is preferable to topsoil if it is available.

The stormwater wetland should be staked at the onset of the planting season. Depths in the wetland should be measured to the nearest inch to confirm the original planting zones. At this time, it may be necessary to modify the pond scape plan to reflect altered depths or the availability of wetland plant stock. Surveyed planting zones should be marked on an “as-built” or design plan and located in the field using stakes or flags.

The wetland drain should be fully opened at least three days prior to the planting date (which should coincide with the delivery date for the wetland plant stock).

Wetland mulch is another technique to establish a plant community which utilizes the seedbank of wetland soils to provide the propagules for marsh development. The majority of the seedbank is contained within the upper six inches of the donor soils. The mulch is best collected at the end of the growing season. Best results are obtained when the mulch is spread 3 to 6 inches deep over the high marsh and semi-wet zones of the wetland (-6 inches to +6 inches relative to the normal pool).

Donor soils for wetland mulch shall not be removed from natural wetlands without proper permits.

6. Wetland Maintenance Criteria

If a minimum vegetative coverage of 50% is not achieved in the planted wetland zones after the second growing season, reinforcement plantings will be required.

7. Shortcut assessment method for determining the adequacy of water balance

In the design of a wetland or stormwater pond, a water balance must be performed, to insure that the wet pool can be maintained over a 30 day period without rainfall. This section presents a simple method for calculating whether a stormwater pond or wetland has an appropriate water balance. When conducting this analysis, the following should be considered:

a) Calculate maximum drawdown during periods of high evaporation and during an extended period of no appreciable rainfall
b) The change in storage within a pond (ΔV) = Inflows - Outflows
c) Potential inflows: runoff, baseflow and rainfall
d) Potential outflows: infiltration, surface overflow and evaporation (and evapotranspiration)
e) Assume no inflow from baseflow, no losses for infiltration and because only the permanent pool volume is being evaluated, no losses for surface overflows
f) Therefore, ΔV = runoff - evaporation

Using the example site data and precipitation and evaporation conditions in Tables A and B below, a wetland drawdown assessment may be determined as follows:

Table A Example Site Data from Typical Subdivision

Drainage Area	40 ac
Impervious Area	10 ac
Percent Imperviousness (I) or 10/40	25%
Rainfall Depth (P)	1.14 in.
Surface Area of Wetland/Pond (minimum 1.5% of drainage area to BMP)	0.6 ac

Table B Precipitation and Evaporation Rates for Wentzville

(From the NWS Climate Prediction Center. This average month provides the greatest evaporation rate, in combination with the lowest precipitation rate for the year.)

	Average Per Month (ft.)
Precipitation (P_x)	0.16
Evaporation	0.26

Sample Water Balance Analysis:

Calculate Rv = .05 + (.009)(25) [Use percent imperviousness as a whole number)
= .05 + .225
= .28

Calculate WQv = [(P/12)(Rv)(Acres)]
= (1.14/12)(.28)(40)
= 1.064 acre-feet

Calculate surface area of wetland/pond = 40 ac. total site X 1.5% minimum area = 0.6 acres.

Calculate maximum drawdown during periods of high evaporation:

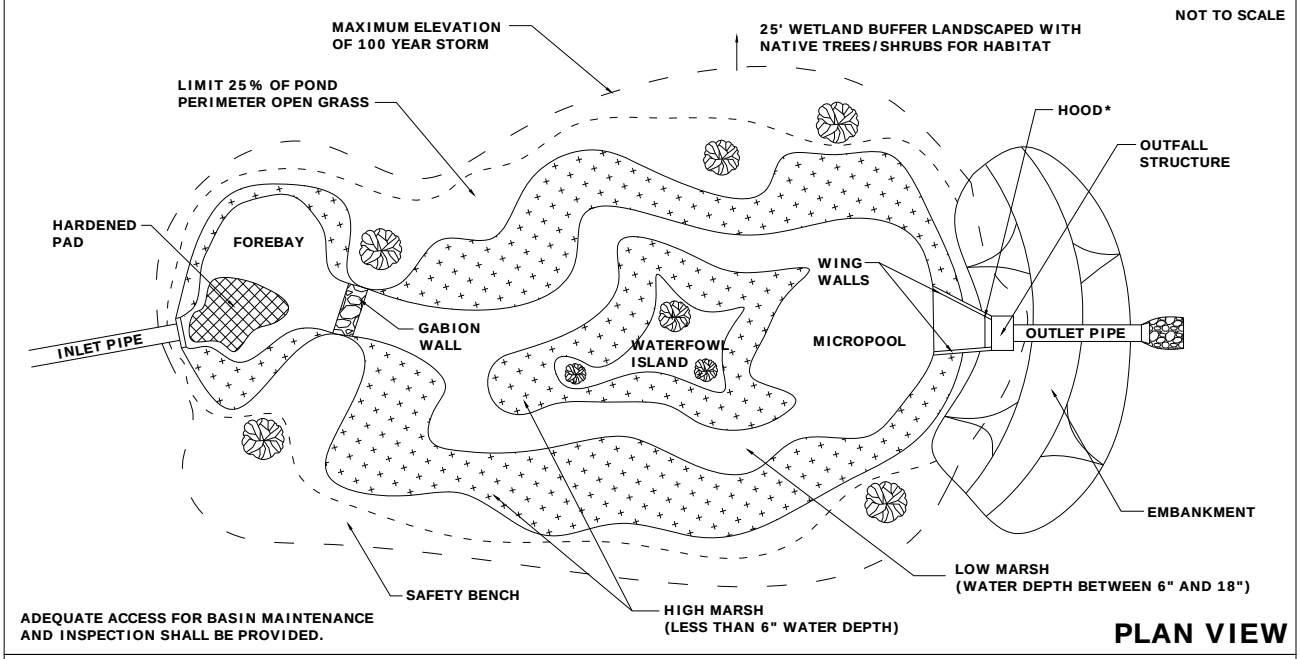
- Runoff Volume = $P_x(R_v)$ (Where P_x = Precipitation, R_v = Runoff Coefficient)
- P_x = 0.16
- R_v = 28%
- Inflow = P_x x R_v = 0.16' x 28% = .0448'
  Over entire site: 0.16 x 28% x 40 acres = 1.79 ac-ft
- Outflow = surface area x evaporation losses
  = 0.6 ac x 0.26' = 0.156 ac-ft
- Inflow (1.79 ac-ft) is greater than Outflow (0.156 ac-ft) therefore, drainage area is adequate to support wet pond/wetland during normal conditions.

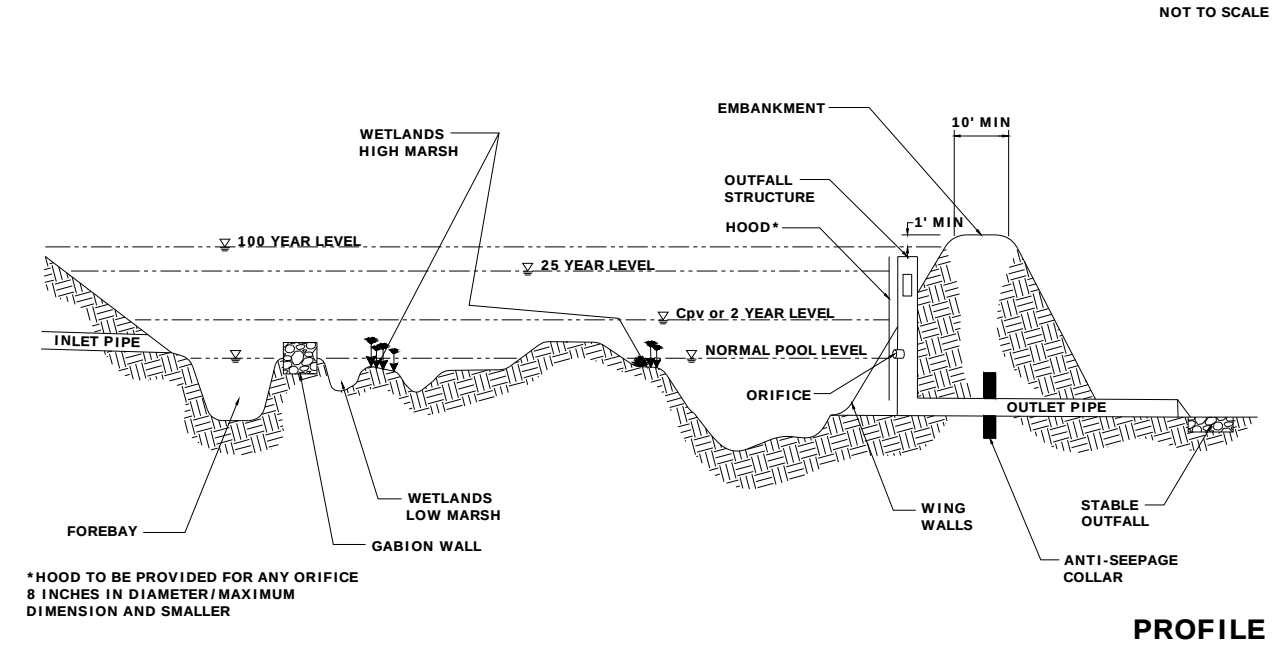
Check for drawdown over an extended period without rainfall:

- Use a 30 day interval using worst case conditions
- Highest evaporation – 0.26 ft per month.
- Surface of permanent pool will therefore drop up to 0.26 feet (3.1 inches) over this period.

Therefore, specify vegetation for the aquatic shelves that can tolerate periods of drawdowns of up to 3.1 inches.

W-1	**Figure 6.07.06** Example of Shallow Wetland	W-1

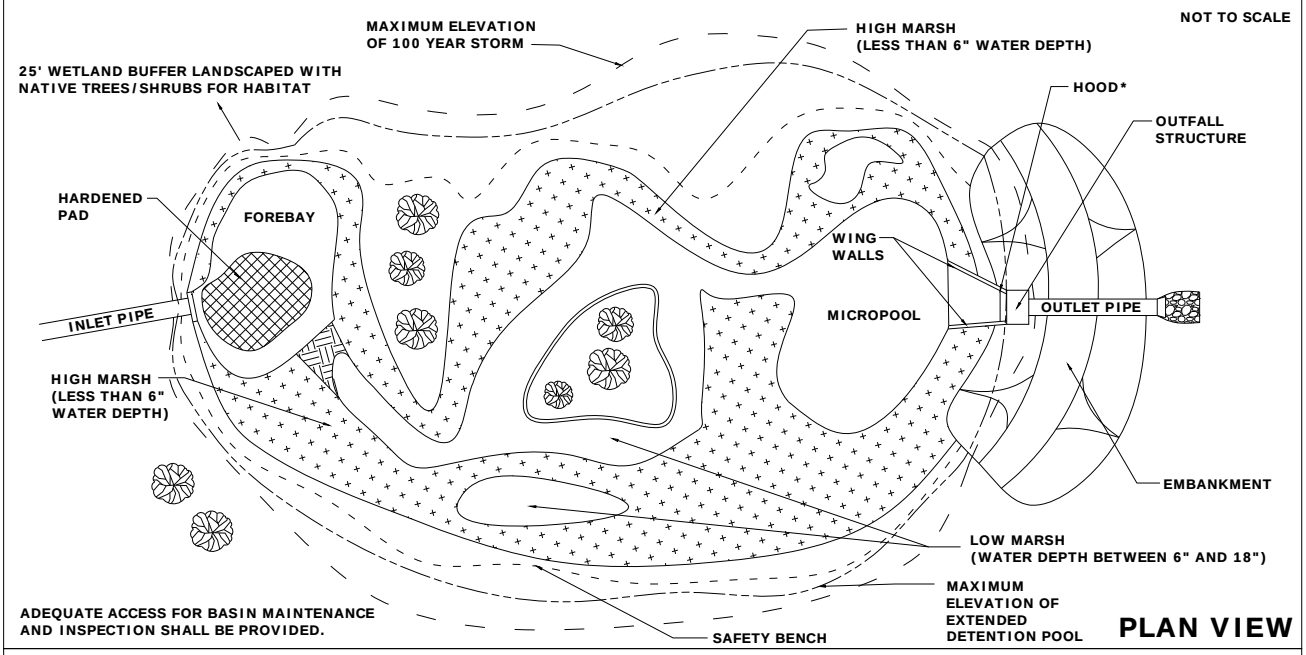


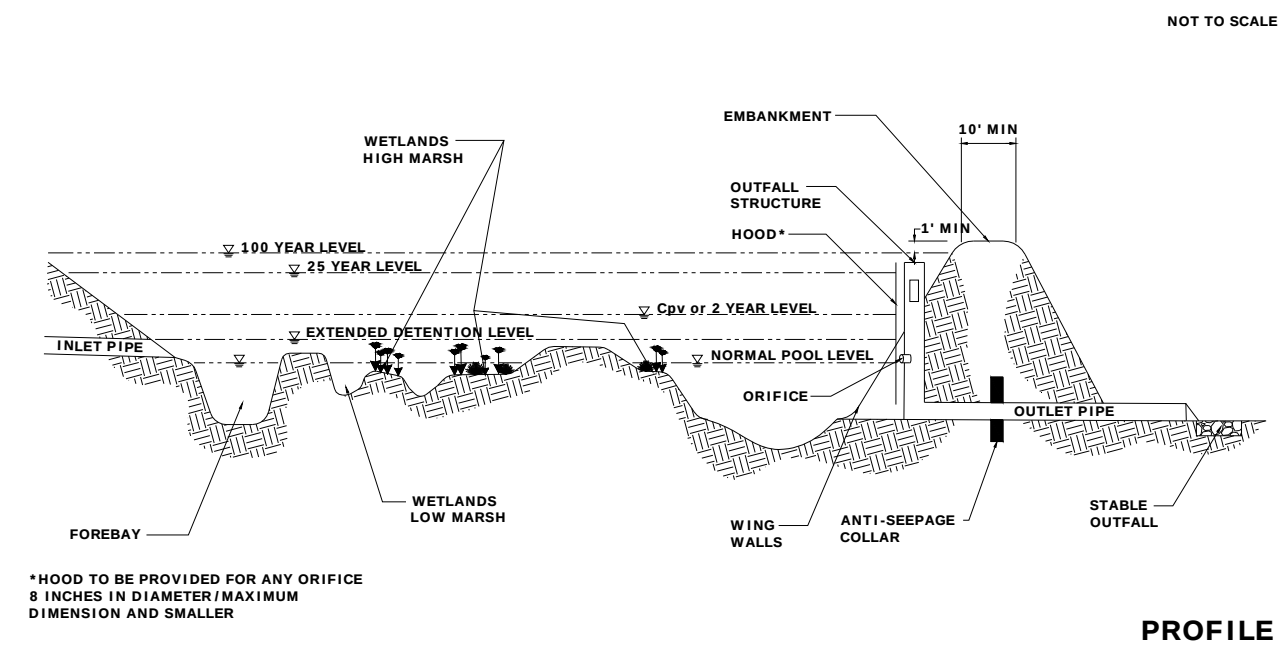


Shallow wetlands provide WQv in a shallow pool that has a large surface area.

This example does not constitute a design and is for illustrative purposes only.

W-2	**Figure 6.07.07** Example of Extended Detention Shallow Wetland	W-2

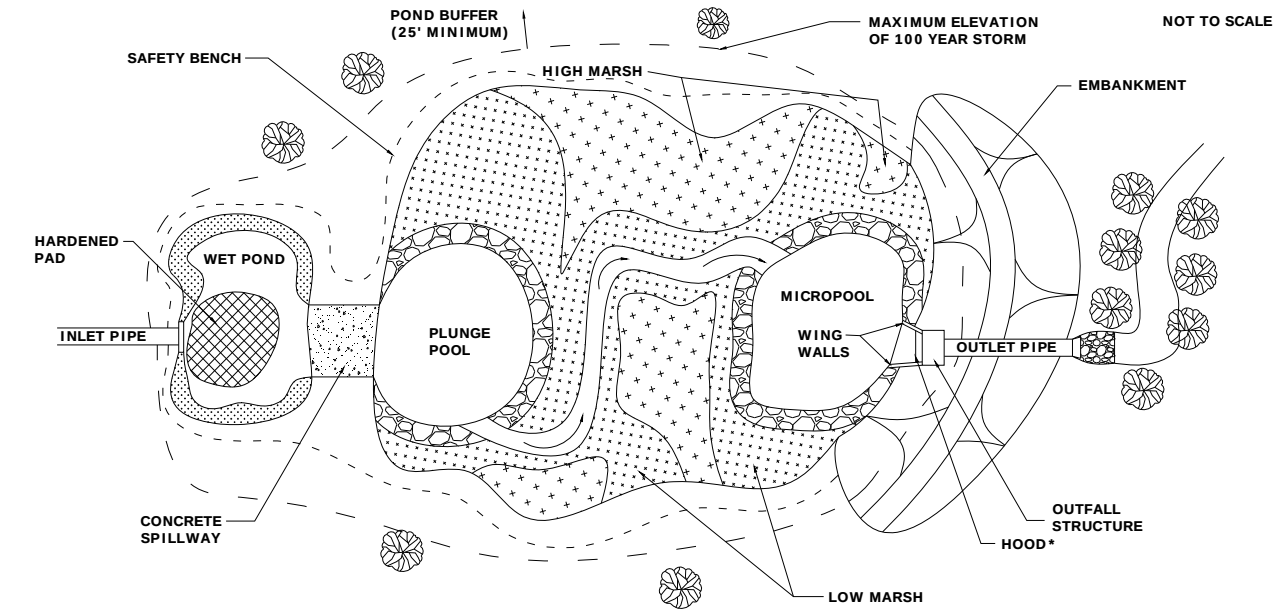




Extended detention wetlands provide water quality storage by a combination of shallow wetland pool and extended detention storage.

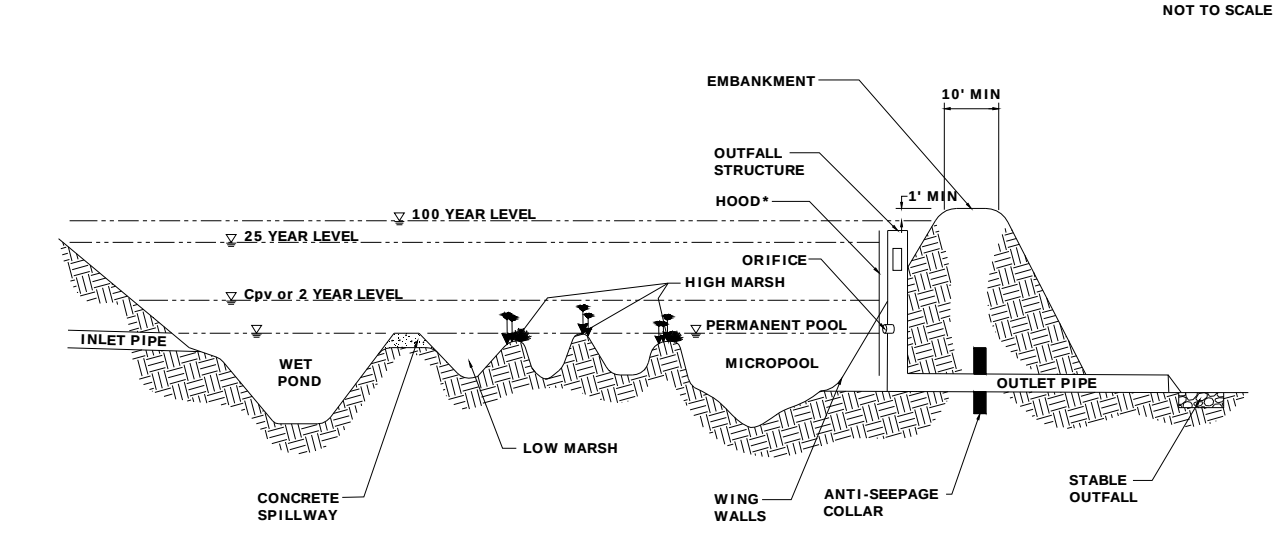
This example does not constitute a design and is for illustrative purposes only.

W-3	**Figure 6.07.08** Example of Pond/Wetland System	W-3



ADEQUATE ACCESS FOR BASIN MAINTENANCE AND INSPECTION SHALL BE PROVIDED.

PLAN VIEW



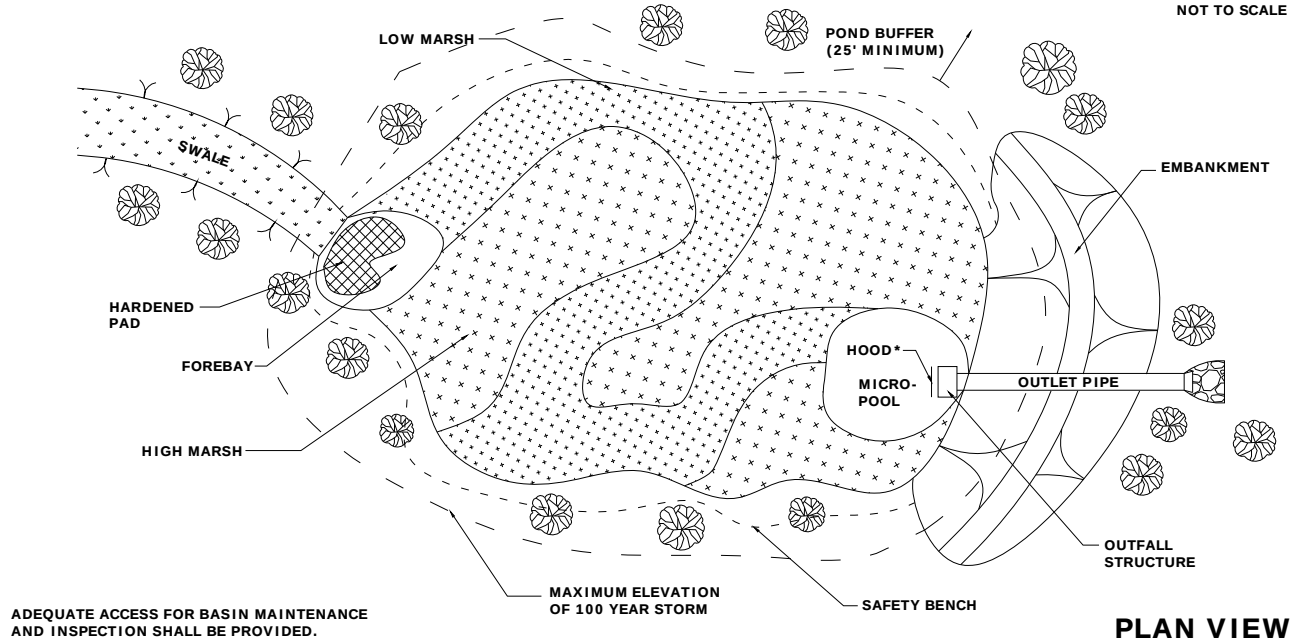
*HOOD TO BE PROVIDED FOR ANY ORIFICE 8 INCHES IN DIAMETER/MAXIMUM DIMENSION AND SMALLER

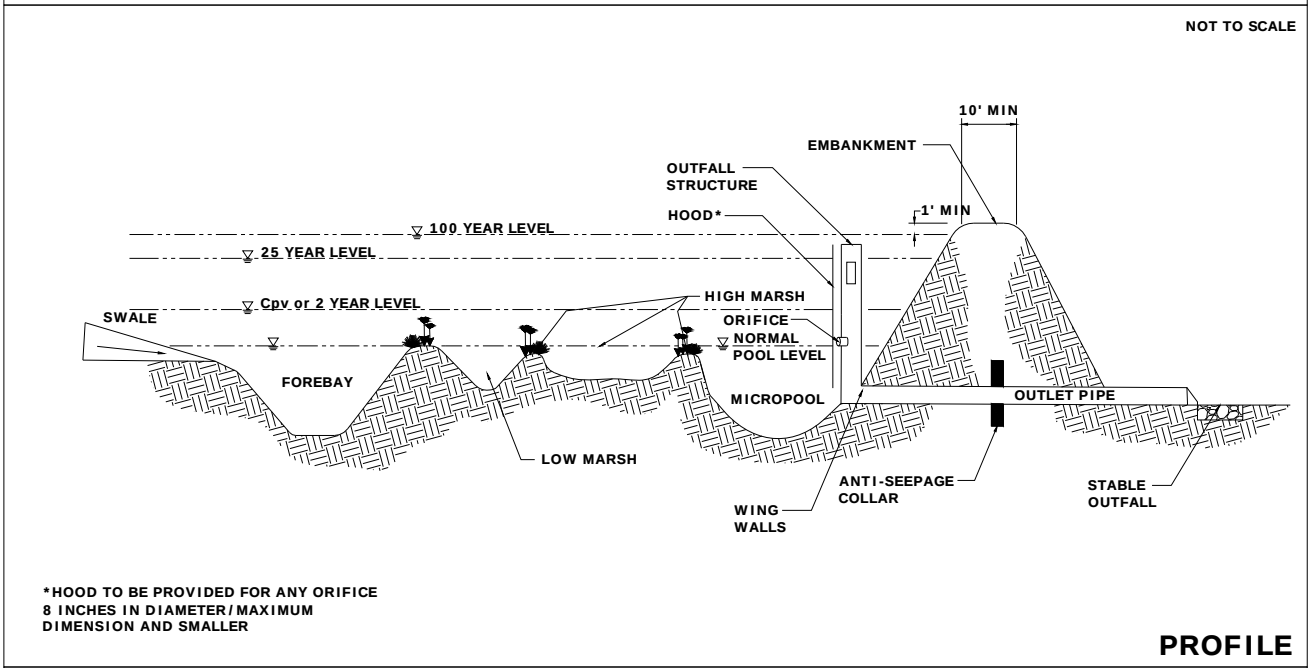
PROFILE

In this BMP, a deep permanent pool is placed before the shallow wetland.

This example does not constitute a design and is for illustrative purposes only.

W-4	**Figure 6.07.09** Example of "Pocket" Wetland	W-4





A high groundwater table or groundwater interception helps maintain the shallow marsh pool in a pocket wetland.

This example does not constitute a design and is for illustrative purposes only.

6.07.03 Stormwater Infiltration

Definition: Practices that capture and temporarily store the WQ_v while allowing infiltration into the soil over a prescribed period. Design variants include:

- I-1 infiltration trench (Figure 6.07.10)
- I-2 infiltration basin (Figure 6.07.11)

Infiltration practices may provide Cp_v and Q_p storage in certain limited cases.

1. Infiltration Feasibility Criteria

To be suitable for infiltration, underlying soils shall have an infiltration rate (f) of 0.52 inches per hour or greater, as initially determined from NRCS soil textural classification and subsequently confirmed by field geotechnical tests. Approved geotechnical testing procedures for feasibility and design are outlined in Appendix D-1 of the Maryland Stormwater Design Manual. The minimum geotechnical testing is one test hole per 5000 sf, with a minimum of two borings per facility (taken within the proposed limits of the facility).

Soils should also have a clay content less than 20% and a silt/clay content less than 40%.

Infiltration cannot be located on slopes greater than 15% or within fill soils.

To protect groundwater from possible contamination, runoff from common stormwater hotspot land uses or activities cannot be infiltrated without proper pretreatment to remove hydrocarbons, trace metals, or toxicants.

Infiltration may be prohibited within areas of karst topography. If a site overlies karst geology, the local approval authority should be consulted for specific design requirements.

The bottom of the infiltration facility shall be separated by at least four feet vertically from the seasonally high water table or bedrock layer, as documented by on-site soil testing.

Infiltration facilities should be located a minimum of 100 feet horizontally from any water supply well.

The maximum contributing area to an individual infiltration practice should generally be less than 5 acres.

Infiltration practices should not be placed in locations that cause water problems to downgrade properties. Infiltration facilities should be setback 25 feet (10 feet for dry wells) down-gradient from structures.

2. Infiltration Conveyance Criteria

A conveyance system shall be included in the design of all infiltration practices in order to ensure that excess flow is discharged at non-erosive velocities.

The overland flow path of surface runoff exceeding the capacity of the infiltration system shall be evaluated to preclude erosive concentrated flow. If computed flow velocities do not exceed the non-erosive threshold, overflow may be accommodated by natural topography (see Appendix D-12 of the Maryland Stormwater Design Manual for the critical erosive velocities for grass and soil).

All infiltration systems should be designed to fully de-water the entire WQ_v within 48 hours after the storm event.

If runoff is delivered by a storm drain pipe or along the main conveyance system, the infiltration practice should be designed as an off-line practice. (See Detail No. 5, Appendix D-8 of the Maryland Stormwater Design Manual for example of an off-line infiltration practice.)

Adequate stormwater outfalls shall be provided for the overflow associated with all design storm events (non-erosive velocities on the down-slope).

3. Infiltration Pretreatment Criteria

Pretreatment Volume

A minimum of 25% of the WQ_v must be pretreated prior to entry to an infiltration facility. If the f for the underlying soils is greater than 2.00 inches per hour, 50% of the WQ_v shall be pretreated prior to entry into an infiltration facility. This can be provided by a sedimentation basin, stilling basin, sump pit or other acceptable measures. *Exit velocities from pretreatment shall be non-erosive during the two-year design storm.*

The Camp-Hazen equation (Section 6.07.04, sub-section 3) may be used as an acceptable alternative for determining infiltration pretreatment requirements.

Pretreatment Techniques to Prevent Clogging

Each infiltration system shall have redundant methods to protect the long term integrity of the infiltration rate. The following techniques, at least three per trench (I-1) and two per basin (I-2), must be installed in every infiltration practice:

- *grass channel (see Section 6.08 - Credit #5 for example computation and requirements for use)*
- *grass filter strip (minimum 20 feet and only if sheet flow is established and maintained)*
- *bottom sand layer*
- *upper sand layer (6" minimum) with filter fabric at sand/gravel interface*
- *use of washed bank run gravel as aggregate*

The sides of infiltration practices shall be lined with an acceptable filter fabric that prevents soil piping but has greater permeability than the parent soil (see Appendix B-2).

4. Infiltration Treatment Criteria

Infiltration practices shall be designed to exfiltrate the entire WQ_v less the pretreatment volume through the floor of each practice using the design methods outlined in Appendix D-13 of the Maryland Stormwater Design Manual.

Infiltration practices are best used in conjunction with other BMPs and often downstream detention is still needed to meet the Cp_v and Q_p sizing criteria.

The construction sequence and specifications for each infiltration practice shall be followed, as outlined in Appendix B-2 of the Maryland Stormwater Design Manual. Experience has shown that the longevity of infiltration practices is strongly influenced by the care taken during construction.

A porosity value *"n"* ($n=V_v/V_t$) of 0.40 should be used in the design of stone reservoirs for infiltration practices.

5. Infiltration Landscaping Criteria

A dense and vigorous vegetative cover shall be established over the contributing pervious drainage areas before runoff can be accepted into the facility. Infiltration trenches shall not be constructed until the contributing drainage area has been stabilized. Vegetated areas shall be uniformly and evenly distributed prior to final inspection.

6. Infiltration Maintenance Criteria

An observation well shall be installed in every infiltration trench, consisting of an anchored six-inch diameter perforated PVC pipe with a lockable cap. (See Detail No. 4, Appendix D-8 of the Maryland Stormwater Design Manual.)

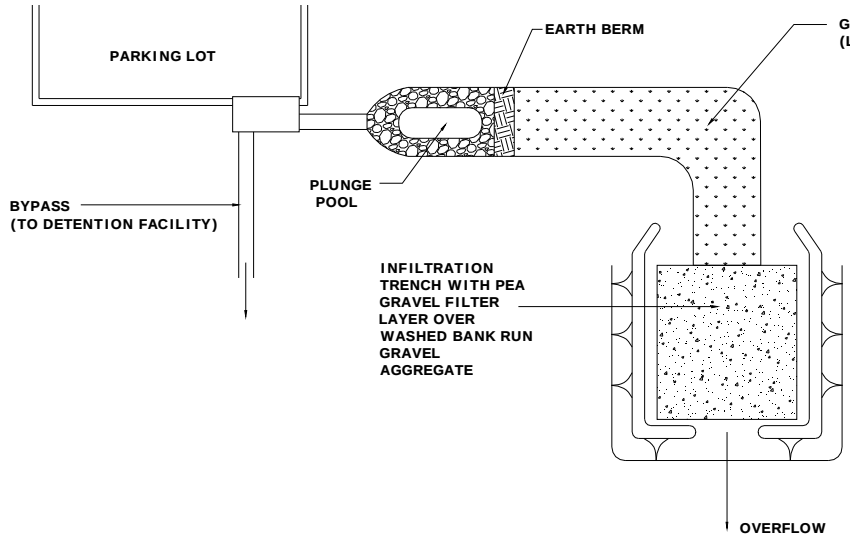
It is recommended that infiltration designs include dewatering methods in the event of failure. This can be done with underdrain pipe systems that accommodate drawdown.

Direct access shall be provided to all infiltration practices for maintenance and rehabilitation.

Infiltration practices should not be covered by an impermeable surface.

I-1	**Figure 6.07.11** Example of Infiltration Trench	I-1

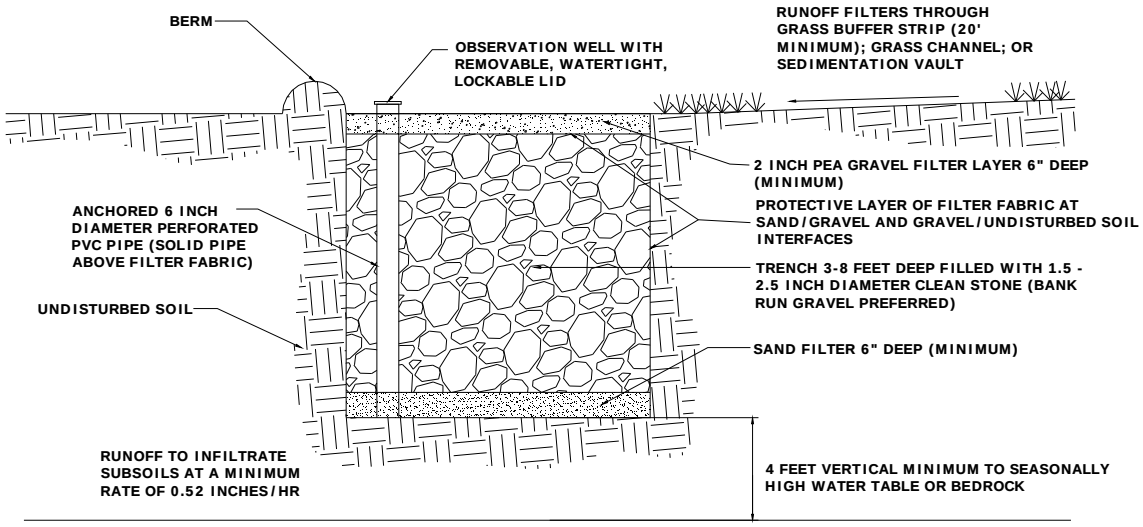
NOT TO SCALE



ADEQUATE ACCESS FOR MAINTENANCE AND INSPECTION SHALL BE PROVIDED.

PLAN VIEW

NOT TO SCALE



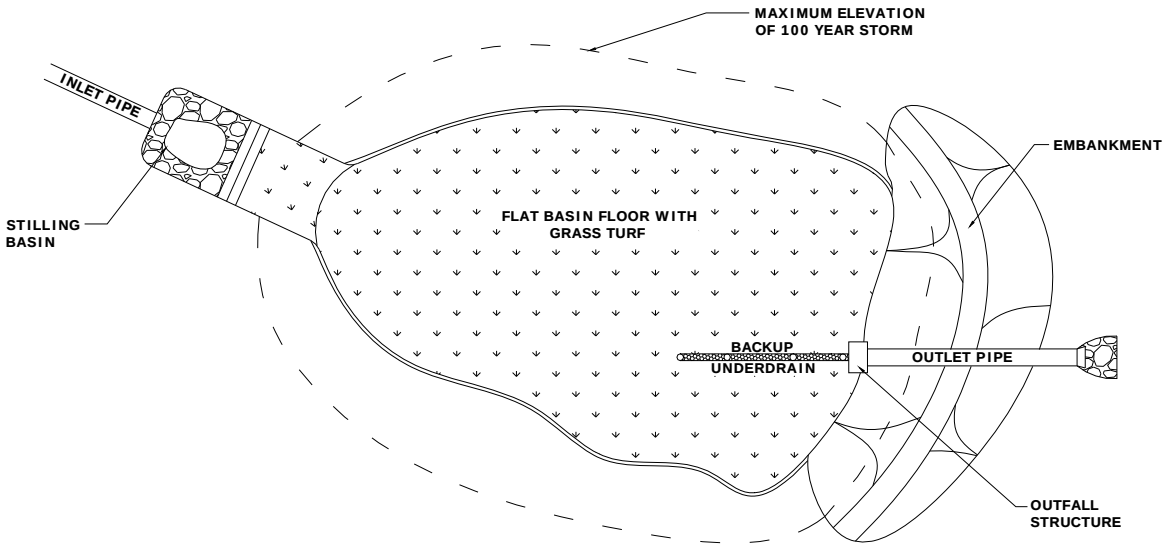
SECTION

The infiltration trench provides groundwater recharge and WQv in one location.

This example does not constitute a design and is for illustrative purposes only.

I-2 | **Figure 6.07.11** Example of Infiltration Basin | I-2

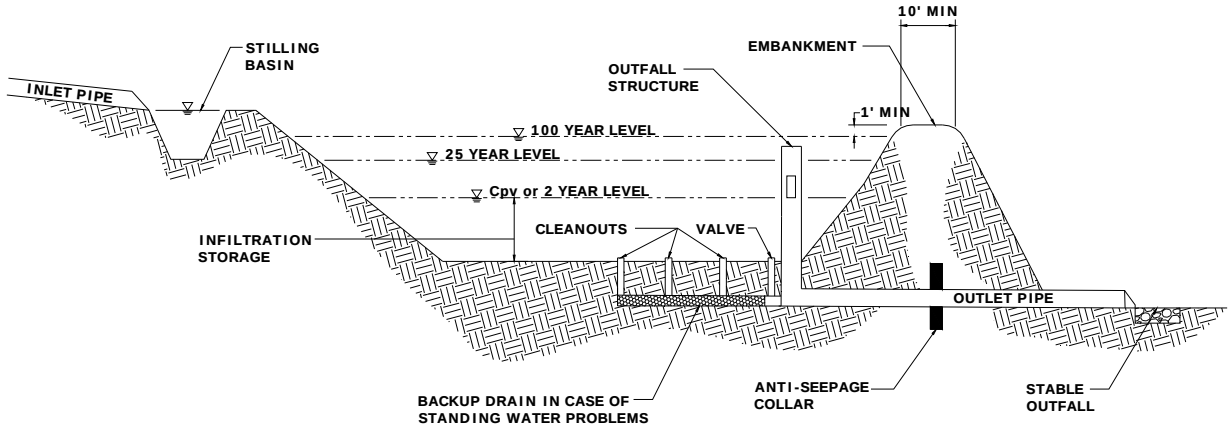
NOT TO SCALE



ADEQUATE ACCESS FOR BASIN MAINTENANCE AND INSPECTION SHALL BE PROVIDED.

PLAN VIEW

NOT TO SCALE



*HOOD TO BE PROVIDED FOR ANY ORIFICE 8 INCHES IN DIAMETER/MAXIMUM DIMENSION AND SMALLER

PROFILE

The WQv is retained in an infiltration basin, where it percolates through the floor of the basin in a two day period.

This example does not constitute a design and is for illustrative purposes only.

6.07.04 Stormwater Filtering Systems

Definition: Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media. Filtered runoff may be collected and returned to the conveyance system or allowed to partially exfiltrate into the soil. Design variants include:

- F-1 surface sand filter (Figure 6.07.12)
- F-2 underground sand filter (Figure 6.07.13)
- F-3 perimeter sand filter (Figure 6.07.14)
- F-4 organic filter (Figure 6.07.15)
- F-5 pocket sand filter (Figure 6.07.16)
- F-6 bioretention (Figure 6.07.17)

Filtering systems shall not be designed to meet Cp_v or Q_p requirements except under extremely unusual conditions. Filtering practices shall generally be combined with a separate facility to provide those controls.

1. Filtering Feasibility Criteria

Most stormwater filters normally require two to six feet of head. However, the perimeter sand filter (F-3) can be designed to function with as little as one foot of head.

The maximum contributing area to an individual stormwater filtering system is usually less than 10 acres.

Sand and organic filtering systems are generally applied to land uses with a high percentage of impervious surfaces. *Drainage area imperviousness less than 75% discharging to a filtering practice shall require full sedimentation pretreatment techniques (see Equation in the following sub-section 3).*

2. Filtering Conveyance Criteria

If runoff is delivered by a storm drain pipe or is along the main conveyance system, the filtering practice shall be designed off-line. (See Detail No. 5 in Appendix D-8 of the Maryland Stormwater Design Manual.)

Overflow for the 15-year, 20-minute storm shall be provided to a non-erosive outlet point (e.g., prevent downstream slope erosion). See Appendix D-12 of the Maryland Stormwater Design Manual for critical non-erosive velocities for grass and soil.

A flow regulator (or flow splitter diversion structure) shall be provided to divert the WQ_v to the filtering practice (see Detail No. 5, Appendix D-8 of the Maryland Stormwater Design Manual).

Stormwater filters shall have side slopes 4:1 or flatter and be equipped with a minimum 4" perforated pipe underdrain (6" is preferred) in a gravel layer. A permeable filter fabric (Appendix B-3 of the Maryland Stormwater Design Manual) shall be placed between the gravel layer and the filter media in sand filters and on the sides in bioretention.

3. Filtering Pretreatment Criteria

Dry or wet pretreatment equivalent to at least 25% of the computed WQ_v shall be provided prior to filter media. The typical method is a sedimentation basin that has a length to width ratio of 2:1. The Camp-Hazen equation, which accounts for the effects of turbulent flow, is used to compute the required minimum surface area for sand and organic filters for pretreatment (WSDC, 1992).

The required sedimentation basin minimum surface area is computed using the following equation:

$$A_s=(Q_o/W)xE'$$

where:

A_s = sedimentation basin surface area (ft^2)
Q_o = discharge rate from basin = (WQ_v/24 hr)
W = particle settling velocity (ft/sec)
for I ≤ 75%, use 0.0004 ft/sec (particle size=20 microns)
for I > 75%, use 0.0033 ft/sec (particle size=40 microns) (1)
(I = percent impervious)
E' = sediment trapping efficiency constant; for sediment trapping efficiency (E) of 90%, E' = 2.30 (2)

(1). Sites with greater than 75% imperviousness have a higher percentage of course-grained sediments (Shaver and Baldwin, 1991). Therefore, the target particle size for sedimentation basins may be increased to 40 microns and the surface area reduced.

(2). The sediment trapping efficiency constant (E') may be calculated from the sediment trapping efficiency (E) using the following equation: $E' = -\ln [1-(E/100)]$

The equation reduces to

A_{sf} = (0.066) (WQ_v) ft^2 for I ≤ 75%
A_{sp} = (0.0081) (WQ_v) ft^2 for I > 75%

where:

A_{sf} = sedimentation basin surface area full
A_{sp} = sedimentation basin surface area partial

Adequate pretreatment for bioretention systems (F-6) is provided when all of the following are provided: (a) 20' grass filter strip below a level spreader or optional sand filter layer, (b) gravel diaphragm and (c) a mulch layer.

4. Filtering Treatment Criteria

The entire treatment system (including pretreatment) shall temporarily hold at least 75% of the WQ_v prior to filtration.

The filter bed typically has a minimum depth of 18". *Sand filters shall have a minimum filter bed depth of 12".*

Filtering practices typically cannot provide Cp_v or Q_p under most site conditions.

The filter media shall conform to the specifications listed in Table B.3.1 (Appendix B.3 of the Maryland Stormwater Design Manual).

The filter area for filter designs F-1 to F-5 shall be sized based on the principles of Darcy's Law. A coefficient of permeability (k) shall be used as follows:

Sand:	*3.5 ft/day (City of Austin 1988)*
Peat:	*2.0 ft/day (Galli 1990)*
Leaf compost:	*8.7 ft/day (Claytor and Schueler, 1996)*
Bioretention Soil:	*0.5 ft/day (Claytor and Schueler, 1996)*

Bioretention systems (F-6) shall consist of the following treatment components: A 2 ½ to 4 foot deep planting soil bed, a surface mulch layer, and a 12" deep surface ponding area.

The required filter bed area (A_f) is computed using the following equation

$$A_f = (WQ_v)\ (d_f) / [\ (k)\ (h_f + d_f)\ (t_f)]$$

where:

A_f = Surface area of filter bed (ft^2)
WQ_v = water quality volume (ft^3)
d_f = filter bed depth (ft)
k = coefficient of permeability of filter media (ft/day)
h_f = average height of water above filter bed (ft)
t_f = design filter bed drain time (days)*

*1.67 days is recommended maximum for sand filters, 2.0 days for bioretention)

5. Filtering Landscaping Criteria

Landscaping is critical to the performance and function of bioretention areas. Therefore, a landscaping plan must be provided for bioretention areas per the guidance provided in MSD Landscape Guide for Stormwater Best Management Practice Design. Side slopes shall be sodded, or seeded using an erosion control blanket appropriate for the application per the manufacturer's specifications. Vegetated areas shall be uniformly and evenly distributed with vigorous growth of permanent vegetation prior to final inspection.

Filters F-1, F-4 and F-5 may have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought (see MSD Landscape Guide for Stormwater Best Management Practice Design for species selection guide).

Planting recommendations for bioretention facilities are as follows:

- Native plant species should be specified over non-native species.
- Vegetation should be selected based on a specified zone of hydric tolerance.
- Species should be planted in larger groupings to emphasis intentionality of pond landscaping.
- A selection of trees with an understory of shrubs and herbaceous materials should be provided.
- Woody vegetation should not be specified at inflow locations.

6. Filtering Maintenance Criteria

The sediment chamber outlet devices shall be cleaned/repaired when drawdown times within the chamber exceed 36 hours. Trash and debris shall be removed as necessary.

Sediment should be cleaned out of the sedimentation chamber when it accumulates to a depth of more than six inches. Vegetation within the sedimentation chamber should be limited to a height of 18 inches.

When the filtering capacity of the filter diminishes substantially (e.g., when water ponds on the surface of the filter bed for more than 72 hours), the top few inches of discolored material shall be removed and shall be replaced with fresh material. The removed sediments should be disposed in an acceptable manner (e.g., landfill). Silt/sediment should be removed from the filter bed when the accumulation exceeds one inch.

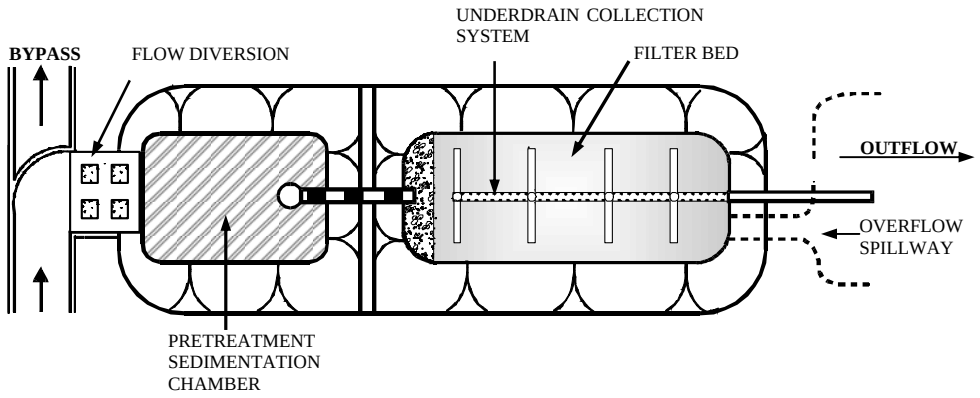
Organic filters (F-4) or surface sand filters (F-1) that have a grass cover should be mowed a minimum of 3 times per growing season to maintain maximum grass heights less than 12 inches.

*A drop of at least six inches shall be provided at the inlet of bioretention facilities (F-6) (*stone diaphragm*). Dead or diseased plant material shall be replaced.* Areas devoid of mulch should be re-mulched on an annual basis.

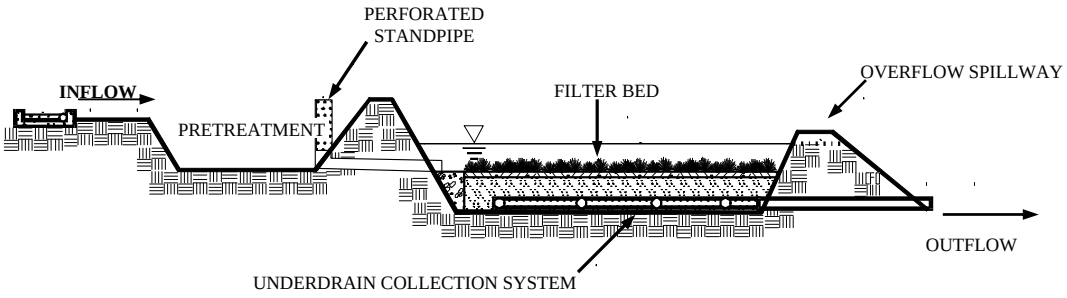
Direct maintenance access shall be provided to the pretreatment area and the filter bed.

Construction of sand filters and bioretention areas shall conform to the specifications outlined in Appendix B-3 of the Maryland Stormwater Design Manual.

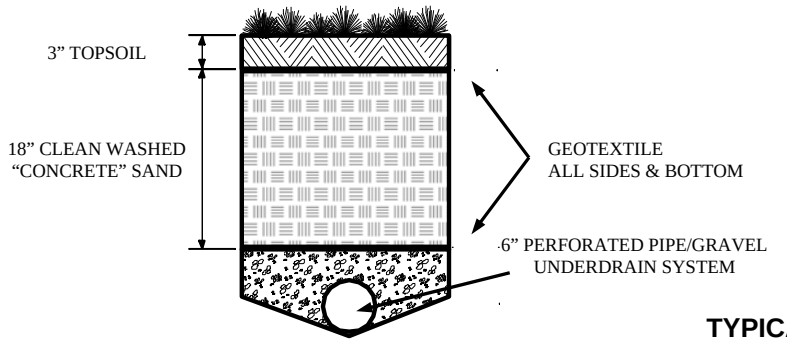
F-1	**Figure 6.07.12** Example of Surface Sand Filter	F-1



PLAN VIEW



PROFILE

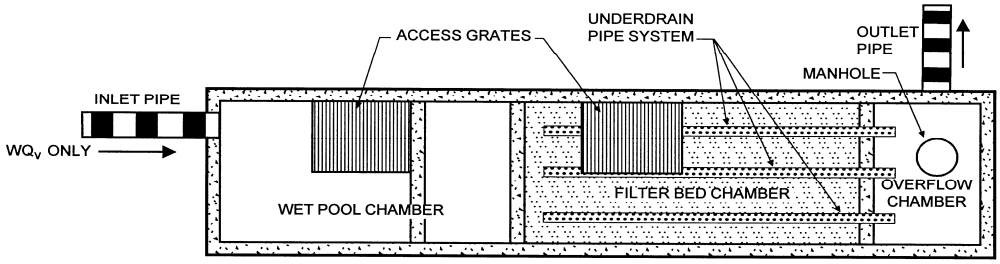


TYPICAL SECTION

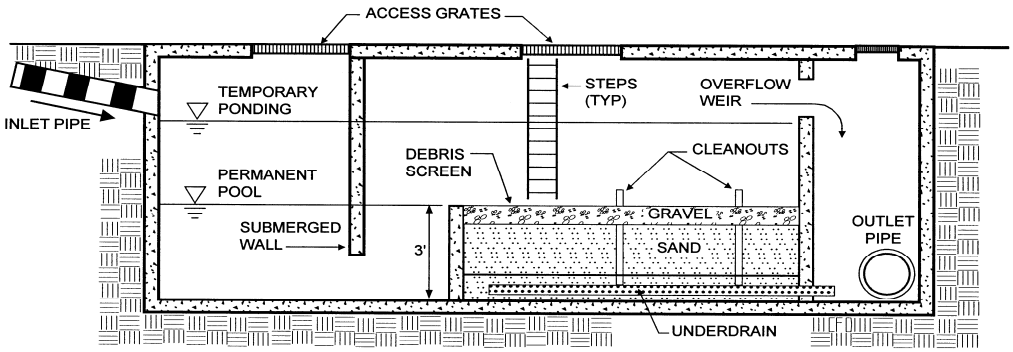
Surface sand filters can serve the largest drainage area of all the filtering systems.

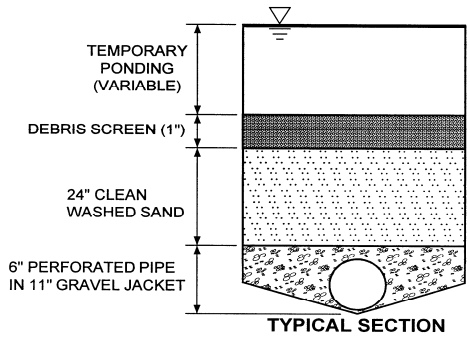
This example does not constitute a design and is for illustrative purposes only.

F-2	**Figure 6.07.13** Example of Underground Sand Filter	F-2



PLAN VIEW



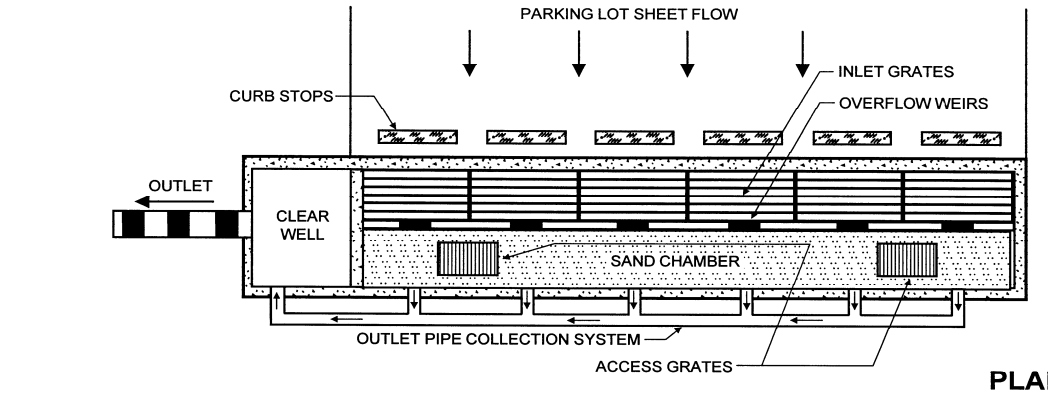


PROFILE

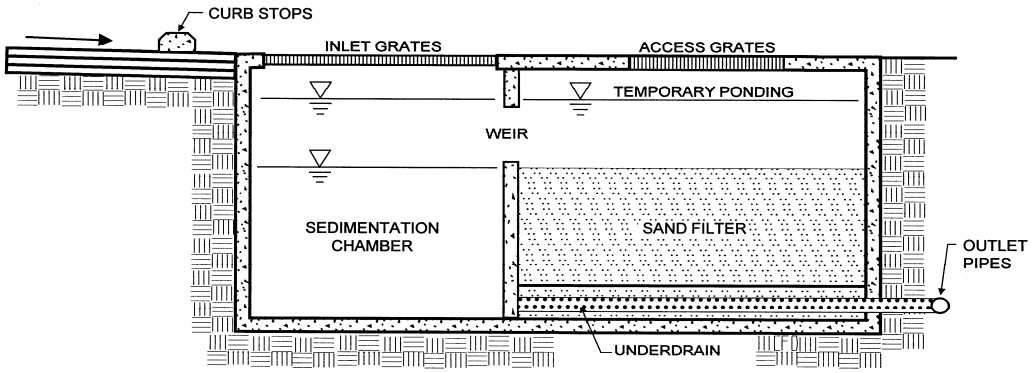
The underground sand filter is an option for providing WQ_v where space is limited.

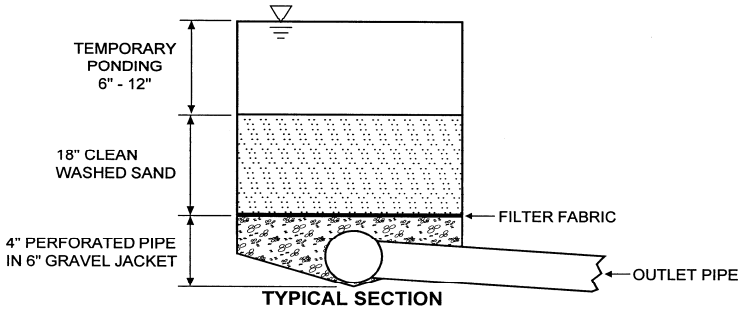
This example does not constitute a design and is for illustrative purposes only.

F-3	**Figure 6.07.14** Example of Perimeter Sand Filter	F-3



PLAN VIEW



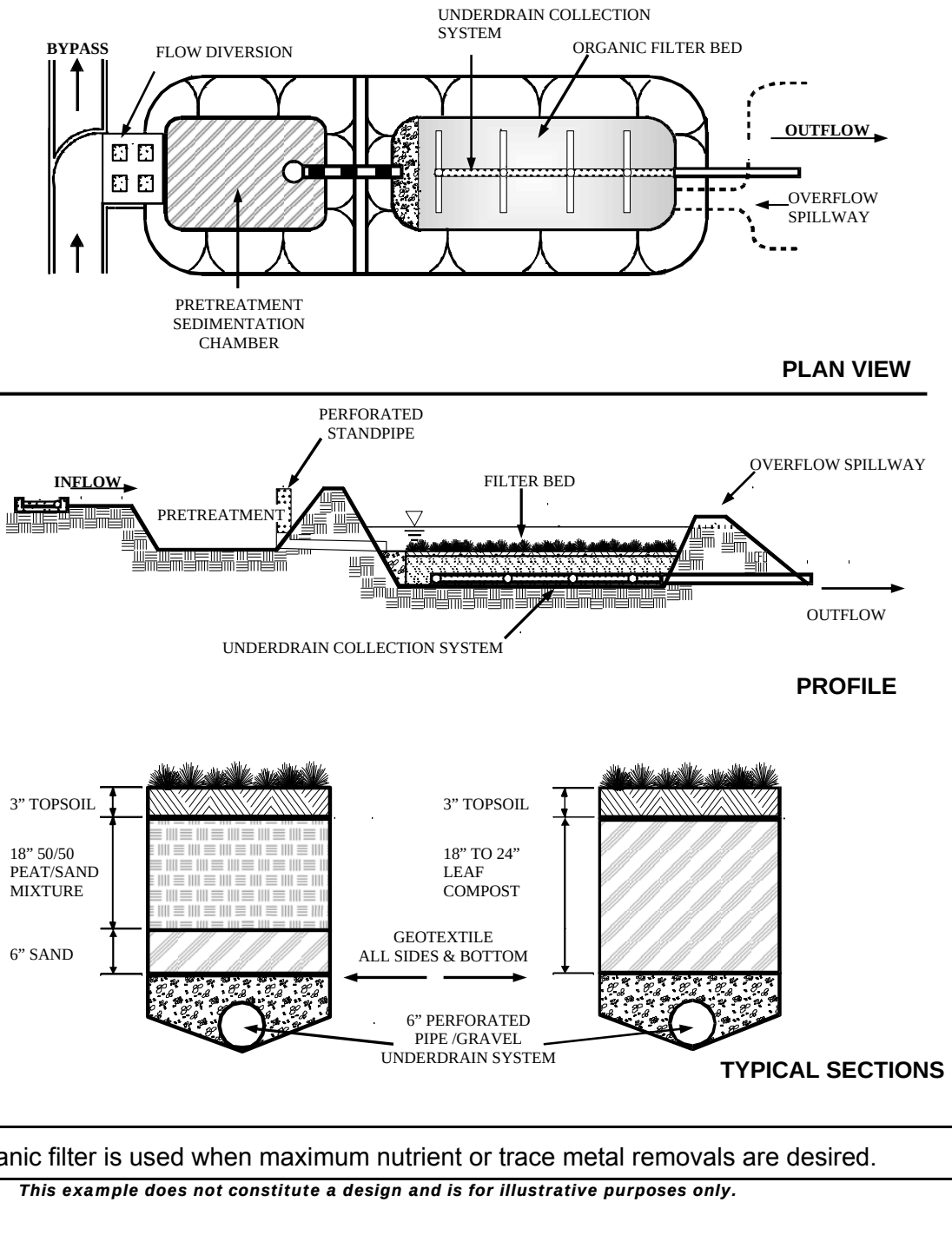


PROFILE

The perimeter sand filter is most practical for small sites with flat terrain or a high water table.

This example does not constitute a design and is for illustrative purposes only.

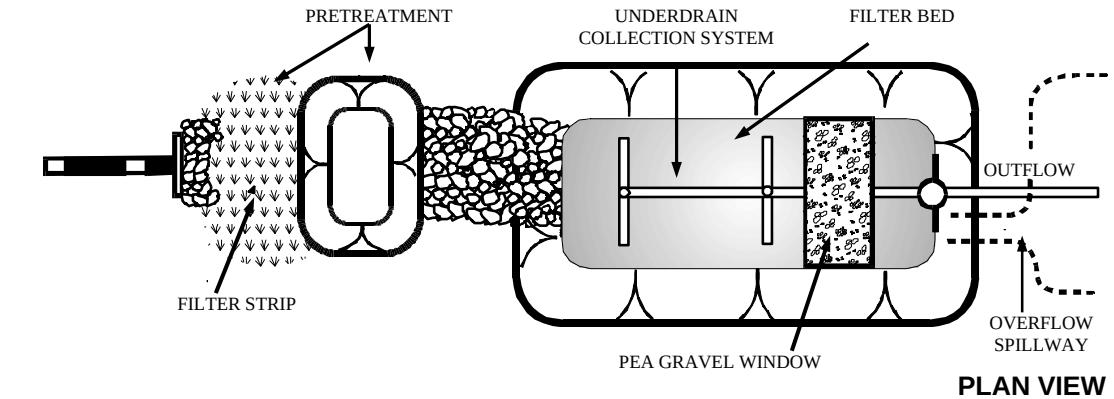
F-4	**Figure 3.15** Example of Organic Filter	F-4



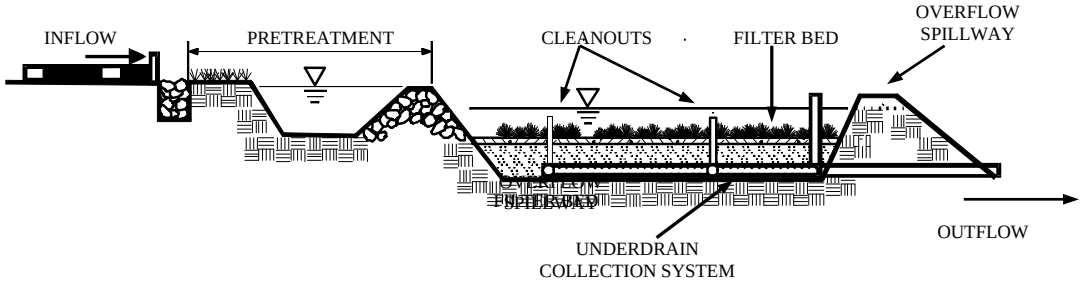
The organic filter is used when maximum nutrient or trace metal removals are desired.

This example does not constitute a design and is for illustrative purposes only.

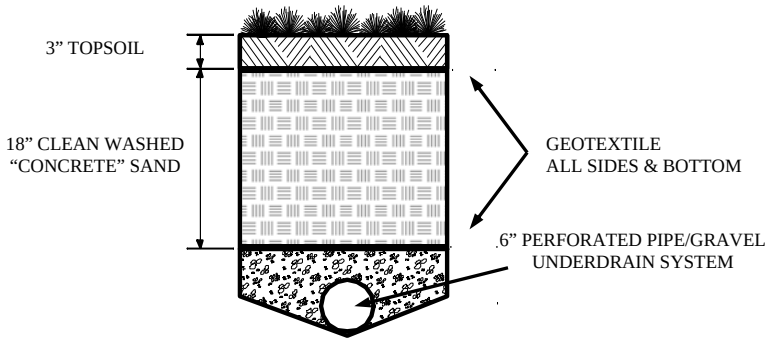
F-5	**Figure 6.07.16** Example of "Pocket" Sand Filter	F-5



PLAN VIEW



PROFILE

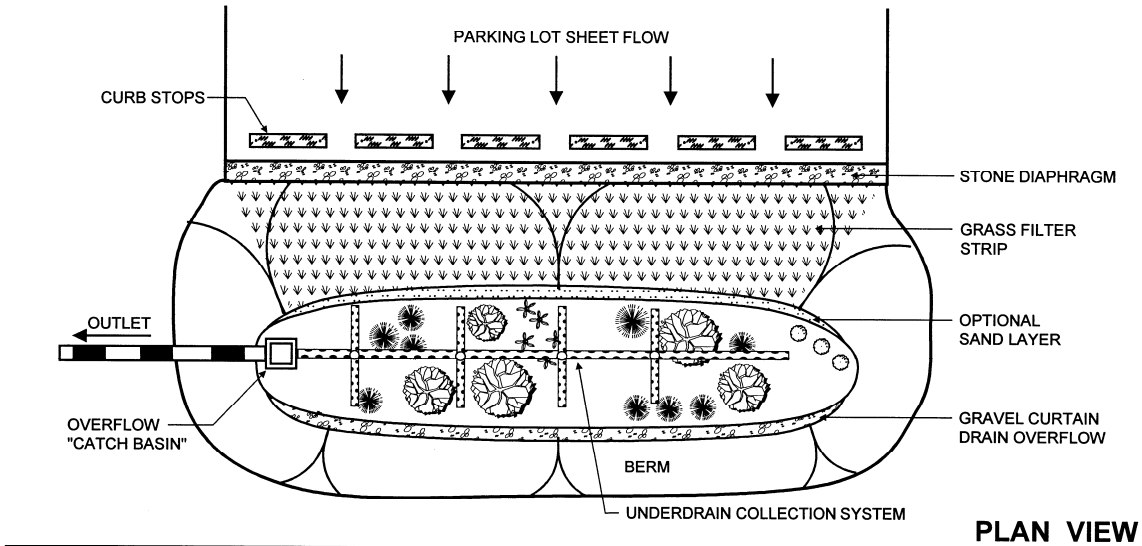


TYPICAL SECTION

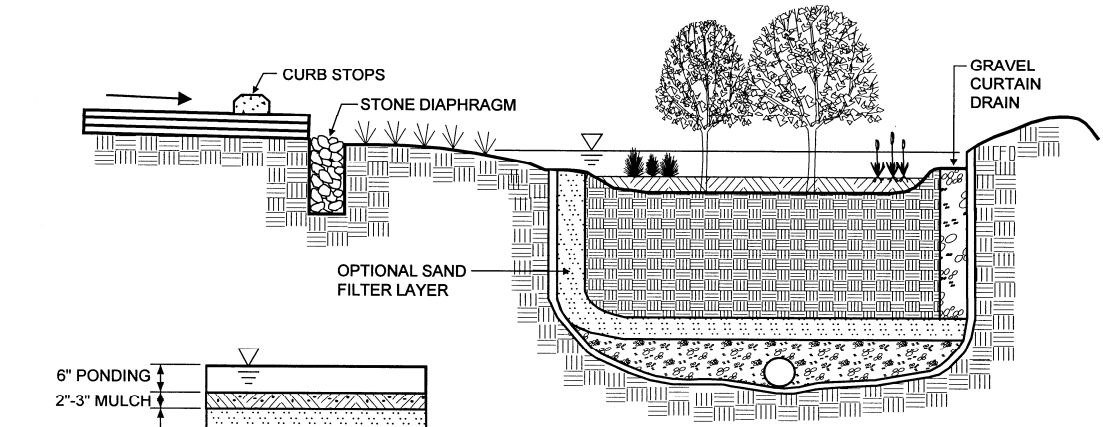
The pocket sand filter is applied to small sites where sediment loads are expected to be moderate to low. The pea gravel windows allow runoff into the filter if the surface becomes clogged.

This example does not constitute a design and is for illustrative purposes only.

F-6	**Figure 6.07.17** Example of Bioretention	F-6



PLAN VIEW



PROFILE

Bioretention combines open space with stormwater treatment.

This example does not constitute a design and is for illustrative purposes only.

6.07.05 Open Channel Systems

Definition : Vegetated open channels that are designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or other means. Design variants include:

- O-1 dry swale (Figure 6.07.18)
- O-2 wet swale (Figure 6.07.19)

Open channel systems shall not be designed to meet Cp_v or Q_p requirements except under extremely unusual conditions. Open channel practices shall generally be combined with a separate facility to provide those controls.

Grass channels (also known as biofilters) that are not designed in accordance with this section are not considered an acceptable practice to meet the WQ_v requirement unless designed as a non-structural stormwater credit according to the criteria in Section 6.07. (See Credit #5.)

1. Open Channel Feasibility Criteria

   Open channel systems shall have longitudinal slopes less than 4.0% to qualify for WQ_v treatment.

   Open channel systems, designed for *WQ_v* treatment, are primarily applicable for land uses such as roads, highways, residential development (dry swales only), and pervious areas.

2. Open Channel Conveyance Criteria

   The peak velocity for the 15-year, 20-minute storm shall be non-erosive (see Appendix D-12 of the Maryland Stormwater Design Manual for critical non-erosive velocities for grass and soil) for the soil and vegetative cover provided.

   Open channels shall be designed to safely convey all design storm events. Three inches of freeboard should be provided.

   Channels should be designed with moderate side slopes (flatter than 3:1) for most conditions. *In no event, may side slopes be steeper than 2:1.*

   The maximum allowable ponding time within a channel shall be less than 48 hours. The minimum ponding time of 30 minutes is recommended for meeting WQ_v treatment goals.

   Open channel systems that directly receive runoff from impervious surfaces may have a six inch drop onto a protected shelf (pea gravel diaphragm) to minimize clogging of the inlet.

   An underdrain system shall be provided for the dry swale to ensure a maximum ponding time of 48 hours.

3. Open Channel Pretreatment Criteria

   Pretreatment storage of 0.1 inch of runoff per impervious acre storage shall be provided. This storage is usually obtained by providing check dams at pipe inlets and/or driveway crossings.

A pea gravel diaphragm and gentle side slopes should be provided along the top of channels to accommodate pretreatment for lateral sheet flows.

Direct discharge of concentrated flow (e.g., by pipe) shall be pretreated.

4. Open Channel Treatment Criteria

Dry and wet swales shall be designed to temporarily store the WQ_v within the facility for a maximum 48 hour period.

Open channels shall have a bottom width no wider than 8 feet or a meandering drainage pattern shall be established to avoid gullying or channel braiding.

Dry and wet swales should maintain a maximum ponding depth of one foot at the "mid-point" of the channel profile (longitudinal dimension) and a maximum depth of 18" at the downstream end point of the channel (for storage of the WQ_v).

5. Open Channel Landscaping Criteria

Wet swales are not recommended for residential developments as they can create potential nuisance or mosquito breeding conditions.

Landscape design should specify proper grass species and wetland plants based on specific site, soils and hydric conditions present along the channel (see MSD Landscape Guide for Stormwater Best Management Practice Design for species selection guide).

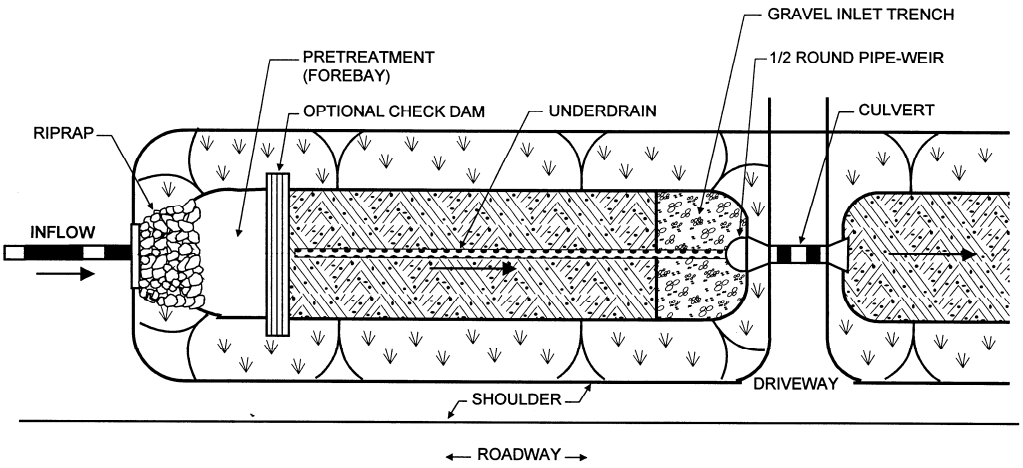
6. Open Channel Maintenance Criteria

Open channel systems and grass filter strips should be mowed as required during the growing season to maintain grass heights in the 4 to 6 inch range. Wet swales, employing wetland vegetation or other low maintenance ground cover do not require frequent mowing of the channel.

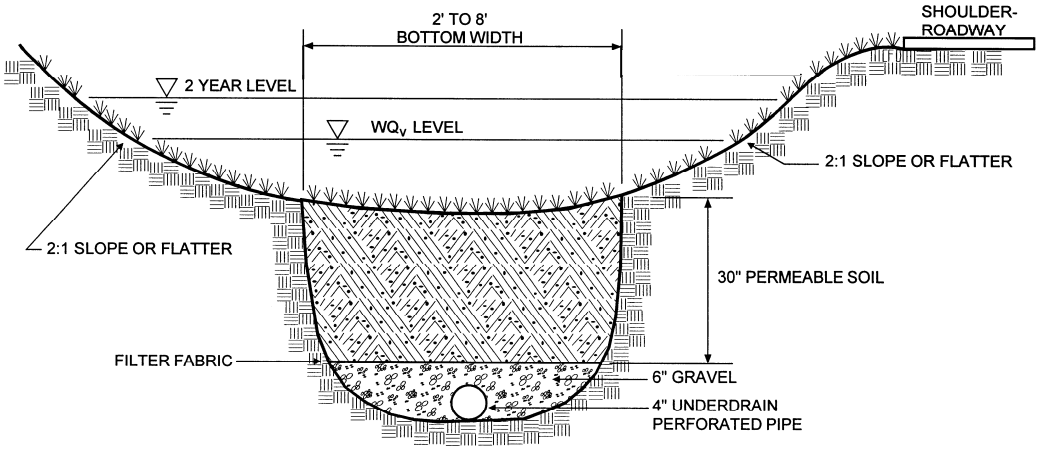
Sediment build-up within the bottom of the channel or filter strip shall be removed when 25% of the original WQ_v has been exceeded.

Construction specifications for open channel systems are specified in Appendix B-3 of the Maryland Stormwater Design Criteria.

O-1	**Figure 6.07.18** Example of Dry Swale	O-1



PLAN VIEW

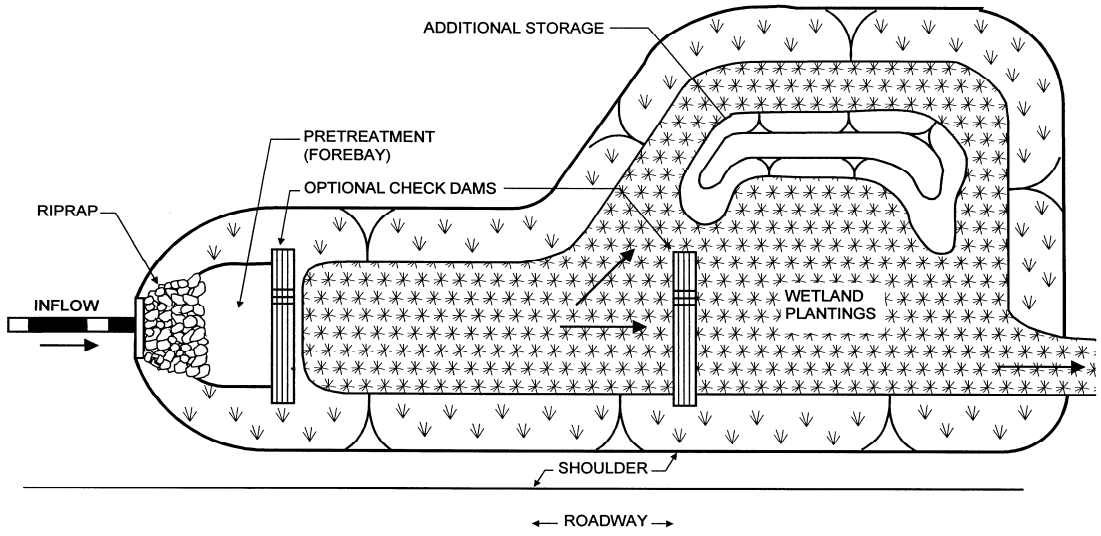


SECTION

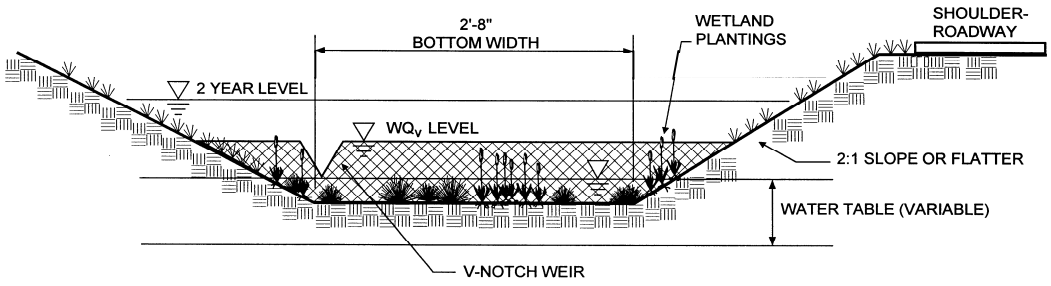
Dry swales are used at low density residential projects or for very small impervious areas.

This example does not constitute a design and is for illustrative purposes only.

O-2	**Figure 6.07.19** Example of Wet Swale	O-2



PLAN VIEW



PROFILE

Wet swales are ideal for treating highway runoff in low lying or flat terrain areas.

This example does not constitute a design and is for illustrative purposes only.

6.08 Stormwater Credits for Innovative Site Planning, from the Maryland Stormwater Design Manual, Chapter 5.0

Note: The text from this section has been adapted from the *Maryland Stormwater Design Manual, Volumes I & II (2000)* [1]. Adaptations have been made for local natural conditions and criteria. Additional adaptations may be necessary but shall be as approved by the City.

(1) Schueler, T. and Claytor, R. 2000. *2000 Maryland Stormwater Design Manual Volumes 1&2*. Prepared for the Maryland Department of the Environment Water Management Administration. Center for Watershed Protection. Ellicott City, MD.

This section describes each of the credits for the groups of non-structural practices, specifies minimum criteria to be eligible for the credit, and provides an example of how the credit is calculated. Clearly both of the site designs used to illustrate the credits could be more creative to provide more non-structural opportunities.

In general, the stormwater sizing criteria provide a strong incentive to reduce impervious cover at development sites (e.g., WQ_v, Cp_v and Q_p). Storage requirements for all of the stormwater sizing criteria are directly related to impervious cover. Thus, significant reductions in impervious cover result in smaller required storage volumes and, consequently, lower BMP construction costs.

These and other site design techniques can help to reduce impervious cover, and consequently, the stormwater treatment volume needed at a site. The techniques presented in this chapter are considered options to be used by the designer to help reduce the need for stormwater BMP storage capacity. Due to safety codes, soil conditions, and topography, some of these site design features will be restricted. Designers are encouraged to consult with the City to determine restrictions on non-structural strategies.

NOTE: In this section, *italics* indicate mandatory performance criteria, whereas suggested design criteria are shown in normal typeface.

These credits are an integral part of a project's overall stormwater management plan and BMP storage volume calculation. Therefore, use of these credits shall be documented at the initial (concept) design stage, documented with submission of final grading plans, and verified with "as-built" certifications. If a planned credit is not implemented, then BMP volumes shall be increased appropriately to meet WQ_v, Cp_v and Q_p where applicable.

Table 6.08.1 Summary of Stormwater Credits

Stormwater Credit	WQ_v	Cp_v or Q_p
Natural Area Conservation	Reduce Site Area	Forest/meadow CN for natural areas
Disconnection of Rooftop Runoff	Reduced R_v	Longer t_c (increased flow path). CN credit.
Disconnection of Non-Rooftop Runoff	Reduced R_v	Longer t_c (increased flow path). CN credit.
Sheet Flow to Buffers	Subtract contributing site area to BMP	CN credit.
Open Channel Use	May meet WQ_v,	Longer t_c (increased flow path). No CN credit.
Environmentally Sensitive Development	Meets WQ_v	No CN credit. t_c may increase.

6.08.01 Credit 1: Natural Area Conservation Credit

Natural Area Conservation Credit

A stormwater credit is given when natural areas are conserved at development sites, thereby retaining pre development hydrologic and water quality characteristics. A simple WQ_v credit is granted for all conservation areas permanently protected under conservation easements. Examples of natural area conservation include:

- forest retention areas
- wetlands, streams, and associated buffers
- other lands in protective easement (floodplains, open space, steep slopes)

Under the credit, a designer can subtract conservation areas from total site area when computing the water quality volume. The volumetric runoff coefficient, R_v, is still calculated based on the percent impervious cover for the entire site.

As an additional incentive, the post development curve number (CN) used to compute the Cp_v or Qp_2, and Qp_{25} for all natural areas protected by conservation easements can be assumed to be woods in good condition when calculating the total site CN.

As an example, the required WQ_v for a ten acre site with three acres of impervious area and three acres of protected conservation area before the credit would be:

[use impervious percent as a whole number]

WQ_v = (P/12) (Rv) (A); where P=1.14", Rv=0.05+0.009(30)
WQ_v = (1.14/12) (0.32) (10 acres) = 0.304 acre-feet.

Under the credit, three acres of conservation are subtracted from total site area, which yields a smaller storage volume:

WQ_v = (1.14/12) (0.32) (7 acres) = 0.213 acre-feet.

Criteria for Natural Area Credit

To receive the credit, the proposed conservation area:

- *Shall not be disturbed during project construction (e.g., cleared or graded) except for temporary impacts associated with incidental utility construction or mitigation and forestation projects,*
- *Shall be protected by having the limits of disturbance clearly shown on all construction drawings and delimited in the field except as provided for above,*
- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked [Note: managed turf (e.g. playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management), and*
- *Shall be located on the development project.*

6.08.02 Credit 2: Disconnection of Rooftop Runoff Credit

Disconnection of Rooftop Runoff Credit

A credit is given when rooftop runoff is disconnected and then directed to a pervious area where it can either infiltrate into the soil or filter over it. The credit is typically obtained by grading the site to promote overland filtering or by providing bioretention areas.

If a rooftop is adequately disconnected, the disconnected impervious area can be deducted from total impervious cover (therefore reducing WQ_v).

Post development CNs for disconnected rooftop areas used to compute Cp_v and Qp can be assumed to be open space in good condition.

Criteria for Disconnection of Rooftop Runoff Credit

The credit is subject to the following restrictions:

- *This credit is only allowed on commercial/industrial properties.*
- *Disconnection must ensure no basement seepage,*
- *The contributing area of rooftop to a disconnected discharge shall be 500 square feet or less,*
- *The length of the "disconnection" shall be 75' or greater,*
- *Disconnections will only be credited for lot sizes greater than 6000 sq. ft.,*
- *The entire vegetative "disconnection" shall be on an average slope of 5.0% or less,*
- *The disconnection must drain continuously through a vegetated channel, swale, or through a filter strip to the property line or BMP,*
- *Downspouts must be at least 10 feet away from the nearest impervious surface to discourage "re-connections", and*
- *For those rooftops draining directly to a buffer, only the rooftop disconnection credit or the buffer credit can be used, not both.*

6.08.03 Credit 3: Disconnection of Non Rooftop Runoff Credit

Disconnection of Non Rooftop Runoff Credit

Credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). This credit can be obtained by grading the site to promote overland vegetative filtering or providing bioretention areas.

These "disconnected" areas can be subtracted from the impervious area when computing WQ_v.

Criteria for Disconnection of Non Rooftop Runoff Credit

The credit is subject to the following restrictions:

- *This credit is only allowed on commercial/industrial properties.*
- *The maximum contributing impervious flow path length shall be 75 feet,*
- *The disconnection must drain continuously through a vegetated channel, swale, or filter strip to the property line or BMP,*
- *The length of the "disconnection" must be equal to or greater than the contributing length,*
- *The entire vegetative "disconnection" shall be on an average slope of 5% or less,*
- *The surface imperviousness area to any one discharge location cannot exceed 1,000 ft2,*
- *Disconnections are encouraged on relatively permeable soils (HSG's A and B), and*
- *For those areas draining directly to a buffer, only the non-rooftop disconnection credit or the buffer credit can be used, not both.*

6.08.04 Credit 4: Sheetflow to Buffer Credit

Sheetflow to Buffer Credit

This credit is given when stormwater runoff is effectively treated by a natural buffer to a stream or forested area. Effective treatment is achieved when pervious and impervious area runoff is discharged to a grass or forested stream buffer through overland flow. The use of a filter strip is also recommended to treat overland flow in the green space of a development site. The credits include:

1. The area draining by sheet flow to a stream buffer is subtracted from the total site area in the WQ_v calculation.
2. A *wooded* CN can be used for the contributing area if it drains to a forested buffer.

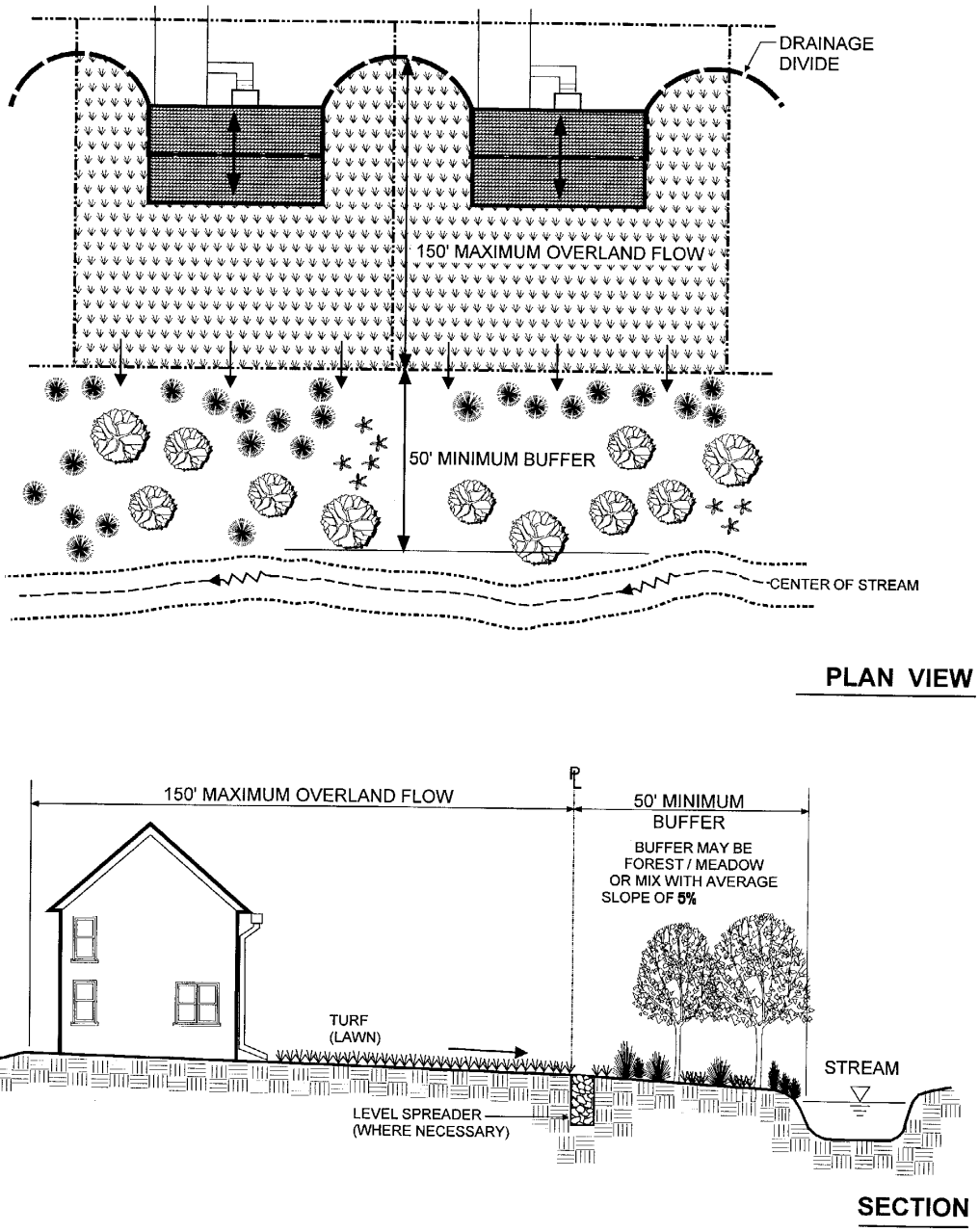
Criteria for Sheetflow to Buffer Credit

The credit is subject to the following conditions:

- *The minimum buffer width shall be 50 feet as measured from bankfull elevation or centerline of the buffer,*
- *The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces,*
- *Runoff shall enter the buffer as sheet flow. Either the average contributing overland slope shall be 5.0% or less, or a level spreading device shall be used where sheet flow can no longer be maintained (see Detail No. 9 in Appendix D-8 of the Maryland Stormwater Design Manual),*
- *Not applicable if rooftop or non-rooftop disconnection is already provided (see Credits 2 & 3),*
- *Buffers shall remain unmanaged other than routine debris removal, and*
- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked [Note: managed turf (e.g. playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management).*

Figure 6.08.1 illustrates how a stream buffer or filter strip can be used to treat stormwater from adjacent pervious and impervious areas.

Figure 6.08.1 Example of Stream Buffer Credit Option



6.08.05 Credit 5: Grass Channel Credit

Definition of Grass Channel Credit (in lieu of Curb and Gutter):

Credit may be given when open grass channels are used to reduce the volume of runoff and pollutants during smaller storms (e.g., < 1 inch). The schematic of the grass channel is provided in Figure 5.3.

If designed according to the following criteria, the grass channel will meet the WQ_v.

CNs for channel protection or peak flow control (Cp_v or Q_p) will not change.

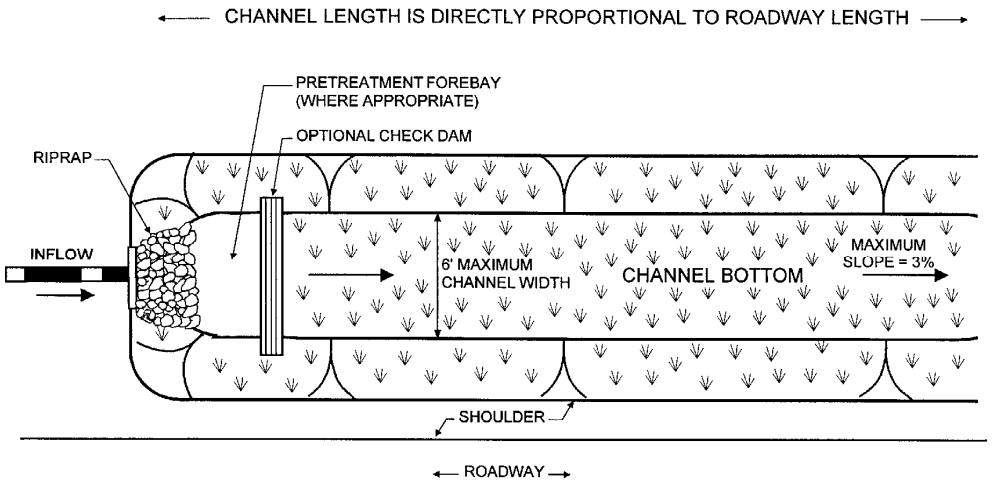
Criteria for the Grass Channel Credit

The WQ_v credit is obtained if a grass channel meets the following criteria:

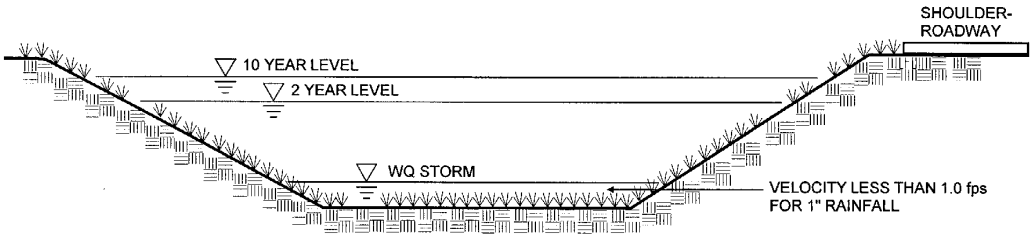
- *The maximum flow velocity for runoff from the one-inch rainfall shall be less than or equal to 1.0 fps (see Appendix D-10 for methodology to compute flowrate),*
- *The maximum flow velocity for runoff from the 15-year, 20-minute design event shall be non erosive,*
- *The bottom width shall be 2 feet minimum and 8 feet maximum,*
- *The side slopes shall be 3:1 or flatter,*
- *The channel slope shall be less than or equal to 4.0%, and*
- *Not applicable if rooftop disconnection is already provided (see Credit 2).*
- *In addition to the requirements above, Grass Channels shall meet the requirements of Engineered Channels in Section 6.03.*

An example of a grass channel is provided in Figure 6.08.2.

Figure 6.08.2 Example of Grass Channel



PLAN VIEW



SECTION

6.08.06 Credit 6: Environmentally Sensitive Development Credit

Environmentally Sensitive Development
Credit is given when a group of environmental site design techniques are applied to low density or residential development. The credit eliminates the need for structural practices to treat the WQ_v and is intended for use on large lots.

Criteria for Environmentally Sensitive Development Credit

These criteria can be met without the use of structural practices in certain low density residential developments when the following conditions are met:

For Single Lot Development:

- *Total site impervious cover is less than 15%,*
- *Lot size must be at least one acre,*
- *Rooftop runoff is disconnected in accordance with the criteria outlined under Credit 2, and*
- *Grass channels are used to convey runoff versus curb and gutter.*

For Multiple Lot Development:

- *Total site impervious cover is less than 15%,*
- *Lot size must be at least one acre if clustering techniques are not used,*
- *If clustering techniques are used, the average lot density shall not be greater than one acre.*
- *Rooftop runoff is disconnected in accordance with the criteria outlined under Credit 2,*
- *Grass channels are used to convey runoff versus curb and gutter,*
- *A minimum of 25% of the site is protected in natural conservation areas (by permanent easement or other similar measure), and*
- *The design shall address stormwater (WQv, Cpv and/or Qp) for all roadway and connected impervious surfaces.*

6.08.07 Dealing with Multiple Credits

Site designers are encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined (e.g., disconnecting rooftops and protecting natural conservation areas). However, credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area).

LIST OF TABLES, FIGURES AND FORMS

P FACTOR FOR RUNOFF

% IMPERVIOUS	DURATION OF RAIN IN MINUTES					
	15	20	30	60	90	120
0	0.30	0.35	0.41	0.51	0.56	0.60
5	0.32	0.37	0.43	0.53	0.58	0.62
10	0.34	0.39	0.46	0.56	0.60	0.64
15	0.36	0.41	0.48	0.58	0.62	0.66
20	0.38	0.44	0.50	0.60	0.64	0.67
25	0.40	0.46	0.52	0.62	0.66	0.69
30	0.42	0.48	0.54	0.64	0.68	0.71
35	0.44	0.50	0.57	0.66	0.70	0.73
40	0.46	0.52	0.59	0.68	0.72	0.74
45	0.48	0.54	0.61	0.71	0.74	0.76
50	0.50	0.56	0.63	0.73	0.75	0.78
55	0.52	0.58	0.65	0.75	0.77	0.80
60	0.54	0.60	0.68	0.77	0.79	0.81
65	0.56	0.63	0.70	0.79	0.81	0.83
70	0.58	0.65	0.72	0.81	0.83	0.85
75	0.60	0.67	0.74	0.84	0.85	0.87
80	0.62	0.69	0.76	0.86	0.87	0.88
85	0.64	0.71	0.79	0.88	0.89	0.90
90	0.66	0.73	0.81	0.90	0.91	0.92
95	0.68	0.75	0.83	0.92	0.93	0.94
100	0.70	0.77	0.85	0.94	0.95	0.95

VALUES OF P FOR 0% AND 100% ARE THOSE USED FOR ST. LOUIS MODIFIED 9-1939

RAINFALL INTENSITY OF 1 INCH PER HOUR ON 1 ACRE = 1.008 CU. FT. PER SECOND ON 1 ACRE

= 1 CU. FT. PER SEC ON 1 ACRE

(APPROXIMATELY)

P x I = Q = RUNOFF IN CU. FT. PER SEC. PER ACRE FOR GIVEN % IMPERVIOUS OF CONTRIBUTING AREA DURING A RAINFALL OF GIVEN INTENSITY CORRESPONDING TO THE GIVEN DURATION AND A SELECTED FREQUENCY.

I = INTENSITY OF RAINFALL IN INCHES PER HOUR FOR GIVEN DURATION AND GIVEN FREQUENCY.

$\frac{\text{RUNOFF}}{\text{RAINFALL}}$ = P = RATIO OF RUNOFF CONTRIBUTING BY AN AREA OF GIVEN % IMPERVIOUSNESS FOR A GIVEN DURATION PERIOD TO THE RAINFALL OF A GIVEN INTENSITY CORRESPONDING TO THE SAME DURATION PERIOD AND A SELECTED FREQUENCY.

TABLE 6-1

P.I. FACTOR IN CUBIC FEET PER SECOND PER ACRE

DURATION OF RAIN IN MINUTES	% IMPERVIOUS	15-YEAR RAINFALL FREQUENCY						20-YEAR RAINFALL FREQUENCY					
		15	20	30	60	90	120	15	20	30	60	90	120
	0	1.59	1.61	1.52	1.22	1.04	0.92	1.65	1.68	1.60	1.29	1.08	0.96
	5	1.70	1.70	1.59	1.27	1.08	0.95	1.76	1.78	1.68	1.34	1.11	0.99
	10	1.80	1.79	1.68	1.33	1.12	0.97	1.87	1.87	1.77	1.40	1.15	1.02
	15	1.91	1.89	1.76	1.38	1.15	1.00	1.98	1.97	1.85	1.45	1.19	1.05
	20	2.01	2.00	1.85	1.43	1.18	1.03	2.09	2.09	1.95	1.50	1.22	1.07
	25	2.12	2.09	1.92	1.49	1.22	1.06	2.20	2.18	2.03	1.56	1.26	1.10
	30	2.23	2.19	2.00	1.54	1.26	1.08	2.31	2.28	2.11	1.61	1.30	1.13
	35	2.33	2.28	2.09	1.58	1.29	1.11	2.42	2.38	2.20	1.66	1.33	1.16
	40	2.44	2.39	2.16	1.63	1.33	1.13	2.53	2.50	2.28	1.71	1.37	1.18
	45	2.54	2.48	2.26	1.69	1.37	1.16	2.64	2.59	2.38	1.78	1.41	1.22
	50	2.65	2.58	2.33	1.74	1.40	1.19	2.75	2.69	2.46	1.83	1.44	1.24
	55	2.76	2.67	2.41	1.79	1.43	1.22	2.86	2.78	2.54	1.88	1.48	1.27
	60	2.86	2.76	2.50	1.85	1.47	1.24	2.97	2.88	2.63	1.94	1.52	1.30
	65	2.97	2.88	2.57	1.90	1.51	1.27	3.08	3.00	2.71	1.99	1.56	1.33
	70	3.07	2.97	2.66	1.94	1.54	1.29	3.19	3.10	2.81	2.04	1.59	1.35
	75	3.18	3.06	2.74	2.00	1.58	1.32	3.30	3.19	2.89	2.10	1.63	1.38
	80	3.29	3.15	2.81	2.05	1.62	1.35	3.41	3.29	2.96	2.15	1.67	1.41
	85	3.39	3.24	2.90	2.10	1.65	1.38	3.52	3.38	3.06	2.21	1.70	1.44
	90	3.50	3.36	2.98	2.16	1.68	1.40	3.63	3.50	3.14	2.27	1.74	1.46
	95	3.60	3.45	3.07	2.21	1.72	1.43	3.74	3.60	3.24	2.32	1.78	1.50
	100	3.71	3.54	3.15	2.26	1.76	1.45	3.85	3.70	3.32	2.37	1.81	1.52
	RAINFALL	5.30	4.60	3.70	2.40	1.86	1.53	5.50	4.80	3.90	2.52	1.92	1.60

TABLE 6-2

P.I. VALUES FOR VARIOUS IMPERVIOUS CONDITIONS
(15 YEAR & 20 YEAR RAINFALL FREQUENCIES)

P.I. FACTOR IN CUBIC FEET PER SECOND PER ACRE

DURATION OF RAIN IN MINUTES	% IMPERVIOUS	2-YEAR RAINFALL FREQUENCY						5-YEAR RAINFALL FREQUENCY					
		15	20	30	60	90	120	15	20	30	60	90	120
	0	1.08	1.09	1.00	0.79	0.66	0.58	1.31	1.3	1.25	1.00	0.83	0.72
	5	1.15	1.15	1.05	0.82	0.68	0.60	1.40	1.41	1.31	1.04	0.86	0.74
	10	1.22	1.21	1.11	0.86	0.70	0.61	1.48	1.48	1.38	1.09	0.89	0.76
	15	1.30	1.27	1.16	0.89	0.73	0.63	1.57	1.56	1.44	1.13	0.92	0.79
	20	1.37	1.35	1.22	0.92	0.74	0.64	1.66	1.65	1.52	1.17	0.94	0.80
	25	1.44	1.41	1.27	0.96	0.77	0.66	1.74	1.73	1.58	1.22	0.97	0.83
	30	1.51	1.47	1.32	0.99	0.79	0.68	1.83	1.81	1.64	1.25	1.00	0.85
	35	1.58	1.54	1.38	1.02	0.81	0.70	1.92	1.88	1.72	1.29	1.03	0.87
	40	1.66	1.61	1.43	1.05	0.84	0.71	2.01	1.98	1.78	1.33	1.06	0.89
	45	1.73	1.67	1.49	1.09	0.86	0.73	2.09	2.05	1.85	1.38	1.09	0.91
	50	1.80	1.74	1.54	1.12	0.88	0.74	2.18	2.13	1.92	1.42	1.11	0.93
	55	1.87	1.80	1.59	1.16	0.90	0.76	2.27	2.20	1.98	1.46	1.14	0.95
	60	1.94	1.86	1.65	1.19	0.92	0.78	2.35	2.28	2.05	1.51	1.17	0.97
	65	2.02	1.94	1.70	1.23	0.95	0.80	2.44	2.38	2.11	1.55	1.20	1.00
	70	2.09	2.00	1.76	1.26	0.97	0.81	2.53	2.45	2.19	1.59	1.23	1.01
	75	2.16	2.06	1.81	1.29	0.99	0.83	5.62	2.53	2.25	1.64	1.26	1.04
	80	2.23	2.12	1.85	1.33	1.02	0.85	2.70	2.60	2.31	1.68	1.29	1.06
	85	2.30	2.19	1.92	1.36	1.04	0.86	2.79	2.68	2.39	1.72	1.31	1.08
	90	2.38	2.26	1.96	1.40	1.06	0.88	2.88	2.77	2.45	1.76	1.34	1.10
	95	2.45	2.33	2.03	1.43	1.08	0.90	2.96	2.85	2.52	1.80	1.37	1.12
	100	2.52	2.39	2.07	1.46	1.11	0.91	3.05	2.93	2.58	1.84	1.40	1.10
	RAINFALL	3.60	3.10	2.44	1.55	1.17	0.96	4.36	3.80	3.04	1.96	1.48	1.20

TABLE 6-3

P.I. VALUES FOR VARIOUS IMPERVIOUS CONDITIONS
(2 YEAR & 5 YEAR RAINFALL FREQUENCIES)

P.I. FACTOR IN CUBIC FEET PER SECOND PER ACRE

DURATION OF RAIN IN MINUTES	% IMPERVIOUS	10-YEAR RAINFALL FREQUENCY						100-YEAR RAINFALL FREQUENCY					
		15	20	30	60	90	120	15	20	30	60	90	120
	0	1.48	1.51	1.42	1.15	0.95	0.83	2.10	2.17	2.06	1.68	1.40	1.18
	5	1.57	1.59	1.49	1.19	0.99	0.86	2.24	2.29	2.16	1.75	1.45	1.22
	10	1.67	1.68	1.57	1.25	1.02	0.88	2.38	2.42	2.28	1.83	1.50	1.24
	15	1.77	1.76	1.64	1.29	1.05	0.90	2.52	2.54	2.38	1.90	1.55	1.28
	20	1.87	1.87	1.73	1.34	1.08	0.92	2.66	2.70	2.51	1.96	1.59	1.31
	25	1.97	1.96	1.80	1.40	1.11	0.95	2.80	2.82	2.61	2.05	1.64	1.35
	30	2.07	2.04	1.87	1.44	1.15	0.97	2.94	2.95	2.71	2.11	1.69	1.38
	35	2.16	2.13	1.95	1.49	1.18	1.00	3.08	3.07	2.84	2.18	1.74	1.42
	40	2.26	2.24	2.02	1.53	1.22	1.02	3.22	3.22	2.94	2.24	1.79	1.45
	45	2.36	2.32	2.11	1.59	1.25	1.05	3.36	3.35	3.06	2.33	1.84	1.49
	50	2.46	2.41	2.18	1.63	1.28	1.07	3.50	3.47	3.16	2.39	1.88	1.52
	55	2.56	2.49	2.25	1.68	1.31	1.10	3.64	3.60	3.26	2.46	1.93	1.56
	60	2.66	2.58	2.34	1.73	1.34	1.12	3.78	3.72	3.39	2.54	1.98	1.59
	65	2.76	2.69	2.40	1.78	1.38	1.15	3.92	3.88	3.49	2.61	2.03	1.63
	70	2.85	2.77	2.49	1.82	1.41	1.17	4.06	4.00	3.61	2.67	2.07	1.66
	75	2.95	2.86	2.56	1.88	1.44	1.19	4.20	4.12	3.71	2.76	2.13	1.70
	80	3.05	2.95	2.63	1.92	1.48	1.21	4.34	4.25	3.82	2.82	2.18	1.72
	85	3.15	3.03	2.72	1.97	1.50	1.24	4.48	4.37	3.94	2.89	2.21	1.76
	90	3.25	3.14	2.79	2.03	1.54	1.26	4.62	4.53	4.04	2.97	2.26	1.79
	95	3.35	3.23	2.87	2.07	1.57	1.29	4.76	4.65	4.17	3.04	2.31	1.83
	100	3.44	3.31	2.94	2.11	1.61	1.31	4.90	4.77	4.27	3.10	2.36	1.86
	RAINFALL	4.92	4.30	3.46	2.25	1.70	1.38	7.00	6.20	5.02	3.30	2.50	1.96

TABLE 6-4

P.I. VALUES FOR VARIOUS IMPERVIOUS CONDITIONS
(10 YEAR & 100 YEAR RAINFALL FREQUENCIES)

TABLE 6-5: NRCS RUNOFF COEFFICIENTS

Runoff curve numbers for urban areas[1]					
Cover description		**Curve numbers for hydrologic soil group**			
Cover type and hydrologic condition	**Average percent impervious area[2]**	**A**	**B**	**C**	**D**
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries etc.)[3]					
Poor condition (grass cover<50%)		**68**	**79**	**86**	**89**
Fair (grass cover 50%-75%)		**49**	**69**	**79**	**84**
Good (grass cover>75%)		**30**	**61**	**74**	**80**
Impervious areas					
Pavement, roof, etc.		**98**	**98**	**98**	**98**
Streets and roads					
Paved w/ curb (excluding right-of-way)		**98**	**98**	**98**	**98**
Paved w/ roadside swale (including right-of-way)		**83**	**89**	**92**	**93**
Gravel (including right-of-way)		**76**	**85**	**89**	**91**
Dirt (including right-of-way)		**72**	**82**	**87**	**89**
Urban Districts					
Commercial and business	**85**	**89**	**92**	**94**	**95**
Industrial	**72**	**81**	**88**	**91**	**93**
Residential districts by avg. lot size					
1/8 acre or less	**65**	**77**	**85**	**90**	**92**
1/4 acre	**38**	**61**	**75**	**83**	**87**
1/3 acre	**30**	**57**	**72**	**81**	**86**
1/2 acre	**25**	**54**	**79**	**80**	**85**
1 acre	**20**	**51**	**68**	**79**	**84**
2 acre	**12**	**46**	**65**	**77**	**82**
Developing urban areas					
Newly graded areas					
(pervious areas only, no vegetation)[4]		**77**	**86**	**91**	**94**

From USDA, TR-55, Urban Hydrology for Small Watersheds, 1986

[1]Average runoff condition, and Ia=0.2S.

[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious are considered equivalent to open space in good hydrologic condition. CN's for other combination of conditions may be computed as shown in TR-55, 1986—Figure 2-3 or 2-4.

[3]CN's shown are equivalent to those of pasture. Composite DN's may be computed for other combinations of open space cover type.

[4]Composite CN's to use for the design of temporary measures during grading and construction should be computed as shown in TR-55, 1986—Figure 2-3 or 2-4.

TABLE 6-5: (Continued)

Runoff curve numbers for undeveloped areas[1]					
		Curve numbers for hydrologic soil group			
Cover description	**Hydrologic Condition**	**A**	**B**	**C**	**D**
Pasture, grassland or range-continuous grazing[2]	**Poor**	**68**	**79**	**86**	**89**
	Fair	**49**	**69**	**79**	**84**
	Good	**39**	**61**	**74**	**80**
Meadow-continuous grass, protected from grazing, generally mowed for hay.		**30**	**58**	**71**	**78**
Brush-brush/weed/grass mix with brush the major element[3]	**Poor**	**48**	**67**	**77**	**83**
	Fair	**35**	**56**	**70**	**77**
	Good	**30[4]**	**48**	**65**	**73**
Woods-grass combination (orchard or tree farm)[5]	**Poor**	**57**	**73**	**82**	**86**
	Fair	**43**	**65**	**76**	**82**
	Poor	**32**	**58**	**72**	**79**
Woods[6]	**Poor**	**45**	**66**	**77**	**83**
	Fair	**36**	**60**	**73**	**79**
	Good	**30[4]**	**55**	**70**	**77**
Farmsteads-buildings, lanes, driveways, and surrounding lots		**59**	**74**	**82**	**86**

[1]Average runoff condition, and I_a=0.2S.
[2]Poor: <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and not heavily grazed.
[3]Poor: <50% ground cover
Fair: 50 to 75% ground cover
Good: >75% ground cover
[4]Actual curve number is less than 30; use CN = 30 for runoff computations.
[5]CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
[6]Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

TABLE 6-6
MANNING'S ROUGHNESS COEFFICIENTS

Type of Channel	n
Closed Conduits	
Reinforced Concrete Pipe (RCPs)	0.013
Reinforced Concrete Elliptical Pipe	0.013
Corrugated Metal Pipe (CMPs):	
2⅔ x ½in. Annular or Helical Corrugations unpaved - plain	0.024
2⅔ x ½in. Annular or Helical Corrugations paved invert	0.021
3x1 in. Annular or Helical Corrugations unpaved - plain	0.027
3x1 in. Annular or Helical Corrugations paved invert	0.023
6x2 in. Corrugations unpaved - plain	0.033
6x2 in. Corrugations paved invert	0.028
Vitrified Clay Pipe	0.013
Asbestos Cement Pipe	0.012
Open Channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.033
Grass (Sod)	0.030
Riprap	0.035
Grouted Riprap	0.030
Open Channels (Unlined) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Channels, not maintained, weeds & brush uncut	0.090
Natural Stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100
Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street Curbing	0.014

TABLE 6-7

CRITICAL SHEAR STRESSES FOR CHANNEL MATERIALS
(Solely for use in stream assessments as described in section 6.04.02. Not to be used as allowable shear stresses for design)

	psf
Granular Material	
Boulders (100 cm) (40 in)	20.295
Boulders (75 cm) (30 in)	15.222
Boulders (50 cm) (20 in)	10.148
Boulders (25.6 cm) (10 in)	5.196
Rip Rap	3.132
Cobbles (6.4 cm) (2.5 in)	1.299
Cobbles and shingles	1.100
Cobbles and shingles, **clear water**	0.910
Coarse sand (1mm)	0.015
Coarse sand (1mm)	0.015
Coarse gravel, noncolloidal (GW), **clear water**	0.300
Coarse gravel, noncolloidal, (GW)	0.670
Gravel (2cm)	0.406
Fine gravel	0.320
Fine gravel, **clear water**	0.075
Fine sand (0.125 mm)	0.002
Fine sand (0.125 mm) (SP)	0.002
Fine sand (SW), (SP), colloidal	0.075
Fine sand, colloidal, (SW), (SP), **clear water**	0.027
Graded loam to cobbles, noncolloidal (GM)	0.660
Graded loam to cobbles, noncolloidal,(GM), **clear water**	0.380
Graded silts to cobbles, colloidal (GC)	0.800
Graded silts to cobbles, colloidal, (GC), **clear water**	0.430
Fine Grained	
Resistant cohesive (CL), (CH)	1.044
Stiff clay, very colloidal, (CL)	0.460
Stiff clay, very colloidal, (CL), **clear water**	0.260
Moderate cohesive (ML-CL)	0.104
Ordinary firm loam (CL-ML)	0.150
Ordinary firm loam, (CL-ML), **clear water**	0.075
Alluvial silts, colloidal (CL-ML)	0.460
Alluvial silts, colloidal,(CL-ML), **clear water**	0.260
Alluvial silts, noncolloidal (ML)	0.150
Alluvial silts, noncolloidal, (ML), **clear water**	0.048
Sandy loam, noncolloidal (ML)	0.075
Sandy loam, noncolloidal, (ML), **clear water**	0.037
Silt loam, noncolloidal (ML)	0.110
Silt loam, noncolloidal, (ML), **clear water**	0.048
Shales and hardpans	0.67

Others	
Jute net	0.46
Plant cuttings	2.09
Well established dense vegetation to the normal low water	2.16
Geotextile (synthetic)	3.01
Large Woody Debris	3.13

Note: For non-cohesive soils, the table values are based on spherical particles and Shield equation, as follows: $\tau_c = \Theta(\gamma_s - \gamma) D$ where γ_s is the specific weight of sediment (165 pcf), γ is specific weight of water, D is the reference particle size, and Θ is the Shield's parameter (0.06 for gravel to cobble, 0.044 for sand). For cohesive soils the values are based on limited testing as reported in Chow (1988) and USDA (2001).

TABLE 6-8: BEST MANAGEMENT PRACTICE APPLICABLILITY MATRIX
(Adapted from Maryland Stormwater Design Manual Table 4.3)

Stormwater Management Practice		Treatment Suitability			Acceptable Use	
		Water Quality	Channel Protection	Flood Protection	Residential	Commercial/ Industrial
BMP Group 1. Stormwater Ponds						
P-1	Micropool extended detention pond	Y	Y	Y	Y	Y
P-2	Wet pond	Y	Y	Y	Y	Y
P-3	Wet extended detention pond	Y	Y	Y	Y	Y
P-4	Multiple pond system	Y	Y	Y	Y	Y
P-5	Pocket pond	Y	Y	Y	Y	Y
BMP Group 2. Stormwater Wetlands						
W-1	Shallow wetland	Y	Y	N	Y	Y
W-2	Extended detention shallow wetland	Y	Y	N	Y	Y
W-3	Pond/wetland system	Y	Y	N	Y	Y
W-4	Pocket wetland	Y	S	N	Y	Y
BMP Group 3. Infiltration Practices						
I-1	Infiltration trench	Y	S[1]	N	S[1]	S[1]
I-2	Infiltration basin	Y	S[1]	N	S[1]	S[1]
BMP Group 4. Filtering Practices						
F-1	Surface sand filter	Y	S	N	Y	Y
F-2	Underground sand filter	Y	N	N	N	Y
F-3	Perimeter sand filter	Y	N	N	Y	Y
F-4	Organic filter	Y	S	N	Y	Y
F-5	Pocket sand filter	Y	S	N	Y	Y
F-6	Bioretention	Y	S	N	Y	Y
BMP Group 5. Open Channel Practices						
O-1	Dry swale	Y	N	N	Y	Y
O-2	Wet swale	Y	N	N	S[2]	Y
Other Stormwater Management Practices						
	Dry extended detention pond	N	Y	Y	Y	Y
	Underground detention	Y	Y	Y	N	Y

Y: Yes S: Sometimes N: No

Notes:

1 Infiltration practices will be allowed on sites where it is proven that infiltration will work. This must be supported by a soils report.

2 Wet swales are not allowed on single-family residential projects. They may be allowed on condominium or apartment projects if maintenance is provided by a management company.

TABLE 6-9: **BEST MANAGEMENT PRACTICE PHYSICAL FEASIBILITY**
(Adapted from Maryland Stormwater Design Manual Table 4.4)

Physical Feasibility Factors

After BMP options have been narrowed down based on site factors, this table cross-references testing protocols needed to confirm physical conditions at the site. The six primary factors are:

Soils. The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note that more detailed geotechnical tests are usually required for infiltration feasibility and during design to confirm permeability and other factors (see Appendix D-1 of the Maryland Stormwater Design Manual).

Water Table. This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a BMP.

Drainage Area. This column indicates the recommended minimum or maximum drainage area that is considered suitable for the practice. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway is permitted or more than one practice can be installed. The minimum drainage areas indicated for ponds and wetlands are flexible depending on water availability (baseflow or groundwater) or the mechanisms employed to prevent clogging.

Slope Restriction. This column evaluates the effect of slope on the practice. Specifically, the slope restrictions refer to how flat the area where the practice is installed may be.

Head. This column provides an estimate of the elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the practice.

TABLE 6-9 (cont.): **BEST MANAGEMENT PRACTICE PHYSICAL FEASIBILITY**
(Adapted from Maryland Stormwater Design Manual Table 4.4)

CODE	BMP LIST	SOILS	WATER TABLE	DRAINAGE AREA (Acres)	SLOPE RESTRICT.	HEAD (ft)
P-1	Micropool ED	"A" Soils May Require Pond Liner "B" Soils May Require Testing	4 Feet[1] If Hotspot Or Aquifer	10 Min[2]	None	6 to 8 ft
P-2	Wet Pond			25 Min[2]		
P-3	Wet ED Pond					
P-4	Multiple Pond					
P-5	Pocket Pond	OK	Below WT	5 Max[3]		4 ft
W-1	Shallow Wetland	"A" Soils May Require Liner	4 Feet[1] If Hotspot Or Aquifer	25 Min	None	3 to 5 ft
W-2	ED Wetland					
W-3	Pond/Wetland					
W-4	Pocket Marsh	OK	Below WT	5 Max		2 to 3 ft
I-1	Infiltration Trench	*f* > 0.52 inch/hr	4 Feet[1]	5 Max	Installed in No More Than 15% Slopes	1 ft
I-2	Shallow Basin			10 Max		3 ft
F-1	Surface Sand Filter	OK	2 Feet	10 Max[3]	None	5 ft
F-2	Underground SF			2 Max[3]		5 to 7ft
F-3	Perimeter SF			2 Max[3]		2 to 3 ft
F-4	Organic Filter			5 Max[3]		2 to 4 ft
F-5	Pocket SF			5 Max[3]		2 to 5 ft
F-6	Bioretention	Made Soil				5 ft
O-1	Dry Swale	Made Soil	2 Feet	5 Max	4% Max Cross-slope	3 to 5 ft
O-2	Wet Swale	OK	Below WT	5 Max		1 ft

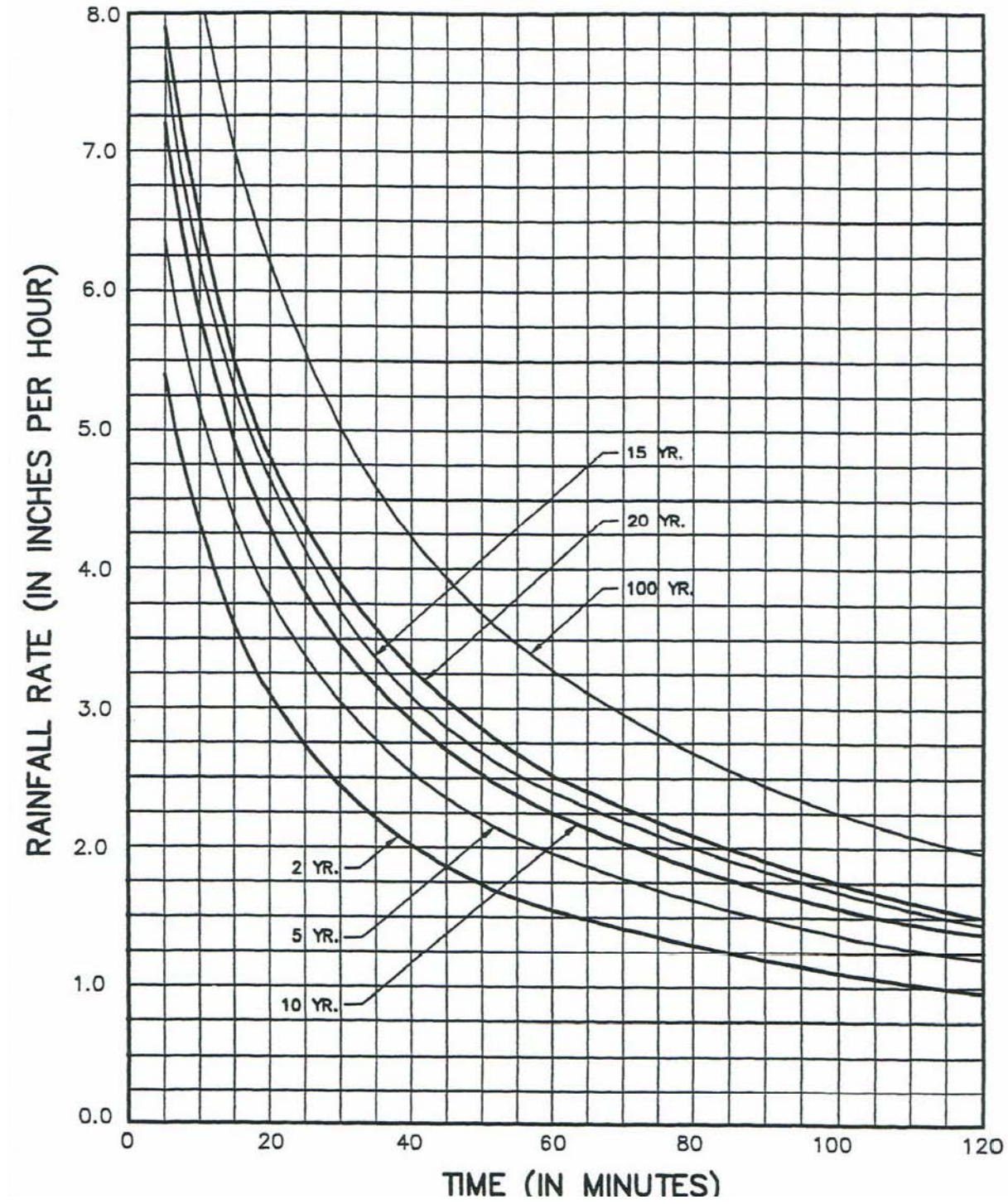


FIGURE 6-1

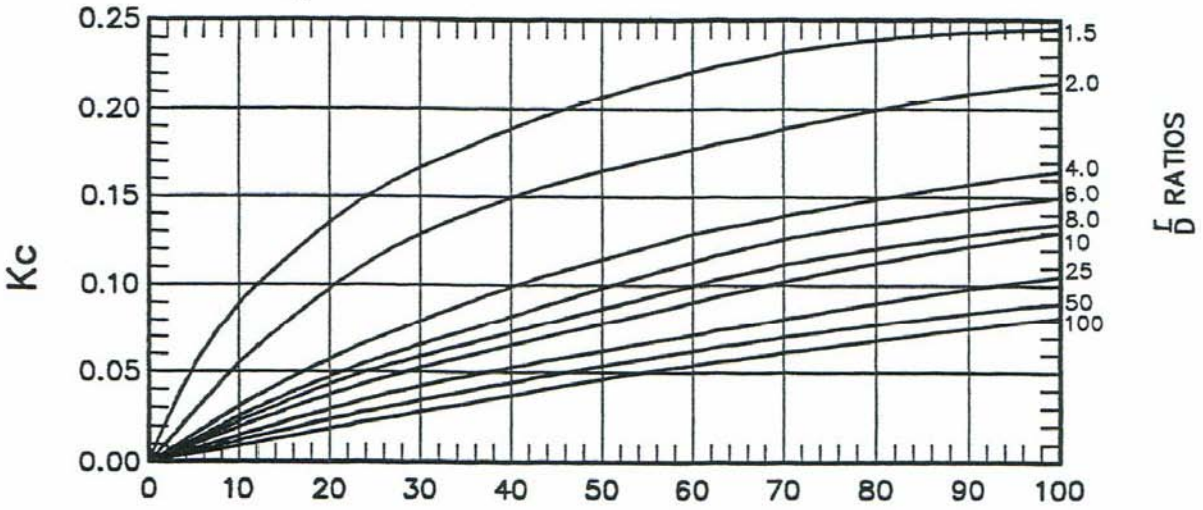
RAINFALL INTENSITY – DURATION CURVES
(2, 5, 10, 15, 20 & 100 YEAR RAINFALL FREQUENCIES)

SYMBOLS

D = DIAMETER OF PIPE
r = RADIUS OF CURVE
V = VELOCITY IN FT. PER SEC.
Kc = CURVE LOSS COEFFICIENT
h_c = HEAD LOSS DUE TO CURVED ALIGNMENT
α = DEFLECTION ANGLE IN RADIANS
C = FACTOR OF CONSERVATISM TO ACCOUNT FOR THE VARIATION IN THE EXPERIMENTAL DATA. FOR THESE CURVES C = 1.5 FOR THE DESIGN OF HYDRAULIC CAPACITY.
L_n = NATURAL LOG

$$Kc = C \frac{2\alpha}{\pi^2 (L_n \frac{r}{D} + \alpha)}$$

$$h_c = Kc \frac{V^2}{2g}$$



α = DEFLECTION ANGLE (IN DEGREES)

EXAMPLE

Q = 260cfs V = 13.2fps
D = 60" α = 90°
r = 50' $V^2/2g$ = 2.71'
r/D = 10

FROM α = 90° ON THE ABSCISSA FOLLOW A VERTICAL LINE UP TO THE INTERSECTION WITH THE $\frac{r}{D}$ = 10 CURVE. THEN TRANSFER ON A HORIZONTAL LINE TO THE ORDINATE AND READ THE CORRESPONDING CURVE LOSS COEFFICIENT
Kc = 0.123
THE HEAD LOSS DUE TO CURVED ALIGNMENT =

$$h_c = Kc \frac{V^2}{2g} = (0.123)(2.71) = 0.33$$

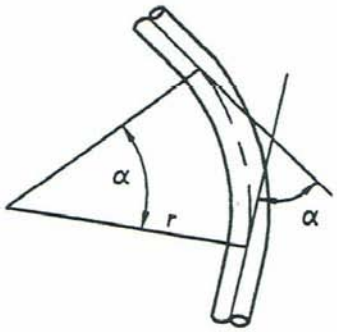


FIGURE 6-2

HEAD LOSS FOR CURVED
ALIGNMENT OF CONCRETE PIPES

GENERAL NOTES:

DO NOT SCALE DRAWING. FOLLOW DIMENSIONS

LOW POINT INLETS ARE CONTROLED BY CAPACITY AT GUTTER BASED ON PERCENT OF GRADE OF THE GUTTER AT THE BEGINNING POINT OF THE STANDARD SUMP, E.G., 0.5% GRADE, 2% CROSS SLOPE, 3" DEEP, 0.02n = 2.1 C.F.S.

ASSUME INLET INTERCEPTS 100% OF FLOW

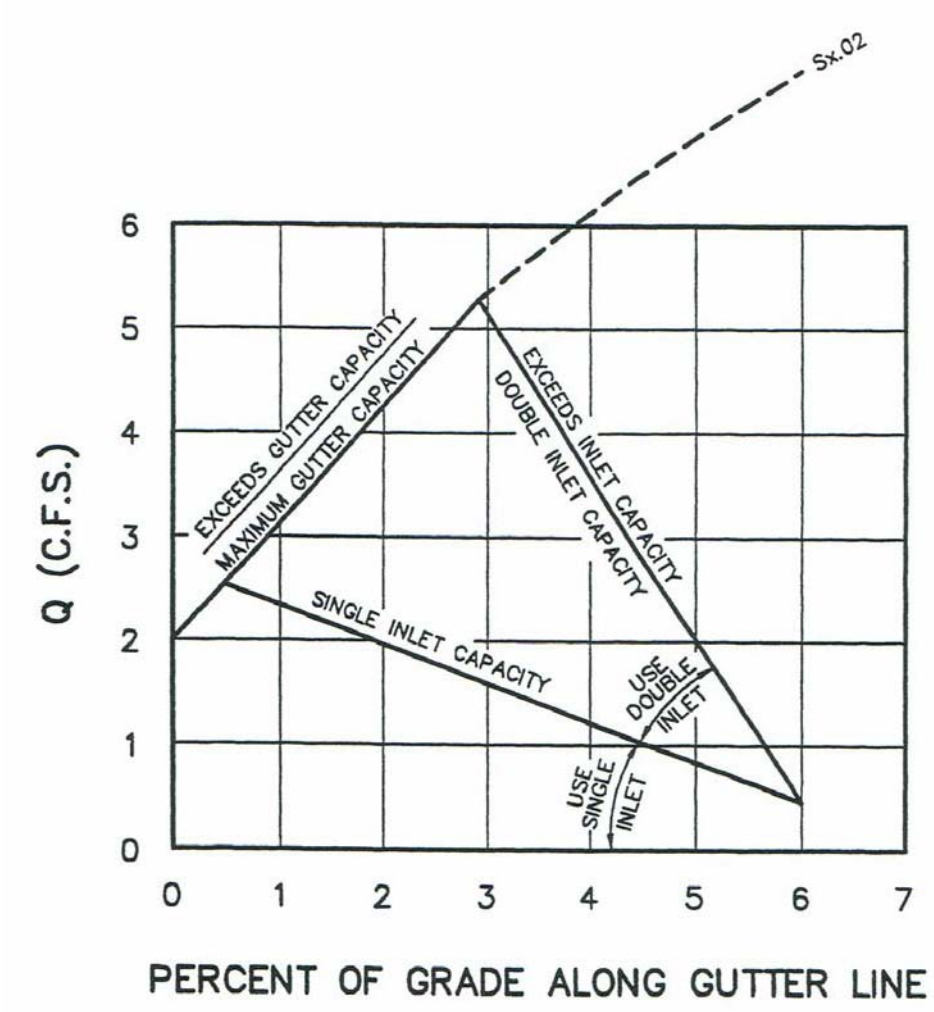
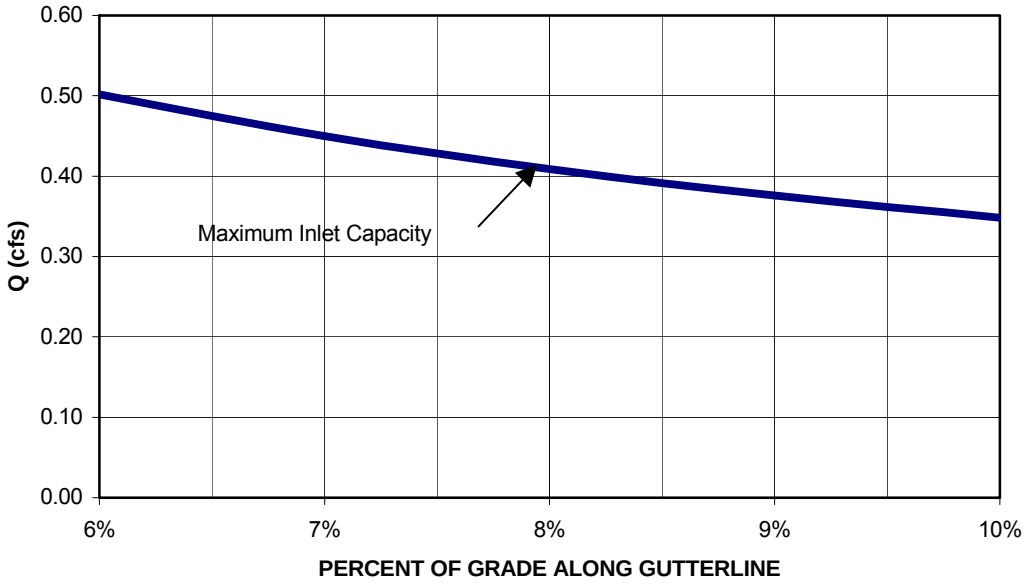


FIGURE 6-3

INLET AND GUTTER
INTERCEPT AND CAPACITY CHART

FIGURE 6-3A - ***DOUBLE INLET CAPACITY***

Standard Double Inlet, 6% to 10% Roadway Grade



Notes:

Assumes 100% capture by a standard double inlet under standard sump condition.

Based on FHWA HEC12 method for calculating curb inlet capacity on a continuous grade:

L_T=K*Q^0.42*S^0.3*(1/(n*S_e)^0.6

Solved for Q to determine total Q captured for given inlet length.

Inlet length = 13.5' = the length at front of curb
(Not including 2.5' curb rounding on DS end).

S_e = 0.053 ft/ft = composite cross slope with standard sump

Figure 6-4A: **NATURAL CHANNEL PLAN PROFILE EXHIBIT**

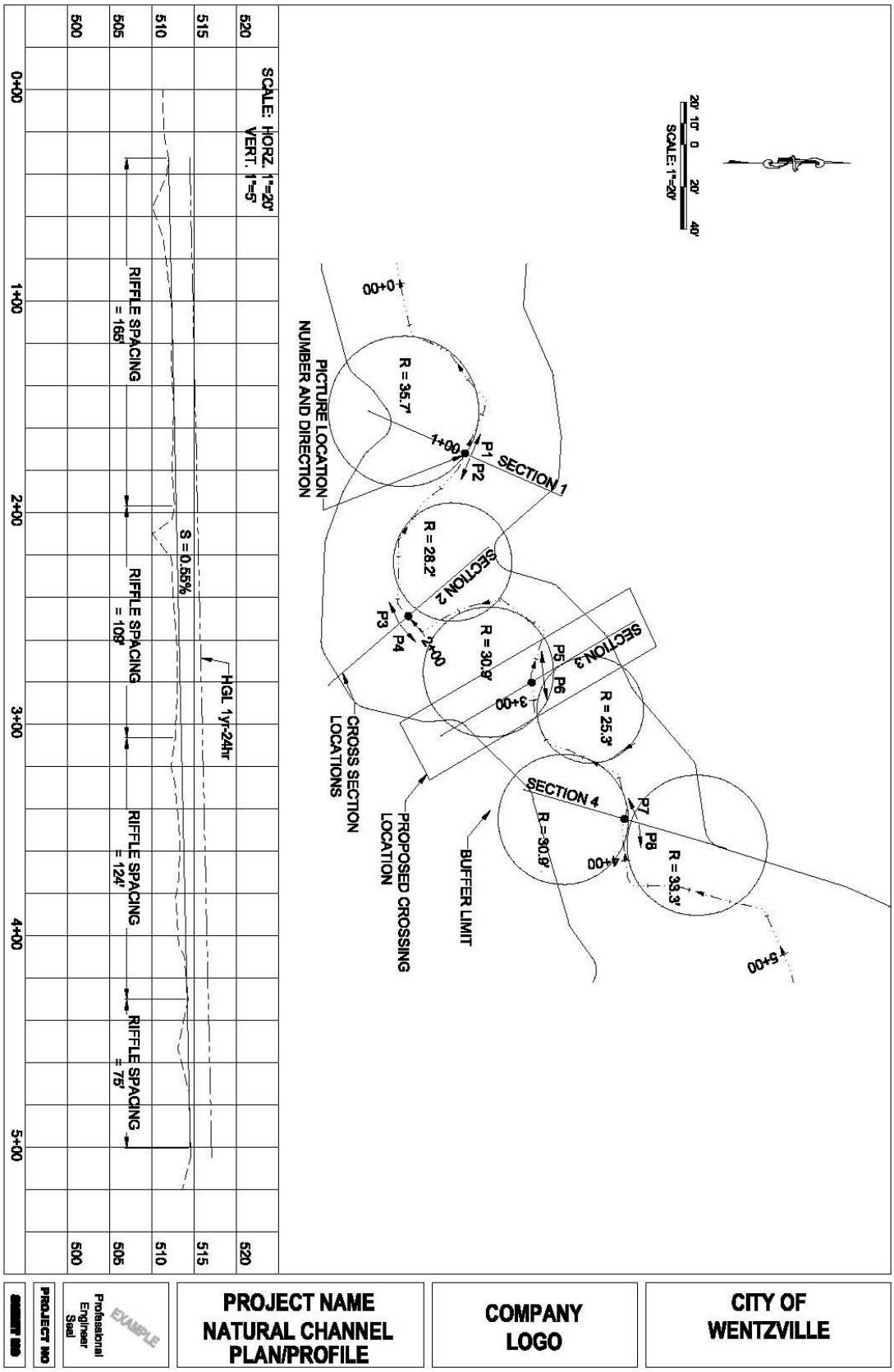


Figure 6-4B: **NATURAL CHANNEL CROSS SECTION EXHIBIT**

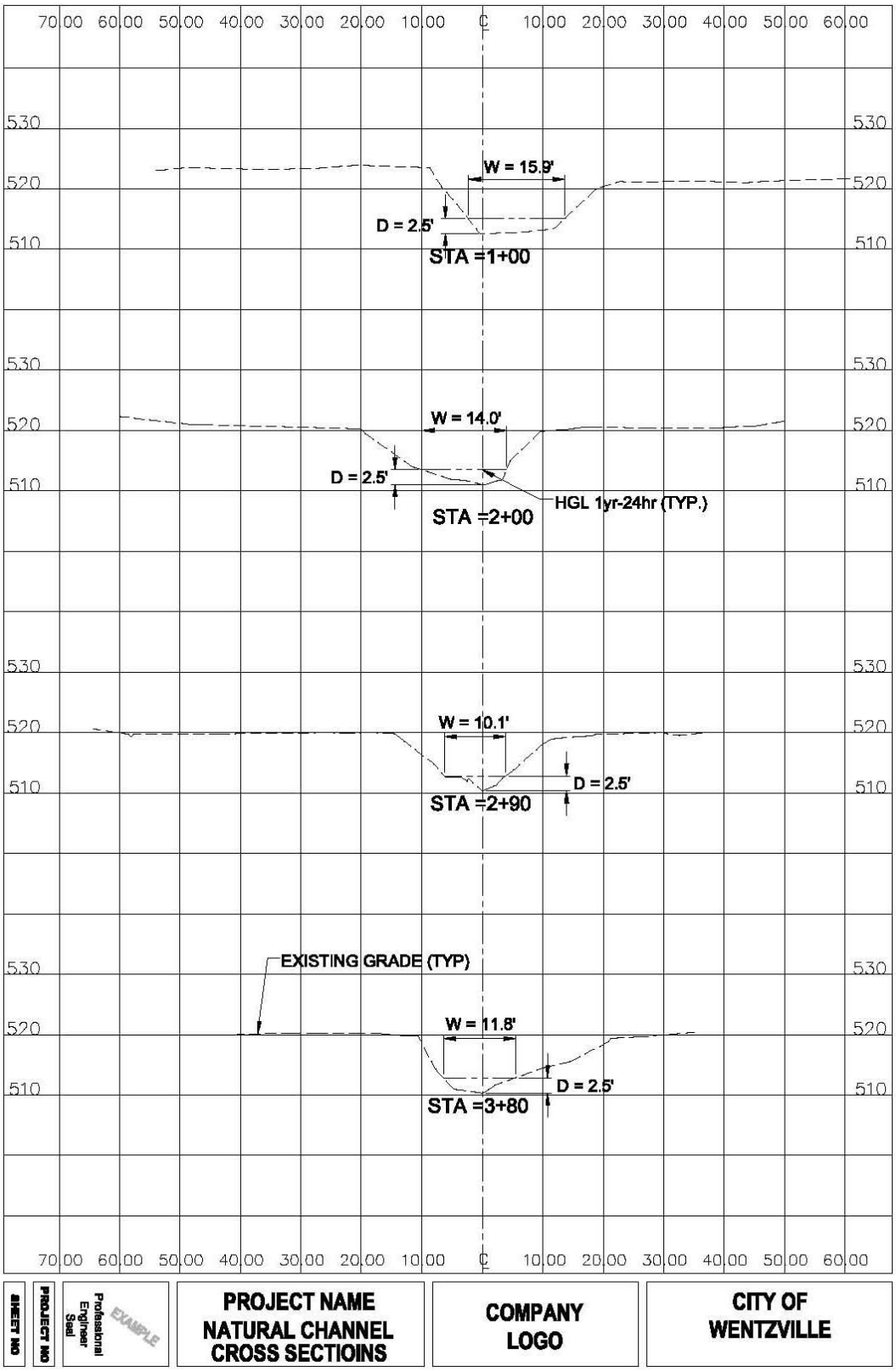
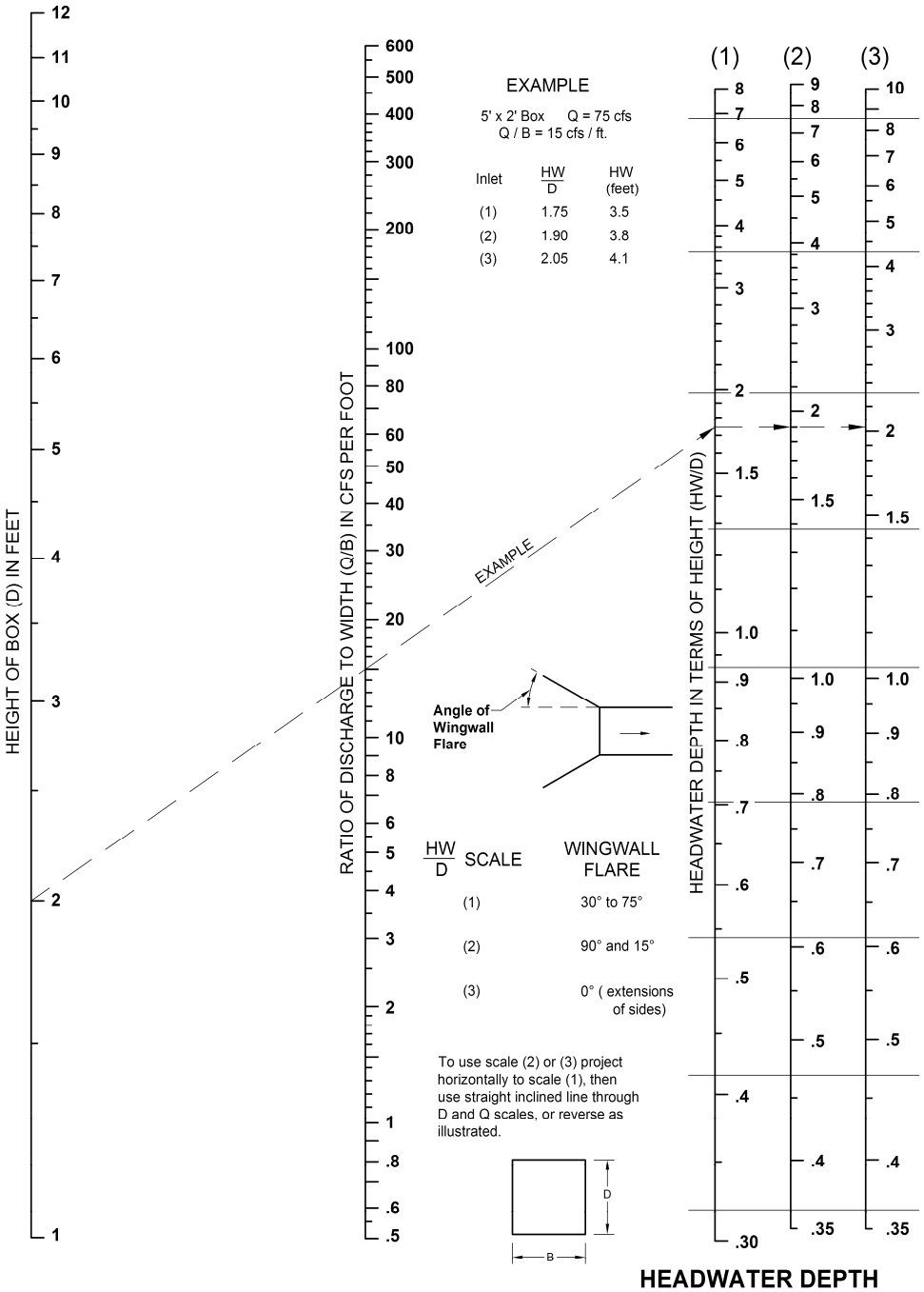


Figure 6-5A

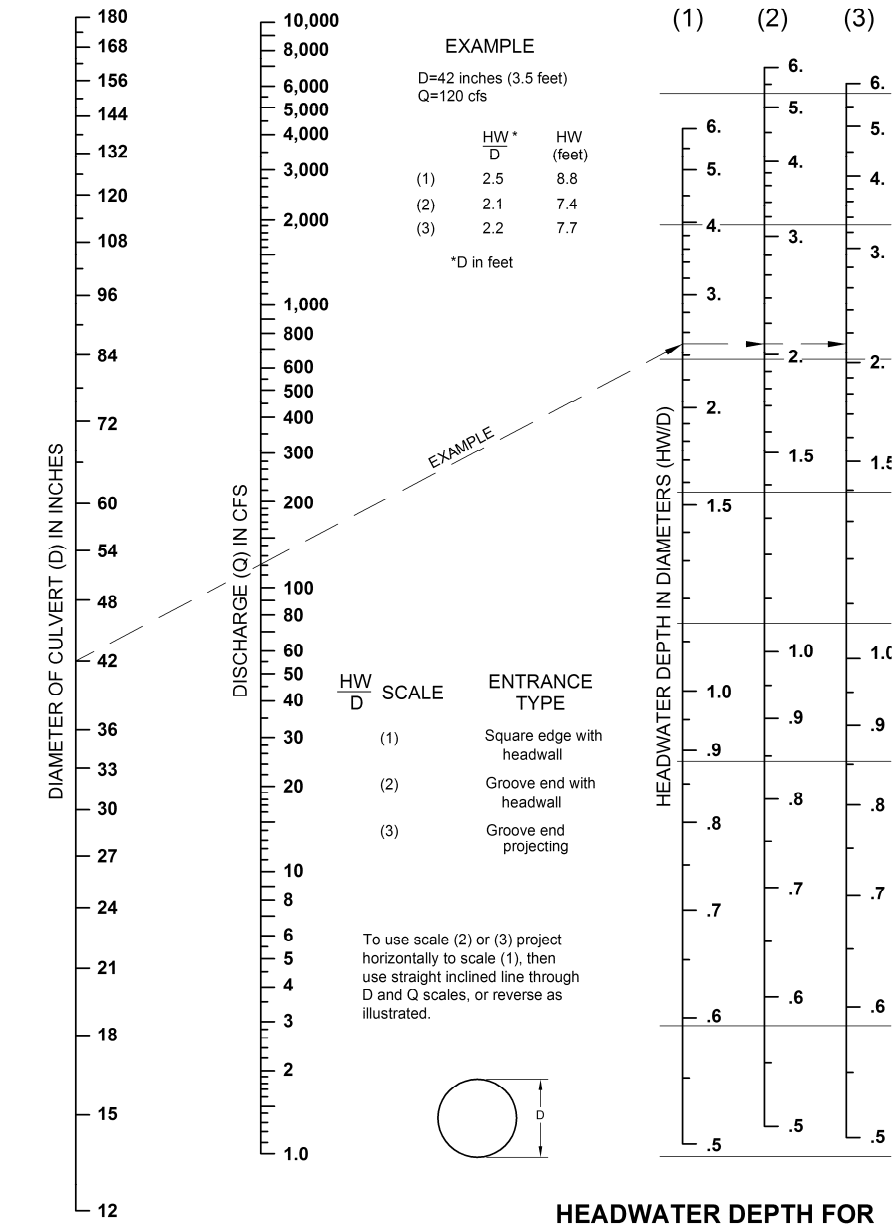
FIGURE 5603-1



BUREAU OF PUBLIC ROADS JAN. 1963

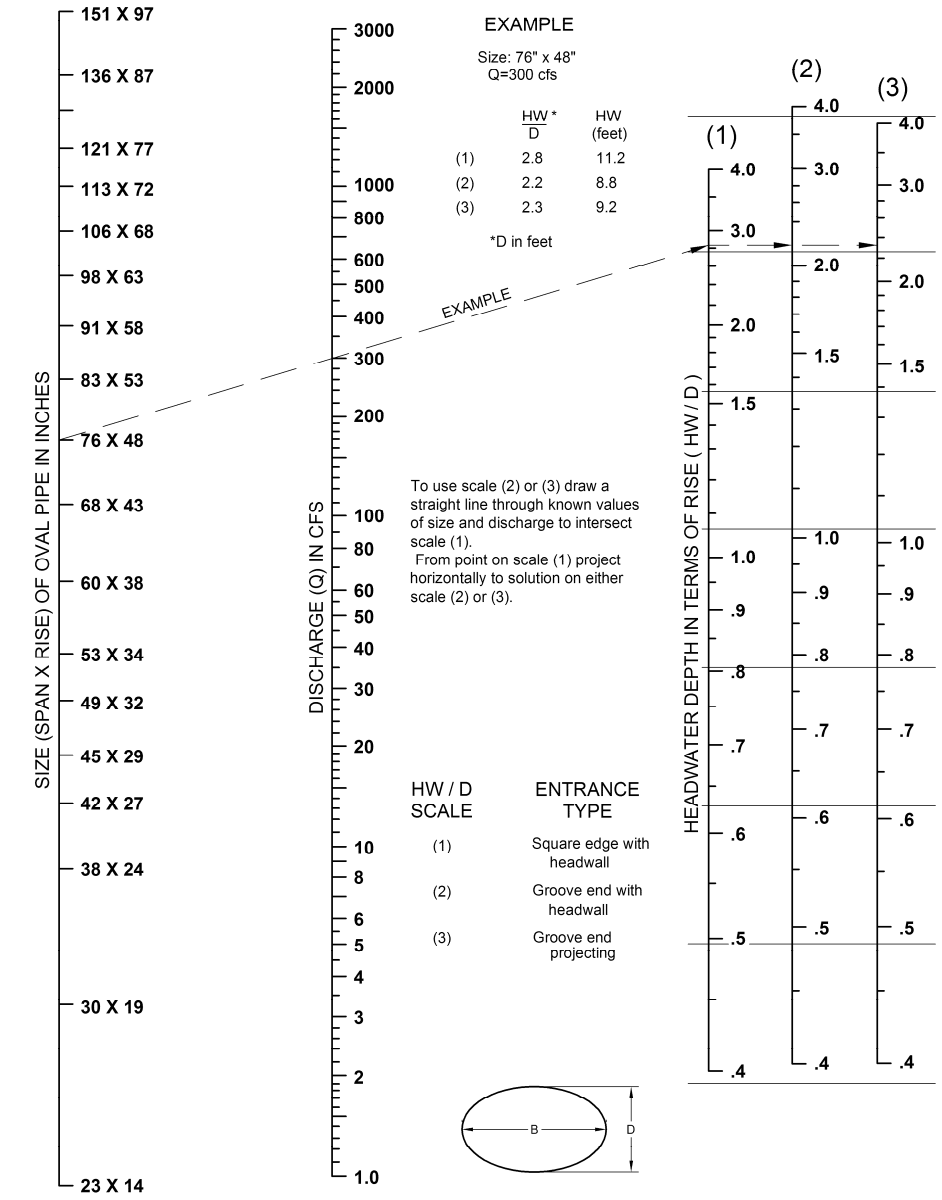
HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

Figure 6-5B



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

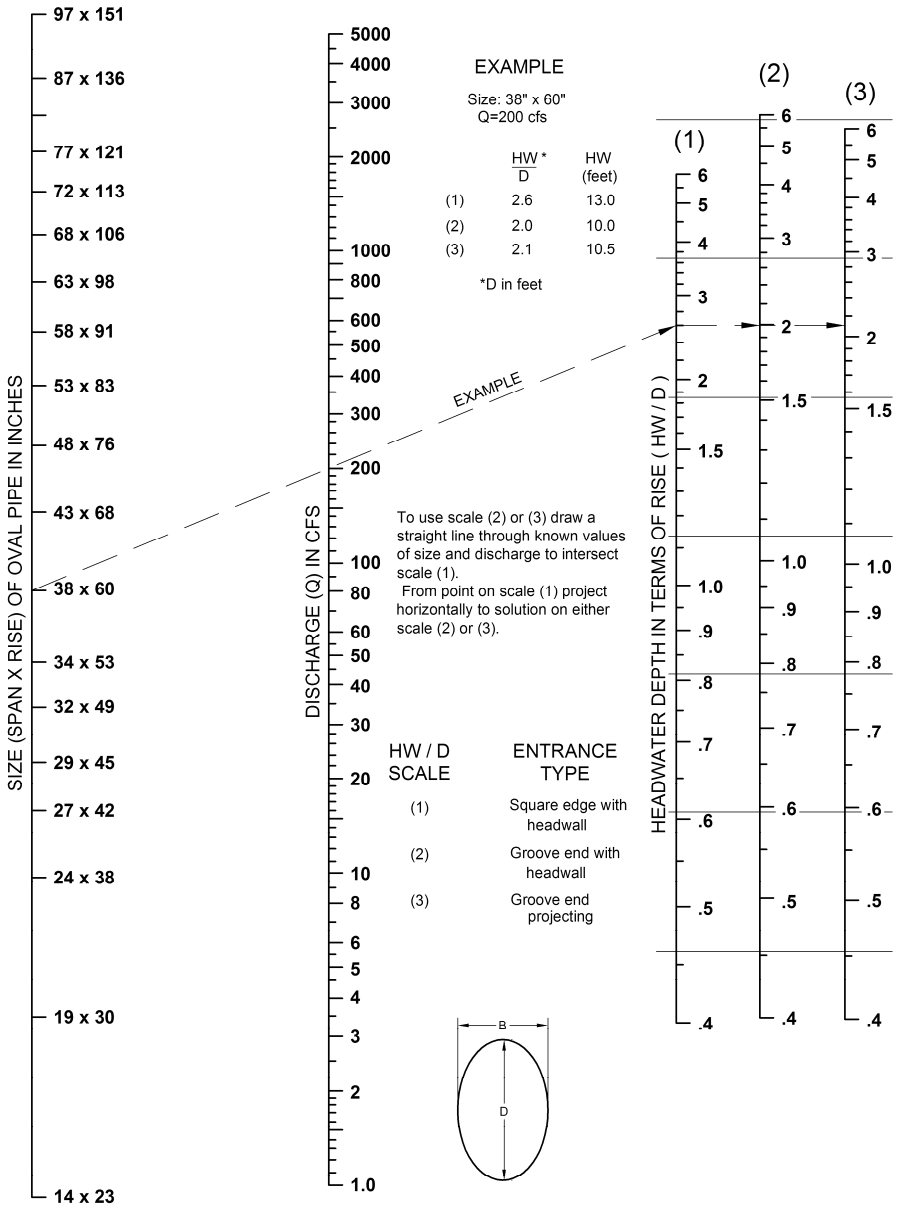
Figure 6-5C



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL

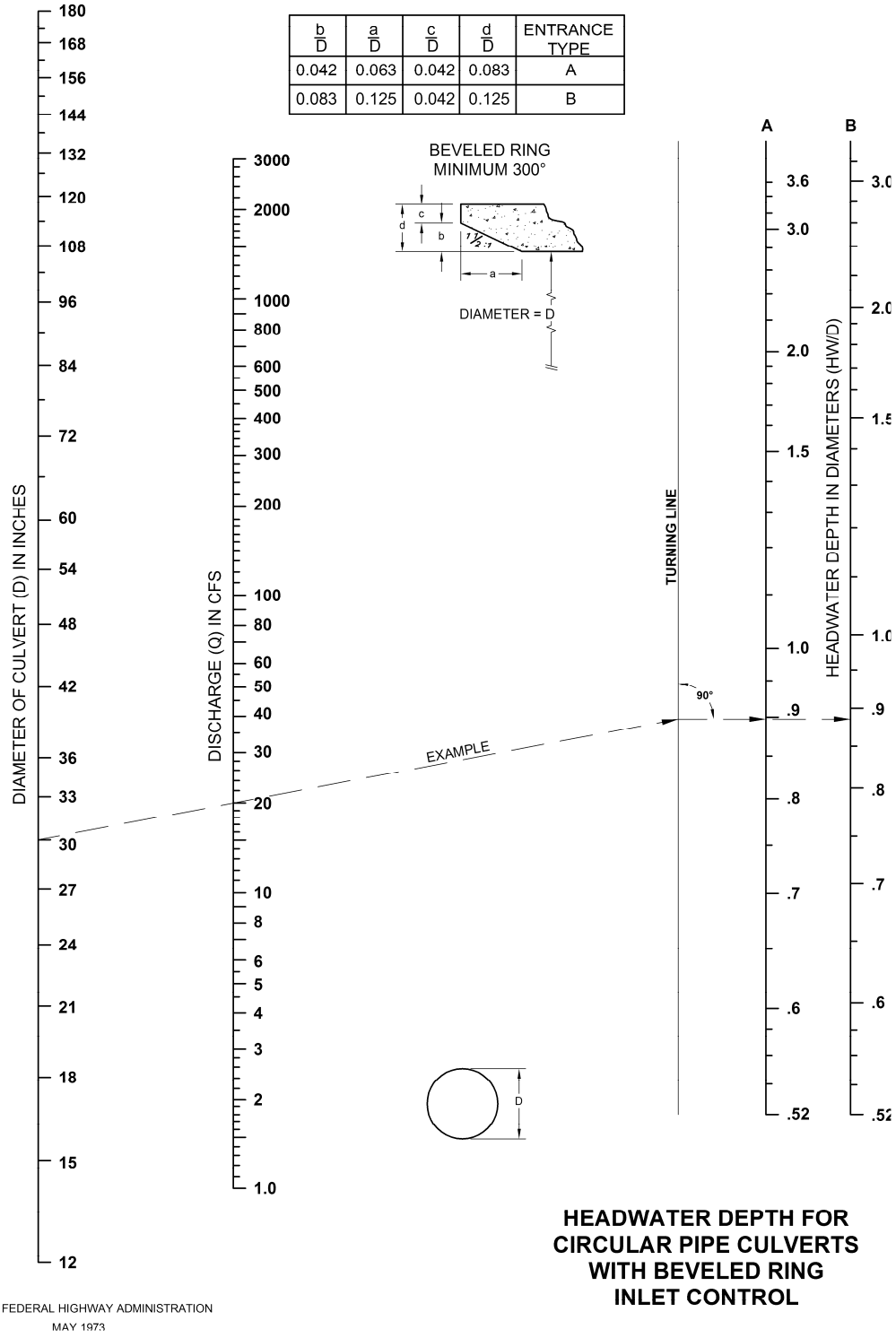
Figure 6-5D



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS VERTICAL WITH INLET CONTROL

Figure 6-5E



HEADWATER DEPTH FOR CIRCULAR PIPE CULVERTS WITH BEVELED RING INLET CONTROL

Figure 6-6A

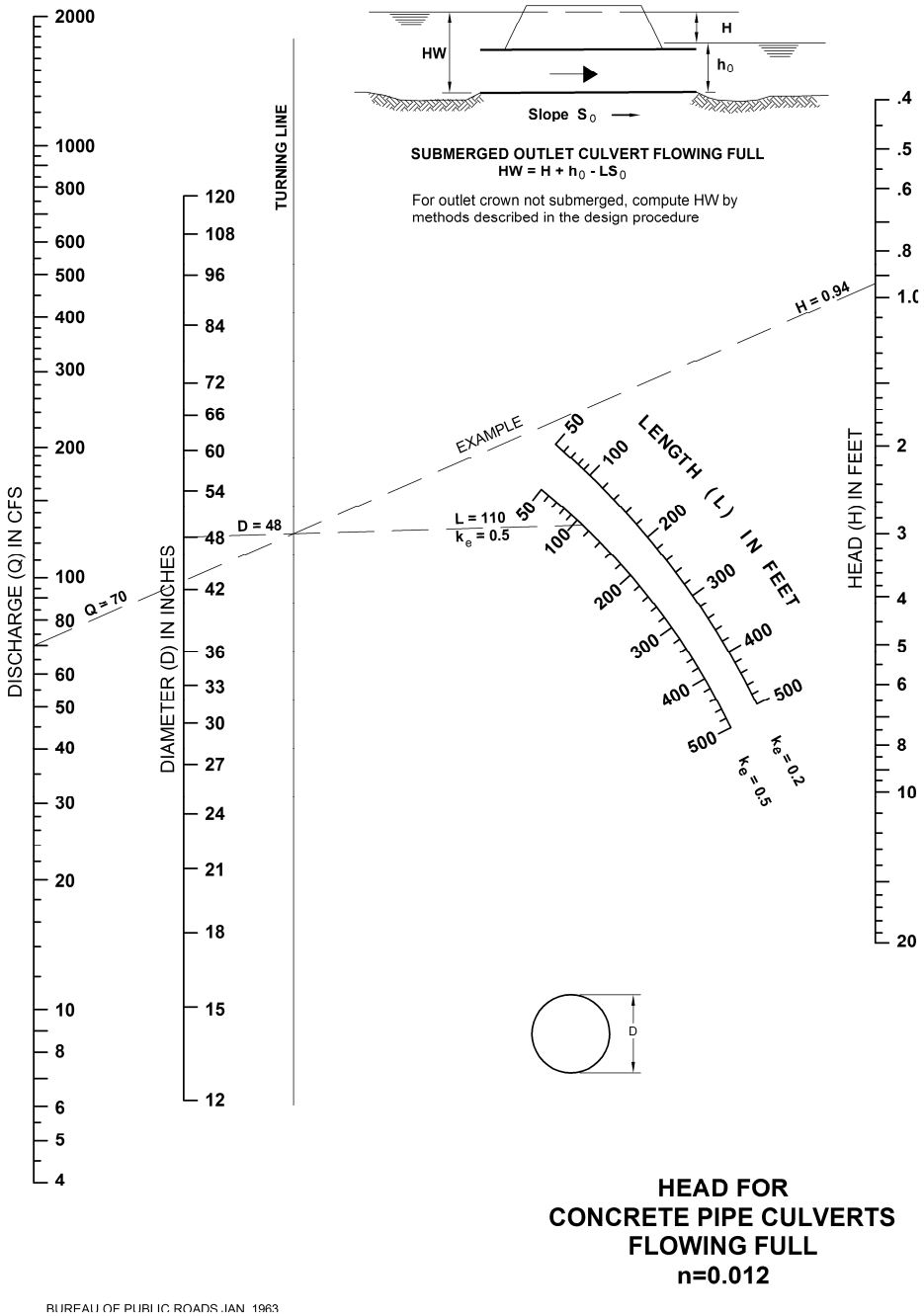
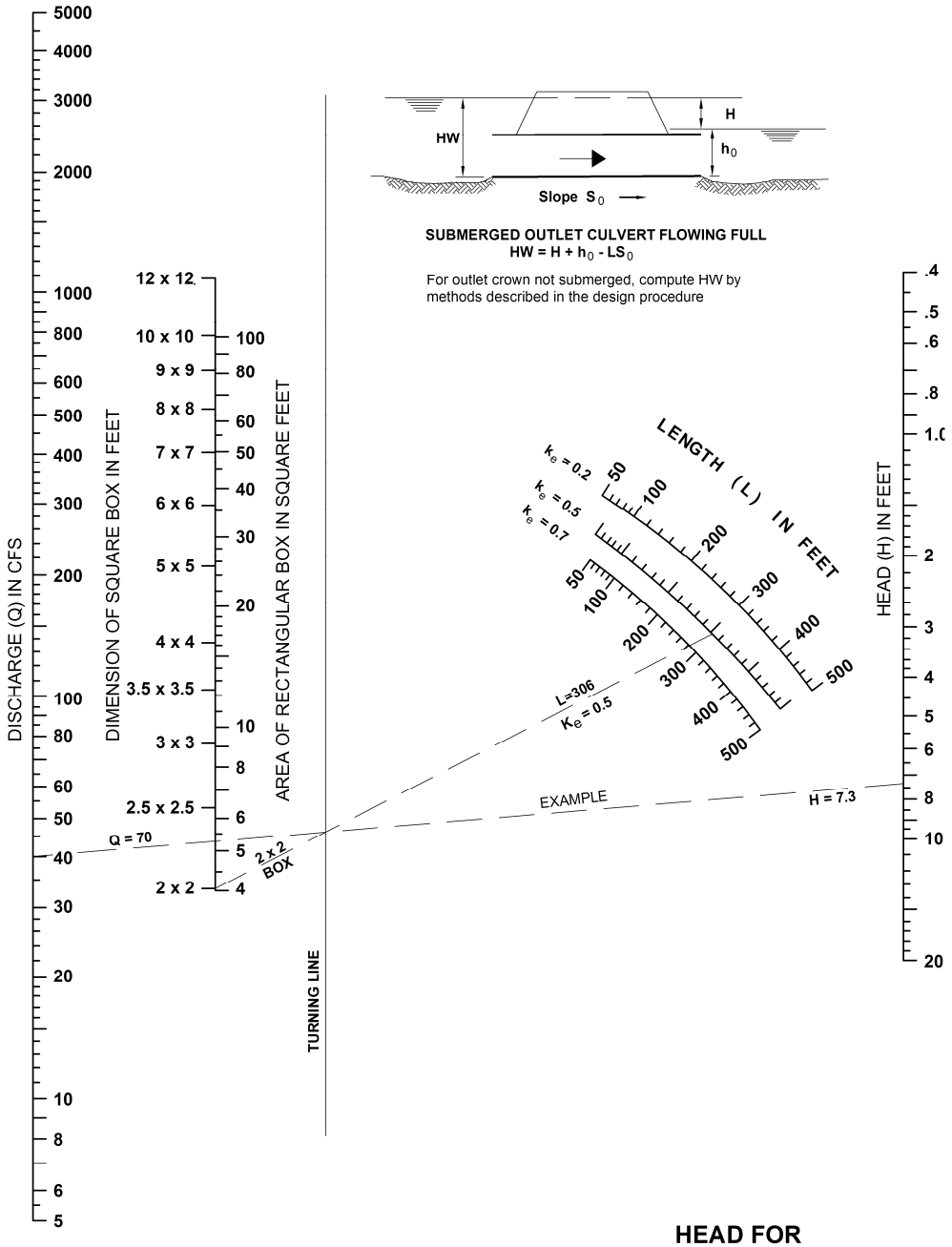

HW
H
h_0
Slope S_0
SUBMERGED OUTLET CULVERT FLOWING FULL
HW = H + h_0 - LS_0
For outlet crown not submerged, compute HW by methods described in the design procedure
DISCHARGE (Q) IN CFS
DIAMETER (D) IN INCHES
TURNING LINE
HEAD (H) IN FEET
LENGTH (L) IN FEET
EXAMPLE
Q = 70
D = 48
H = 0.94
L = 110
k_e = 0.5
k_e = 0.2
D
HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n=0.012
BUREAU OF PUBLIC ROADS JAN. 1963

Figure 6-6B



HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n=0.012

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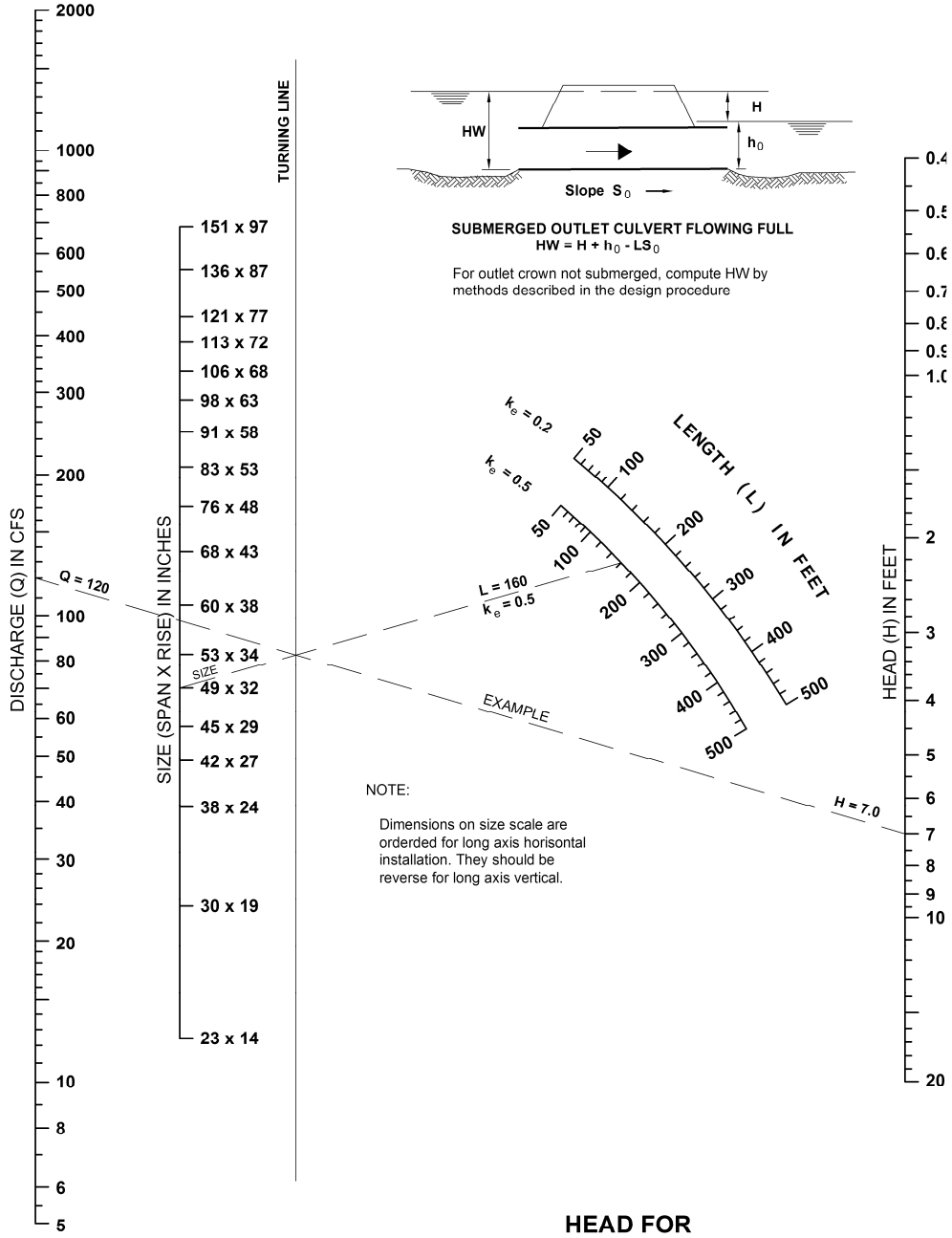
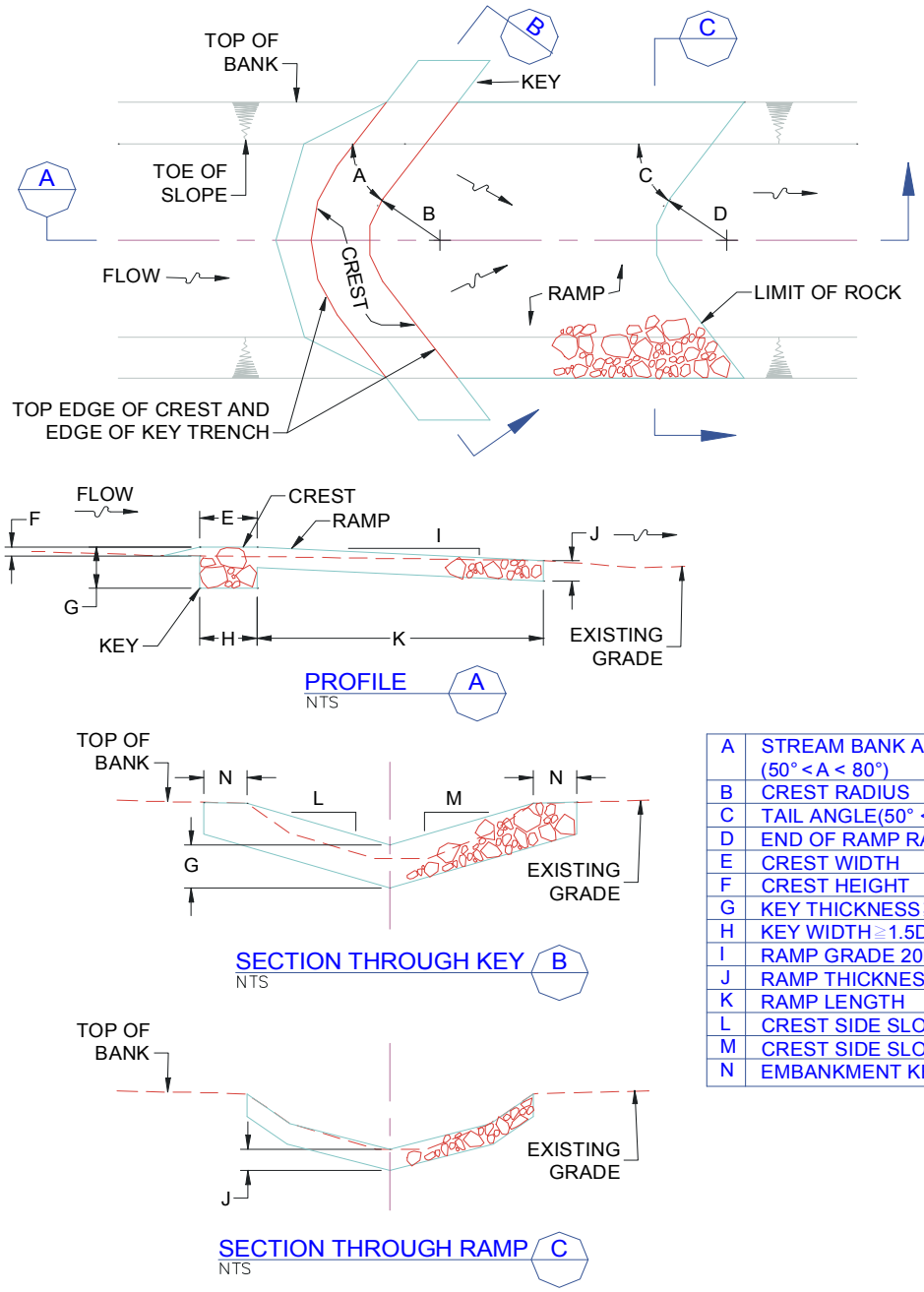
Figure 6-6C



HEAD FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS HORIZONTAL OR VERTICAL
FLOWING FULL
n=0.012

BUREAU OF PUBLIC ROADS JAN. 1963

Figure 6-7: **Grade Control Structure**



A	STREAM BANK ANGLE (50° < A < 80°)
B	CREST RADIUS
C	TAIL ANGLE(50° < A < 80°)
D	END OF RAMP RADIUS
E	CREST WIDTH
F	CREST HEIGHT
G	KEY THICKNESS ≥ 1.5D_{90}
H	KEY WIDTH ≥ 1.5D_{90}
I	RAMP GRADE 20H:1V
J	RAMP THICKNESS ≥ 1.5D_{100}
K	RAMP LENGTH
L	CREST SIDE SLOPE
M	CREST SIDE SLOPE
N	EMBANKMENT KEY

1. The depth of key trench shall be a minimum of 1.5 D_{90}. The crest shall slope downward from the stream bank to the center of the structure to focus the flow to the channel center. The tail ramp is generally sloped at 20 horizontal to 1 vertical and dissipates energy gradually over it length. The upstream face is not perpendicular to the flow but has an upstream oriented “V” or arch shape in plan form.
2. For item A, Stream Bank Angle, and item C Tail Angle, the lower end of the range should be used for softer soils.
3. For items L and M, crest angle, the typical range is 5 to 1 to 10 to 1.

FORM 6 - 1

4. Project:_____ Project Number:_____

Stream Name and Location: _____

Evaluated by: _____ Firm: _____ Date:_____

FORM 6-1: **Channel Condition Scoring Matrix**
(Adapted from Johnson et al 1999)

	Stability Indicator	Good (1)	Fair (2)	Poor (3)	Score (S)	Weight (W)	Rating S*W=(R)
1	Bank soil texture and coherence per Uniform Soil Classification using the visual-manual procedures (ASTM D 2488-00)	Cohesive materials, clay (CL), silty clay (CL-ML), massive limestone, continuous concrete, clay loam (ML-CL), silty clay loam (ML-CL), thinly bed limestone	Sandy clay (SC), sandy loam (SM), fractured thinly bedded limestone	Non-cohesive materials, shale in bank, (SM), (SP), (SW), (GC), (GM), (GP), (GW)		0.6	
2	Average bank slope angle as measured where obvious breaks in slope create a top of bank and toe of slope	Slopes ≤ 2H:1V on one or occasionally both banks	Slopes from 2H:1V to1.7H:1V common on one or both banks	Slopes steeper than to1.7H:1V on one or both banks		0.6	
3	Average bank height as measured from the lowest point in the channel cross section to the top of bank as defined in City of Wentzville Municipal Code, TitleIV, Regulation for the Protection of Natural Watercourses Ordinance #2863	Less than 6 feet	Greater than 6 and less than 12 feet	Greater than 12 feet		0.8	

FORM 6-1: **Channel Condition Scoring Matrix** (Adapted from Johnson et al 1999)							
4	Vegetative bank protection	Wide to medium band (≥ the width of the riparian buffer) of woody vegetation with 70-90% plant density and cover. Majority are hardwood, deciduous trees with well-developed understory layer, minimal root exposure	Narrow band (>20 feet up to the buffer width) of woody vegetation, poor species diversity, 50-70% plant density, most vegetation on top of bank and not extending onto bank slope, some trees leaning over bank, root exposure common	Thin or no band (20 feet or less) of woody vegetation, poor health, monoculture, many trees leaning over bank, extensive root exposure, turf grass to edge of bank		0.8	
5	Bank cutting	Little to some evident along channel bends and at prominent constrictions, some raw banks up to 4 foot	Significant and frequent. Cut banks 4 feet high. Root mat overhangs common.	Almost continuous cut banks, some over 4 feet high. Undercut trees with sod-rootmat overhangs common. Bank failures frequent		0.4	
6	Mass wasting (wedge or slide slope failure)	Little to some evidence of slight or infrequent mass wasting, past events healed over with vegetation. Channel width relatively uniform with only slight scalloping	Evidence of frequent and significant mass wasting events. Indications that higher flows aggravated undercutting and bank wasting. Channel width irregular with bank scalloping evident	Frequent and extensive mass wasting evident. Tension cracks, massive undercutting and bank slumping are considerable. Highly irregular channel width.		0.8	
7	Bar development	Bar width is less than ¼ of the channel width at low flow, well-consolidated, vegetated and composed of coarse bed material to slight recent growth of bar as indicated by absence of vegetation on part of bar	Bar widths ¼ to ½ of channel width at low flow with freshly deposited sand to small cobbles with sparse vegetation	Bar widths greater than ½ the channel width at low flow. Bars are composed of extensive deposits of finer bed material with little vegetation		0.6	
8	Debris jam potential	Slight – small amounts of debris in channel. Small jams could form	Moderate – noticeable debris of all sizes present	Significant – moderate to heavy accumulations of debris apparent		0.2	

FORM 6-1: **Channel Condition Scoring Matrix** (Adapted from Johnson et al 1999)							
9	Obstructions, flow deflectors and sediment traps	Negligible to few or small obstructions present causing secondary currents and minor bank and bottom erosion but no major influence on meander bend	Moderately frequent and occasionally unstable obstructions, noticeable erosion of channel. Considerable sediment accumulation behind obstructions	Frequent and unstable causing continual shift of sediment and flow		0.2	
10	Channel bed material consolidation and armoring	Massive competent to thinly bed limestone, continuous concrete, hard clay, moderately consolidated with some overlapping. Assorted sizes of particles, tightly packed and overlapped, possibly imbricated. Small % of particles < 4mm	Shale in bed, soft silty clay, little consolidation of particles, no apparent overlap, moderate % of particles < 4mm	Silt, weathered, thinly bedded, fractured shale, high slaking potential, very poorly consolidated, high % of material < 4mm		0.8	
11	Percentage of channel cross section constriction	< 25% of average cross section area	26-50% of average cross section area	> 50% of average cross section area		0.8	
12	Sediment movement	Little to no loose sediment	Scour and/or deposition, some loose sediment	Near continuous scour and/or deposition and/or loose sediment		0.8	

The following parameters shall be determined from the longitudinal profile and cross section surveys							
13	Sinuosity (ratio of the channel length to valley length) channel length = longitudinal profile survey length	1.2 ≤ Sinuosity ≤ 1.4	1.1<Sinuosity <1.2	Sinuosity <1.1		0.8	
14	Ratio of radius of curvature to channel width	$3 \leq R_c/W_b \leq 5$	$2 < R_c/W_b < 3$, $5 < R_c/W_b < 7$	$2 > R_c/W_b$, R_c /Wb > 7		0.8	
15	Ratio of pool-riffle spacing to channel width at elevation of 1-year flow	$4 \leq \text{Length}/W_b < 8$	$3 \leq \text{Length}/W_b < 4$, $8 < \text{Length}/W_b \leq 9$	$3 > \text{Length}/W_b$, Length/Wb > 9, unless long pool or run because of geologic influence		0.8	

TOTAL _____

FORM 6-2: City of Wentzville Stormwater Design Summary

Project Name:_____ Project No: _____

Land use of the improvement area _____

Is the project a revision or addendum to a previous project? YES NO

If YES, what is the project number and name of the previous project? _____

_____

Describe the revision or addendum: _____

_____

_____

Section 1: Determination of Detention and BMP Requirement

	Pre-Developed	Post-Developed
Total Site Area (acres)*		
Total Disturbed Area (acres)*		
Total Impervious Area (acres)*		
Total % Impervious		
15-yr, 20-minute PI (cfs/ac)		
15-yr, 20-minute Q (cfs)		

* If project is revision or addendum to a previous project, include area of the previous project, as required per Section 6.05.02

Differential Runoff (Post-Developed Q – Pre-Developed Q) _____ cfs

Are detention and water quality BMPs required? YES NO

Section 2: Summary of Total Discharge From Site

Include all detention and/or BMP discharges including any area flowing to a Riparian Buffer Widening BMP. Areas not disturbed need not be included provided the drainage from these areas is not captured in any proposed stormwater facility.

	Pre-Developed	Post-Developed
Total 1-yr, 24-hr flow (cfs)		
Total 2-yr, 24-hr flow (cfs)		
Total 25-yr, 24-hr flow (cfs)		
Total 100-yr, 24-hr flow (cfs)		

FORM 6-3: City of Wentzville Discharge Summary

Complete a separate form for each discharge location leaving the site.

Project Name:_____ Project No: _____

Complete the following for the entire drainage area tributary to this discharge location:

	Pre-Developed	Post-Developed
Total Site Area (acres)		
Total Disturbed Area (acres)		
Total Impervious Area (acres)		
Total % Impervious		

Is the discharge a Riparian Buffer Widening BMP? YES NO

If **YES**, indicate what detention facility number, as indicated on the plans, is used to handle the Cp_v and Qp_2 and Qp_{100} requirements: _____

_____

If **NO**, complete the remainder of this form.

End of Pipe Location (structure number as indicated on the plans): _____

Complete the following for all design storms that apply per the Engineering Design Criteria:

Storm Event	Pipe Size (in)	Discharge (cfs)	Slope (%)	Flow Depth (ft)	Velocity (fps)
1-yr, 24-hr					
2-yr, 24-hr					
15-yr, 20-min					
25-yr, 24-hr					
100-yr, 24-hr					

Describe below how each of the following stormwater requirements are handled for the entire area tributary to this discharge location. Include detention pond and/or BMP numbers as indicated on the plans. If the flood protection volume is handled by over-detaining elsewhere on the site, indicate the detention facility number used.

	Facility number(s) and description	Total Volume Captured (ft^3)
WQ_v		
Cp_v		
Qp_2		
QP_{25}		

FORM 6-4: City of Wentzville Detention and BMP Summary

Project Name:_____ Project No: _____

Complete the following for the entire site. Include all detention and/or BMP facilities.

	Pre-Developed	Post-Developed
Total WQ_v (ft^3)		
Total Cp_v (max volume of Cp_v captured in ft^3)		
Total Qp_{25} (max volume of Qp_{100} captured in ft^3)		

How many facilities on the site are to be used as water quality BMPs? _____

List the facility numbers and types of BMPs used: _____

_____

_____

How many facilities on the site are to be used as detention for Flood Protection? _____

_____

List the facility numbers and describe the facility (dry detention pond, wet detention pond, underground, etc): _____

_____

_____

How many facilities on the site are to be used as detention of Channel Protection? _____

List the facility numbers and describe the facility (dry detention pond, wet detention pond, underground, etc): _____

_____

FORM 6-5: City of Wentzville Water Quality (BMP) Design Summary

Project Name:_____ Project No: _____

If site is divided into multiple drainage areas, complete a separate form for each drainage area on the site.

BMP Facility Number (as indicated on the plans) _____

BMP Type _____

Is the BMP combined with a channel protection and/or flood protection facility?

____ Channel protection

____ Flood protection

Complete the following:

		Drainage Area (acres)	Impervious Area (acres)
Total Drainage Area			
Total Impervious Area			
Non-structural BMP Credits:	**Applies?**	**Reduction**	
Area permanently protected under conservation easements (acres)			
Rooftop area adequately disconnected (acres)			
Non-rooftop impervious area adequately disconnected (acres)			
Area to reserved buffer permanently protected under conservation easements (acres)			
Open channel use - No WQv needed			
Environmentally Sensitive Development - No WQv needed			
Net Drainage Area for WQv			
Net Impervious Area for WQv			

For each Non-structural BMP Credit checked above, explain why the credit applies: _____

_____

_____

WQv Calculation:

Net Drainage Area (acres)	
Net Impervious Area (acres)	
Percent Impervious (%)	
Rv=0.05+0.009 (I)	
WQv=(P/12)(Rv)(A)(43,560) (ft^3)	

FORM 6-5: (cont.) City of Wentzville Water Quality (BMP) Design Summary

Fill out the following section that applies:

BMP Group 1 Stormwater Ponds

Depth of permanent pool (ft) _____ Volume of permanent pool (ft^3) _____

Is extended detention (ED) used? _____ ED Volume (ft^3) _____

Depth of ED Volume _____ Draw down for ED portion (hr) _____

Forebay volume (ft^3) _____

Note: forebay shall be sized for 0.1 inches per impervious acre of contributing drainage

BMP Group 2 Stormwater Wetlands

Length of flowpath from inflow to outflow (ft)_____ Width of the wetland (ft) _____

Ratio of flowpath length: width _____ (≥1.5:1 recommended)

Surface Area of wetland (ft^2) _____ (≥ 1% of drainage area or ≥ 1.5% for shallow)

Depth of permanent pool (ft) _____Volume of permanent pool (ft^3) _____

Is extended detention (ED) used? _____ ED Volume (ft^3) _____

Depth of ED Volume _____

Draw down for ED portion (hr) _____

Forebay volume (ft^3) _____

Note: forebay shall be sized for 0.1 inches per impervious acre of contributing drainage
Submit a water balance to demonstrate the wetland can withstand a 30-day drought at summer evaporation rates without completely drawing down.

BMP Group 3 Infiltration Practices

Hydraulic conductivity of the least permeable layer between the infiltration facility bottom and ground water (in/hr) _____ Depth to ground water (ft) _____

Surface area of the facility (ft^2) _____

Maximum pond depth (ft) _____ Maximum pond volume (ft^3) _____

Draw down to completely drain facility (hrs) _____

Note: Submit a sealed geotechnical report, including soil borings and testing results, to prove that the soil strata beneath the infiltration BMP is highly permeable between the infiltration facility bottom and ground water.

FORM 6-5: (cont.) City of Wentzville Water Quality (BMP) Design Summary

BMP Group 4 Filtering Practices

Calculate required filter bed area: $A_f = (WQ_v)(d_f) / [(k)(h_f+d_f)(t_f)]$ = _____

Where: A_f = Surface area of filter bed (ft2)

WQ_v = water quality volume (ft3) = _____

d_f = filter bed depth (ft) = _____

k = coefficient of permeability of the filter media (ft/day) = _____

h_f = average height of water above filter bed (ft) = _____

t_f = design filter bed drain time (days) = _____
(max 1.67 days for sand filters, 2 days for bioretention)

Maximum ponding depth _____ Maximum ponding volume _____

For sand filters, pretreatment sediment basin sizing: As = (Qo/W) (E') = _____

Where: As = sediment basin surface area (ft2)

Qo = discharge rate from the basin = WQv/24 hr = _____

W = particle settling velocity (ft/sec)

For I ≤ 75%, use 0.0004 ft/sec (particle size = 20 microns)

For I > 75%, use 0.0033 ft/sec (particle size = 40 microns)

E' = sediment trapping efficiency constant = 2.30

Sediment basin length L (ft) _____ Sediment basin width W (ft) _____
Note: L:W shall be at least 2:1

For Bioretention, pretreatment system used _____

Calculate the Rate of draw using Darcy's Equation:

$Q = (.0000232)*k* A_f *(H/ d_f)$ = _____

Where : Q = Rate of draw through Bioretentioin Soil (cfs)

k = coefficient of permeability of the filter media (ft/day) = _____

A_f = Surface area of filter bed (ft2) = _____

H = height of water above drainage pipe (underdrain)

d_f = filter bed depth (ft) = _____

Underdrain shall be sized for a minimum flow of 5 times the rate of draw (cfs) = _____

Number of underdrains _____ (minimum 2 recommended)

Underdrain pipe size (in)_____ (4" minimum)

Underdrain pipe slope (%) _____

FORM 6-5: (cont.) City of Wentzville Water Quality (BMP) Design Summary

BMP Group 5 Open Channel Practices

Slope (%) _____ (4% max)

Channel side slopes _____ (3:1 or flatter)

Channel bottom width _____ (2' min, 8' max)

Maximum ponding depth at the midpoint of the swale _____ (1.0 ft max)

Maximum ponding depth at the end of the swale _____ (1.5 ft max)

Maximum ponding volume (ft^3) _____

For Dry Swale:

Calculate the Rate of draw using Darcy's Equation: $Q = (.0000232)*k* A_f *(H/ d_f) =$ _____

Where: Q = Rate of draw through Bioretention Soil (cfs)

k = coefficient of permeability of the filter media (ft/day) = _____

A_f = Surface area of filter bed (ft2) =_____

H = height of water above drainage pipe (underdrain)

d_f = filter bed depth (ft) = _____

Underdrain shall be sized for a minimum flow of 5 times the rate of draw (cfs) = _____

Number of underdrains _____ (minimum 2 recommended)

Underdrain pipe size (in) _____ (4" minimum)

Underdrain pipe slope (%) _____

Draw-down time (hrs) _____ (48 hr maximum)

Forebay volume (ft^3) _____

Note: forebay shall be sized for 0.1 inches per impervious acre of contributing drainage

BMP Group 6 Riparian Buffer Widening

Name of stream or tributary _____

Width of Riparian Buffer per City of Wentzville Municipal Code, Ordinance #2863, Regulation for the Protection of Natural Watercourses (ft) _____

Addition width added to Riparian Buffer (ft) _____ (25' minimum)

Linear feet of widened riparian buffer (ft) _____

FORM 6-6: City of Wentzville Detention/Retention Pond Design Summary

Project Name:_____ Project No: _____

Complete a separate form for each detention/retention pond

Detention Pond Number (as indicated on the plans) _____

Detention Pond Type: (Dry, Wet, Underground, Micropool, etc.) _____

Note: Dry detention ponds may only be used to meet the Cp_v, Qp_2 and Qp_{100} requirements, they are not acceptable to treat the WQ_v.

Hydrology	**Pre-Developed**	**Post-Developed**
Drainage Area (acres)		
Impervious Area (acres)		
% Impervious		
Curve Number		
Sheet flow length (ft)		
Shallow concentrated flow length (ft)		
Channel flow length (ft)		
Time of Concentration (min)		
1-yr, 24-hour peak flow (cfs)		
2-yr, 24-hour peak flow (cfs)		
25-yr, 24-hour peak flow (cfs)		
100-yr, 24-hour peak flow (cfs)		

Pond Routing

1-yr, 24-hour peak outflow (cfs)	
2-yr, 24-hour peak outflow (cfs)	
25-yr, 24-hour peak flow (cfs)	
100-yr, 24-hour peak outflow (cfs)	
Maximum storage volume for 1-yr, 24-hour event (ft^3)	
Maximum storage volume for 2-yr, 24-hour event (ft^3)	
Maximum storage volume for 25-yr, 24-hour event (ft^3)	
Maximum storage depth for 1-yr, 24-hour event (ft)	
Maximum storage depth for 2-yr, 24-hour event (ft)	
Maximum storage depth for 25-yr, 24-hour event (ft)	
Detention Lag Time for the 1-yr, 24-hour event (hrs)	

Maximum Ponding (low-flow outlet(s) blocked) 100-yr, 24-hr event

Maximum depth to maximum ponding (ft)	
Berm Height (ft)	
Elevation of the maximum ponding (ft)	
Low sill elevation of nearest structure (ft)	
Horizontal distance from limit of maximum ponding to nearest structure (ft)	

7. Design Requirements for Streets and Other Public Improvements

7.01 General

This section gives the minimum technical design requirements for the City of Wentzville for streets and other public improvements.

7.02 General Requirements for Street Construction

All streets shall meet the following general requirements:

7.02.01 Street Improvements

All streets shall be graded and the roadway improved by surfacing. Roadway surfacing shall be in accordance with City of Wentzville Standard Specifications and Construction Details. All grading and surfacing shall be done under observation and inspection of the Division and shall be subject to its approval. The treatment of the intersection of any new street with a State highway shall be subject to approval by the District Engineer of the Missouri Department of Transportation. The treatment of the intersection of any new street with a County road shall be subject to approval by the St. Charles County Highway Department.

At such times as a subdivision is proposed adjacent to a street that is accepted and maintained by the City of Wentzville, that street and other streets required shall be improved to handle the increased traffic due to said subdivision as directed by the City of Wentzville Transportation Master Plan, and the additional right-of-way and the cost of improvement of the right-of-way adjacent to the proposed subdivision shall be included in the overall subdivision improvements. The improvements shall be made to the current City of Wentzville Standard Specifications and Construction Details.

The construction of a standard street intersection approach and right-of-way dedication only may be required as necessary for the relocation and/or widening of an adjoining City road.

In certain cases involving the subdivision of tracts of property, the reservation of right-of-way access may be required for future road improvements as authorized by the tract's preliminary plat.

1. Street Design - All street construction, modification or widening shall be designed in accordance with the requirements of the Transportation Master Plan and the classification, design criteria and standards of the Division as follows:

Classification	Section
Arterial	7.03.01
Collector	7.03.02

Residential	7.03.03
Rural	7.03.03

All construction, details and specifications pertaining to roadway improvements within City of Wentzville right-of-way shall be accomplished under the observation and inspection of the Division and shall be subject to its approval.

2. Street Name Signing - Reflectorized street signs bearing the name of the street, as designated on the record plat, shall be placed at all street intersections. Each and every intersection formed by the developer shall have at least one street name sign for each intersecting street mounted in a bracket on top of one post. Refer to Standard Construction Details 700.18, 700.19 & 700.20.

   The Division shall approve the location and inspect the installation of street name signs in all subdivisions. The size, height, and type of sign shall be in accordance with the specifications of the Division.

   The required sign post location shall depend upon the traffic volume on the roadway and the width of pavement. Each post shall be placed a minimum of 3.5 feet from the back of the curb.

3. Medians - Raised median strips may be required by the Division to restrict through and/or left turning movements at or near driveways, commercial entrances and/or street intersections. Raised medians may also be utilized for ornamental entrance monuments and signs. For ultimate tee type street intersections, where the median is proposed on the minor side street, wider medians may be permitted by the Division to accommodate larger entrance monument designs.

4. Guard Rail - Guard rail shall be required to protect traffic from hazardous features. Guard rail will be required for roadway fill sections when the fill height and fill slope for a particular location fall within the “Barrier Warranted” area of Exhibit 7-1 as included on the following page.

   Terminal sections will be required for both directions of traffic flow on two-way pavement. Where the distance between terminal sections of two sections of guard rail will be 100 feet or less, one continuous length of guard rail shall be installed.

   Guard rail shall be provided for protection of traffic adjacent to creeks and lakes, at bridge ends, piers, signs and headwalls, and other obstacles as directed by the Division.

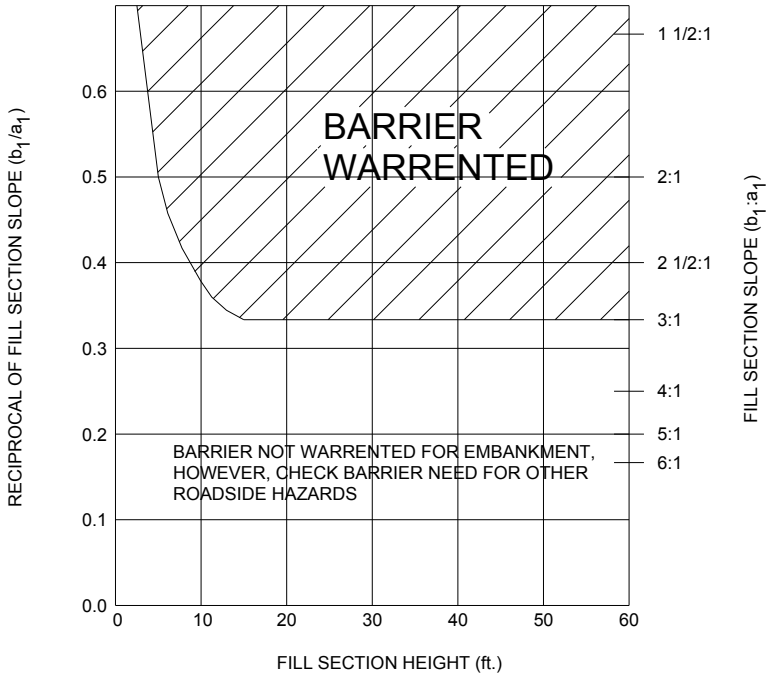


Exhibit 7-1

5. Street Lighting – Street Lighting shall be installed in accordance with the approved street lighting plan which shall be coordinated with the applicable Electric Utility. The plan shall show all standard locations in accordance with the City's plan of intent and policies for street lighting. Construction of such facilities will be coordinated by the developer with the City and Electric Utility. This requirement applies to all streets. Street lights in subdivisions shall be placed between the curb and the sidewalk near a side yard property line at the end of Cul-de-Sacs, and near the midpoint of eyebrows. It is preferred that a street light be positioned in the stop sign quad of T intersections and at one of the stop sign quads of a full intersection. See details 700.19 and 700.20. Additional street lights shall be interspaced along the street at no more than 400 feet intervals. Special fixtures and posts may be approved on a case by case basis, with any additional costs to be born by the developer and/or homeowners association. The City reserves the right to install street lights which they will own and operate in lieu of leasing street lights from the Electric Utility Company.

6. Retaining Walls
All walls built within City maintained right-of-way are subject to the review of, and approval by the Division. The following walls shall also be subject to the Division's design criteria and review:
   a. Retaining walls supporting the roadway fill of a City maintained road, provided that the horizontal distance from the right-of-way line to the fill face of wall is less than 1.75 times the vertical grade

difference between the ground elevation at the right-of-way line and the bottom of footing (not bottom of shear key) elevation

b. Retaining walls supporting roadway cuts adjacent to City maintained roads, provided that the distance between the right-of-way line and face of the wall is less than the exposed wall height.

All retaining walls built for the purpose of retaining roadway fill, or built in roadway cuts must be designed by an Engineer, who must submit plans and calculations to the Division for approval. The design submittal to the Division must include a comprehensive geotechnical report, design calculations using a 2.0 factor of safety for overturning and 1.5 factor of safety for sliding. They shall not be reduced for seismic design loads. The design shall include checking for global stability of the retaining walls. Complete construction plans shall also be submitted, including all necessary details to fully show the design of the wall, foundation, reinforcement and backfill. All reports, calculations and plans shall be sealed by a Registered Engineer in the State of Missouri.

7. Driveways - Private drives accessing streets having rolled type curbs shall be designed and constructed in accordance with the requirements shown in SCD 700.23, which requires the use of full depth expansion and construction joints between the curb and driveway, driveway and sidewalk, and driveway and garage.

7.02.02 Street Standards

The arrangement, character, extent, width, grade and location of all streets and required improvements shall be considered in their relation to existing and proposed streets, to topographical conditions, to public convenience and safety, and in their appropriate relation to the proposed uses of the land to be served by such streets. The following standards shall apply:

1. Arrangement of subdivision streets shall conform as nearly as possible to City of Wentzville Thoroughfare Plan and the developer shall make provision for the extension and/or relocation of major, collector and minor streets, which impact the property. Except for dead-end streets, streets normally shall connect with streets already established, or provide for future connections to adjoining unsubdivided tracts, or shall be a reasonable projection of streets in the nearest subdivision tracts.

2. Stub streets shall be constructed to the property lines when required to provide for future connections to adjoining undeveloped tracts. Reasonable projections of streets in nearby subdivisions will establish the location of certain stub streets.

3. Minor street intersection jogs or discontinuities with centerline offsets of less than one hundred (100) feet shall be avoided.

4. Reserved strips of land which control or limit access at the terminus of streets or prevent access to streets located adjacent to undeveloped land are prohibited.

5. A subdivision entrance street shall intersect the major or collector street with an interior angle of seventy (70) to ninety (90) degrees unless otherwise approved by the Division. Each entrance street shall be positioned to provide required sight distance along each intersecting roadway as determined by the Division. Refer to Exhibit 7-2 for Sight Distance at Intersections criteria.

6. A minimum radius of twenty (20) feet at street right-of-way intersection and a minimum radius of thirty-two (32) feet at the back of the curb shall be required. Greater radii and channelization may be required at an intersection with a major or collector street or to provide access for vehicles having large turning radius requirements. The Division may permit a series of comparable cut-off or chords approximating the edge of pavement radius.

7. All interior residential streets intersecting on collector streets shall be directly opposite existing or other proposed streets or shall be a minimum of three hundred (300) feet distant, as measured between street center lines. All other streets intersecting on arterial, county or non-residential streets shall be directly opposite existing or other proposed streets or shall Conform to Section 7.02.03 – Access Management.

8. Where a collector street enters or connects with a major street, the Division must approve the entrance plan.

9. Streets shall be constructed to The City of Wentzville Standard Specifications and Construction Details.

10. All stub streets in excess of four hundred and fifty (450) feet in length measured from the centerline of the street intersection to the property line or plat boundary, shall be provided with a temporary turnaround. Permits will not be issued for building construction on lots abutting a temporary turnaround as shown on any recorded subdivision plat, unless and until the temporary facility is actually constructed and has been approved by the Division.

11. All streets shall be designed to meet the minimum requirements set forth in Section 7.03 Street Design Criteria. The widths of right-of-way and pavement are allowed to vary as functions of the type of street and the corresponding intensity of use.

Residential rural street design standards are permitted in agricultural and R-1A zoned residential developments, and within Planned Development – Residential projects.

12. Where in the best interest of the traveling public, to provide circulation, health and safety measures, the Division may require a street to be dedicated to public use.

13. The pavement width set forth in Section 7.03 Street Design Criteria for multiple family access streets does not allow for, nor will parking be permitted on these streets. For each parallel parking space adjacent to these streets, an additional width of 10 feet shall be provided. Additional parking requirements shall be provided herein and/or to the standards set by the Division.

14. Roadways designated to be private shall be constructed to public roadway specifications. These roadways shall remain private forever. Maintenance of private roadway will be the responsibility of the property owner(s) or trustees forever. Disclosure of Street Maintenance Responsibility shall be made in accordance with the requirement of Section 410.230 of the City Code.

15. Additional lanes and/or widening, pavement thickness, drainage facilities, granular base and/or traffic control devices may be required to accommodate heavy traffic volumes, unsuitable soil conditions, steep grades or other conditions not apparent at the time of the Preliminary Plan approval.

16. The developer shall provide adequate temporary off-street parking for construction employees. Parking on non-surfaced areas shall be prohibited in order to eliminate the condition whereby mud from construction and employees vehicles is tracked onto the pavement causing hazardous road and driving conditions.

17. If any public roads are proposed within a development, they must be built above the FEMA 100-year flood elevation with proper freeboard, or protected from flood damage by an approved levee. Any roads and/or drives proposed below this elevation, not protected by an approved levee, are to be private and shall remain private forever.

18. A tangent of less than one hundred (100) feet in length shall be avoided between reverse curves on major and collector streets.

19. Temporary or permanent turnarounds may be requested to accommodate school buses. The turnarounds shall have a pavement radius of fifty-five (55) feet. If school bus turnarounds are required, the school district will submit verification that they will permit buses to enter the subdivision utilizing the turnarounds.

20. In order to reduce the adverse effects of street movement, the installation of Type A2 expansion joints (See Standard Construction Detail 700.07) are required on concrete streets at the following locations:

    a) At end of radius on each approach to “T” intersection;

    b) Across the throat of cul-de-sacs and eyebrows;

    c) The beginning (PC) and the end (PT) of curved sections of street.

    For construction details of pavement sections at cul-de-sacs and “T” intersections, refer to Standard Construction Detail 700.09.

    The installation of subgrade underdrains are required on all streets where storm inlet structures are present (See Standard Construction Detail 700.28)

21. If proposed streets with grades in excess of 6% are accepted by the City of Wentzville for maintenance, it will be necessary for the developer to provide a public disclosure that the development will have steep grades and that the City of Wentzville will not provide priority snow removal services to this development. This disclosure shall be noted on all approved plans for the site and posted in the display area.

22. In subdivision developments of more than 100 residential units it is required that two (2) or more access points be established for the benefit of roadway maintenance and access by emergency vehicles.

23. Sight distance criteria shall be based upon the ultimate number of lanes required for the roadway. Refer to Standard Construction Detail 700.37 for Sight Distance at Intersections criteria. If required sight distance cannot be provided at the access location, acquisition of right-of-way and/or sight distance easements, removal of plant material, reconstruction of pavement, and other off-site improvements may be required to provide the required sight distance as directed by the Division.

24. When portions of roadway improvements required for the safety of the public require the acquisition of additional right-of-way and easements from private property, the normal sequence of design, right-of-way acquisition and construction shall commence immediately upon approval of the requested rezoning.

25. Installation of Landscaping and Ornamental Entrance Monument construction, shall be reviewed by the Division for sight distance considerations and approved prior to installation or construction.

26. Proposed development, utilizing roadways with structurally deficient pavement within the site, or providing access to the development from such roadways, may be required to overlay the existing road surfacing or make other remedial improvements, as required by the Division, to bring the structural stability of the pavement up to minimum requirements.

27. Where two streets intersect, the minor street shall be designed with a minimum of a 60 foot long platform, having a profile grade of a minimum of 2% ± and a maximum of 4% ±. This platform shall intersect with the major street which would normally have a 2 % cross slope, sloping down towards the intersecting street. From this platform the profile grade of the minor street shall transition into the grade of the street, which under normal circumstances should normally not exceed a slope of 6%, but under all cases less than 10%.

7.02.03 Access Management

Access management involves determining the control of side access in order to maintain or preserve the capacity and function of the road. It involves determining appropriate signal spacing, median openings and driveway/side street spacing distances. Recommendations for access management of Wentzville's arterials and collectors are described in the following sections.

The purpose of these standards is to establish criteria to promote the safe and efficient movement of people and goods and to preserve the investment in the roadway system in the City of Wentzville and the surrounding community.

The criteria and procedures described in this document are established pursuant to the State of Missouri enabling legislation regarding access management guidelines.

1. Access Category Standards

Described below is a proposed major thoroughfare system and access management standards that is based on roadway functional classification. The system describes for each roadway classification the roadway function, desired level of access, desired emphasis of through movement, and typical speed ranges.

Purpose and Use

a. The number, spacing, type and location of access and traffic signals have a direct and often significant effect on the capacity, speed, and safety of a roadway and are limited in a hierarchical method by this category system. The location, operation and

design standards within each category are necessary to ensure that the roadway will continue to function at the level (category) assigned.

b. The standards in this section have been written so that the safety and operations of the complete general street system will be considered when determining access to the arterial roadway.

c. The "Functional Characteristics and Category Assignment Criteria", subsection of each category is intended to describe the existing or future function of roadways for which that category is most appropriate. The access category assigned to a roadway segment may consider the extent of the development on the abutting land, as it exists at the time the access category is assigned. Three levels of development are considered in the assignment of an access category to a roadway segment. These are:

    i. Sparsely developed - the abutting land is sparsely developed and there is considerable flexibility as to the location and design of future access;

    ii. Partly developed - some development abutting the roadway segment has already developed but there is flexibility in the location of additional access; and

    iii. Fully developed - the abutting land is heavily developed, numerous access connections already exist and access to any additional development will be highly influenced by the existing development pattern. However, opportunities to improve the access spacing and design may occur as abutting properties are redeveloped over a long period of time. The paramount objective for roadway segments categorized as `fully developed' is to prevent further deterioration in the quality of service and to improve safety as may be practical. The purpose of spacing standards for this access category is to provide a `vision' that might be obtained over a period of many years or several decades.

Roadway segments shall be classified based on as sparsely developed, partially developed or fully developed at the time an access category is assigned. The degree of development will be based on development already in place, a building permit has been issued, an application for a building permit has already been made, or a subdivision plat has been approved.

The existing design of the roadway is not required to meet the design standards at the assigned category at the time it is assigned. A proposed access that may be allowed under the

standards set forth in this section, but fails to meet the design or safety criteria of the City of Wentzville, may be permitted if a design waiver is approved by the City or by the St. Charles County Engineer or the District Engineer of the Missouri Department of Transportation if located beyond the municipal limits and extraterritorial jurisdiction of the City of Wentzville.

d. Traffic signals and their installation are also regulated by the Manual on Uniform Traffic Control Devices, (M.U.T.C.D.). Nothing in this section is intended or shall be interpreted as requiring the City of Wentzville, St. Charles County or the Missouri Department of Transportation authorize a traffic signal or a left-turn movement at any location. No traffic signal shall be authorized without the completion of an analysis of traffic signal system operation, construction feasibility, and safety study as required by the City or, if outside of jurisdiction of the City, by the St. Charles County Engineer or by the District Engineer of Missouri Department of Transportation as well as meeting the M.U.T.C.D. signal warrants.

The City of Wentzville, St. Charles County or the Missouri Department of Transportation may at its discretion in consideration of granting an access permit, require design and operational modifications as it considers necessary, restrict one or more turning movements, or deny the access so long as such discretion does not violate law.

2. Functional Classification Categories

The proposed system of classifying roadways is consistent with the conventional system included as part of the City of Wentzville Transportation Master Plan and A Community's Vision, the City of Wentzville's Comprehensive Plan. Typical speed ranges have been included with Table 7-1.

Table 7-1 Functional Classification System Description for Access Management

Functional Class	Level of Mobility	System Access	Level of Accessibility
Freeway or Interstate (category 1)	Connects all urban sub regions together, connects urban and rural service areas with metro major activity centers; connection to outside cities.	To other freeways, major arterials; no direct land access.	Long trips at high speed within and through the metro area; express transit trips. Typical speed ranges between 55 and 70 m.p.h.
Major Arterial (category 2)	Connects two or more sub regions; provides secondary connections outside cities; complements freeways in high volume corridors.	To freeways, other major arterials, and major collectors; no direct land access except major traffic generators.	Medium distance to long trips at high to moderate speeds within the urban area; express transit trips. Posted speeds typically range from 35 to 55 m.p.h.
Minor Arterial (category 3)	Connects adjacent sub regions and activity centers within sub regions.	To freeways, major arterials, minor arterials, major collectors and minor collectors; restricted direct land access.	Medium to short trip at moderate to low speeds; local transit trips. Posted speeds typically range from 35 to 55 m.p.h.
Major and Minor Collectors (category 4)	Connects neighborhoods within and between sub regions.	To major and minor arterials, other collectors and local streets; direct land access.	Primarily serves collection and distribution function for the arterial system at low speeds; local transit trips. Posted speeds typically range from 25 to 40 m.p.h.
Local Streets (includes urban and rural) (category 5)	Connects blocks within neighborhoods and specific activities within homogeneous land use areas.	To major and minor collectors and other local streets; direct land access.	Almost exclusively collection and distribution; short trips at low speeds.

3. Access Categories and Standards

The following table can be used to quickly reference the access standards described in the sections below. The table shall supplement and not replace the detailed descriptions. More detail regarding the flexibility of each standard can not be interpreted by the summary table but is described in the text. Spacing distances and corner clearances are measured as the minimum distance from center-to-center between access connections on the same side of the roadway.

Table 7-2 Access Standards Reference Table

Functional Class	Signal Spacing*	Unsignalized Median Opening Spacing*	Access Connection Spacing and Corner Clearance*	Auxiliary Lanes
Freeway or Interstate (Category 1)	MoDOT jurisdiction and access standards.			
Major Arterial (Category 2) Sparsely Developed	2640 feet	1320 feet with auxiliary lanes per Section	660 feet when 50 m.p.h. or less	Left and right-turn bays desired al all signalized intersections. Right-turn bays are encouraged at all unsignalized access connections. City may require left and right-turn bays at any access connection.
Major Arterial (Category 2) Partially Developed	2640 feet	1320 feet with auxiliary lanes per Section	660 feet when 45 m.p.h. or less	
Major Arterial (Category 2) Fully Developed	2640 feet desired, 1320 feet at City discretion	Spacing in case by case per Section	Note less than 300 feet at 30 m.p.h. 350 feet at 35 m.p.h. 405 feet at 40 m.p.h.	
Minor Arterial (Category 3) Sparsely Developed	2640 feet	1320 feet with auxiliary lanes per Section	660 feet when 45 m.p.h. or less	Left and right-turn bays desired at all signalized intersections. Right-turn bays are encouraged at all unsignalized access connections. City may require left and right-turn bays at any access connection.
Minor Arterial (Category 3) Partially Developed	2640 feet	1320 feet with auxiliary lanes per Section	660 feet when 40 m.p.h. or less	
Minor Arterial (Category 4) Fully Developed	2640 feet desired, 1320 feet at City discretion	Spacing in case by case per Section	Not less than 300 feet at 30 m.p.h. 350 feet at 35 m.p.h. 405 feet at 40 m.p.h.	
Major and Minor Collectors (Category 4)	1320 feet	Two way middle turn lanes are typically allowed without an access control median.	Not less than 255 feet at 25 m.p.h. 300 feet at 30 m.p.h. 350 feet at 35 m.p.h. 405 feet at 40 m.p.h.	Left –turn bays are desired at signalized intersections. City may require left and right-turn bays at any access connection.
Local Streets (includes urban and rural) (Category 5)	Signals are typically not warranted.	Access control medians are typically not used.	One access connection per property with less than 200 feet of frontage. At City discretion, two access connections per property with more than 200 feet of frontage.	Left and right-turn bays are typically not used. City may require left and right-turn bays at any access connection.

* Spacing distances and corner clearances are measured as the minimum distance from center-to-center between access connections on the same side of the roadway. Speed references convey posted speed limits.
Sources: Research completed by Vergil G. Stover
National Highway Institute Course No. 15255 Access Management, Location and Design.
City of Wentzville Public Works Department, 2003.

a. Property Access Standards

Regardless the quantity of access connections, all adjacent commercial zoned properties shall develop alternative access and interconnect to adjacent parcels so that pedestrians and vehicles can circulate between them without using the abutting public roadway.

When adjacent properties (residential lots or other land uses) have frontage less than the access connection spacing or when one

connection per parcel violates the access connection spacing standards, the City Public Works Department shall strongly encourage property owners to implement access connection plans so their public access connections conform to the spacing guidelines. Such plans and solutions could include property owners consolidating driveways, replacing individual driveways with shared access drives, developing alternative access and interconnecting to adjacent parcels so that pedestrians and vehicles can circulate between them without using the abutting public roadway.

Access to a corner property located at the intersection of two roadways of different functional classification shall be to the roadway having the lower functional classification unless the City, St. Charles County Engineer or District Engineer based on jurisdiction, find that access on both frontages will improve safety or the traffic operations on the public roadway system. Where a corner property fronts on two roadways having the same functional classification, the City, St. Charles County Engineer or District Engineer based on jurisdiction, shall specify the street to which access is to be provided. Access to a corner property shall be located near the property line most distant from the intersection.

The same spacing standards and criteria for durations apply to public roadways and private access connections.

b. Freeway or Interstate, Category 1

Freeways and interstates within the City of Wentzville are under the maintenance and jurisdiction of the Missouri Department of Transportation. Access management standards shall be in accordance with the Missouri Department of Transportation's current practices and standards.

c. Major Arterial, Category 2

Major arterials are second only to freeways and interstates in providing movement throughout the City of Wentzville-St. Charles County metropolitan region. This category is appropriate for roadways that have extensive continuity and that carry high volumes at relatively high speed in an efficient and safe manner. In accordance with the current practices of the Public Works Department of the City of Wentzville, no direct land access, except major traffic generators, is provided to this category of roadway. Directional traffic on major arterials shall be separated by a non-traversable median. Access points shall be constructed only if they meet the spacing criteria described in the following sections.

c.i. Access Category 2a Major Arterial, Abutting Land is Sparsely Developed

Signal spacing

The standard for the spacing of all intersecting public ways and other accesses that will be full movement, or are or may become signalized, is 2640 feet center-to-center. Exceptions to this 2640 feet standard will not be permitted unless the proposal documents that there are no other reasonable alternatives to achieve a 2640 feet interval, there is a documented necessity for the intersection at the proposed location, and a signal study acceptable to the City if the proposed location is within the City of Wentzville or its territorial jurisdiction or to the St. Charles County Engineer or District Engineer of the Missouri Department of Transportation (MoDOT) if outside the city's territorial jurisdiction.

Where its not feasible to meet the 2640 feet spacing interval, a full signalized median opening may be permitted where a traffic signal progression analysis acceptable to the City, or the St. Charles County Engineer or to the MoDOT District Engineer if outside the City's territorial jurisdiction, demonstrates that, at a minimum, traffic progression with at least 45% efficiency can be achieved for both peak and off-peak conditions.

Where topography or other existing conditions make 2640 feet intervals inappropriate or not feasible, location of the access will be determined with consideration given to topography, established property ownerships, unique physical limitations and/or unavoidable or pre-existing historical land use patterns and physical design constraints with every attempt to achieve a spacing of 2640 feet center-to-center. The final location shall serve as many properties and interests as possible to reduce the need for additional direct access to the roadway. In selecting locations for full movement intersections, preference will be given to public roads.

Unsignalized median openings

Where a non-traversable median exists, unsignalized median openings may be permitted at a distance 1320 feet center-to-center from a signalized intersection provided that: (1) the opening is designed as a directional opening for left-turns and u-turns from the major arterial, and (2) an auxiliary lane for the left-turns/u-turns in accordance with the procedure and criteria given in Section 4.2.

If the roadway is undivided or has a continuous two-way left-turn lane; left-turns will be permitted unless an operational or safety problem is identified.

Access connection spacing

Direct land access at locations that do not conform to the signalized intersection spacing interval of 2640 feet is discouraged. When permitted, the spacing standard is 660 feet center-to-center on roadways where the posted speed is 50 mph or less. Major arterials under City of Wentzville jurisdiction are not expected to be posted greater than 50 mph. The access shall be limited to right-in/right-out only unless it is located directly across from a directional median opening.

Where it is not feasible to comply with the above-stated spacing standards, and alternative access is not available, a deviation where the proposed location is within 150 feet ± the standard spacing interval will be considered to be a minor deviation.

Auxiliary lanes

All median openings, signalized and unsignalized, shall have a left-turn lane in accordance with the provisions of Section 4.2 that will permit left-turning vehicles to clear the through traffic lane at a speed not more than 10 mph less than the speed of through traffic and come to a stop before reaching the end of the longest expected queue based on a 95% probability of storing all left-turning vehicles. The length of the turn bay shall be analyzed for both the peak and off-peak conditions and designed for whichever is the longest. Dual left-turns are encouraged where the expected left-turn volume exceeds 200 vehicles per hour.

A right-turn deceleration lane shall be provided at all signalized locations. Auxiliary lanes for right-turns are encouraged at all unsignalized access connections and will be required at all connections where the volume in the outside (curb) traffic lane exceeds 350 vehicles per hour.

Right-turn acceleration lanes may be required by the City (or St. Charles County Engineer or MoDOT District Engineer).

Development subsequent to classification of a roadway segment

No additional access rights shall accrue upon the splitting or dividing of existing parcels of land or contiguous parcels under or previously under the same ownership or controlling interest. All access to newly created properties shall be provided internally from any existing access or a new access determined by the above design standards.

c.ii. Access Category 2b Major Arterial, Abutting Land is Partially Developed

Signal spacing

The standard for the spacing of all intersecting public ways and other accesses that will be full movement, or are or may become signalized is 2640 feet measured center-to-center.

Exceptions to this 2640 feet standard will not be permitted unless the proposal documents that there are no other reasonable alternatives to achieve the 2640 feet, there is a documented necessity for the intersection at the proposed location, and a signal study acceptable to the City or the St. Charles County Engineer or the MoDOT District Engineer if not within the jurisdiction of the City of Wentzville is completed in accordance with Section 4.1.

Unsignalized median openings

Where a nontraversable median exists, unsignalized median openings may be permitted at a desired distance 1320 feet center-to-center from a signalized intersection. Where a nontraversable median exists, an unsignalized median opening may deviate from the 1320 feet spacing provided that (1) it is designed as a directional opening and (2) an auxiliary lane for left-turns is provided in accordance with Section 4.2.

Access connection spacing

Access connections may be permitted if the junction spacing intervals 660 feet center-to-center where the posted speed is 45 mph or less. Major arterials under City of Wentzville jurisdiction are not expected to be posted greater than 50 mph.

Where it is not feasible and alternative access is not available, a deviation of 100 feet from the standard spacing interval will be considered to be a minor deviation.

c.iii. Access Category 2c Major Arterial Abutting Land is Fully Developed

This access category is applicable where the abutting land is heavily developed, numerous access connections already exist and there is little opportunity to achieve long and uniform access spacing. The guiding principles for access management on these roadway segments is to: (a) keep the safety and operations from deteriorating further, (b) increase access spacing and improve access design as opportunities arise and as abutting properties are redeveloped, and (c) encourage property owners to consolidate driveways, replace individual driveways with shared access drives, to develop alternative

access and to interconnect adjacent parcels so that pedestrians and vehicles can circulate between them without using the abutting public roadway.

Signal spacing

The ideal signal spacing on category 2c roadways is the same as for category 2b. Where development precludes such spacing, a uniform interval of 1320 feet center-to-center may be adopted. At the very minimum, no additional signal will be permitted where it would degrade traffic progression speeds or efficiency.

Unsignalized median openings

Unsignalized median openings on category 2c roadways that have a nontraversable median, or when a nontraversable median is constructed, may be permitted where: (1) the median is of sufficient width to be designed as a directional opening and (2) a left-turn lane can be provided in accordance with Section 4.2.

Access connection spacing

The principle objective is to avoid further degradation in the safety of operation of a category 2c roadway.

When properties develop, redevelop or change use, marginal access spacing shall not be less than the stopping sight distance for the 85"' percentile, off-peak speed (adjusted to represent center-to-center distances): 300 feet of 30 mph, 350 feet of 35 mph and 405 feet of 40 mph. Major arterials under City of Wentzville jurisdiction are not expected to be posted less than 30 mph. Where access connections already exist and if spacings are less than these intervals, increased spacing and improved design shall be implemented, to the extent feasible, where abutting properties are consolidated or redeveloped. Alternative access shall also be encouraged when development occurs. Consolidation of two or more existing access connections, or relocation of an access connection to improve safety or questions, is encouraged even though the consolidation, or relocation, will result in a spacing that is less than the above spacings based on speed.

Auxiliary lanes

Auxiliary lanes for left-turns and right-turns are encouraged at all signalized intersections and higher volume access connections. Local constraints may require that these auxiliary lanes will be much shorter than the standard design.

d. Minor Arterial, Category 3

Minor arterials constitute a large portion of major roadway system in Wentzville-St. Charles County metropolitan region. This category is appropriate for roadways that have extensive continuity and that carry

high volumes at relatively high speed in an efficient and safe manner. The major difference between major arterials (access category 2) and minor arterials (access category 3) is in the number of through traffic lanes. In accordance with current practices of the City of Wentzville Public Works Department, direct land access is restricted. Directional traffic on minor arterials shall be separated by a non-traversable median. Access points shall be constructed only if they meet the spacing criteria described in the following sections.

d.i. Access Category 3a Minor Arterial Abutting Land is Sparsely Developed

Signal spacing

The standard for the spacing of all intersecting public ways and other accesses that will be full movement, or are or may become signalized, is 2640 feet measured center-to-center. Exceptions to this 2640 feet standard will not be permitted unless the proposal documents that there are no other reasonable alternatives to achieve a 2640 feet interval, there is a documented necessity for the intersection at the proposed location, and a signal study acceptable to the City if the proposed location is within the City of Wentzville or its territorial jurisdiction or to the St. Charles County Engineer or to the District Engineer of the Missouri Department of Transportation (MoDOT) if outside the city's territorial jurisdiction.

Where its not feasible to meet the 2640 feet spacing interval, a full signalized median opening may be permitted where a traffic signal progression analysis acceptable to the City, or the St. Charles County Engineer or to the MoDOT District Engineer if outside the City's territorial jurisdiction, demonstrates that, at a minimum, traffic progression with at least 45% efficiency can be achieved for both peak and off-peak conditions.

Where topography or other existing conditions make 2640 feet intervals inappropriate or not feasible, location of the access will be determined with consideration given to topography, established property ownerships, unique physical limitations and/or unavoidable or pre-existing historical land use patterns and physical design constraints with every attempt to achieve a spacing of 2640 feet center-to-center. The final location shall serve as many properties and interests as possible to reduce the need for additional direct access to the roadway. In selecting locations for full movement intersections, preference will be given to public roads.

Unsignalized median openings

Where a non-traversable median exists, unsignalized median openings may be permitted at a distance 1320 feet center-to-center from a signalized intersection provided that: (1) the opening is designed as a directional opening for left-turns and u-turns from the

major arterial, and (2) an auxiliary lane for the left-turns/u-turns in accordance with the procedure and criteria given in Section 4.2.

If the roadway is undivided or has a continuous two-way left-turn lane; left-turns will be permitted unless an operational or safety problem is identified.

Access connection spacing

Direct land access at locations that do not conform to the signalized intersection spacing interval of 2640 feet center-to-center is discouraged. When permitted, the spacing standard is 660 feet center-to-center on roadways where the posted speed is 45 mph or less. Minor arterials under City of Wentzville jurisdiction are not expected to be posted greater than 45 mph. The access shall be limited to right-in/right-out only unless it is located directly across from a directional median opening.

Where it is not feasible to comply with the above-stated spacing standards, and alternative access is not available, a deviation where the proposed location is within ± 150 feet the standard spacing interval will be considered to be a minor deviation.

Auxiliary lanes

All median openings, signalized and unsignalized, shall have a left-turn lane in accordance with the provisions of Section 4.2 that will permit left-turning vehicles to clear the through traffic lane at a speed not more than 10 mph less than the speed of through traffic and come to a stop before reaching the end of the longest expected queue based on a 95% probability of storing all left-turning vehicles. The length of the turn bay shall be analyzed for both the peak and off-peak conditions and designed for whichever is the longest. Dual left-turns are encouraged where the expected left-turn volume exceeds 200 vehicles per hour.

A right-turn deceleration lane shall be provided at all signalized locations. Auxiliary lanes for right-turns are encouraged at all unsignalized access connections and will be required at all connections where the volume in the outside (curb) traffic lane exceeds 350 vehicles per hour.

Right-turn acceleration lanes may be required by the City (St. Charles County Engineer or MoDOT District Engineer).

Development subsequent to classification of a roadway segment

No additional access rights shall accrue upon the splitting or dividing of existing parcels of land or contiguous parcels under or previously under the same ownership or controlling interest. All access to newly created properties shall be provided internally from any existing access or a new access determined by the above design standards.

d.ii. Access Category 3b Minor Arterial Abutting Land is Partially Developed

Signal spacing

The standard for the spacing of all intersecting public ways and other accesses that will be full movement, or are or may become signalized is 2640 feet measured center-to-center.

Exceptions to this 2640 feet standard will not be permitted unless the proposal documents that there are no other reasonable alternatives to achieve the 2640 feet, there is a documented necessity for the intersection at the proposed location, and a signal study acceptable to the City, or to the St. Charles County Engineer or to the MoDOT District Engineer if not within the jurisdiction of the City of Wentzville, is completed in accordance with Section 4.1.

Unsignalized median openings

Where a nontraversable median exists, unsignalized median openings may be permitted at a desired distance 1320 feet center-to-center from a signalized intersection. Where a nontraversable median exists, an unsignalized median opening may deviate from the 1320 feet spacing provided that (1) it is designed as a directional opening and (2) an auxiliary lane for left-turns is provided in accordance with Section 4.2.

Access connection spacing

Access connections may be permitted if the junction spacing intervals 660 feet center-to-center where the posted speed is 40 mph or less. Minor arterials under City of Wentzville jurisdiction are not expected to be posted greater than 40 mph.

Where it is not feasible and alternative access is not available, a deviation of 150 feet from the standard spacing interval will be considered to be a minor deviation.

d,iii. Access Category 3c Minor Arterial Abutting Land is Fully Developed

This access category is applicable where the abutting land is heavily developed, numerous access connections already exist and there is little opportunity to achieve long and uniform access spacing. The guiding principles for access management on these roadway segments is to: (a) keep the safety and operations from deteriorating further, (b) increase access spacing and improve access design as opportunities arise and as abutting properties are redeveloped, and (c) encourage property owners to consolidate driveways, replace individual driveways with shared access drives, to develop alternative

access and to interconnect adjacent parcels so that pedestrians and vehicles can circulate between them without using the abutting public roadway.

Signal spacing

The ideal signal spacing on category 2c roadways is the same as for category 2b. Where development precludes such spacing, a uniform interval of 1320 feet measured center-to-center may be adopted. At the very minimum, no additional signal will be permitted where it would degrade traffic progression speeds or efficiency.

Unsignalized median openings

Unsignalized median openings or category 2c roadways that have a non-traversable median, or when a non-traversable median is constructed, may be permitted where: (1) the median is of sufficient width to be designed as a directional opening and (2) a left turn lane can be provided in accordance with Section 4.2.

Access connection spacing

The principle objective is to avoid further degradation in the safety of operation of a category 2c roadway.

When properties develop, redevelop or change use, marginal access spacing shall not be less than the stopping sight distance for the 85th percentile, off-peak speed (adjusted to represent center-to-center distances): 300 feet at 30 mph, 350 feet at 35 mph and 405 feet at 40 mph. Minor arterials under City of Wentzville jurisdiction are not expected to be posted less than 30 mph. Where access connections already exist and if spacings are less than these intervals, increased spacing and improved design shall be implemented, to the extent feasible, where abutting properties are consolidated or redeveloped. Alternative access shall also be encouraged when development occurs. Consolidation of two or more existing access connection, or relocation of an access connection to improve safety or questions, is encouraged even though the consolidation, or relocation, will result in a spacing that is less than the above spacings based on speed.

Auxiliary lanes

Auxiliary lanes for left-turns and right-turns are encouraged at all signalized intersections and higher volume access connections. Local constraints may require that these auxiliary lanes will be much shorter than the standard design.

e. Major and Minor Collector Streets, Category 4

This category of roadway provides direct land access as well as the collection - distribution of traffic. Lower traffic volumes, slower speeds and driver expectation permit more closely spaced access

connections than provided on arterial roadways. A speed differential of more than 10 mph between turning vehicles and through traffic may be acceptable.

e.i. Access Category 4a

Major or Minor Collector, Abutting Land is Sparsely Developed or Partly Developed

Signal spacing

The standard signal spacing is 1320 feet measured center-to-center. Where it is not feasible to achieve the 1320 feet interval, a traffic signal may be permitted if traffic progression with at least 35% can be achieved during off-peak periods. Traffic progression during peak periods is not usually expected.

Access connection spacing

Stopping sight distance is the principal criterion for access connection spacing. This will enable drivers to clear an access connection before the need to possibly respond to an event at another connection. Based on posted speed limits, minimum spacings are (adjusted to represent center-to-center distances): 255 feet at 25 mph, 300 feet at 30 mph, 350 feet at 35 mph and 405 feet at 40 mph.

Auxiliary lanes

A left-turn bay is required at all signalized access connections unless the City, St. Charles County Engineer or District Engineer based on jurisdiction, finds that one is not justified. The City, St. Charles County Engineer or District Engineer based on jurisdiction, may require a left-turn bay and/or a right-turn bay at any access connection - signalized or unsignalized.

f. Urban and Rural Local Streets, Category 5

Local streets serve direct land access and provide connection with collector roadways. Properties having less than 200 feet of frontage shall be limited to one access connection unless the City, St. Charles County Engineer or the District Engineer based on jurisdiction, finds that two connections will improve traffic operations or safety on the roadway system. At the discretion of the City, St. Charles County Engineer or District Engineer based on jurisdiction, two access connections may be considered where the abutting property has 200 feet or more frontage on the local roadway.

4. Deviations

a. Signal Spacing

Where its not feasible to meet the signal spacing interval, a signalized intersection may be permitted where a traffic signal progression analysis acceptable to the City, St. Charles County Engineer or the District Engineer if outside the City's territorial jurisdiction, demonstrates that, at a minimum, traffic progression efficiency specified for the access category of the roadway segment can be achieved for both peak and off-peak conditions. The minimum progression efficiency shall not be less than that given in Table II-3. The City (or St. Charles County Engineer or the District Engineer based on jurisdiction) will specify, (1) the cycle length(s) and progression speed(s) for the a.m. and p.m. peaks, (2) the cycle lengths, and progression speed(s) for the midday period and any other off-peak period(s) to be analyzed, (3) the section of roadway to be used in the analysis, (4) traffic volumes, (5) the computer model to be used, and (6) any other conditions as may be appropriate.

Table 7-3 Minimum Progression Efficiency

Functional Class	Access Category	Progression Efficiency	
		Peak Periods	Off-Peak
Major Arterial	2a	45%	50%
	2b	45%	45%
	2c	(1)	(1)
Minor Arterial	3a	40%	50%
	3b	35%	45%
	3c	(1)	(1)
Major and Minor Collector	4a	(2)	35%
	4b	(2)	30%
	4c	(2)	(1)

(1) No decrease in progression efficiency shall be permitted.
(2) Traffic progression usually not provided.
Sources: Research completed by Vergill G. Stover
National Highway Institute Course No. 15255 Access Management, Location and Design

b. Unsignalized Median Openings

An unsignalized median opening may deviate from the spacing standard if the location will not interfere with the safety or operation of a nearby signalized intersection. The following procedure will be used in this evaluation.

Step 1: Determine the functional distance (distance traveled during perception-reaction plus maneuvering distance plus queue storage) of the signalized intersections.

Step 2: Determine the space available for an unsignalized opening by subtracting the sum of the functional intersection distances from Step 1 from the distance between the two signalized intersections.

Step 3: Determine the functional distance (distance traveled during perception-reaction time plus maneuver distance plus queue storage) of the proposed unsignalized median opening.

Step 4: Compare the distance needed for the unsignalized opening from Step 3 with the distance available from Step 2.

Step 5: The unsignalized opening may be provided if the space available (Step 2) is longer than that needed (Step 3).

c. Non-conforming Properties

A property that has frontage that is less than the access connection spacing, or that due to topographic or other condition will be considered to be a nonconforming lot. Such lots will be permitted one access connection. Vehicle use limitations included as a condition of the access permit will include volume limitation in accordance with the following equation.

$$V = 50 + \frac{L + R^2}{2S} 100$$

Where:

V = Permissible peak hour vehicular trips (total to and from the lot).

L = Left distance between the lot centerline and either the centerline of the next adjacent non single-family residential lot, the centerline of the adjacent side street or corner lot, or one-half of the major roadway frontage plus one-half of the minor side street frontage for a corner lot with alternative access. The maximum distance for L cannot exceed S.

R = Right distance measured similar to L above. The maximum distance R cannot exceed S.

S = Spacing distance, based on the posted speed limit and access connection spacing for category 4a above (i.e. minimum spacings, adjusted to represent center-to-center distances, of: 255 feet at 25 mph, 300 feet at 30 mph, 350 feet at 35 mph and 405 feet at 40 mph).

A = Acreage of the lot, but no greater than 3.0 acres on category 2 and 3 segments and 2.0 acres on category 4 roadway segments.

The City shall increase the permissible peak-hour vehicular use (V) by a 15 percent bonus if a lot has either (i) or (ii) below. There is a maximum of two bonuses (V_{max} = 1.3V) for those lots having both of the following features.

i. Shared access with another lot. Motorist must be able to drive directly between the two lots.

ii. Alternative access to a street other than a Category 2 or 3 roadway. On divided roadways, two one-way access points may be substituted for a two-way access point.

7.02.04 Entrance Standards

All entrance construction within the City of Wentzville roadway right-of-way shall be constructed in accordance with the City of Wentzville Standard Specifications and Standard Construction Details, current edition.

Refer to Exhibit 7-2 below for Sight Distance at Intersections criteria.

1. Residential Entrances - Residential entrances on existing City streets or roads shall not be less than ten (10) feet wide at the right-of-way line. When the distance between the sidewalk and pavement edge is less than four (4) feet, the minimum entrance width shall be twelve (12) feet.

   Residential entrances on existing City streets or roads shall be located so the edges of the curb opening shall be a minimum of five (5) feet from the nearest edge of street inlets and ten (10) feet from the street corner radius point. The edges of the curb opening shall not project beyond the side property line extended normal to the pavement. Clearances and dimensions are shown on Exhibit 7-2.

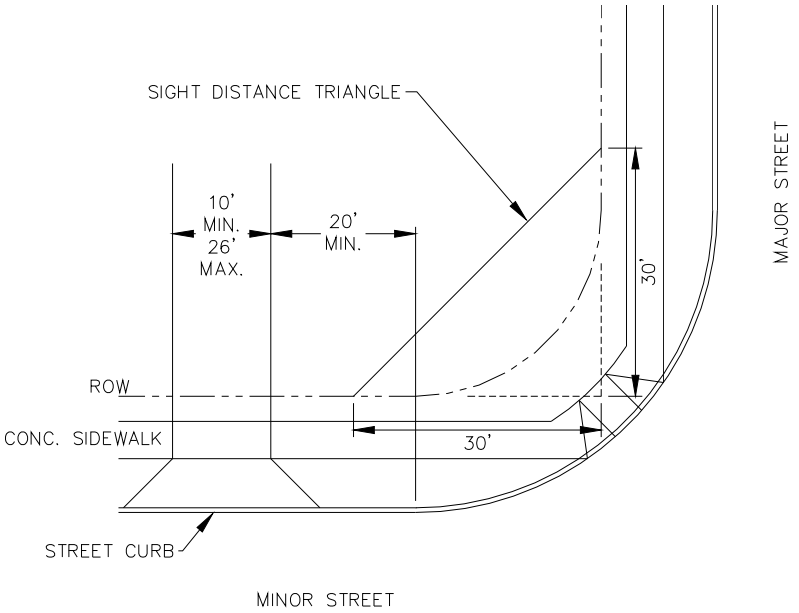


Exhibit 7-2
Sight Distance at Intersections
& Residential Entrances

In the case of corner lots, no driveways shall be constructed within the sight triangle area bounded by the property lines of a corner lot, and a

line connecting two (2) points on the property lines each measured thirty (30) feet from the intersection of the two property lines at the intersection. Where applicable, easement lines shall be substituted for property lines.

The distance between adjacent residential entrances shall be a minimum of twenty (20) feet measured along the road right-of-way line. When residential development conditions necessitate reduction of the distance between adjacent residential entrances to ten (10) feet or less, the Division may require a Common Entrance Approach.

2. Commercial Entrances - Commercial entrances shall not be less than twenty-four (24) feet wide or more than forty (40) feet wide at the right-of-way line. The radius used to increase the opening at the curb or pavement edge shall not be less than ten (10) feet nor more than forty (40) feet. Exception to the width and/or radius may be required, or allowed with special approval by the Division, to insure adequate provisions for large vehicles and/or high traffic volumes.

Commercial entrances shall be located in accordance with the site plan requirements and shall be designed so the edges of the curb opening shall be a minimum of five (5) feet from the nearest edge of street inlets and as far as possible from the street corner radius point. The edges of the curb opening shall not project beyond the side property line extended normal to the pavement.

In the case of corner lots, no entrances, parking spaces or other obstacles shall be constructed or placed within the sight triangle area bounded by the property lines of a corner lot and a line connecting two (2) points on the property lines each measured thirty (30) feet from the intersection of the two property lines at the intersection. Sign poles may be allowed if they are fifteen (15) inches or less in diameter and if the sign they support is not visually obstructing traffic at the intersection.

The number of commercial entrances for each property or site shall be restricted on the basis of traffic requirements as determined by the Division, and shall follow the access management guidelines as set forth in section 7.02.03 .

Properties which have frontage on two or more streets shall have the number of commercial entrances on each street restricted in accordance with traffic requirements and the above guideline. When feasible, opposing commercial entrances shall be aligned opposite or shall be off-set a minimum of 100'. Higher volume driveways may require greater offset to be determined by the Division.

For a service and/or gas station or a convenience store with gas sales development on a corner lot, the following guidelines are established.

For a new development on a lot for which previous use was not associated with service and/or gas station or a convenience store with gas sales: One (1) entrance intersection from each street shall be permitted and located as, far as possible from the street intersection corner. For redevelopment (complete rebuilding) of a lot for which present use is associated with service and/or gas station or a convenience store with gas sales which is presently served by less than three (3) entrances: One (1) entrance intersection from each street shall be permitted at a location approved by the Division.

For redevelopment of a present use which is presently served by three (3) or more entrances: The two (2) entrances located farthest from the corner may remain. The entrance located nearest to the comer on the inbound approach of the intersection shall be removed and the right-of-way restored to surrounding conditions or improved as required. The entrance located nearest to the comer on the outbound approach of the intersection may remain provided that this entrance is restricted, where required by the Division, to right turns in and right turns out by an existing or required median. For remodeling or renovation of an existing use (i.e. canopy addition, island replacement or addition, dispenser replacement or addition, sales area renovation or addition, car wash addition) all existing entrances shall be permitted to remain except when changes to circulation patterns to the driveways result in an increased emphasis on the entrance located nearest the inbound approach of the intersection. Such entrance shall then be subject to further review and possible elimination by the Division.

3. Left Turn Restrictions - The restriction of entrance turning movements will require the construction of right in-right out channelized entrances or raised median, as directed by the Division, based upon proximity to the nearest intersecting street or driveway, left turn storage requirements within the public right-of-way, development land use and traffic generation, sight distance limitations and cross access provisions as indicated in the above guidelines or as required in section 7.02.03.

4. Temporary Emergency Access - In certain instances, the Division may grant temporary access to roadways for emergency vehicles only. The access shall be a 12-foot wide, 12-inch thick rock drive with a standard paved approach within the right-of-way constructed of Type “X” Asphaltic Concrete Base - 6” thick and Type “C” Asphaltic Concrete Wearing Surface - 2” thick. A gate must be provided across the drive at the right-of-way line with the sign, “Emergency Vehicles Only” on each side of the gate. The gate shall have a lock with the only keys thereto in possession of the City of Wentzville Department of Public Works, the City of Wentzville Police Department and the Wentzville Fire Protection District.

5. Cross Access - Cross access is defined as a commonly shared or used pedestrian way or vehicular driveway that connects or serves two or more properties.

   The purpose of cross access may be to reduce the number of entrance intersections to an arterial or county street, to provide access via a signalized intersection, to provide direct access between adjacent developments, to provide access to lots not having road frontage, etc.

   Cross access may be required as part of the Site Plan or Subdivision Review Procedure, zoning request, and/or special procedure request and shall be provided in accordance with the following conditions:

   a) At the time the site plan is submitted for review, the Division will identify adjacent existing land use and its potential for change, existing traffic volumes and design features of the surrounding roadways, etc. in order to ascertain requirements for cross access. If cross access is required, the plan shall show the area to be included for cross access to include the driveway approach, internal driving and parking lot aisles and their extension to the property line(s) at the area(s) designated for connection to adjacent property.

   b) If cross access has previously been established on adjacent property, the developer will be required to provide cross access and construct a pavement connection to the existing internal driving and parking lot aisle within that area of cross access. In the event that cross access has not previously been established on adjacent property, no pavement connection to adjacent property is required other than that necessary for the functioning of the site.

   c) The area designated for cross access shall be kept free of all landscaping, fences, trash enclosures, parking/ loading spaces, and/or other improvements except as required by The Zoning Ordinance. Any approved improvements located in the areas designated for cross access shall be removed by the developer who is required to construct the pavement connection.

   d) A Temporary Slope Construction License shall be provided to facilitate construction of the future cross access by the adjacent development or property owner. Maintenance of cross access areas shall be accomplished by each property owner or as may be agreed to by the owners. The owners shall provide copies of all such agreements to the Division for approval prior to execution and recording.

7.02.05 Sidewalks, Curb Ramps, Crosswalks & Pedestrian Ways

All sidewalks and curb ramps within City of Wentzville road right-of-way or easement shall be constructed in accordance with City of Wentzville Standard Specifications and Construction Details (see Standard Construction Details 700.14, 700.15 & 700.16), the current approved Public Right-of-Way Accessibility Guidelines (PROWAG). ADA detectable warning surfaces are required within residential subdivisions. Sidewalks and pedestrian ways shall be designed to be accessible to the maximum extent feasible to all people according to the Americans with Disabilities Act of 1990 (ADA). ADA detectable warning surfaces are required at all curb ramps, transit platforms, reflecting pools, and hazardous vehicular areas.

1. Sidewalks

   a. Placement - Sidewalks are required on both sides of all streets, and shall be continuous and parallel to the street pavement. The back edge of sidewalk shall be located a distance of one (1) foot inside the ROW line. Sidewalks are not required within residential developments which are zoned agricultural or R-1A. Sidewalks are also not required within developments which are zoned industrial.

   b. Sidewalk Construction - Sidewalks shall be six (6) feet wide on Arterial, Collector and Non-residential street sections and four (4) feet wide on Residential sections and be constructed of four (4) inch thick concrete, except across driveways and temporary turnarounds where the thickness shall be increased to match the driveway approach or adjacent pavement thickness. Additional width shall be required when sidewalks are adjacent to curbs and/or in commercial areas. Where sidewalks are located adjacent to or intersect with a vertical curb within the City road right-of-way or easement, concrete curb ramps will be required.

   c. Grades – Vertical changes in grade shall not exceed 0.25 inches. Vertical changes in grade between 0.25 and 0.50 inches shall be beveled with a slope not to exceed 2(H):1(V). The bevel shall be applied across the entire level change.

   d. Slope – The cross slope of a sidewalk is to be a minimum slope of one (1) percent for drainage and shall not exceed two (2) percent for pedestrian safety. The running slope shall not exceed five (5) percent. When it is infeasible for a sidewalk to have less than five (5) percent running slope, sidewalks may follow the running slope of the adjacent roadway. If the sidewalk cannot be kept at the same running slope as the adjacent roadway and the running slope is greater than five (5) percent, the sidewalk may be considered a ramp and is applicable to ramp design criteria as specified within the current approved ADAAG. Where a running

slope is met with an opposing counter slope, the combined change in slope shall not exceed 13 percent.

e. Clearance – An 80-inch (6.67-feet) vertical clearance from encroachments is to be provided within the limits of the sidewalk. Consideration shall be made for future growth of plantings to uphold the clearance.

f. Landings – The slope of a landing shall allow for drainage and be designed and built with a minimum one (1) percent slope and may not exceed a slope of two (2) percent in any direction. The clear width of landings shall be five (5) feet minimum and the clear length shall be five (5) feet minimum.

g. Sidewalk Passing Space – For sidewalk widths less than five (5) feet, a five (5) foot by five (5) foot passing space is to be provided at intervals no greater than 200 feet. Residential driveways within a Residential roadway shall be constructed with a sidewalk passing space in accordance with detail 700.23.

h. Surfaces – Gratings, access covers, and other appurtenances shall not be located along the sidewalks. Surface slopes that meet at grade breaks shall be flush.

i. Roadway Grade Exception – Where pedestrian access routes are contained within a street right-of-way, the grade of the pedestrian access route is permitted to equal the general grade established for the adjacent street.

j. Easements - Where sidewalks are to be located adjacent to a roadway under the jurisdiction of the Missouri Highways and Transportation Department, they may be required to be placed in a public easement outside of the State right-of-way. Other City owned sidewalks not located within City right-of-way require a sidewalk easement unless the sidewalk is located on City property.

k. Sidewalk Variances – Sidewalks shall be provided along road rights-of-way in accordance with the Division's requirements. A determination as to the need for sidewalks is made by reviewing existing conditions, future development and projected pedestrian needs. Only the Board of Aldermen (BOA) may grant a sidewalk variance in subdivisions per the Wentzville Municipal Code. The BOA may grant a variance in the following cases:

    I. Where sidewalks are not deemed necessary for the public safety or where topographical or other conditions make their installation impractical.

II. Where tracts of land are created having at least three hundred (300) feet of frontage which could be resubdivided into smaller lots at a future time.

III. Where the subdivision designer has submitted for review a proposed sidewalk plan that provides for more direct and safer movement of pedestrian traffic.

IV. Where justifiable conditions can be shown that the strict application of the requirements contained in this Section would impose practical difficulties or particular hardship, cause additional walks that would not be in the public interest, and public safety could be adequately accommodated without the sidewalks.

2. Curb Ramps

a. Curb Ramp Construction – Curb ramps shall be constructed at the same thickness of concrete as the adjacent roadway but at a minimum of six (6) inches on four (4) inches of aggregate base.

b. Grades – Adjacent surfaces at curb ramp transitions and grade breaks to walks, gutters, and streets shall be at the same level. Curb ramps must be flush with the street.

c. Slope – The cross slope of a curb ramp shall be a minimum of one (1) percent and a maximum two (2) percent for pedestrian safety. The running slope is to not exceed a slope of 12(H):1(V). Where curb ramp is met with a counter slope, the maximum counter slope shall be five (5) percent.

d. Alignment – Where feasible, the curb ramp shall be aligned parallel with the direction of travel as shown by the Sidewalk & Curb Ramp Type 2 Standard Construction Detail 700.15. Type 1 Diagonal Curb Ramps (Standard Construction Detail 700.14) are not a preferred design type of the US Access Board. Site constraints including, but not limited to varying roadway intersection radii, existing grades, sidewalk offsets from back of curb, and use of islands may require the curb ramps to be aligned perpendicular to the curb as shown by the Sidewalk & Curb Ramp Type 1 Standard Construction Detail 700.14. Perpendicular ramps shall be located as close to the tangent point as feasible to reduce the distance of the pedestrian crossing.

e. Detectable Warnings Properties – The detectable warnings shall extend the entire width of the sidewalk and shall be brick red in color. Detectable warnings on walking surfaces are to be truncated domes with a diameter of 0.9 to 1.4 inches, a height of 0.2 inches, and a center to center spacing of 1.6 to 2.4 inches in each direction. The truncated dome surface area shall be a minimum length of two (2) feet in the direction of pedestrian travel.

Detectable warnings shall be pre-formed and installed as per manufacturer's recommendations. Stamped Concrete will not be accepted. A list of qualified suppliers include: Detectile: ADA Solutions, Inc., Arcis Corporation, and Armorcast Products Co.

f. Detectable Warning Alignment - The truncated domes shall align with the direction of pedestrian travel wherever possible. The detectable warning shall be placed at the bottom of the ramp, or six (6) to eight (8) inches from the front of the curb depending on the type and location of the curb ramp. Where both ends of the bottom grade break are five (5) feet or less from the back of curb, the detectable warning shall be located on the ramp surface at the bottom grade break. Where either end of the bottom grade break is more than five (5) feet from the back of curb, the detectable warning shall be located on the lower landing.

g. Flares – Traversable flairs, flairs located within the pedestrian pathway, shall have a maximum slope of 10(H):1(V). Non-traversable flairs, flairs located outside of the pedestrian pathway, shall have a minimum transition width of 30 inches (2.5 feet) at the front of curb or extend to the limits of the Right-of-Way, whichever is wider.

h. Surfaces – Gratings, access covers, and other appurtenances shall not be located along the sidewalks. Surface slopes that meet at grade breaks shall be flush.

i. Roadway Grade Exception – The cross slope of curb ramps, blended transitions, landings, and turning spaces at pedestrian street crossings without yield or stop control where vehicles can proceed through the intersection without slowing or stopping, and at midblock pedestrian street crossings are permitted to equal the street grade

3. Crosswalks

a. Curb ramps are to be located within the crosswalk.

b. A four (4) feet by four (4) feet clear landing space is to be provided within the crosswalk.

c. Diagonal curb ramps with flared sides shall have a segment of curb 24 inches long minimum located on each side of the curb ramp and within the marked crossing.

d. Stop bar shall be a minimum of 4 feet from the crosswalk.

e. Curb ramps at marked crossing shall be wholly contained within the markings, excluding any flared sides.

f. Marked crosswalks shall be 6 feet wide minimum.

4. Pedestrian Ways.

a. Where pedestrian ways are provided for access to parks, schools, shopping areas, public transportation facilities, common land, or similar facilities, or where otherwise required, they shall be designed in accordance with these requirements.

b. Where a pedestrian way is required, the pedestrian way shall be provided for in accordance with the following:
   I. Minimum of 15 feet of right-of-way, or easement, shall be provided for the pedestrian way.
   II. Where the pedestrian way is necessary to provide access to an area intended for the installation of active recreation facilities, a walkway shall be required within the pedestrian way. The walkway shall be constructed with a minimum of a 6 foot wide, four (4) inch thick concrete surface on prepared subgrade, or 3 inch thick asphalt pavement on a compacted base of 3 inch thick stone base.
   III. Pedestrian Ways are not a substitution for sidewalks required on both sides of streets, but rather are in addition to sidewalks, and would generally be for use along streams, surrounding common ground areas, and around water quality basins.

7.03 Street Design Criteria

7.03.01 Arterial Street Design Criteria

1. Right-of-Way and Pavement Width Requirements:

Street Classification	R/W Width	Pav't Width	Standard Dwg. No.
4 Lane Arterial	80	51	700.05
5 Lane Arterial	100	67	700.06

2. Pavement Thickness Requirements:(1)

All classifications and pavement widths	Rigid Pavement 8" Portland Cement Concrete* 4" Type 1 or Type 5 Aggregate Base

(1) Pavement thickness on recently improved Arterials may be greater than shown due to federal requirements. Any additional widening to these pavements must match existing conditions as directed by the Division.

* Type "G" Transverse Joints required (Refer to Standard Construction Detail 700.07.

3. Horizontal and Vertical Alignment Requirements:

Street Classification	Grades (2)	Centerline Alignment	Anticipated Posted Speed Limit (3)
4 or 5 Lane Arterial	2% Min. 6% Max. 6% to 8% by special approval of Division. Special design may be required.	10 Degree Max. (575' R)	35 MPH min.
4 or 5 Lane Arterial	2% Min. 6% Max. 6% to 8% by special approval of Division. Special design may be required.	6 Degree Max. (955' R) 6 to 10 Degrees by special approval of Division.	40 MPH min.

(2) Roadway grades less than 2% or in excess of 6%, must be approved by the Division prior to the preparation of improvement plans. Refer to Exhibit 7-3 for Design Control for Vertical Curves.

(3) Design Speed - On existing roadways, design speed shall be the 85th percentile speed of motorists on the roadway as established by radar studies, or 5 m.p.h. greater than the posted speed limit, whichever is greater. On new roadways, design speed shall be 5 m.p.h. greater than the anticipated posted speed limit.

7.03.02 Collector Street Design Criteria

1. Right-of-Way and Pavement Width Requirements:

Street Classification	R/W Width	Pav't Width	Standard Dwg. No.
3 Lane Collector	70	39	700.04

2. Pavement Thickness Requirements:(1)

All classifications and pavement widths	Rigid Pavement 8" Portland Cement Concrete* 4" Type 1 or Type 5 Aggregate Base

(1) Pavement thickness on recently improved Collector may be greater than shown due to federal requirements. Any additional widening to these pavements must match existing conditions as directed by the Division.

* Type "G" Transverse Joints required (Refer to Standard Construction Detail 700.07).

3. Horizontal and Vertical Alignment Requirements:

Street Classification	Grades (2)	Centerline Alignment	Anticipated Posted Speed Limit (3)
3 Lane Collector	2% Min. 6% Max. 6% to 10% by special approval of Division. Special design may be required.	15 Degree Max. (375' R)	30 MPH min.
3 Lane Collector	2% Min. 6% Max. 6% to 10% by special approval of Division. Special design may be required.	10 Degree Max. (575' R)	35 MPH min.

(2) Roadway grades less than 2% or in excess of 6%, must be approved by the Division prior to the preparation of improvement plans. Refer to Exhibit 7-3 for Design Control for Vertical Curves.

(3) Design Speed - On existing roadways, design speed shall be the 85th percentile speed of motorists on the roadway as established by radar studies, or 5 m.p.h. greater than the posted speed limit, whichever is greater. On new roadways, design speed shall be 5 m.p.h. greater than the anticipated posted speed limit.

7.03.03 Residential/Commercial Street Design Criteria

1. Right-of-Way and Pavement Width Requirements:

Street Classification	R/W Width	Pav't Width [1]	Standard Dwg. No.
2 Lane Rural	30	24[3]	700.01b
2 Lane Local	50	26	700.01a
3 Lane Local	60	39[2]	700.02
2 Lane Commercial Local	50	32	700.03

[1] All of the above-designated pavement widths shall be constructed with rolled curb with the exception of the following conditions:

a. Where subdivisions are approved with commercial lot frontages which require mountable curb.
b. Where subdivision Collector streets are designed with mountable curb and restricted access and adjacent lots are served from the internal cul-de-sac and loop streets.
c. Curbing not required on 2 Lane Rural streets.

[2] The 39' pavement width shown for 3 Lane Local streets shall be designed in accordance with the following lane configurations:

a. 3 driving lanes where adjacent residential lots are served from internal cul-de-sac and loop streets.
b. 2 driving lanes with 2 emergency parking lanes where adjacent residential lots are served from the 3 lane local roadway. However, at major intersections 3 driving lanes with tapers, appropriate pavement joint transitions and posted parking restrictions will be required.

[3] Where Rural Streets are designed with 30 foot wide right-of-way widths, sufficient easements shall be provided behind the ROW line to accommodate public utilities, sewers and drainage swales and/or BMPs.

2. Pavement Thickness Requirements:

All Subdivision Streets equal to or less than 30' wide	Rigid Pavement 7" Portland Cement Concrete* 4" Type 1 or Type 5 Aggregate Base
All Subdivision Streets more than 30' wide	Rigid Pavement 8" Portland Cement Concrete* 4" Type 1 or Type 5 Aggregate Base

* Type "G" Transverse Joints required for commercial streets (Refer to Standard Construction Detail 700.07). Not required for residential streets.

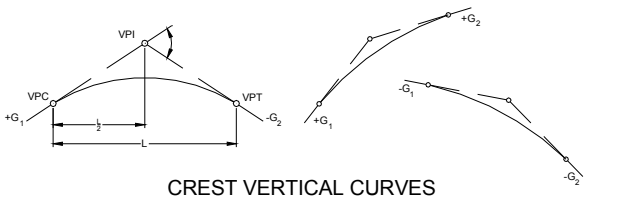
3. Horizontal and Vertical Alignment Requirements:

Street Classification	Grades [4]	Centerline Alignment	Anticipated Posted Speed Limit [5]
2 Lane Local	2% Min. 10% Max.	150' R Min.	25 MPH Min.
2 Lane Rural	Greater than 6% may require special design.	150' to 75' R by special approval of the Division	Under 25 MPH By special approval of the Division
3 Lane Local	2% Min. 10% Max. Greater than 6% may require special design.	15 Degree Max. (375' R)	30 MPH min.

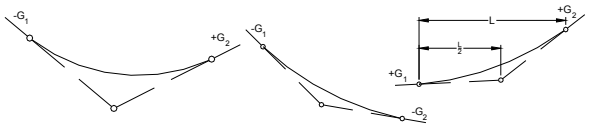
[4] Roadway grades less than 2%, must be approved by the Division prior to the preparation of improvement plans. Refer to Exhibit 7-3 for Design Control for Vertical Curves.

[5] Design Speed - On existing roadways, design speed shall be the 85th percentile speed of motorists on the roadway as established by radar studies, or 5 m.p.h. greater than the posted speed limit, whichever is greater. On new roadways, design speed shall be 5 m.p.h. greater than the anticipated posted speed limit, except for 2 lane residential streets, where the design speed may be equal to the anticipated posted speed limit.

Design Speed M.P.H.	"K" Values for Crest & Sag Vertical Curves								Minimum Value of "L"
	2 Lane Pavement		3 Lane Pavement		4 Lane Pavement		5 Lane Pavement		
	Crest	Sag	Crest	Sag	Crest	Sag	Crest	Sag	
15	10	10	10	10	15	10	15	10	50'
20	20	20	20	20	20	20	25	20	60'
25	25	25	30	30	35	30	35	30	75'
30	35	35	40	40	45	40	55	40	90'
35	50	50	55	50	65	50	70	50	105'
40	80	70	80	70	80	70	90	70	120'
45	120	90	120	90	120	90	120	90	135'
50	160	110	160	110	160	110	160	110	150'
55	220	130	220	130	220	130	220	130	165'
60	310	160	310	160	310	160	310	160	180'
65	400	180	400	180	400	180	400	180	195'
70	540	220	540	220	540	220	540	220	210'



CREST VERTICAL CURVES



SAG VERTICAL CURVES

G_1 & G_2 = TANGENT GRADES IN PERCENT
A = ALGEBRAIC DIFFERENCE IN GRADE, PERCENT
L = LENGTH OF VERTICAL CURVATURE, FEET
K = RATE OF VERTICAL CURVATURE, FEET/1% CHANGE IN GRADIENT.

Exhibit 7-3,
Recommended Design Control for Vertical Curves

7.03.04 Cul-de-Sacs

The minimum pavement radius on a cul-de-sac or other section of a roadway that is not a through street, such as an “eye brow”, shall be 42 feet, with the radius of the ROW being 54 feet. Where turnarounds are required for buses, the minimum pavement radius shall be 55 feet, with the radius of the ROW being 67 feet. Pavement thickness, curb design, and sidewalks shall be consistent with the street sections from which it continues.

7.04 Traffic Impact Studies

Traffic impact studies are reports typically prepared in advance of approving a zoning change or a site plan that would result in a discernable traffic impact to the adjacent street system. In this section, guidelines are provided regarding when a traffic study shall be requested to be completed by the developer and what the report shall address.

7.04.01 Traffic Impact Study (TIS) Purpose and Responsibility

A Traffic Impact Study assesses the impact on the transportation system caused by a change in use of property, proposed development, or zoning change. If the impacts cause deficiencies, improvements and mitigation measures are then recommended. The TIS is a tool to:

- Maintain the function and operation of the transportation network so it is not adversely affected by the change in use.
- Identify transportation impacts or problems associated with the property, especially its access to the transportation system.
- Identify solutions to potential impacts and adverse effects.
- Recommend internal and external improvements to be included into the property's proposed development.

The property owner, developer or traffic consultant has the responsibility for performing the Traffic Impact Study associated for the proposed change in use or redevelopment. The City serves as the reviewing agency and shall determine the warrants and scope of the study.

Traffic signal warrants, site plan reviews, permit reviews and other City studies or reviews are separate from a TIS.

7.04.02 Traffic Impact Study (TIS) Warrants

A Traffic Impact Study is typically warranted when one of the following is satisfied:

- The development causes the trip generation of the property to increase by more than 1,500 vehicles in a day.

- The development causes the trip generation of the property's new trips, not pass by trips, to increase by more than 100 vehicles in any 60-minute interval.
- A development where a proposed residential subdivision with 100 or more lots (or units) is expected.
- The property is near streets and intersections previously identified as having poor levels-of-service (LOS) such as LOS E or LOS F.

A traffic signal warrant may still be requested by the City even when a Traffic Impact Study is not. Traffic signal warrants, site plan reviews, permit reviews and other City investigations or reviews are separate from a TIS.

Typical developments that cause the trip generation of the property to satisfy the above warrants are shown in the following table for use as examples. The City shall reference Trip Generation by the Institute of Transportation Engineers (latest revision) when investigating TIS warrants.

Table 7-4 Typical Land uses Satisfying TIS Warrants

Land Use Category	Description or Criteria
Gasoline Station	More than eight pumps
General Light Industrial Use	215,000 square feet and/or 500 employees
Apartments	225 units an/or housing 450 people
Hotel	180 rooms and/or 105 employees
Golf Course	300 acres and/or 40 holes
Movie Theater	20,000 square feet and/or seven screens
Middle School	27,000 square feet and/or 220 students
Office	
Medical or Dental Center	27,000 square feet and/or 94 employees
Fast Food Restaurant	2,000 square feet
Bar or Lounge	6,500 square feet
Car Lot	40,000 square feet
Electronics Store	22,500 square feet
Pharmacy or Drug Store	11,000 square feet
Drive-in Bank	1,850 square feet and/or eight employees

Source: Trip Generation, Institute of Transportation Engineers, 1997.

7.04.03 Scope of TIS

In advance of a Traffic Impact Study, the property owner and/or traffic consultant shall discuss with the City to understand the study's scope. This will help ensure the TIS is properly prepared, and that the recommendations made are realistic and feasible. Contact between the preparer and reviewer is encouraged throughout the preparation of the TIS. Often the City Public Works Department can provide data to the preparer such as land use, zoning and traffic counts if requested.

1. TIS Study Area Limits

The City shall determine the limits of the TIS study area. The TIS study area boundaries shall include:

- Major and minor roadways adjacent to the site.
- The first encountered signalized intersections adjacent to the property on the logical travel path between the site and the City's major roadway transportation network.
- Additional intersections on the logical travel path between the site and the City's major roadway transportation network as determined by the City.
- Critical intersections, access connections and driveways rationally identified to receive impact.
- Railroad crossing intersections and bicycle, pedestrian and transit crosswalk locations rationally identified to receive impact.
- Existing and future traffic impacts of other nearby planned developments known at the time that rationally have a traffic impact on part of the TIS study area, the study corridor or impact a specific intersection under evaluation as determined by the City.

2. Study Horizon

The City shall determine the study horizon or the future year to be studied for the no-build condition (or other baseline alternative condition) and the build condition. The City can require more than one study horizon. The study horizon is usually determined as one or more of the following:

- A scheduled year for completion of the property's change in use.
- A year as determined using the City's Comprehensive Plan.

3. Additional Elements

The Traffic Impact Study Standards are to serve as general guideline for the preparation and review of a property's traffic impact on the City's transportation system, public roadways or right-of-way. Since it cannot cover all situations, some studies will require additional report elements or unique analytical methods that shall be discussed in advance with the City and included in the scope. Additional elements could include:

- Approval of the trip generation and trip distribution methodology.
- Approval of the traffic analysis methodology and/or software.
- Alternative horizon year conditions other than the no-build condition.
- More than one study horizon (horizon year).

- Acceptable and unacceptable level-of-service determination.
- Number and location of traffic counts to be performed.
- Intermediate construction phases and temporary conditions to be analyzed (typically done if transportation improvements are not complete in initial construction phase regardless of the duration the property remains in an intermediate phase).
- Application of traffic safety measures and traffic calming measures.
- TIS schedule milestones and Traffic Impact Study completion date if atypical.

Traffic signal warrants, site plan reviews, permit reviews and other City studies or reviews are separate from a TIS

7.04.04 Traffic Impact Study (TIS) Contents

This section lists a typical table of contents of a Traffic Impact Study to serve as a guideline for preparation of the document. A TIS is often data intensive, so graphics and diagrams in each section are often desired to communicate findings rather than text descriptions.

A. Executive Summary

Description of existing and proposed future property development Description of scope, contacts, site location and TIS study area Findings, LOS and conclusions (graphics and figures desired) Mitigation and improvement plan summary

B. Property and Site Description

Description of existing and proposed land use zoning and type of project.

Size of project in units: such as square footage area by type and density.

Description of project phasing and stages to study horizon.

Socio-economic characteristics of the property users, if atypical of the development.

Description of other major existing and future property developments in TIS study area.

Description of existing transportation facilities and other transportation modes, if impacted.

Document coordination with known capital improvements, City Comprehensive Plan implementation, known transportation plans, other planned external improvements and traffic impact studies.

Typical graphics and/or tables include:

- Location map relative to the City limits or region
- TIS study area map showing property location and area of influence
- Existing and proposed land use map of TIS study area
- Existing transportation map including major and minor roadways adjacent to the site plus roadway, bicycle, pedestrian and transit access
- Site plans showing:
    i. Location of site relative to adjacent roadways and parcels
    ii. Access connections to public roadways and adjacent parcels or sites
    iii. Internal access and circulation control if impacting operations of public roadways or right-of-way

C. Existing Condition

Used for comparison purposes in evaluation. As determined by the City, this section shall consider the existing traffic impacts of other zoned or land uses that are part of the TIS study area, that have a traffic impact on the study corridor or impact a specific intersection under evaluation.

Description of site access and external circulation.

Document items for roadways, intersections and signals within TIS study area such as: Existing traffic volumes, ADT, truck or large vehicle percentages, peak hour volumes for streets and properties.

Existing traffic counts shall not be older than two years of the TIS date.
Volume to capacity (V/C) and level-of-service (LOS) analysis (include LOS of intersections, intersection approaches and turning movements).

Gap acceptance analysis along public roadways for points of egress (LOS for stop control).

Travel characteristics of streets within the TIS study area such as:

- Sight distance limitations on the roadway and at access connections
- Pavement width or right-of-way (ROW) width limitations if impacting operations
- Horizontal or vertical alignment deficiencies if impacting operations

Typical graphics and/or tables include:

- Figures of existing roadways, street corridor plans, intersection diagrams, dimensions, number of lanes, lane uses, and configurations in the TIS study area

- Figures of existing traffic volumes, V/C, LOS, ADT, truck or large vehicle percentages, and peak hour volumes and turning movements for streets, intersections and properties in the TIS study area
- Information that shows sight distance measurements at ingress and egress points in the TIS study area (and crash statistics if available)

D. No-Build (or other baseline alternative) Condition at Study Horizon Year

Analysis assumes property's change in use (proposed site) is not part of TIS study area in the future year. As determined by the City, this section shall consider the future traffic impacts of other zoned or future land uses that are part of the TIS study area, that have a traffic impact on the study corridor or impact a specific intersection under evaluation.

Description of future site access, access connections, and external circulation if different than existing conditions.

Application of trip generation of other known future projects in the TIS study area. Document items for roadways, intersections, and signals within TIS study area such as:

- Forecasted traffic volumes, ADT, truck or large vehicle percentages, peak hour volumes for streets and properties
- Volume to capacity (WC) and level-of-service (LOS) analysis (include LOS of intersections, intersection approaches and turning movements)
- Gap acceptance analysis along public roadways for points of egress (LOS for stop control)
- Analysis of other planned transportation improvements complete by study horizon
- Anticipated travel impacts of streets within the TIS study area such as:
    i. Sight distance limitations on the roadway and at access connections if impacting operations
    ii. Pavement width or right-of-way (ROW) width limitations if impacting operations Horizontal or vertical alignment deficiencies if impacting operations

Typical graphics and/or tables include:

- Anticipated roadways, street corridor plans, intersection diagrams, dimensions, number of lanes, lane uses, and configurations impacting public roadways or right-of-way in the TIS study area
- Forecasted traffic volumes, V/C, LOS, ADT, truck or large vehicle percentages, and peak hour volumes and turning movements for streets, intersections and properties in the TIS study area
- Information that shows sight distance measurements at ingress and egress points impacting public roadways or right-of-way if different than existing conditions in the TIS study area

E. Build Condition at Study Horizon Year

Analysis assumes property's change in use (proposed site) is integrated in the TIS study area in the future year. As determined by the City, this section shall consider the future traffic impacts of other zoned or future land uses that are part of the TIS study area, that have a traffic impact on the study corridor or impact a specific intersection under evaluation. Traffic impacts on the public roadway or right-of-way shall include existing traffic, other future traffic growth, the forecasted property traffic and traffic of other known developments.

Estimate and apply trip generation, average vehicle trips per day, peak hour volumes of streets, peak hour volumes of property, directional distribution, and volume assignments impacting the public roadway or right-of-way

Apply other trip generations of external projects in the TIS study area

Document unique conditions that vary travel demand if any

Description of proposed site access, access connections and external circulation

Evaluate and document application of the City Access Management Standards

Document items for public roadways, intersections and signals within TIS study area such as:

- Volume to capacity (V/C) and level-of-service (LOS) analysis (include LOS of intersections, intersection approaches and turning movements)
- Gap acceptance analysis for points of egress (LOS for stop control)
- Inclusion of external planned transportation improvements complete by study horizon
- Anticipated sight distances, turning movement conflicts and other possible hazards impacting public roadways or right-of-way

Analyze impacts to public roadways or right-of-way of temporary conditions related to construction staging and phasing (typically done only if transportation improvements are not complete in initial construction phase regardless of the duration the property remains in an intermediate phase)

Typical graphics and/or tables include:

- Anticipated impacts to public roadways or right-of-way, street corridor plans, intersection diagrams, dimensions, number of lanes, lane uses, and configurations in the TIS study area
- Anticipated directional distribution and turning volumes of the property's trip generation on the transportation network, public roadways or right-of-way in the TIS study area

- Total forecasted traffic volumes, V/C, LOS, ADT, truck or large vehicle percentages, and peak hour volumes and turning movements for streets, intersections and properties in the TIS study area
- Information that shows anticipated sight distance measurements at proposed ingress and egress points impacting public roadways or right-of-way in the TIS study area

F. Recommendations, Mitigation Plan, Additional Analysis

This section identifies the mitigation measures to the public roadway and right-of-way in areas where the proposed site causes an adverse effect. All roadways and intersections showing a LOS below C shall be provided with specific recommendations for the elimination of the transportation deficiencies to achieve LOS C or above.

Describe recommendations and mitigation measures to counterbalance impacts for traffic or other factors impacting public roadways or right-of-way to achieve LOS C or above such as:

- Application of turn prohibitions or traffic channelization by identifying turning movement conflicts
- Access connection location and design improvements impacting public roadways or right-of-way
- External transportation improvements along street frontage and other roadways affecting roadway design, intersection design, traffic signal installation, signal operation and timing, roadway signage
- Other planned transportation improvements including recommendations to other travel modes if any

Document how recommendations change:

- Volume to capacity (V/C) and level-of-service (LOS) analysis to achieve LOS C or above
- Travel safety such as conflict points, sight distances and possible hazards if any

Provide implementation schedule of recommendations, mitigations, improvements and modifications

Typical graphics and/or tables include:

- Proposed improvements, dimensions and configurations used as mitigation measures impacting public roadways and right-of-way
- Information that shows the mitigated changes in V/C, LOS for streets, intersections and property access connections impacting public roadways and right-of-way
- Information that shows mitigated sight distance measurements at ingress and egress points impacting public roadways and right-of-way

G. Appendix

Description of analysis method, assumptions, limitations, data collection items, demographics, traffic counts etc.

Calculations and work sheets from analysis

References

7.04.05 Reviewing Guidelines

This section describes reviewing considerations of a TIS that can be used to further describe some areas of the contents.

1. Formal Review

Traffic Impact Studies shall be reviewed by the following:

- The City

The formal review after submittal of the Traffic Impact Study shall include the following:

- Lists of acceptable and unacceptable analysis and conclusions
- Acceptability of recommendations, provisions, roadway improvements, site access and external circulation that impact public roadways and/or right-of-way
- List of required improvements that could mitigate impacts of the property's change in use
- List of requested study revisions or a letter of acceptance of the study to submit to the preparer

Requests for study revisions shall identify the findings of the formal review and the specific additional information required. The revisions performed by the preparer can be included as an addendum to the original study, or a revised TIS may be requested by the reviewer.

2. Considerations During TIS Review

This section describes in more detail typical rules of thumb to apply when reviewing a Traffic Impact Study. Since some factors may not apply to all situations, it is up to the discretion of the reviewer to decide when to apply or require certain guidelines. In general, the following factors shall given special focus during review:

Safety Considerations

Stopping sight distances shall meet American Association of State Highway and Transportation Officials (AASHTO) guidelines at all

ingress and egress points. The stopping sight distance for the 85th percentile, off-peak speed are: 155 feet at 25 mph, 200 feet at 30 mph, 250 feet at 35 mph and 305 feet at 40 mph. Deviation shall be noted and approved by the City.

If available, existing crash statistics can be reviewed. Sometimes crash data can aid the identification of existing condition or no-build condition areas in need of improvement. Often crash data is not available, so consideration shall be given toward access control measures, sight distances and other factors to promote travel safety.

Trip Generation Considerations

The estimated site trip generation shall be determined in units of ADT and peak hours. The site trip generation volumes shall be calculated using data and methods from various studies such as:

- Trip Generation, published by the Institute of Transportation Engineers, which contains rates based on development type, size, etc.
- By making counts of turning movements at an existing project or property with similar characteristics, calculating the trip generating rates in terms of an appropriate unit, such as vehicles per 1,000 feet of gross lease able floor area or vehicles per maximum number of patrons and employees, and then applying those rates to the proposed property.
- Other studies approved by the City in accordance with what is considered the industry standard and best practices by transportation professionals.

The Traffic Impact Study shall determine the directional distribution of trips impacting public roadways and right-of-way. The analysis shall allocate trips generated and traffic volumes to access connections based on directions of approach and departure. By relating this information to existing roadway traffic volumes a basis is provided for selecting access connection designs, identifying turning movement conflicts and applying turn prohibitions or traffic channelization recommendations. Alternatively, population and employment distribution by census block group, or simpler geographic area, may be allowed as approved by the City.

The existing, no-build (or other baseline alternative) and build conditions shall include an estimation of specific turning movements by combining trip generation results with directional distribution of trips. These estimates are important tools to determine the cumulative effect upon street capacities and levels-of-service within the TIS study area caused by the development proposals.

Traffic Operational Considerations

The peak hour LOS shall not drop more than one level at any one location when comparing the build condition to the no-build condition (or other baseline alternative condition). The reviewer may ignore this consideration if the LOS of the location is still acceptable (LOS C or above) by the City. Recommendations and mitigation to achieve LOS C or above shall otherwise be given in the TIS.

The LOS of a street segment or of an intersection approach within the TIS study area shall not drop below LOS C in the build condition. Recommendations and mitigation to achieve LOS C or above shall otherwise be given in the TIS.

The ADT of any street in the build condition shall not be greater than 33% above the ADT of the street in the no-build condition (or other baseline alternative condition). The reviewer may ignore this consideration if the LOS or volume to capacity of the street is still considered acceptable by the City.

Street capacities and traffic volumes in the TIS study area shall include the cumulative effects of other planned developments known at the time when performing the Traffic Impact Study that shall be determined and agreed upon when defining the scope of a TIS.

The Traffic Impact Study shall evaluate potential conflicts with street traffic or traffic on other public roadways or right-of-way in the TIS study area. The TIS shall examine:

- Potential conflicts created along the access street(s), public roadway(s) or right-of-way
- Impacts of ingress and egress turning movements, particularly left turning movements if impacting public roadways or right-of-way
- Determine the need for transportation improvements adjacent to the property, i.e. left turn and right turn bays, access control measures according to the City's Access Management Standards, medians, driveway islands, sidewalks, bicycle lanes, etc.
- Describe and analyze the "downstream" impacts at critical intersections and other access connections and assess the needs for improvement in the TIS study area.
- Operational analysis shall include techniques from the Highway Capacity Manual and other methods approved by the City in accordance with what is considered the industry standard and best practices by transportation professionals.

Site Considerations

Access connection (driveway) locations and spacings shall be designed using the City's Access Management Standards. Measurements and dimensions shall be called out. Deviations shall be shown to fit the needs and uses of the property as determined and approved by the City.

Access connections and/or driveways shall be placed so queuing vehicles do not block the connection resulting in congestion along the public roadways or right-of-way.

Circulation between adjacent properties shall be provided in the site plan so vehicles can travel between sites without needing to exit and reenter along the access street(s). Access connections along the access street(s) can serve more than one property or site, so internal circulation between adjacent properties shall be provided per the City's Access Management Standards:

- Regardless the quantity of access connections, all adjacent commercial zoned properties shall develop alternative (cross) access and interconnect to adjacent parcels so that pedestrians and vehicles can circulate between them without using the abutting public roadway.
- When adjacent properties (residential lots or other land uses) have frontage less than the access connection spacing or when one connection per parcel violates the access connection spacing standards, the City Public Works Department shall strongly encourage property owners to implement alternative access connection plans so their public access connections conform to the spacing guidelines. Such plans and solutions could include property owners consolidating driveways, replacing individual driveways with shared access drives, developing alternative access and interconnecting to adjacent parcels so that pedestrians and vehicles can circulate between them without using the abutting public roadway.
- Access to a corner property located at the intersection of two roadways of different functional classification shall be to the roadway having the lower functional classification unless the City, St. Charles County Engineer or District Engineer based on jurisdiction, find that access on both frontages will improve safety or the traffic operations on the public roadway system. Where a corner property fronts on two roadways having the same functional classification, the City, St. Charles County Engineer or District Engineer based on jurisdiction, shall specify the street to which access is to be provided. Access to a corner property shall be located near the property line most distant from the intersection.

Phasing-Considerations

Study and analysis of the temporary build conditions or construction phasing of the property shall be performed with detail similar to the analysis performed for the ultimate build condition. In some cases, intermediate build phases of the property could generate poor safety and traffic conditions before the property's transportation improvements are complete. Where possible, transportation improvements that are part of the site plan shall be completed prior to the time when impacts from the property's change in use are expected. Any deviations shall be approved by the City.

8 Easements

8.01 General

All public sewers, water mains, storm drainage facilities and open channels shall be constructed in public rights-of-way or in easements. No permit for construction of improvement of any public sewer, water main, drainage facility or storm channel will be issued without the provision of suitable permanent easements. Easements required shall be acquired and submitted to the City, for recording, before improvement plans will be approved. Subdivision plats, upon which improvements are to be made need to include all applicable easements which are necessary for the improvements. Utility easements shall be prepared in full accordance with the City's Requirements and Guidelines for Plan and Specification Preparation, latest edition.

8.02 Use of Existing Easements

Every existing easement to be used shall be shown on the plans submitted for review and approval. The information on the plans shall include the County book and page numbers of the recorded instrument.

All restrictive clauses as to the use of the easements, i.e. for utility purposes, storm sewers only, sanitary sewers only, etc. shall be noted on the plan adjacent to the pertinent easement. Construction of a sewer in the same easement with a water or gas main will not be approved unless the easement is of such size that the locations of the sewer and utility relative to each other comply with dimensional clearances required by the regulatory authorities.

8.03 Location of Easements

In locating easements, consideration shall be given to the property owner's interests. Undue splitting and angling across property shall be avoided. Easement locations shall be fixed by distances to known property lines or public right-of-way lines and, where necessary, by angles.

8.04 Width of Easements

The width of the easement shall be sufficient to allow proper access for maintenance of the sewer. Easement widths shall provide a two (2) feet minimum clearance between outside limit of utility pipe wall or utility structure to easement line with a ten (10) foot minimum width. All easements shall include use of additional space adjacent to the easement so granted as may be required for working room.

8.05 Utility Easement Preparation Guidelines

8.05.01 Label Established Lines Affecting Tract and/or Mentioned in its Legal Description:

The following lines shall be shown, where pertinent:

1. Lot lines

2. Subdivision lines (affected, adjacent, or near)

3. Section lines (or sub-section lines)

4. U.S. Survey lines

5. Street, road, highway and/or alley lines

Property is to be located in relation to known corners along the above listed established lines.

8.05.02 Identify Parcel or Tract

The following written information shall be shown, where pertinent:

1. Legal subdivision name, with Lot and Block, Plat Book and Page; if in a recorded subdivision.

2. For metes and bounds described parcels, the current owner with Book and Page labeled across tract; add N/F (Now or Formerly) preceding owners' names

3. Fully dimension owner's property (or as much as shown)

4. Show "North" arrow and scale with "North" to top or side of easement document.

5. Above owner's name indicate property locator number per current assessor's records.

8.05.03 Accurate Title Box Information

The following information shall be shown, where pertinent:

1. Label as "Utility Easement"

2. Describe only where easement is sought, not wherein all the owner’s land lies.

8.06 Easement Script Pages

Easement script shall be the standard City of Wentzville easement script. Any revisions to the script must first be approved by the City Engineer and the City Attorney.

9 Inspection, In-service, and Dedication

9.01 General

The City of Wentzville will accept for dedication, all public sewers, pump stations, water mains, storm drainage facilities, and streets within easements and rights-of-way dedicated to the City of Wentzville that have been constructed to City of Wentzville standards and for which the requirements stated herein have been met. The requirements stated below are for informational purposes and conform to the requirements in Chapter 410, Article VI ACCEPTANCE OF IMPROVEMENTS of the City of Wentzville Municipal Code.

The maintenance of these public facilities will remain the responsibility of the project owner until such time that they have been accepted for dedication by the City.

9.02 Construction Approval

The developer shall obtain a construction permit from the City of Wentzville Engineering Division. The steps necessary to obtain a construction permit are as follows:

a. Improvement plan submittal and approval, including submittal fee.
b. Payment of requisite construction permit fee.
c. If Record Plat is recorded, establish a completion guarantee. The guarantee can be in the form of an escrow agreement, letter of credit, deposit agreement, or performance bond based on the engineer's estimated construction costs as approved by the Engineering Division for each of the following:
    1. 110% of the estimated cost for public infrastructure, not including residential stormwater quality BMPs, and
    2. 110% of the engineer's estimated construction cost for all sediment and erosion control BMPs.

After obtaining a construction permit, but before construction may begin, the developer and his/her contractor(s) shall conduct a pre-construction meeting with the City of Wentzville Engineering Division. A representative of the contractor and the developer are required to attend this meeting.

If the project is a phased project, and more than one phase are depicted on a set of improvement plans, the permitting, fees, escrow, pre-construction meeting and construction may be completed per phase.

9.03 Inspections

The developer and/or contractor(s) shall coordinate construction inspections with the Engineering Division personnel. If the contractor stops work for any period of time, the City will require 48 hours notice prior to the re-commencement of work.

All required testing for water, stormwater and sanitary sewer systems shall be coordinated by the contractor with the City of Wentzville inspector. The water and sanitary systems will not be placed into service until such time as all testing has been adequately completed for both systems, and initial construction inspection is complete and as-built drawings (see chapter 11 for as-built requirements) have been submitted to the Engineering Division.

Service connections will not be allowed until the systems have passed the in-service inspection process. Additionally, water and sanitary sewer improvements will not be placed into service except according to the phasing as depicted on the improvement plans. The City will notify the developer and contractor in writing that the systems have passed the in-service inspection process and/or satisfactory completion of stormwater BMP construction in compliance with approved plans.

9.04 Escrow Release and Dedication Procedure

1. After notification by the City that all initial construction inspection items are satisfactorily completed, the Developer may request, in writing, the release of escrowed funds not to exceed 95% of the estimated cost of improvements. Prior to any escrow release, the developer shall submit the required affidavit stating that all improvements have been completed, as well as as-built drawings. The City shall within 30 days, issue an escrow release letter to the respective holding institution, with a copy to the developer.

2. If necessary, an inspection report will be generated and sent to the Developer. The Developer will have 60 days to correct deficiencies and request a follow-up inspection. Should the Developer fail to correct all or any deficiencies, the City shall have the option to re-inspect and create a new deficiency list or to make identified corrections and have all costs reimbursed through the established escrow. The City shall perform an initial inspection and a re-inspection at no additional charge. Any subsequent inspections will require the payment of a re-inspection fee of $100.

3. The Developer shall, in writing, request a final dedication inspection. The City shall, within 30 days of notice, perform a final dedication inspection. With the receipt of all documents and inspection corrections, the City will prepare a dedication ordinance for the effected improvement. With the approval of the Board of Aldermen, an executed ordinance will be forwarded to the Developer along with the notice to release the 5% escrow to the respective holding institution.

Chapter 10

Currently Not Being Used

11. As-built Drawing Requirements

11.01 General

All entities that construct public waterlines or facilities, storm drainage systems, impoundments, or sanitary sewers to be maintained by the City of Wentzville shall submit to the Engineering Division an as-built set of construction drawings as a part of the City's acceptance process. All applicable information listed below shall be included on all as-built drawings.

11.02 General Information.

The following project summary information shall be included on the as-built drawings.

a. Project Name
b. City of Wentzville Engineering Project Number (to be included on the lower right corner of each sheet)
c. Total linear footage and size of streets, water mains, sanitary sewer mains, storm sewer mains, number of valves, fire hydrants, manholes (sanitary and storm), and inlets (by type)
d. Boundary of tract by courses and distance with references
e. All items in section 11.03 thru 11.05 shall be tied to Missouri State Plane Coordinate System, NAD 1983 and vertical datum, NAVD 1988.
f. Vicinity map
g. Scale of drawings and bar scale
h. North arrow
i. Location of benchmark
j. Seal and signature of registered P.E. or P.L.S. licensed in the State of Missouri
k. All easements identified and dimensioned
l. Statement designating drawings are "as-built"

11.03 Water System Information.

The following information related to the water system shall be provided.

a. Pipe location
b. Pipe material
c. Pipe size
d. Location of all fire hydrants, valves, air release valves, bends, fittings, taps, pump stations
e. Pipe lengths between fittings and other system facilities

11.04 Sanitary Sewer System Information.

The as-built drawings shall indicate the horizontal and vertical location of the sanitary sewer system in plan and shall include the following information.

a. Pipe material
b. Pipe size

c. Structure top elevation and the elevations of all incoming and outgoing pipe flowlines
d. Pipe slope and distance
e. Pump station location including wet well, valve vault, retention chambers
f. Pump station top and invert elevations
g. Retention chamber size, pipe material, slope and flowline elevations
h. Location of all sanitary sewer force main tracer wire access points and air release valves.

11.05 Storm Water Management System Information.

The as-built drawings shall indicate the horizontal and vertical location of the storm water management system in plan and shall include the following information.

a. Outline of 100 year flood plain
b. Pipe material
c. Pipe size
d. Structure top elevation and the elevations of all incoming and outgoing pipe flowlines.
e. Pipe slope and distance
f. Show permanent stormwater impoundments.
g. Include topography of the as-built condition of all stormwater detention facilities (under ground detention shall be dimensioned in lieu of topography)
h. Control and overflow structure location and size, and elevations. This shall include all information relevant to the proper operation of the structure (i.e. opening size, low flow and outlet pipe size, slope and flowline elevation, etc.)
i. Detention basin low flow swale location.

11.06 Deliverables

As-builts shall be submitted to the City of Wentzville Engineering Division within 30 days after the improvements have been placed into service. The following shall be submitted as part of the as-built requirements.

a. 1 copy of as-built drawings on reproducible mylar.
b. 1 copy of as-built drawings in autocad format
c. 1 copy of record plats and amendments in autocad format
d. Recorded copy of any easements within the project area not included on the record plat.
e. 1 copy of any MoDNR deed restrictions and or 401 permit conditions.

Wentzville Missouri The Crossroads of the Nation	City of Wentzville Engineering Division 1001 Schroeder Creek Blvd Wentzville, MO 63385 636-639-2045	***Application For Engineering Permits***	**OFFICE USE ONLY** Date Received: Received by: Forward to: Check No.:

NAME OF PROJECT/DEVELOPMENT

OWNER/DEVELOPER

NAME	CONTACT	PHONE
		EMAIL

ADDRESS	STREET	CITY	STATE	ZIP CODE

ENGINEER/CONTRACTOR

NAME	CONTACT	PHONE
		EMAIL

ADDRESS	STREET	CITY	STATE	ZIP CODE

PROJECT INFORMATION

All submittals must be accompanied by a completed Application for Engineering Permit, completed Engineering Improvement Plan Submittal Checklist, submittal fee, and necessary attachments to perform a complete review of the project. All incomplete submittals may be returned without review or comment.

IF THIS SUBMITTAL IS A REVISION AND/OR ADDENDUM TO A PREVIOUS PROJECT, PLEASE NOTE THE PERMIT NUMBER, ENG-_____

TYPE OF PERMIT APPLIED FOR

- ☐ GRADING AND SEDIMENT & EROSION CONTROL
- ☐ WATER MAIN EXTENSION
- ☐ SANITARY SEWER MAIN EXTENSION
- ☐ STORM WATER DRAINAGE FACILITIES
- ☐ STREET, OTHER PUBLIC, AND PRIVATE SITE IMPROVEMENTS
- ☐ UTILITY EXCAVATION FACILITY

ATTACHMENTS:

- ☐ PLANS/PRINTS
- ☐ REVIEW FEE $150 plus $10 per lot (residential) or $150 plus $10 per acre (non-residential)
- ☐ IMPROVEMENT PLAN SUBMITTAL CHECKLIST
- ☐ CALCULATIONS
- ☐ ENGINEERING REPORT (PUMP STATION)
- ☐ SOILS REPORT
- ☐ OTHER _____

SANITARY SEWAGE FLOW: ____GPD (PROVIDE SUPPORTING CALCULATIONS ON SEPARATE SHEET)

PLANNING AND ZONING APPROVAL PZ-_____ DATE: _____

BOARD OF ALDERMEN APPROVAL: ORD.#_____ DATE: _____

I certify that I am familiar with the information contained in this application, and that to the best of my knowledge, such information is true, complete and accurate. If granted this permit, I agree all construction will be in accordance with the approved improvement plans and with current requirements of the City of Wentzville, Missouri.

PERMITEE: NAME AND OFFICIAL TITLE (TYPE OR PRINT)	PHONE NO.
	SSN or Tax ID#
SIGNATURE	DATE SIGNED

NOTICE: CALL 1-800-DIG-RITE FOR UTILITY LOCATIONS PRIOR TO EXCAVATION

Wentzville Missouri
The Crossroads of the Nation

Engineering Improvement Plan Submittal Checklist

The following items, as a minimum, should be included on all plans and reports submitted for review by the City of Wentzville, Engineering Division. For any item checked either "No" or "N/A", a separate sheet must be attached explaining why this item is not being submitted.

Project Name: _____ Project Number: _____
(Provided by Engineering Division)

I. Application for Construction Permit

Yes	No	N/A	
☐	☐	☐	An application for construction permit must be included with the initial submittal of all improvement plans.

II. General Information

All plan sheets must be signed and sealed by a professional engineer licensed in the State of Missouri.

Yes	No	N/A	
☐	☐	☐	Provide a copy of the MoDOT permit for any work in the State of Missouri right of way.
☐	☐	☐	Provide a copy of the St. Charles County Highway Department permit for any work in right of way of St. Charles County.
☐	☐	☐	Provide a copy of Missouri Department of Natural Resources NPDES Land Disturbance Permit for all sites greater than one acre.
☐	☐	☐	Provide a copy of USACE 404 permit.
☐	☐	☐	Provide a copy of Missouri Department of Natural Resources 401 certification.
☐	☐	☐	Floodplain Development permit from the City of Wentzville Planning Division.
☐	☐	☐	Provide cross access agreements for use of entrances (if applicable).
☐	☐	☐	Provide off-site utility easements (if applicable).
☐	☐	☐	Provide an engineer's construction cost estimate for the proposed development.
☐	☐	☐	Provide an engineer's cost estimate for sediment and erosion control BMPs.
☐	☐	☐	Provide hydraulic gradeline calculations for all storm sewer pipes signed and sealed by a professional engineer licensed in the State of Missouri.
☐	☐	☐	Provide stormwater detention calculations signed and sealed by a professional engineer licensed in the State of Missouri.
			Provide the following Forms, as found in the City's current Design Criteria, beginning on page 6-133.
☐	☐	☐	Channel Condition Scoring Matrix Form 6-1, page 6-135.
☐	☐	☐	Stormwater Design Summary Form 6-2, page 6-139.
☐	☐	☐	Discharge Summary Form 6-3, page 6-140.
☐	☐	☐	Detention and BMP Summary Form 6-4, page 6-139.
☐	☐	☐	Water Quality (BMP) Design Summary Form 6-5, page 6-142.
☐	☐	☐	Detention/Retention Pond Design Summary Form 6-6, page 6-146.
☐	☐	☐	Provide Fire Flow Test results, as required for all projects including water mains.
☐	☐	☐	Provide geotechnical soils report signed and sealed by a professional engineer licensed in the State of Missouri as required by the City Engineer.
☐	☐	☐	Provide a copy of the Wentzville Fire Protection District approval for the fire suppression system.

III. Cover Sheet

Yes	No	N/A	
☐	☐	☐	Name of Project & type of plan.
☐	☐	☐	Location Map (Proximity to two main streets minimum.)
☐	☐	☐	Key map of subdivision layout and phases.
☐	☐	☐	Title block showing name and address of owner/developer and engineering firm.
☐	☐	☐	Standard City of Wentzville general notes.
☐	☐	☐	Standard City of Wentzville project notes.
☐	☐	☐	Index of sheets.
☐	☐	☐	Legend.
☐	☐	☐	City of Wentzville Engineering Project Number (lower right corner).

IV. Flat Plans

Yes	No	N/A	
☐	☐	☐	City of Wentzville Engineering Project Number (lower right corner).
☐	☐	☐	Outboundary information
☐	☐	☐	Adjacent parcel owner information including St. Charles County Parcel I.D. number.
☐	☐	☐	Lot information (lot lines, lot numbers, addresses, etc.)
			Show all proposed improvements which includes, but is not limited to:
☐	☐	☐	Storm sewers.
☐	☐	☐	Sanitary sewers and laterals, including connection to the existing sanitary sewage collection system.
☐	☐	☐	Water Distribution. The water layout shall be provided on a separate sheet with the other improvements shown lighter in the background and include:
☐	☐	☐	Existing water mains, valves and fire hydrants.
☐	☐	☐	All proposed fire hydrants, valves, tees, air relief valves and meter settings.
☐	☐	☐	For commercial sites, show the fire suppression line.
☐	☐	☐	Streets (noted as public or private) including:
☐	☐	☐	Street lights.
☐	☐	☐	Street signs, including stop signs.
☐	☐	☐	Sidewalks and handicap ramps.
☐	☐	☐	Radius size of all entrances (minimum of 32’).
☐	☐	☐	Radius size of all cul-de-sacs (minimum of 42’).
☐	☐	☐	All common ground and detention basins.

V. Grading, and Sediment and Erosion Control Plans

Yes	No	N/A	
☐	☐	☐	City of Wentzville required grading, and sediment and erosion control general notes.
☐	☐	☐	Show all existing utilities and indicate their impact to the grading operation.
☐	☐	☐	Provide existing and proposed contours at 1 foot intervals for non-residential sites and 2 foot intervals for residential sites.

☐	☐	☐	Total acreage of site.
☐	☐	☐	Construction access to site, including a 25' x 50' temporary gravel wash down area with note that all trucks shall be washed down prior to leaving site.
☐	☐	☐	Show grading limits.
☐	☐	☐	Estimated grading quantity.
☐	☐	☐	Location of siltation and erosion control BMPs and details.
☐	☐	☐	Siltation basins and calculations.
☐	☐	☐	Show detention basin(s) and location(s).
☐	☐	☐	Hauling routes.
☐	☐	☐	Identify all 3:1 slopes.
☐	☐	☐	Location of 100 year flood plain and floodway.
☐	☐	☐	Flood plain development permit (if applicable)
☐	☐	☐	Density of proposed fills.
☐	☐	☐	Show any proposed retaining walls. Note: retaining walls may require a separate permit from the City of Wentzville Building Department.
☐	☐	☐	Diversion ditch details.
☐	☐	☐	Re-vegetation specifications.
☐	☐	☐	Note on plan to provide City with copy of grading compaction test results.
☐	☐	☐	Temporary entrance parking and truck wash down area.
☐	☐	☐	Copy of Corps of Engineers approval for wetland and waters of the U.S. (if applicable).
☐	☐	☐	Hydraulic calculations for any temporary channels/swales.
☐	☐	☐	Flood plain study (if applicable).
☐	☐	☐	Schedule of operations, start, finishing dates.
☐	☐	☐	Indicate any temporary grading easements required. A signed copy of any required easements must be received by the Engineering Division prior to plan approval and issuance of a permit.

VI. Street Centerline Profiles

Yes	No	N/A	
☐	☐	☐	Provide existing and proposed grades.
☐	☐	☐	Provide roadway stationing.
☐	☐	☐	Intersection details.
☐	☐	☐	Vertical curve information.
☐	☐	☐	Cul-de-sac details.
☐	☐	☐	Location of storm sewer inlets.

VII. Storm and Sanitary Profiles

Yes	No	N/A	
☐	☐	☐	Show all other existing and proposed utility crossings on the profiles
☐	☐	☐	Show existing and proposed grades
☐	☐	☐	Call out/label all structures with top and flowline elevations of all pipes entering structures.

☐	☐	☐	Length, grade, size and type of pipe.
☐	☐	☐	Show all lateral locations for sanitary sewers with stationing.
☐	☐	☐	Show cutoff wall on all flared end sections and rip rap blanket size.
☐	☐	☐	Show total Q on storm sewer profiles.
☐	☐	☐	Label each reach of pipe as public/private.

VIII. Drainage Area Map

Yes	No	N/A	
☐	☐	☐	Drainage area in acres with PI factor and Q to each inlet.
☐	☐	☐	Give flow through each pipe branch.
☐	☐	☐	Show off-site drainage onto site with appropriate Q and/or on-site drainage that flows off-site with appropriate Q.

CERTIFICATION STATEMENT

I hereby certify I have checked the plans and review checklist for completeness, accuracy, compliance, and conformity with the plat, zoning and subdivision report, board of alderman bill, Engineering Design Criteria, and Construction Specifications and Standard Construction Details, and FEMA flood plain data. I further understand that review submittals without a signed checklist, without information required on the checklist, or without information or changes requested by a previous review may be returned to the Engineer without comment.

_____ _____

Date Registered Engineer of Record and Seal

CITY OF WENTZVILLE GENERAL NOTES

1. ALL CONSTRUCTION SHALL CONFORM TO THE CITY OF WENTZVILLE STANDARD SPECIFICATIONS AND CONSTRUCTION DETAILS, CURRENT EDITION.

2. NO CONSTRUCTION ACTIVITY SHALL COMMENCE UNTIL ALL PERMITS HAVE BEEN OBTAINED FROM THE CITY OF WENTZVILLE ENGINEERING DIVISION AND A PRE-CONSTRUCTION MEETING HAS BEEN COORDINATED WITH ENGINEERING DIVISION PERSONNEL.

3. A COPY OF THE CITY OF WENTZVILLE STANDARD SPECIFICATIONS AND CONSTRUCTION DETAILS, MOST CURRENT EDITION, AND A COPY OF THE APPROVED IMPROVEMENT PLANS SHALL BE ON SITE AT ALL TIMES WHILE CONSTRUCTION ACTIVITY IS OCCURRING.

4. CARE SHALL BE TAKEN BY THE CONTRACTOR NOT TO CAUSE ANY SOIL, MUD, EARTH, SAND, GRAVEL, ROCK, STONE, CONCRETE, OR OTHER MATERIALS OR LIQUIDS TO BE FLUNG OR DEPOSITED, DROPPED UPON OR TO ROLL, FLOW, STAND, OR WASH UPON OR OVER ANY PUBLIC STREET, STREET IMPROVEMENT, ROAD, SEWER, STORM DRAIN, WATERCOURSE OR RIGHT-OF-WAY OR ANY OTHER PUBLIC PROPERTY IN VIOLATION OF CITY ORDINANCE NUMBER 884.

5. ALL TRAFFIC CONTROL AND BARRICADING WITHIN CITY OF WENTZVILLE RIGHT-OF-WAY SHALL CONFORM TO PART VI OF THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (LATEST EDITION). STREET CLOSURES WILL NOT BE ALLOWED WITHOUT PRIOR APPROVAL OF THE CITY OF WENTZVILLE ENGINEERING DIVISION. ALL LANE CLOSURES SHALL BE COORDINATED WITH THE ENGINEERING DIVISION 24 HOURS IN ADVANCE

6. MODIFICATIONS TO THE APPROVED PLANS REQUIRE REVIEW AND APPROVAL BY THE CITY OF WENTZVILLE ENGINEERING DIVISION. WORK PERFORMED WITHOUT WRITTEN APPROVAL WILL REQUIRE REMOVAL AT THE OWNER'S/CONTRACTOR'S EXPENSE.

7. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK BY CONTACTING MISSOURI ONE-CALL SYSTEM, INC. OR OTHER NECESSARY ENTITIES. HOWEVER, CONTACTING MISSOURI ONE-CALL SYSTEM DOES NOT RELIEVE THE CONTRACTOR FROM THEIR RESPONSIBILITY OF CHECKING WITH THE RECORDER OF DEEDS FOR OWNER/OPERATORS OF ALL UNDERGROUND UTILITIES IN THE AREA.

MODOT IS NOT A PART OF DIG-RITE. CALL MODOT @ 314-340-4100 BEFORE DIGGING.

8. ALL GRADING ACTIVITIES SHALL COMPLY WITH THE CITY OF WENTZVILLE STANDARD SPECIFICATIONS AND CONSTRUCTION DETAILS, MOST CURRENT EDITION. ALL SEDIMENT AND EROSION CONTROL BMPS SHALL BE INSTALLED AND MAINTAINED IN ACCORDANCE WITH THE STORM WATER POLLUTION PREVENTION PERMIT AND THE APPROVED STORM WATER POLLUTION PREVENTION PLAN.

9. SUFFICIENT STAKING SHALL BE PROVIDED TO ENSURE PROPER LOCATION, ALIGNMENT AND GRADE OF ALL PROPOSED IMPROVEMENTS.

10. THE CONTRACTOR OR DEVELOPER SHALL NOT DISTURB ANY EXISTING SURVEY MONUMENTS OR BENCHMARKS NOTED ON THE PLANS OR FOUND DURING CONSTRUCTION. REMOVAL AND REPLACEMENT SHALL BE DONE BY A PROFESSIONAL LAND SURVEYOR LICENSED BY THE STATE OF MISSOURI ONLY.

CITY OF WENTZVILLE PROJECT NOTES:

1. ST. CHARLES COUNTY PARCEL ID NUMBER(S): *#-####-####-##-#.##*

2. AREA OF TRACT: *##.# acres*

3. CURRENT ZONING: *Zoning*

4. ORDINANCE NUMBER (FOR PDR): *####*

5. THIS PROPERTY IS SERVED BY THE FOLLOWING UTILITIES/AGENCIES:

ELECTRIC:	*electric provider name*	TELEPHONE #
FIRE:	*fire protection district name*	TELEPHONE #
GAS:	*gas provider name*	TELEPHONE #
SANITARY SEWER:	*sanitary sewer provider name*	TELEPHONE #
TELEPHONE:	*telephone service provider name*	TELEPHONE #
WATER:	*water provider name*	TELEPHONE #
OTHER:	*other entities name(s)*	TELEPHONE #

6. REQUIRED BUILDING AND PARKING SETBACKS:

FRONT YARD:	*##'*
SIDE YARD:	*##'*
REAR YARD:	*##'*
PARKING:	*##'*

7. PARKING REQUIREMENTS AND PROVISIONS:
   Provide calculations here

PARKING REQUIRED =	*##*
PARKING PROVIDED =	*##*
HANDICAP SPACES REQUIRED =	*##*
HANDICAP SPACES PROVIDED =	*##*

8. FLOOD PLAIN INFORMATION:
   PER F.I.R.M FLOOD INSURANCE RATE MAP NUMBER *######-#####-#,*
   EFFECTIVE DATE *########,*

   THIS TRACT LIES WITHIN ZONE *(description of zone)*

9. SANITARY SEWAGE FLOW CALCULATION:
   Provide calculations here
   TOTAL SEWAGE FLOW GENERATED FOR THIS PERMIT: *####* GPD

10. BENCHMARK INFORMATION

SITE BENCHMARK:
ENTER BENCHMARK DATA

U.S.G.S. BENCHMARK:
ENTER BENCHMARK DATA

CITY OF WENTZVILLE GRADING NOTES

1. CONSTRUCTION ACCESS TO SITE SHALL CONSIST OF A MINIMUM 25' x 50' TEMPORARY GRAVEL WASH DOWN AREA, LOCATED ADJACENT TO PAVEMENT. ALL TRUCKS SHALL BE WASHED DOWN PRIOR TO LEAVING SITE.

2. ALL SOFT SOILS SHOULD BE REMOVED, DOWN TO FIRM MATERIAL, PRIOR TO THE PLACEMENT OF FILL MATERIAL. THE SOFT SOILS MAY BE UTILIZED AS FILL, PROVIDED THAT THE MATERIAL IS SPREAD OUT TO DRY SUFFICIENTLY AND CAN BE COMPACTED TO THE REQUIREMENTS OF THE PROJECT SPECIFICATIONS.

3. NO SLOPE SHALL BE STEEPER THAN 3(HORIZONTAL): 1(VERTICAL). ALL SLOPES SHALL BE SODDED OR SEEDED AND MULCHED.

4. CITY SHALL BE PROVIDED WITH A COPY OF GRADING COMPACTION TESTS RESULTS. IN AREAS OF PROPOSED PAVEMENT, A MINIMUM COMPACTION TO AT LEAST 90% OF MAXIMUM DRY DENSITY, AS DETERMINED BY THE MODIFIED PROCTOR TEST, OR 95% OF MAXIMUM DRY DENSITY, AS DETERMINED BY THE STANDARD PROCTOR TEST WILL BE REQUIRED, OR AS OTHERWISE RECOMMENDED BY THE GEOTECHNICAL SOILS REPORT.

5. ANY TRASH, DEBRIS, PAVEMENT OR FOUNDATION MATERIALS FROM ANY EXISTING OR PREVIOUS ON-SITE BUILDING, STRUCTURE, OR IMPROVEMENT MUST BE REMOVED FOR PROPER DISPOSAL OFF SITE, OR AS RECOMMENDED BY THE OWNERS LICENSED PROFESSIONAL ENGINEER.

6. ANY WELLS OR SPRINGS WHICH MAY EXIST ON THE PROPERTY SHOULD BE LOCATED. WELLS SHALL BE CAPPED AND SEALED IN ACCORDANCE WITH THE REQUIRMENTS OF THE MISSOURI DEPARTEMENT OF NATURAL RESOURSCES, AND IN A MANNER ACCEPTABLE TO THE CITY OF WENTZVILLE. SPRINGS SHALL BE HANDLED IN ACCORDANCE WITH THE RECOMMENDATIONS OF THE OWNERS LICENSED PROFESSIONAL ENGINEER.

7. ANY CONTAMINATED SOILS ENCOUNTERED DURING GRADING OPERATIONS SHALL BE HANDLED IN ACCORDANCE WITH THE OWNERS LICENSED PROFESSIONAL ENVIORNMENTAL ENGINEERING REPRESENTATIVE.