CITY OF BRANSON

DESIGN CRITERIA

FOR PUBLIC IMPROVEMENT PROJECTS

January 2024

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REVISED JANUARY 2024

DESIGN CRITERIA

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SECTION I. PROCEDURE FOR PUBLIC IMPROVEMENT PROJECT PLAN SUBMITTAL

All developers and engineering consultants submitting plans for public improvement projects to the City for review are required to follow the procedures outlined in the following. No public improvement projects may be constructed in the City of Branson without the prior approval of the office of the City engineer.

1. Three complete sets of prints of the project plans shall be submitted to the office of the City engineer for review.

2. Upon receipt by the city, the checkprints will be date stamped and recorded in the project submittal status log.

3. The normal time for review shall be 10 working days. In the case of abnormally large sets of prints (greater than 20 sheets) or of extremely complicated drawings, a longer time may be required for review.

4. The checkprints will be routed through appropriate city departments and/or divisions to obtain a complete review of all facilities that may be affected by the proposed construction. In each review, comments and necessary revisions will be noted on the checkprints.

5. The consultant will be required to make all necessary corrections or revisions as noted on the checksets. Upon completion of the revisions and/or corrections the plans will again be submitted to the city engineer's office for further review. Revised sheets submitted shall contain a revision block with identifying notations and date of revisions. All previous checksets must accompany each re-submittal. If the checksets are not submitted with the revised drawings, the plans shall be returned to the consultant without action until such time as they are included with the submittal.

6. Plans will not receive final approval until all associated plats and required easements have been accepted by the City Council.

Additionally, and in conjunction with submittal of final plans, all permits and/or application for permits, shall be submitted to the appropriate agency for approval prior to final approval of the plans by the city engineer (i.e., State Highway Department, Department of Natural Resources, etc.).

7. The length of time for final plan approval will normally be within 5 working days. Upon notification of final approval of the plans by the city engineer, the number of sets of plans as specified in the appropriate section of the Design Criteria Manual shall be submitted for signing and distribution.

8. A title sheet of the plans shall be submitted for final approval by the city engineer. The city engineer shall sign and date the cover sheet serving as the city's approval. This cover

sheet shall be returned to the consultant and shall be utilized for all further cover sheets in bid documents sent out for proposals.

9. Public improvement plans and engineering reports are approved initially for one (1) year after the date noted on the returned cover sheet. After one (1) year, the plans or report shall become null and void and must be resubmitted prior to approval of construction of that project. Such plans and/or reports shall be resubmitted to the office of the city engineer in accordance with the foregoing outlined procedures and requirements.

10. The design engineer shall send one set of plans to each of the private and public utility companies having territorial jurisdiction in the area of the improvement upon notification that the drawings have been approved.

SECTION II. GENERAL PLAN REQUIREMENTS FOR PUBLIC IMPROVEMENT PROJECTS

A. *GENERAL.* All plans and reports submitted shall be prepared by, or under the direction of, a professional engineer, licensed in the State of Missouri, and shall be reviewed by the city for compliance with the minimum design requirements as established in the Design Criteria Manual for Public Improvement Projects of the City of Branson and with all other applicable city codes and standards.

Attention is directed to the design engineer that whenever extraordinary or unusual problems are encountered in conjunction with a proposed project, additional information and analysis beyond the minimum requirements of these standards and criteria will be required.

The City of Branson is not responsible for the accuracy and adequacy of the design or dimensions and elevations as depicted on the plans (which shall be confirmed and correlated at the site of the work). The City of Branson, through the approval of the plans and/or report, assumes no responsibility for the completeness and/or accuracy of the public improvement plan or report.

B. *REQUIRED NOTES.* The following general notes will be required as a minimum on all plan submittals for public improvement projects. These notes are not meant to be all-inclusive, and in certain situations the city engineer may require the use of additional notes.

WATER MAINS

1. Development plans are approved initially for one (1) year after which they automatically become void and must be updated and re-approved by the city engineer before any construction will be permitted.

2. The City of Branson plan review is only for general conformance with City of Branson Design Criteria and the City Code. The city is not responsible for the accuracy and adequacy of the design, or dimensions and elevations that shall be confirmed and correlated at the job site. The City of Branson through approval of this document assumes no responsibility other than that as stated above for the completeness and/or accuracy of this document.

3. The contractor shall have one (1) signed copy of the plans (approved by the City of Branson) and one (1) copy of the appropriate Construction Standards and Specifications at the job site at all times.

4. Construction of the improvements shown or implied by this set of drawings shall not be initiated or any part thereof undertaken until the city engineer is notified of such intent, and all required and properly executed bonds and permit fees are received and approved by the city engineer.

5. The City of Branson Technical Specifications, latest edition, shall govern construction of this project.

6. All existing utilities indicated on the drawings are according to the best information available to the Engineer; however, all utilities actually existing may not be shown. Utilities damaged through the negligence of the contractor to obtain the location of same shall be repaired or replaced by the contractor at his expense.

7. All backfill shall be tamped.

8. Contractor shall not be allowed to work on Sundays. Holiday or Saturday work shall be as approved in advance by the city engineer.

9. All materials and workmanship associated with this project shall be subject to inspection by the City of Branson. The City of Branson reserves the right to accept or reject any such materials and workmanship that does not conform to the City of Branson Technical Specifications.

The contractor shall notify the City of Branson Engineering Department twenty-four (24) hours prior to the beginning of construction.

10. Relocation of any water line, sewer line or service line thereof required for the construction of this project shall be the responsibility of the contractor at his expense.

11. The proposed water line improvements shown by this set of drawings have been designed to provide the following fire flow requirements as determined by the City of Branson: _____GPM (Note to be placed on development drawings that contain areas zoned for higher densities than R-2).

SANITARY SEWERS

1. Development plans are approved initially for one (1) year, after which they automatically become void and must be updated and re-approved by the city engineer before any construction will be permitted.

2. The City of Branson plan review is only for general conformance with City of Branson Design Criteria and the City Code. The city is not responsible for the accuracy and adequacy of the design, or dimensions and elevations that shall be confirmed and correlated at the job site. The City of Branson through approval of this document assumes no responsibility other than as stated above for the completeness and/or accuracy of this document.

3. The contractor shall have (1) signed copy of the plans (approved by the City of Branson) and one (1) copy of the appropriate Construction Standards and Specifications at the job site at all times.

4. Construction of the improvements shown or implied by this set of drawings shall not be initiated or any part thereof undertaken until the city engineer is notified of such intent and all required and properly executed bonds and permit fees are received and approved by the city engineer.

5. The City of Branson Technical Specifications latest edition shall govern construction of this project.

6. All existing utilities indicated on the drawings are according to the best information available to the engineer; however, all utilities actually existing may not be shown. Utilities damaged through the negligence of the contractor to obtain the location of same shall be repaired or replaced by the contractor at his expense.

7. All backfill shall be tamped.

8. All stublines shall be laid on 1.00% grade unless approved otherwise.

9. _____ denotes Minimum Basement Floor Elevation.

10. All materials and workmanship associated with this project shall be subject to inspection by the City of Branson. The City of Branson reserves the right to accept or reject any such materials and workmanship that does not conform to the City of Branson Technical Specifications.

The contractor shall notify the City of Branson Engineering Department twenty-four (24) hours prior to the beginning of construction.

11. Contractor shall not be allowed to work Sundays. Holiday or Saturday work shall be as approved in advance by the city engineer.

12. Relocation of any water line, sewer line or service line thereof required for the construction of this project shall be the responsibility of the contractor and shall be at his expense.

13. The Contractor shall install and properly maintain a mechanical plug at all connection points with existing lines until such time that the new line is tested and approved.

STREETS AND STORM DRAINAGE

1. Development plans and drainage reports are approved initially for one (1) year, after which they automatically become void and must be updated and re-approved by the city engineer before any construction will be permitted.

2. The City of Branson plan review is only for general conformance with City of Branson Design Criteria and the City Code. The city is not responsible for the accuracy and adequacy of the design, or dimensions and elevations that shall be confirmed and correlated at the job site. The City of Branson through approval of this document assumes no responsibility other than as stated above for the completeness and/or accuracy of this document.

3. The contractor shall have one (1) signed copy of the plans (approved by the City of Branson) and one (1) copy of the appropriate Construction Standards and Specifications at the job site at all times.

4. Construction of the improvements shown or implied by this set of drawings shall not be initiated or any part thereof undertaken until the city engineer is notified of such intent, and all required and properly executed bonds and permit fees are received and approved by the city engineer.

5. The City of Branson Technical Specifications latest edition shall govern construction of this project.

6. All existing utilities indicated on the drawings are according to the best information available to the engineer; however, all utilities actually existing may not be shown. Utilities damaged through negligence of the contractor to obtain the location of same shall be repaired or replaced by the contractor at his expense.

7. All backfill shall be tamped.

8. A minimum of one (1) compaction test and a maximum of two (2) compaction tests shall be performed by a qualified testing laboratory for every 1,000 feet of street construction. Soil samples for such tests shall be collected by laboratory technicians. All testing laboratory expenses shall be paid for by the contractor.

9. All materials and workmanship associated with this project shall be subject to inspection by the City of Branson. The City of Branson reserves the right to accept or reject any such materials and workmanship that does not conform to the City of Branson Technical Specifications.

The Contractor shall notify the City of Branson Engineering Department twenty-four (24) hours prior to the beginning of construction.

10. Contractor shall not be allowed to work Sundays. Holiday or Saturday work shall be as approved in advance by the city engineer.

11. Relocation of any water line, sewer line or service line thereof required for the construction of this project shall be the responsibility of the contractor and shall be at his expense.

C. APPROVAL BLOCK. A signature block shall be required on the cover sheet of all plans and reports submitted for review and approval. All plans require the signature of the city engineer and the date of such signing for formal approval by the city.

The general form of the approval block shall be as follows:

APPROVED

_____ _____

Director of Public Works/Engineering Date

APPROVED FOR ONE YEAR FROM THIS DATE

D. ***PRIVATE IMPROVEMENTS.*** Private improvements, if any, shown on public improvement plans, shall be clearly defined and marked as such. These improvements will not be maintained by the City of Branson and, as such, an appropriate note shall be included on the drawings.

SECTION III. REQUIREMENTS FOR PUBLIC IMPROVEMENT PROJECT PLAN PREPARATION

A. INTRODUCTION. The following criteria are being established to provide a uniform system of plan preparation that will aid the engineer in preparing plans for work within the City of Branson. It is not intended that the criteria be an iron-clad set of rules that would restrict the engineer from utilizing imaginative design; however, all items as described below shall be shown on the plans in some manner.

B. GENERAL. All plans and specification for public improvement construction within either publicly-financed or privately-financed developments shall be prepared by a professional engineer licensed in the State of Missouri and submitted to the office of the city engineer for review. Subsequent to the review, the engineer will be notified of approval of the plans as submitted, or of any necessary changes. (Refer to the section "Public Improvement Project Plan Submittal" for plan review procedures.)

Upon completion of the review and approval of the plans by the city engineer, four (4) sets of plans (as approved) must be submitted for signing and distribution.

In addition, one set of approved plans shall be sent to each of the utility companies providing service in the proposed construction area.

The suggested plan sheet size is 24" X 36" with all sheets in a given set of plans being of the same size. Plan and profile views shall be drawn on double or single plan and profile sheets to minimum scales of one (1) inch equals fifty (50) feet horizontal by one (1) inch equals ten (10) feet vertical, unless otherwise approved by the city engineer for special cases.

The plans shall consist of:

1. Title Sheet, (Cover Sheet)
2. General Layout Sheet, (Overall main plan, for street, storm, water and sewer)
3. Sediment & Erosion Control Plan (SECP)
4. Drainage Area Maps
5. Grading Plan (Street and/or storm drainage improvement plans only unless otherwise required by the city engineer)
6. Plan and Profile Sheets
7. Cross-Section Sheets (Street improvement plans only unless otherwise required by the Director of Public Works/Engineering)
8. Standard and Special Detail Sheets
9. Other sheets as required

Each sheet should contain a sheet number, including the individual sheet number and total number of sheets, the engineer's seal, revision block, proper project identification and date.

Each respective type of development project (i.e. sanitary sewer, streets, water mains, etc.) shall be submitted on a separate set of plans unless otherwise allowed by the city engineer.

When required by the city engineer, plans depicting the location of the street lights and all related appurtenances shall be submitted with the street improvement drawings for review. Such review shall be for the purpose of verifying easement locations to be indicated on the final plat. Plans for street light installation shall conform to all applicable standards of the power company having jurisdiction over the work.

Where feasible, storm sewer construction details should be incorporated into street construction drawings.

C. TITLE SHEET. The following items shall be included on the title sheet.

1. Name of project
2. City project number (if available)
3. Index of sheets included in plans
4. A location map adequately showing project location in relation to major streets (minimum scale of 1" = 2000')
5. General description of project area (by Township, Range, and Section)
6. A summary of plan quantities of principal items, such as:

    * Pipe size and material, lengths, number of manholes, etc.. (sanitary sewers)
    * Length of curb and gutter, square yardage or tonnage of asphaltic concrete pavement, etc.. (streets)
    * Pipe sizes and material, lengths, number of inlets, etc.. (storm sewers)
    * Pipe sizes and material, lengths, number of valves, etc.. (water lines)

    Additionally, a separate column shall be provided for listing of "as-built" quantities once the project has been completed and accepted by the city.

7. The project control bench mark shall be identified as to location and elevation; USGS datum. (Not required on Water Line Plans.)
8. Name, address and telephone number of consulting engineer and owner/developer.
9. List containing name and telephone number of each utility company and public agency listed below;
    Electric Power
    Telephone
    Cable television
    Gas
    Highway Department (Local Office)
    Water & Sewer
    City Engineering Department
10. Approval block (see paragraph C of General Plan Requirements)
11. Project engineer's name and seal.

12. Revision schedule.

D. GENERAL LAYOUT SHEET. The following items shall be included on the general layout sheet for all improvement projects.

1. A legend of symbols and abbreviations shall be shown which shall apply to all sheets.
2. North arrow and graphic scale. Scale of the general layout map shall be one (1) inch equals one hundred (100) feet, unless otherwise approved.
3. Layout shall include names of subdivision, block designation, if any, lot designation, or proposed block and lots, all street names, and an accurate tie to at least one-quarter section corner. An unplatted tract shall have an accurate tie to at least one (1) quarter section corner.
4. Boundary line of project area.
5. A list of general notes to the contractor that include at least those notes indicated in the "Procedure For Public Improvement Project Plan Submittal" section of this manual.

In addition, the following items shall be included on the general layout sheet for the particular type of improvement stated below.

Streets

1. Location of all existing and proposed streets and roadways within and adjacent to the project area (list City project name and number if available).
2. Location of all existing and proposed drainage system improvements (list city project name and number if available).

Storm Drainage

1. Drainage calculation summary table containing the following information.
    * Pipe size and slope
    * Pipe capacity
    * Velocity (design and at capacity)
    * Time of concentration
    * Runoff coefficient
    * "K" factor (antecedent precipitation)
    * Design storm (return frequency)
    * Incremental tributary acreage
    * Accumulative acreage
    * Rainfall intensity
    * Rainfall runoff

Sanitary Sewer and Water Lines

1. Location of all existing (water or sewer) lines properly designated within or adjacent to the project area (list City project name and number if available).

2. Connection point or points to existing facilities (tied to a known point on existing facility) and the type of connection to be utilized.
3. Location of all proposed (water or sewer) lines and appurtenances with designation and sheet number on which they appear in plan and profile.

E. SEDIMENT & EROSION CONTROL PLAN, (SECP)

1. An overall plan of the site showing proposed sediment and erosion control measures shall be included in the construction drawings. The sediment and erosion control plan may be superimposed upon the site dimension plan, grading plan or storm drainage facilities plan if legible. The sediment and erosion control plan shall also show the following:
2. General limits of the area to be stripped of vegetation or disturbed by construction activities shall be shaded or otherwise clearly delineated.
3. A summary table showing the total site area and the total area estimated to be disturbed.
4. Proposed location(s) of temporary construction entrance(s) and concrete washout area.
5. Proposed sediment containment measures: vegetative filter areas, straw bale dikes, silt fences, temporary containment berms, diversion berms, inlet protection, etc. Adequate details and notes for each containment measure shall be included.
6. Site stabilization measures, showing the type of surface stabilization to be provided in various areas of the site, whether sod, erosion control blanket, mulch, concrete, etc. If more than one (1) type of erosion control blanket or mulch is specified, the different areas should be distinguished by use of varying shading or symbols.
7. Seeding and mulching specifications, and allowable seasons for temporary and permanent seeding.
8. Temporary and permanent erosion control measures, such as outlet protection, channel linings, or paved chutes, etc.

F. DRAINAGE AREA MAPS

1. Drainage area maps shall be provided for both on-site areas and off-site areas. Due to the difference in area, it will typically be necessary to provide a larger scale map for on-site drainage areas, and a smaller scale map for off-site drainage areas.
2. Off-site drainage areas shall be shown as a minimum scale of 1"= 2000' (one inch equals two thousand feet).
3. On-site drainage area maps shall be shown superimposed upon the site plan, with existing and proposed topographic contours shown.
4. Drainage areas shall be clearly outlined on the map, and the identifying designation clearly shown.
5. Drainage areas shall be given the same designation as the inlet or reference point to which they are tributary (i.e., drainage area 1-A is tributary to inlet 1-A, and etc.).
6. The schematic plan of the proposed storm drainage improvements shall be shown on the drainage area map.

7. Both pre- and post-development drainage areas must be shown for each primary outfall from the site.
8. Include the flow path used for the development of the time of concentration used in detention basin calculations.

G. SITE GRADING PLAN. The following items shall be included on the general layout sheet for all street and/or drainage improvement projects.

1. Property lines identified as to existing or proposed lot and block number.
2. Elevation and location of nearest bench mark (U.S.G.S. datum)
3. One-hundred year flood plain line.
4. Existing streets, transportation facilities, utilities, and storm drainage facilities.
5. Existing physical features including waterbodies and watercourses, sinkholes, springs, caves, faults, fracture trends, and photolineaments.
6. Existing structures, pavements, sidewalks, tree masses, pavements, and fences.
7. Proposed streets, transportation facilities, utilities, and storm drainage facilities.
8. Proposed structures, sidewalks, and pavements.
9. Proposed topographic contours.
10. Existing and final grading contours drawn at intervals not to exceed five feet. Each fifth contour shall be drawn as an index contour by using a heavier line weight. Index contours must be labeled. Intervals of less than five (5) feet may be required by the City dependent on the character of the topography

H. PLAN AND PROFILE SHEETS. The following items shall be included on the plan and profile sheets for all improvement projects.

1. North arrows and graphic scale.
2. Elevation and location of all applicable bench marks (USGS datum).
3. Existing and proposed streets with names and widths.
4. Property lines properly identified as to existing or proposed lot, block and subdivision.
5. All existing and proposed utilities such as power, gas, oil, water, telephone, sewer, cable television, and other items shall be properly located in conformance with the best information available (from the records of the owner of such facilities or field location) and identified as to size, material, and type of construction.
6. All existing and known proposed improvements within seventy-five (75) feet each side of center line shall be shown at their proper locations. This shall include such existing items as paved streets, curbs and gutters, driveways, culverts, fire hydrants, utility poles, trees, shrubs, fences, walls, houses, and other such items, and shall be identified as to type, size, material, etc., as may be applicable. In case of new developments, some irrelevant items may be omitted.
7. All existing easement and right-of-way information recorded with the county.
8. All proposed easement and right-of-way information.
9. Minor construction notes shall appear on the proper plan and profile sheets.
10. Locations and widths of existing and proposed sidewalks.

In addition, the following items shall be included on the plan and profile sheets for the particular type of improvement stated below.

Streets

1. Station and critical elevation (flowline, invert of pipe, etc.) of all utility or drainage appurtenances, existing and proposed.
2. Width of right-of-way and width of pavement, (BOC to BOC), on all plan sheets.
3. Typical cross-section for roadway(s).
4. Indicate vertical and horizontal locations of all existing and proposed utility crossings on street profiles, including curb inlets.
5. Flow direction arrows, particularly at intersections.
6. Match lines and consecutive sheet number, beginning with cover sheet.
7. Station and elevation of all curb returns (at 1/5 points); horizontal P.C.'s, P.T.'s, etc.; high or low point of all vertical curves; existing and proposed.
8. Curb return radii, existing and proposed.
9. Complete horizontal curve data. (R, L, Tan)
10. Centerline stations of all non-single family residential driveways and all intersecting roadways.
11. Basis of plan view and profile elevations shall be the same, i.e., flowline and flowline, top of curb and top of curb, etc.
12. Existing grades or established street grades shown as a solid line.
13. All design elevations shall be centerline, top of curb, lip of gutter, or flowline (preferred) for 6" vertical curb and gutter; or lip of gutter, or flowline (preferred) for combination curb, gutter and walk. The basis for as-built information shall be the same as the design (both flowline or both top of curb, etc.).
14. Stationing continuous for the entire portion of the roadway shown in the plan view (100 feet minimum stationing), with the centerline station of all non-single family residential driveways and all intersecting roadways clearly labeled.
15. Location of any pavement expansion joints in the plan view.
16. All existing curbs, gutters, sidewalks, and pavement adjacent to the proposed design (minimum distance of 100 feet). Basis for existing grades shall be "as-built" or field verified elevations at intervals not to exceed fifty (50) feet. Previously approved designs are not an acceptable means of establishing existing grades.
17. Station and elevation of all P.C.R.'s, horizontal P.C.'s, P.C.C.'s, etc; existing and proposed.
18. Station and elevation of all vertical grade breaks, existing (as-built) and proposed. (The use of grade breaks with proposed construction is discouraged.)
19. Distance and grade or slope between grade breaks.
20. Vertical curves, where necessary, with VPI, VPC, and VPT, high or low point (if applicable) stations and elevations. All vertical curves shall be labeled with length of curve (L) and K (=L/A). All vertical curves shall be symmetrical.
21. Design speeds and stopping sight distances for all vertical and horizontal curves.
22. Existing and proposed utilities. Field verified elevations and locations are required to be indicated on the plans for all utilities (existing or proposed) which will potentially affect the design and construction of the improvement.

Storm Drainage

1. Detailed alignment of the storm sewer along with all appurtenances, sizes of lines, conduit material and wall thickness, and other details relating to the storm drainage system including inlet and junction box (manhole) stations and top and invert elevations.
2. All existing drainage facilities and structures such as, but not limited to, irrigation ditches, roadside ditches, improved or unimproved drainage channels, gutter flow directions, culverts, etc. All pertinent information such as size, shape, slope, location, etc. of such facilities shall be included to facilitate review and approval of the plans.
3. Roadway section and grade including type of curb and gutter and gutter flow directions.
4. Erosion control and energy dissipation devices.
5. Proposed outfall point for runoff from the project area along with required easement information.
6. Routing and cumulative flows at various critical points along storm runoff.
7. Critical minimum finished floor elevations of all buildings adjacent to the project for protection from major storm runoff.
8. Distances between storm sewer system components and other existing or proposed utilities within the right-of-way or drainage easement.
9. Supporting calculations for storm drainage facilities must be included within the plan submittal. Supporting calculations shall include the following:
    a. Drainage area map
    b. Summary table for inlet calculations.
    c. Summary table for storm sewer and channel design.
    d. Backwater computations for culverts and bridges.
    e. Hydraulic data for drainage channels with uniform flow.
    f. Water surface profile computations for drainage channels with gradually or rapidly varied flow.
    g. Calculations for detention facilities.
    h. Calculations for sediment basins and other sediment and erosion control facilities specified on the Sediment & Erosion Control Plan.
    i. Where required, calculations for directly connected impervious area, water quality capture volume, and stormwater quality BMPs.
    j. Flow path for time of concentration calculations.
    k. Detailed time of concentration calculations.
    l. USGS soil map showing breakdown of soil types.
    m. Curve number calculations.
    n. Rational method runoff coefficient calculations.

Sanitary Sewers/Water Lines

1. Existing water distribution facilities including, but not limited to, pipe size and location, valves, fire hydrants, blowoffs, etc.

2. Existing sanitary sewer facilities including, but not limited to size, slope, location, hydraulic capacity, and all pertinent information regarding which trunk line will ultimately receive the wastewater collected by the proposed system.
3. Proposed piping with all appurtenances plainly labeled.
4. Existing or proposed easements and/or tracts through offsite areas.
5. Estimated average quantity of wastewater generated offsite that would be tributary to the proposed development, naturally as developed. The "Land Use Plan", which is a part of the Comprehensive Plan for the City of Branson shall be the basis for determining the future use of offsite undeveloped land.
6. Proposed minimum, maximum, and average design flows at all junction manholes. (Manholes where two (2) or more branches have peak flows in excess of three (3) cfs.)
7. All design elevations shall be invert of pipe. Top of pipe is acceptable for existing utilities.
8. Stationing continuous for the entire length of the utility beginning at the downstream end of the project. Center line of roadway shall be the basis for stationing whenever possible.
9. Existing utilities, particularly where crossed, with "as-built" elevations and stations.
10. Detailed alignment of the proposed sewer with the manhole designation, either by station and angle shown at each manhole or dimensioned ties to property lines at reasonably frequent control points to provide unquestionable locations of the sewer within street right-of-way or on private property.
11. The channel center line of waterways within fifty (50) feet either side of center line of sewer shall be shown.
12. All manholes shall be shown with manhole designation station and invert elevations. Drop manholes shall be designated as such. Invert elevations shown shall be the invert of the pipe in and out of the manhole. Proposed finish grade elevation of top of manhole shall be shown. Distance between manholes shall be shown as well as the gradient, pipe size, and type of material.
13. Results of all rock borings shall be shown at the proper locations.
14. Accurate elevations of either the first-floor surface or the basement floor surface shall be shown, and identified, for all existing and/or proposed structures for all building sites to be served by the proposed sewer system.
15. A uniform system of line and manhole designation shall be used subject to the approval of the city engineer's office.
16. Station, length, and size of each subline.
17. Profile view shall show existing grade above center line as a dashed line, proposed finish grades or established street grades by solid lines, and shall show the flow line of any drainage channel, either improved or unimproved, within fifty (50) feet either side of center line. Each line shall be properly identified. The proposed sewer shall be shown as double solid lines properly showing the height of the pipe.
18. Alignment of the proposed water line dimensioned from curb lines or right-of-way lines.
19. Designation by station of all fire hydrants and line valves.

H. CROSS-SECTION SHEETS. The following items shall be included on the cross-section sheets.

1. Typical roadway cross-section for all roadways, existing or proposed, within and adjacent to the proposed development. These cross sections shall appear on the detail sheet. They shall indicate type of roadway (s), profile grade design point (centerline, flowline, top curb, lip of gutter, etc.), roadway width, right-of-way, type of curb, gutter, and walk, pavement cross slope, etc.. Cross-sections to show existing grade lines a minimum of ten (10) feet beyond right-of-way lines.
2. Cross-sections shall be shown at all intersecting streets and driveways.
3. Channel cross-sections shall be shown for all drainage channel improvements.
4. Additional cross-sections shall be shown as required by the Director of Public Works/Engineering to clearly describe the extent of the grading operations.

I. STANDARD AND SPECIAL DETAIL SHEETS. Detail sheets shall be included to show all details of appurtenances, material, and construction whether or not covered by the Technical Specifications of Branson, Missouri. Details shall conform to the City of Branson Technical Specifications and are to be drawn clearly and neatly with proper identifications, dimensions, materials, and other information necessary to insure the desired construction.

J. PRIVATE IMPROVEMENTS.
Private improvements, if any, shown on public improvement plans, shall be clearly defined and marked as such. They shall meet design standards for the City of Branson. These improvements will not be maintained by the City and, as such, an appropriate note shall be included on the drawings/recordings.

J. CONSTRUCTION RECORD DRAWINGS. The design engineer shall submit construction record (as-built) drawings to the city engineer upon completion of the project and prior to final acceptance of the project. The design engineer shall provide the city with one (1) set of prints for all public improvement projects corrected to show the project as constructed and shall accurately and completely denote all changes made during the course of the work. Each sheet within the plans shall be clearly marked as "Conforming to construction Records" and shall include the date of revision and certifications by the engineer. The design engineer shall also provide as built record drawings in digital format. Acceptable formats are: ARCINFO/ARCVIEW shapefile or geodatabase; AUTOCAD DXF, DWG. Digital data must be provided in Missouri Central state plane coordinate system NAD83 NADV88 (vertical) units – U.S. feet.

SECTION IV. DESIGN CRITERIA FOR SANITARY SEWERS AND APPURTENANCES

A. DESIGN FACTORS. Sanitary sewers should be designed for the ultimate tributary population. Due consideration should be given to current zoning regulations and approved planning and zoning reports where applicable. Sewer capacities should be adequate to handle the anticipated maximum hourly quantities of sewerage and industrial waste together with reasonable consideration given to infiltration/inflow. Sewer depth shall be adequate to provide service to the tributary area.

B. SEWER DESIGN. Sewers shall be designed for the total tributary areas using the following minimum criteria:

Interceptors and trunk lines	0.01 CFS/Acre
Laterals and sub-mains	0.02 CFS/Acre

Using this criteria all pipes are to be sized flowing full.

C. MAXIMUM SIZE. The diameter of sewers proposed shall not exceed the diameter of the existing or proposed outlet, whichever is applicable, unless otherwise approved by the city engineer.

D. MINIMUM SIZE. No public sewer shall be less than eight (8) inches in diameter. Stub lines for service connections shall not be less than four (4) inches in diameter and shall be extended at a 90-degree angle to the main sewer line.

E. MATERIALS OF CONSTRUCTION. Sanitary sewers shall be constructed of pipe material resistant to or protected from bacterial degradation, acid and alkaline solutions, normal sewer temperature variation, abrasion, and industrial wastes or other material, which may be transmitted by the collection system.

The following types of commercial pipe are approved for gravity sanitary sewer systems constructed in the City of Branson:

Vitrified Clay Pipe	ASTM C700 extra strength
Reinforced Concrete Pipe	ASTM C76, Class II (Wall B or C)
PVC Composite Wall Pipe	ASTM D2680, Minimum pipe stiffness shall be 200 psi.
Ductile Iron Pipe	ASTM A21.51; ASTM A536, Grade 60-42-10; thickness Class 50, unless otherwise required by the City engineer.

PVC Pipe, less than 15’ cover	ASTM D3034, Type PSM Polyvinyl (Chloride), SDR 35; PVC Material shall conform to ASTM D and shall have a cell classification of 12454-B, 12454-C, or 13364-B. The minimum pipe stiffness for pipe used for stublines shall be SDR 26.
PVC Pipe, 15’ or more cover	Polyvinyl Chloride Pipe meeting the Requirements of AWWA C-900.

The use of thermoplastic pipe shall be limited to residential or commercial areas as approved by the city engineer and shall not be used for pipelines exceeding 15 inches in diameter unless otherwise approved.

F. MINIMUM SLOPE. All sewers shall be designed to give mean velocities when flowing full of not less than 2.0 feet per second.

All velocity and flow calculations shall be based on the Manning Formula using an "n" value of 0.013. The following slopes shall be minimum for the size indicated.

SEWER SIZE	MINIMUM SLOPE IN PERCENT FULL AND HALF FULL FLOW
8"	0.40
10"	0.28
12"	0.22
15"	0.15
18"	0.12
21"	0.10
24"	0.08

Exceptions to these minimum slopes shall be made at the upper end of the lateral sewers serving under thirty houses. Said sewers shall have a minimum slope of 0.76%.

Where lateral sewers serve less than ten (10) houses, the minimum slope shall not be less than 1% unless otherwise approved by the City engineer.

G. INCREASING PIPE SIZE. When a sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain a continuous energy gradient.

H. HIGH VELOCITY PROTECTION. In situations where flow is continuous and grit is a problem, and where velocities greater than 10 feet per second are possible, special provisions shall be made to protect against abrasion damage to the pipe. Such protection may be attained utilizing ductile iron pipe.

I. ALIGNMENT. All sewers shall be laid with straight alignment between manholes.

J. MANHOLE CONSTRUCTION. Manholes shall be installed at the end of each line; at all changes in grade, size, or alignment; at all intersections; and at a distance not greater than four hundred (400) feet for sewers fifteen (15) inches or less in diameter and not greater than five hundred (500) feet for larger sewers.

K. MANHOLES. The construction of all manholes shall conform to the details shown on the Standard Drawings.

The minimum horizontal clear distance within the barrel of standard manholes shall not be less than four (4) feet. Manholes with connecting pipe diameters greater than 24 inches shall have a minimum inside clear dimension of five (5) feet.

Drop manholes should be avoided as much as possible. However, inside drop pipe shall be provided for a sewer entering a manhole at an elevation of twenty-four (24) inches or more above the manhole invert. The drop pipe shall have the same nominal diameter as that of the incoming sewer. The minimum diameter of an in-side drop type manhole must be increased to five (5) feet. Outside drop manholes will not be allowed.

Without utilizing drop manholes, the difference in elevation between the invert of any incoming sewer and the invert of the outgoing sewer should not exceed twenty-four (24) inches except where required to match crowns. When a sewer joins a larger one, the crown of the smaller sewer shall not be lower than the crown of the larger one. The minimum drop through manholes shall be 0.2 feet.

Where manholes are to be built in close proximity to streets, the top of manhole elevation shall be set within the following limits:

Minimum Elevation	1/4" per foot rise above top back of curb
Maximum Elevation	1/2" per foot rise above top back of curb

All other sanitary sewer lines (sewer lines across unplatted land, etc.) shall have the tops of manholes set flush with the existing ground elevation. Manholes subject to inundation shall be bolt-down rubber gasketed. The top of all manholes shall be located above the 100-year flood plain.

Any variation from the above top of manhole criteria will require a letter of explanation to be submitted with the drawings and be subject to approval by the city engineer.

L. SEWER LOCATIONS. Sanitary sewers shall be located within street or alley rights-of-way unless topography dictates otherwise. When located in easements on private property, access shall be provided to all manholes. A manhole shall be provided at each street or alley crossing.

End lines shall be extended to provide access from street or alley rights-of-way where possible. Imposed loading shall be considered in all locations.

Not less than five (5) feet of cover shall be provided over top of pipe in street and alley rights-of-way and four (4) feet in all other areas unless otherwise approved by the city engineer.

M. CLEANOUTS AND LAMPHOLES. Cleanouts and lampholes will not be permitted.

N. PROTECTION OF WATER SUPPLIES. There shall be no physical connection between a public or private potable water supply system and a sewer, or appurtenance thereto, which would permit the passage of any wastewater or polluted water into the potable water supply.

1. Horizontal Separation: Sewer mains shall be laid at least 10 feet horizontally from any existing or proposed water main. The distances shall be measured edge to edge. In cases where it is not practical to maintain a 10-foot separation, the engineer may allow deviation on a case-by-case sewer closer to a water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer.

2. Crossings: Sewers crossing water mains shall be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to prevent damage to the water main.

3. Special Conditions: When it is impossible to obtain proper horizontal and vertical separation as stipulated above, the sewer shall be designed and constructed equal to water pipe, and shall be pressure tested to assure watertightness prior to backfilling.

   No water pipe shall pass through, or come in contact with, any part of a sewer or a sewer manhole.

O. AERIAL CROSSINGS. Adequate support shall be provided at all joints in pipes utilized for aerial crossings. Only ductile-iron pipe with restrained joints shall be used unless otherwise approved by the city engineer.

SECTION V. DESIGN CRITERIA FOR WATER LINE CONSTRUCTION

A. GENERAL. Proposed extensions of the water distribution system shall, in general, follow the pattern established in the Water Facilities Plan as adopted by the City of Branson. Deviations from this general policy may be deemed necessary by the city engineer should the provision of adequate service to prospective customer or fire protection needs, existing or anticipated, in the area to be served warrant said deviations.

No public water line shall be constructed less than size (6) inches in diameter (except for 2 inch PVC lines permitted on cul-de-sacs).

B. LOCATION OF WATER MAINS AND APPURTENANCES. Proposed water mains shall be so located within street right-of-way to provide the least interference with the location of other utility lines. Street grades and elevations of proposed main shall be taken into consideration so that once constructed they will not require regrading or relocation.

C. DEPTH. All water mains shall have a minimum cover of forty-two (42) inches and a maximum cover of sixty (60) inches.

D. MATERIAL OF CONSTRUCTION. Ductile iron pipes or PVC shall be used for all mains constructed in the City of Branson.

The ductile iron shall conform to ANSI A21.51; ASTM A536, Grade 60-42-10; AWWA C151. The minimum nominal thickness class for ductile iron pipe shall be 50, unless otherwise designated by the city engineer.

Joints, unless otherwise specified, shall be of the push-on type conforming to ANSI A21.11/AWWA C111, except gaskets shall be synthetic rubber. Natural rubber will not be acceptable. The pipe shall be cement mortar lined, conforming to ANSI A21.4/AWWA C104 and shall be coated inside and out with a bituminous coating.

Ductile-iron fittings shall be complete with all accessories and shall be ASTM A536, Grade 70-50-05, conforming to ANSI A21.10 AWWA C110, 350 PSI pressure rating. Joints shall be of the standard mechanical joint type conforming to ANSI A21.10/AWWA C104, and shall be coated inside and out with a bituminous coating.

PVC pressure pipe shall be designed to carry potable water at pressures (including surge) up to the maximum class rating. Materials from which the pipe, couplings, and fittings are manufactured shall conform to ASTM D1784, Type 1, Grade 1, 2,000 psi design stress. The minimum wall thickness for the pipe shall be SCR 21 (Class 200). 2" PVC pressure pipe shall have a minimum wall thickness for the pipe. Pipe shall be DR 17 (Class 250) or Schedule 40 (Class 270).

All PVC pipe shall conform to the latest revisions of ASTM D2241, Department of Commerce PS22-70 (SDR-PR) pressure rated pipe, and National Sanitation Foundation Testing

Laboratories (NSF). Pipe ends shall be tapered to accept gasketed couplings. Flexible elastomeric gaskets, meeting the requirements of ASTM F477, shall be synthetic rubber. Natural rubber will not be acceptable.

The couplings and fittings shall accommodate the pipe for which they are used. The minimum pressure ratings shall be 235 psi for couplings and 250 psi for the fittings.

E. FIRE HYDRANTS. Fire hydrants shall conform to AWWA C502, and shall be Mueller A423 Super Centurion 250 or Clou Model 2545 Medallion.

Hydrants shall be traffic models with breakaway flanges and shall have one 4 1/2 inch pumper nozzle and two 2 1/2 inch nozzles. All hydrants shall be furnished with auxiliary gates valves.

Hydrants should be placed at or near street intersections and at intermediate points when block lengths become long. Under no circumstances shall the spacing of fire hydrants exceed five hundred (500) feet in residential areas or three hundred (300) feet in commercial areas.

Fire Hydrant installations shall conform to the Standard Drawings.

F. LINE VALVES. Gate valves shall be of the resilient-seated configuration and shall conform to the applicable requirements of AWWA C509.

Resilient-seat gate valves shall be American-80 "CRS" or Mueller A-2370-20 or approved equal.

Gate valves shall be used in all water mains twelve (12) inches in diameter and smaller.

Butterfly valves shall conform to AWWA C504 and shall be American (Class 150B), Mueller "Line Seal III", or approved equal. Butterfly valves shall be used in mains larger than twelve (12) inches in diameter or where otherwise approved by the city engineer.

Valves shall be placed in all straight runs of pipe at intervals not to exceed 800 feet. Where two lines intersect, a valve should be placed in each pipe on each side of the intersection. All valves shall be restrained to the tee. Valves should be so placed that any pipe two (2) blocks long can be cut out of the general circulation without interrupting service in the rest of the system.

Extension stems shall be provided for buried valves when the operating nut is more than three feet below finished grade. Each extension stem for a buried valve shall extend to within three feet of the ground surface, shall be provided with spacers which will center the stem in the valve box, and shall be equipped with a wrench nut.

G. TAPPING SLEEVES AND VALVES. Tapping sleeves and valves shall be used where required to connect to existing in-service mains.

The valves shall be 200 psi, resilient-seated, cast iron body, nonrising stem gate valves conforming with all applicable requirements of AWWA C509 and shall be Mueller "No. A-2307-16" or an approved equal. Each tapping valve shall be provided with a flanged inlet end designed, faced and drilled for connection to the outlet end of the tapping sleeve. The outlet end of the tapping valve shall be provided with a tapping flange for attachment of a standard drilling machine and also with a mechanical joint-type bell end for connection of the branch main.

Tapping sleeves shall be of the flanged-outlet type designed for attachment to the flanged inlet end of the tapping valve, and shall be provided with mechanical joint ends at each end of the run and shall be Mueller "No. H-615" for ductile iron pipe or approved equal.

H. CONNECTIONS TO EXISTING WATER MAINS. Connections to existing water mains shall be made in such a manner as to provide the least amount of interruption to water service. In the event closing of valves to make a connection will affect a customer who cannot be without service, provisions shall be made on the plans for a temporary service.

I. PROVISIONS FOR FUTURE EXTENSIONS OF WATER MAINS. At the termination of all water mains or at locations as specified by the city engineer, a dead end assembly in accordance with the Standard Drawings of the Technical Specifications of the City of Branson shall be provided to allow for future water main extensions.

Flushing assemblies shall be used at locations as required to provide for thorough flushing of all water mains in the project area. Whenever practical, water mains five hundred (500) feet and longer shall be provided with a fire hydrant for flushing.

J. THRUST BLOCKING. Reaction blocking of adequate size shall be provided at all tees, elbows and bends to resist all resultant thrusts due to hydrostatic pressure. All blocking shall conform to the Standard Drawings.

K. HIGHWAY AND RAILROAD CROSSINGS. All crossings of highways or railroads shall be made by boring or tunneling. The work shall be in conformity with all requirements and regulations and be under the control of the authority owning or having jurisdiction over and control of the right-of-way in each case.

L. STREET CROSSINGS. Open cutting of streets shall be allowed only where permitted by the City engineer. At locations where open cutting is not permitted, the crossing shall be made by boring or tunneling. Crossings made by boring or tunneling shall require a casing pipe unless otherwise approved by the city engineer. All work and materials shall be in conformity with all requirements of the Technical Specifications of the City of Branson. The diameter and length of the casing pipe to be used shall be as determined by the city engineer.

M. FIRE FLOW REQUIREMENTS. Public improvement plans for water line projects serving development sites other than single family or duplex subdivisions shall be reviewed for fire protection sufficiency. The Chief Building Official shall determine the amount of water that is required for fire protection based on I.S.O. guidelines for the proposed type of structures to be

built within the development. The design engineer shall obtain the flow requirement and then determine if the existing operating conditions. Calculations verifying that the required flows can be met shall accompany the drawings when submitted for approval.

SECTION VI. DESIGN CRITERIA FOR STREET IMPROVEMENTS

A. GENERAL. Proposed street improvements within the city shall conform to the pattern established in the Major Street Plan as adopted by the City of Branson.

Street improvements shall be designed to conform to applicable codes, regulations, ordinances, and the provisions set forth in these criteria as established by the City of Branson. Plans for said improvements shall be submitted to thediretor of public works/engineering for approval and shall include all information as may be required or described hereinafter.

B. FUNCTIONAL CLASSIFICATION OF STREETS. The classification of streets shall be generally defined as follows:

1. *Local Streets.* A street designed to provide access to abutting property from collector and arterial streets.

2. *Collector/Commercial Streets.* Streets, which, in addition to serving abutting properties, intercept local streets, connect with community facilities and carry neighborhood traffic to the arterial street systems. Commercial streets serve areas predominately zoned for commercial or industrial uses.

3. *Arterial Streets.* A street or road of considerable continuity which serves or is intended to serve as a principal trafficway between separated areas or districts and which is the main means of access to the collector street system, highways, or expressways.

   Typical cross-sections of these classifications are shown on Design Aids No. 1 and No. 2.

C. STREET DESIGN STANDARDS

	MAJOR	MINOR	COLLECTOR 2 – Lane *	LOCAL 2-Lane
Right-of-way Width (ft)	120	100	60	50
Street Width (ft)	(86'-70')	52	36	28
Median Width (ft)	(14'-30')	-0-	-0-	-0-
Minimum Pavement Depth (Asphaltic Concrete) inches	11	11	9.5	5.5
Design Volume (VPD) Range	24,000-36,000	12,000-24,000	1,500-12,000	Less than 1,500
**Design Speed (MPH)	45	35-45	30-35	25-30
Maximum Grade	8%	8%	12%	15%
Minimum Grade	0.5%	0.5%	0.5%	0.5%
Curb Return Radius	50'	50'	30'	25'
Minimum Radii Horizontal Curves	1300'	700'	300'	185'
Minimum Private Curb Cut Spacing (ft)	350	One per property	One per property	One per property
Minimum Distance from Intersection of R.O.W. to curb cut (ft)	250	200	150	25
***Sidewalk width (ft)	5	5	5	5
Parking Permitted	No	No	No	One Side Only
Storm Sewers	Yes	Yes	Yes	Yes
Curb & Gutter	Barrier (CG-1)	Barrier (CG-1)	Barrier (CG-1)	Barrier or Roll Back (CG-1 or CG-2)

* Also applicable to commercial streets.

** Design Speed criteria for horizontal and vertical alignment should meet the requirements of the current edition of "A Policy on Geometric Design of Highways and Streets, AASHTO".

*** Both sides of roadway.

D. OFF-CENTER STREET INTERSECTIONS. Off-center street intersections shall be separated by a minimum centerline to centerline dimension of one hundred and fifty feet.

E. INTERSECTION VERTICAL ALIGNMENT. In all cases where a higher functional street intersect with a lower functional street, normal street crown shall be maintained on the higher functional street. Where streets of equal function intersect, street grades shall coincide in the center of the intersection with reduced rideability for both streets, or a warping of the cross slope for both streets. (Design Aid No. 5)

F. MINIMUM ANGLE OF INTERSECTION. It is desirable for all intersections to meet at approximately a 90 degree angle. Skewed intersections should be avoided, and in no case should the angle be less than 60 degrees.

G. MAXIMUM GRADIENT. The maximum gradient for streets as noted in Section C may be exceeded only upon written approval of the city engineer. Such approval will only be granted in unusual cases where grades within the acceptable limits cannot be obtained.

H. GRADING GRADIENTS. The finished grade within the limits of the right- of-way shall slope from one-quarter (1/4) inch vertical to one (1) foot horizontal minimum, to one-half (1/2) inch vertical to one (1) foot horizontal maximum measured above the back of the curb. The grading gradients may be varied only upon written approval of the city engineer.

I. TANGENT LENGTH. The minimum tangent length between reverse curves shall be fifty feet for local streets and one hundred feet for collector/commercial and arterial streets, except that no tangent will be required for radii longer than five hundred feet.

J. SIGHT DISTANCE. Street intersection sight distance shall be in accordance with the requirements of the current edition of "A policy on Geometric Design of Highways and Streets, AASHTO". Driveway intersections sight distance with arterial and collector/commercial streets shall meet the recommendation of the Missouri Department of Transportation.

K. CONNECTIONS TO EXISTING PAVEMENTS. Where a new street is to connect to an existing street, all deteriorated or cracked asphalt within five (5) feet of the connection point shall be removed to a point where sound material is found. If full-depth pavement removal is required the sub-grade will be recompacted to 95% to standard density.

L. STORM DRAINAGE. All storm drainage works constructed in connection with street improvements shall be designed in accordance with the City of Branson Design Criteria for Storm Sewers and Appurtenances.

M. CUL-DE-SACS. At locations where streets are to be terminated and a vehicular connection between adjacent streets is not required a cul-de-sac may be permitted. Such cul-de-sac shall be constructed with a minimum radius of thirty-nine (39) feet to the back of the curb.

N. TEMPORARY TURN-AROUNDS. At locations where streets are to be temporarily terminated which will be extended at a later date, and said street extends beyond the intersection of an adjacent street more than five (5) lots, a temporary cul-de-sac shall be constructed with a minimum radius of thirty-five (35) feet. The temporary cul-de-sac shall be constructed of asphaltic concrete with a minimum depth of six (6) inches. Curb and gutter will not be required. The cul-de-sac shall be constructed within the limits of a permanent construction easement.

O. MONUMENT BOXES. Monument boxes conforming to the Standard Drawings shall be installed at all quarter section corners as involved in the street construction.

P. OTHER DESIGN CRITERIA. All other street design elements not contained within this criteria shall be in accordance with the most current edition of "A Policy on Geometric Design of Highways and Streets" authored by the American Association of State Highway and Transportation Officials (AASHTO) or other applicable AASHTO design guides.

Q. DRIVEWAY ELEVATIONS. Driveways shall attain top of curb elevation within the right-of-way. Driveway grades within right-of-way shall be 8% maximum until curb height is reached. Breakover grades for crest drives shall be 8% maximum and sag drives shall be 12% maximum. Driveway elevation shall not be more than 6" above or below the normal shoulder elevation at the right-of-way line, to allow for a smooth sidewalk profile.

SECTION VII. DESIGN CRITERIA FOR STORM DRAINAGE FACILITIES

A. GENERAL**.** This section sets forth the minimum technical criteria for the analysis and design of drainage systems. All development plans submitted for approval to the City of Branson must be accompanied by an adequate storm drainage system analysis and design in accordance with the criteria as hereinafter described and shall be performed by a licensed professional engineer in the State of Missouri.

The criteria set forth in this section shall apply primarily to that element of the drainage system outside the limits of the 100-year regulatory flood-plain unless otherwise noted. Improvements within the limits of the 100-year floodplain shall conform to requirements set forth in applicable city codes and ordinances and the regulations of any other agency having jurisdiction over such area.

B. MINIMUM STANDARDS OF ANALYSIS. Unless otherwise approved by the city engineer, the following criteria will be utilized to determine the adequacy of any storm drainage facility design submitted for approval.

1. Methodology of Analysis. In determining the amount of stormwater runoff resulting from a development and the amount of flow at various points throughout the drainage system, it is important for the designer to relate the methodology to be utilized in the designers calculations to the proportionate size of the tributary watershed areas. In developments where the area contributing runoff is one hundred (100) acres or less, the Rational Method of calculating the quantity of runoff may be utilized. Developments where the area contributing runoff exceeds one hundred (100) acres shall be designed using the Unit Hydrograph Method (SCS) or other methodologies approved by the city engineer.

2. Criteria for Drainage System. All calculations relating to runoff analysis shall be based upon the proposed land use as related to allowable impervious surface and shall take into consideration any contributing runoff from areas adjacent to the development site. Storm water runoff analysis from adjacent existing developed areas shall be based upon current land usage and topographical features. Property adjacent to the study area which is undeveloped shall be considered as fully developed in accordance with the most probable anticipated future land use. Such land use shall be determined from the City Comprehensive Plan and the City zoning map. In the event that the future land use of a specific undeveloped property cannot be adequately projected from available information, the average runoff coefficient (C) to be used shall not be less than 0.65 for use in the Rational Method or an appropriate equivalent value as approved by the city engineer for any other method. The most likely flow pattern to be utilized for an undeveloped area shall be based upon existing natural topographical features.

   Average land slopes in both developed and undeveloped areas may be utilized to calculate runoff rates. The exception to this shall be in areas with existing well-defined drainage patterns and slopes; in which case the actual slope shall be used.

Existing runoff flow rates and velocities at location of discharge from adjacent upstream developments shall be utilized in drainage system design. Drainage facilities shall be designed to minimize the velocity of overland flow so as not to cause erosion damage. In areas where excessive velocities exist, adequate dissipating structures shall be provided as required to result in velocities appropriate for the type of erosion control to be utilized or as specified in this criteria.

The primary function of roadways within a development shall be reserved for the conveyance of traffic. The use of these facilities as a storm runoff facility shall be restricted to the requirements established and set forth in these design criteria.

The utilization of onsite or on stream detention and natural drainage ways is recommended and encouraged where feasible. Relocation of existing natural drainage ways will not be approved unless such relocation has been substantiated as a result of a thorough and complete analysis of the resultant consequences.

The designer shall consider all problem areas of the design and analysis to prevent the transfer of these problems from one location to another. All points of drainage outfall shall be designed to preclude creation of downstream flooding problems and hazards to the public. Approval will not be given to any project, which involves the construction of any structure or the placement of fill material which will hinder or impair surface or subsurface drainage from surrounding areas.

C. STORMWATER CONVEYANCE MINIMUM STANDARDS OF DESIGN. Storm water runoff shall be carried by enclosed systems or open channels on the basis of criteria established in this section and subject to the final determination and approval of the city engineer.

1. Open Channels: Open channels, natural or improved, may be placed to the rear or side of properties upon approval of the city engineer where the design provides adequate protection to the adjacent property and structures. Such protection shall be through the provision of a 50-year flood plain setback and a minimum clearance from the top of bank to any building of 30 feet.

2. Enclosed Systems: Runoff from drainage areas outside of established or proposed right-of-ways greater than 3 acres in size shall be collected and transported in an enclosed system. Enclosed systems shall also be utilized within the limits of established or proposed right-of-way for roadways and streets. The drainage system shall remain enclosed until the flow rate is such that the runoff from the design storm for a development can no longer be contained within a 72-inch R.C.P. equivalent conduit and an open channel can be entered without negative impact. Additionally, the receiving open channel shall be capable of meeting the appropriate clearances to adjacent buildings as indicated above for open channels.

   All storm sewers and culverts crossing under street pavement shall be reinforced concrete pipe unless a specific waiver is granted from the city engineer. Storm

sewers outside of pavement areas may be corrugated metal pipe (CMP) or corrugated high density polyethylene (HDPE) pipe. Flared end sections are required on all CMP, HDPE and RCP concrete aprons and wing walls are required on all concrete box culverts.

At the point of intersection and discharge with the receiving open channel, an energy dissipating structure acceptable to the city engineer shall be provided to limit the discharge velocity from the enclosed system to not more than 5 fps.

Where storm drainage facilities are located along side property lines, such systems shall be enclosed to a point at least 30 feet beyond the rear corner of adjacent buildings unless otherwise directed or approved by the city engineer. A surface swale shall be designed over this area to contain additional run-off from a 25-year storm and drainage shall remain within drainage easement of the 100-year storm.

Complete side and rear drainage systems meeting the criteria established previously shall be provided along the boundaries of new subdivisions or developments by the developer or property owner.

a. Design Storm Frequencies. The minimum rainfall event to be utilized in determining the intensity of rainfall for storm flow calculations shall be based on the following:

Rainfall Depth-Duration-Frequency Relationships from Rainfall Frequency Atlas of the Midwest (Huff and Angel 1992)

Duration	Depth of Precipitation (in)						
	1-year	2-year	5-year	10-year	25-year	50-year	100-year
5 min	0.36	0.45	0.57	0.67	0.79	0.88	0.98
10 min	0.63	0.79	1.01	1.17	1.38	1.54	1.72
15 min	0.81	1.02	1.29	1.50	1.77	1.98	2.21
30 min	1.11	1.39	1.77	2.05	2.43	2.72	3.03
1 hr	1.41	1.77	2.25	2.61	3.08	3.45	3.84
2 hr	1.74	2.19	2.78	3.22	3.80	4.26	4.74
3 hr	1.92	2.41	3.07	3.55	4.20	4.70	5.24
6 hr	2.25	2.83	3.59	4.16	4.92	5.51	6.14
12 hr	2.61	3.28	4.17	4.83	5.71	6.39	7.12
18 hr	2.82	3.54	4.50	5.22	6.17	6.90	7.69
24 hr	3.00	3.77	4.79	5.55	6.56	7.34	8.18
48 hr	3.30	4.14	5.25	6.07	7.17	8.05	8.97
72 hr	3.68	4.62	5.81	6.69	7.90	8.85	9.85
120 hr	4.16	5.21	6.50	7.45	8.70	9.68	10.77
240 hr	5.37	6.59	8.05	9.13	10.49	11.52	12.61

Rainfall Intensity-Duration-Frequency Relationships from Rainfall Frequency Atlas of the Midwest (Huff and Angel 1992)

Duration	Intensity of Precipitation (in/hr)						
	1-year	2-year	5-year	10-year	25-year	50-year	100-year
5 min	4.32	5.40	6.84	8.04	9.48	10.56	11.76
10 min	3.78	4.74	6.06	7.02	8.28	9.24	10.32
15 min	3.24	4.08	5.16	6.00	7.08	7.92	8.84
30 min	2.22	2.78	3.54	4.10	4.86	5.44	6.06
1 hr	1.41	1.77	2.25	2.61	3.08	3.45	3.84
2 hr	0.87	1.10	1.39	1.61	1.90	2.13	2.37
3 hr	0.64	0.80	1.02	1.18	1.40	1.57	1.75
6 hr	0.38	0.47	0.60	0.69	0.82	0.92	1.02
12 hr	0.22	0.27	0.35	0.40	0.48	0.53	0.59
18 hr	0.16	0.20	0.25	0.29	0.34	0.38	0.43
24 hr	0.13	0.16	0.20	0.23	0.27	0.31	0.34
48 hr	0.07	0.09	0.11	0.13	0.15	0.17	0.19
72 hr	0.05	0.06	0.08	0.09	0.11	0.12	0.14
120 hr	0.03	0.04	0.05	0.06	0.07	0.08	0.09
240 hr	0.02	0.03	0.03	0.04	0.04	0.05	0.05

Storm drainage systems having more than one land use or zoning classification tributary to the system, shall be designed on the basis of the highest runoff producing land use comprising thirty (30) percent or more of the total tributary area.

b. Runoff Computation. The rational method of calculating storm water quantities, Q = KCiA, shall be used with the following definitions of terms and arbitrary values:

Q quantity of runoff in (cfs) cubic feet per second and is the basis for design of the storm drainage system.

K dimensionless coefficient to account for antecedent precipitation.

C weighted coefficient of runoff from the tributary area and shall have the following values where applicable.

i rainfall intensity for a duration equal to the time of concentration (in/hr)

A drainage area (acres) Note: All upstream tributary areas are to be as fully developed as zoned or planned at the time of design.

Land Use	"C"
Business	
Downtown Area	0.98
Residential	
Single-Family Areas	0.45
Multi-Family Areas	0.80
Churches & Schools	0.80
Industrial	
Light Areas	0.85
Heavy Areas	0.85
Parks, Cemeteries	0.35
Playgrounds	0.35
Railroad Yard Areas	0.45
Undeveloped Areas	
Permanent Unimproved Areas, Greenbelts, etc...	0.30
Woods	0.15
Temporary Unimproved Areas which can be considered as fully developed in the future	0.65

As an alternate to the above coefficients or for areas not specifically listed above planned building groups, shopping centers, trailer parks, etc., a composite runoff coefficient based on the percentage of the different types of surfaces involved shall be used.

Coefficients with respect to surface type shall not be less than those listed in the following table:

Asphalt Surfaces	0.98
Concrete Surfaces	0.98
Roof Areas	0.98
Turf	0.30

c. Antecedent Precipitation. "K" represents the frequency factor used to account for antecedent precipitation and shall have the following values:

Storm Return Period (Years)	K (Multiplier)
10	1.0
25	1.1
50	1.2
100	1.25

Time of concentration (TC) equals the overload flow time to the most upstream inlet or other point of interest to the system plus the time of flow in the system upstream from the point under construction. ($T_c = t_o + t_t$)

In which: T_c = time of concentration (minutes)
t_o = overland flow time (minutes)
t_t = travel time (minutes)

For urban areas, the time of concentration, T_c, is typically calculated by breaking the flow path into reaches of overland flow, *to*, and travel time, t_t, where t_t is typically the travel time in the storm system, paved gutter or drainage channel. For non-urban areas, t_c also consists of overland flow and time of travel components where t_o is typically much longer and t_t is the time of travel in natural swales and waterways.
A minimum *Tc* of 10 and 5 minutes should be used for undeveloped and developed areas. Conservative *Nk* values should be chosen to provide a safety factor for adequate design. When determining predevelopment flows, a longer *tc* (larger *Nk* value) will result in conservative design. When determining post-development flows, a shorter *tc* (smaller *Nk* value) will result in a more conservative design.

The Kerby-Hathaway equation for determining the overland flow is:

$$t_0 = 0.83 \left(\frac{N_k L}{S^{0.5}}\right)^{0.47}$$

N_k = coefficient of roughness
L = overland flow length (ft), maximum of 500 feet for undeveloped areas and 300 feet for developed areas
S = average overland slope (ft/ft)

The Kerby-Hathaway Equation Values of N_k

Surface Type	***N_k***
Smooth impervious surface	0.05
Smooth bare packed soil, free of stones	0.10
Poor grass, cultivated row crops, or moderately-rough bare surfaces	0.20
Pasture or average grass cover	0.40
Conifer timberland, deciduous timberland with deep forest litter or dense grass cover	0.80
Deciduous timberland	0.60

The Kirpich equation for calculation of the travel time is:

$$t_t = 0.0078 \left(\frac{L}{S^{0.5}}\right)^{0.77}$$

The Kirpich equation is most applicable for undeveloped watersheds with well-defined channels, bare earth overland flow, or flow in mowed channels. The following adjustment factors are recommended for other conditions (Chow et al. 1988):

Adjustment Table

- For flow in natural grassed channels	multiply by 2
- For overland flow on concrete or asphalt surfaces	multiply by 0.4
- For concrete channels	multiply by 0.2

d. Pipe Sizing. Pipe sizes in integrated underground systems shall be determined in accordance with the Manning Formula

$$Q = \frac{1.49}{n} AR^{\frac{2}{3}}\sqrt{S}$$

Values of "n" to be used in the Manning Formula shall be as shown in (Design Aid) Manning's "n" for HDPE pipe shall be 0.013

The minimum size storm sewer size shall be twelve (12) inches in diameter fifteen (15) inches for CMP.

Storm sewers and inlets shall be of sufficient capacity to adequately carry the anticipated runoff from the design storm. Capacity shall be rated at either inlet or outlet control, whichever condition indicates the least capacity. The drainage system and appurtenant storm inlets shall commence at all locations where the allowable street capacity for the conveyance of storm water runoff is exceeded or where there is a possibility of ponding.

All storm drainage systems shall be designed so as to maintain a minimum velocity of flow of two (2) feet per second and a maximum velocity of fifteen (15) feet per second when flowing full. All systems discharging at a velocity in excess of five (5) feet per second shall be designed with an acceptable energy dissipating structure.

e. Depth. All storm drainage lines shall have a minimum cover of eighteen (18) inches where practical. Cover may be decreased to avoid conflicts or on short laterals, as approved by the city engineer. Special bedding and backfill may be required where cover is less than eighteen (18) inches.

f. Curb Inlet, Junction Boxes and Other Points of Entry. In general, curb inlets shall be installed at intersections and as required at intermediate points to limit gutter flow width during runoff occurring from the design peak discharge from the tributary watershed area to that which will not encroach on the following center width of streets:

Thoroughfare Streets	24 feet
Collector/Service Streets	14 feet
Local Streets	10 feet

Because of the potential for street debris to clog inlets and to reflect potential cross section changes due to resurfacing, inlet capacity shall be rated at 80 percent of the theoretical inlet capacity unless otherwise approved by the city engineer.

Design shall provide that the hydraulic gradient at any opening through which surface water may enter (or backflow from) the system is 0.5 foot or greater below the opening elevation. The hydraulic gradient elevation is defined as:

1) Invert elevation of the outlet channel (pipe) of the structure;

2) Plus depth (diameter) of outlet channel (pipe);

3) Plus "h" = V /64.

The hydraulic gradient elevation shall be calculated at the entrance to the outlet line of each structure.

The crown(s) of pipe(s) entering a structure shall be at or above the crown of the pipe exiting from the structure to provide a minimum fall of the invert in the structure of 0.2 feet for straight flow through the structure or 0.5 feet fall for all other types of flow (bends more than 22.5 degrees deflection angle, multiple lines entering, enlargement transition,....etc.) through the structure.

g. Open Channels. Unless in a 100-year designated floodplain or a critical area as determined by the city engineer, open channels shall be designed for the 25-year frequency storm. Open channels shall be sized to adequately carry the design rate of flow without damage. Whenever practical, the channel shall be characterized as slow flowing, be wide and shallow, and be natural in its appearance and functioning. Drainage easement shall be adequate to contain the 100 year frequency storm.

Channel capacities shall be computed using the Manning Formula for uniform flow.

Design flow rates shall be carried within the confines of the open channel with a minimum allowable freeboard of 1.0 foot measured from the water surface to the top of bank.

Pipe culverts, box culverts, and other structures entering channels shall not project into the normal waterway area.

Channel design shall include lining or treatment of the invert and sides as required to minimize erosion. Minimum treatment shall include seeding.

Channel inverts and sides shall be lined in accordance with the following table:

Mean Flow Velocity	Type of Lining
Less than 3 F.P.S.	Seeded
3 to 5 F.P.S.	Sod, staked
5 to 10 F.P.S.	Stone riprap (15"Min. thickness)
10 to 15 F.P.S.	Grouted stone riprap, gabion revetment or concrete
over 15 F.P.S.	Concrete paved or sound in-situ rock

Lining materials having equivalent erosion control properties to those shown in the foregoing table may be used in lieu thereof with the approval of the city engineer.

Channel sections shall be compatible with the type of lining and maintenance practical to be used. Side slopes shall be as flat as practical. Side slopes of 3:1 shall be considered a normal maximum. Under special circumstances where acceptable lining material is to be utilized, slopes of 2:1 may be considered. Such use in the channel design shall be only where approved by the city engineer. Friction factors used in design shall consider the type of lining.

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

$$R = \frac{V\ W}{8D}$$

R = Minimum radius of centerline in feet.

V = Average velocity of flow in feet/sec.

D = Depth of flow in feet.

Lining height on the outside (concave) side of curves shall be increased by:

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

y = Increased vertical height of lining in feet.

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

1) 30 (y) feet downstream from the point of tangency (p.t.)
2) 10 (y) feet upstream from the point of curvature (p.c.)

h. Natural Channels. Shall conform to the criteria for improved channels except:

1) Mean flow velocity may be 5 feet/sec without lining.
2) Freeboard requirements may be satisfied by dedication of an easement to the freeboard elevation plus 1.0 foot vertically.

i. Culvert. Culverts under major and minor arterials shall have sufficient capacity to pass the runoff from the appropriate design storm considering 20% of the inlet opening plugged.

The following design criteria shall be utilized for all culvert design:

1) The culvert including inlet and outlet structures shall properly take care of water, bed-load and debris at all stages of flow.

2) Inlet. Culvert inlets shall be designed to minimize entrance and friction losses. Inlets shall be provided with either flared-end sections or headwalls with wingwalls. Projecting ends will not be acceptable. For large structures, provisions shall be made to resist possible structural failure due to hydrostatic uplift forces.

3) Outlets. Culvert outlets shall be designed to avoid sedimentation, undermining of the culvert, and erosion of the downstream channel. Outlets shall be provided with either flared-end sections or headwalls with wingwalls. Projecting outlets will not be acceptable. Additional outlet control in the form of riprap, channel shaping, etc., may be required where excessively high discharge velocities occur.

4) Slopes. Culvert slopes should be such that neither silting nor excessive velocities and scour occur. Generally, the minimum slope of culverts shall be limited to 0.005.

5) Headwater. Generally, the headwater to diameter ratio (HW/D) should not exceed those recommended as follows:

Storm Frequency	HW/D
10 year	≤ 1.0
25 year	≤ 1.2
50 year	≤ 1.5
100 year	≤ 1.5

6) Tailwater. The depth of tailwater at the outlet shall be subject to the criteria set forth for headwater.

7) Hydraulic Design. Culverts shall be analyzed to determine whether discharge is controlled by inlet or outlet conditions for design storm discharge. The value of the roughness coefficient (n) used shall not be less than those specified in Design Aid No. 12.

8) Structural Design. The structural design of culverts, whether pipe or concrete box, shall be sufficient for the situation anticipated to be encountered at the site of the proposed work. Such design shall conform fully to all requirements set forth in this criteria and in the Technical Specifications of the City of Branson and shall be as approved by the city engineer.

D. STORMWATER DETENTION MINIMUM STANDARDS OF DESIGN. Storm water detention shall be designed on the basis of criteria established in this section and subject to the final determination and approval of the city engineer.

1. All detention shall be designed based on a 2, 10, 25, and 100 year storm.

2. Stormwater shall be retained such that the rate of run-off leaving the post-developed site is no greater than the pre-development run-off rate.

3. Generally accepted formulas may be used – HEC-1, etc. or Rational equation, etc. Developments over 100 acres must use the unit hydrograph (SCS) or similar method.

4. Calculations must be submitted to the city engineer for review. Calculations shall include a summary sheet which indicates pre-development flows and the post-development flows exiting the detention basin. The summary sheet shall also be shown on the detention basin drawings.

5. Detention may be accomplished in nearly any method viable on the project site. This can include detention ponds, tanks, below ground systems or even parking lot or landscape island detention. Open basins must be soil lined and have soil placed on interior and exterior side slopes. Soil must be seeded and mulched. Rip-rap or rock lined basins and berms will only be allowable under unusual circumstances and with special permission from the city.

6. Discharge may be by use of V-notch walls, slotted weir, or small pipe. Innovative solutions are usually acceptable depending upon city staff review. All detention basin discharge facilities (i.e. orifices and weirs) must be visible for routine inspection and maintenance.

7. The minimum size of an orifice (small pipe) shall be 6" in diameter and the minimum width of a slotted weir shall be 4".

8. A drainage area map must be submitted for detention basins that serve more than one parcel. The map shall utilize the city's GIS mapping as a base.

9. Discharge velocities must not be erosive. The following channel linings are required:

Velocity	Lining Type
<3 fps	Seeded
3 to 5 fps	Staked sod
5 to 10 fps	15" thick stone rip-rap
10 to 15 fps	Grouted stone rip-rap, gabion or concrete paved
Over 15 fps	Concrete paved or bedrock

Velocities must be reduced prior to exiting the appropriate lining.

10. Any disturbance of land over 1 acre in size requires a permit from the Missouri Department of Natural Resources.

11. **A sediment and erosion control plan must be developed and implemented prior to beginning any land disturbance.** The plan shall conform to the requirements set forth in Section IX – Design Criteria for Sediment and Erosion Control.

12. The design engineer shall confirm the adequacy of storm water conveyance downstream of the detention basin outlet. This is of particular importance in areas where the predeveloped characteristics of storm water flow are primarily sheet flow. Storm water downstream of the detention basin discharge shall be conveyed in a well-defined channel and shall not negatively impact downstream properties.

E. Easements. Permanent drainage easements are required to provide adequate access for construction, inspection, and maintenance of all storm drainage system components. All easements shall be dedicated to the city. For new subdivisions, all required easements and setbacks shall be shown on the final plat recorded with the Recorder of Deeds.

Drainage easements shall have minimum widths as described below. A wider easement width may be required at structures or if the easement is shared with other utilities or as determined by the city engineer.

1. Storm Sewer. Easements for storm sewers shall be either 15-feet wide or the outside dimension of the conduit plus 10-feet (centered on the conduit), which ever is greater. A wider easement may be required if the depth of cover exceeds 4 feet.

2. Improved Open Channel. Easements for improved open channels shall be as wide as the top bank width plus 10 feet on each side, and shall be continuous to the end of the channel.

3. Natural Open Channel. Easements for natural open channels shall be the areas between the high bank lines of the channel, plus additional width on each side of the channel as deemed necessary by the city to allow access for maintenance equipment. The minimum width for a natural open channel easement is 30 feet.

G. Water Quality Volume - Storm Water Control. Stormwater systems designed for flood control are typically designed for large, infrequent storm events. In contrast, stormwater controls to protect water quality are designed for small, frequent storm events. In Branson, approximately 90 percent of all rainfall events are 1 inch or less. Studies indicate that most pollutants are washed off in the “first flush,” of these small, frequent storms. Therefore, the volume is based on the runoff from a 1 inch rainfall. The water quality volume must be captured using properly designed, approved storm water control measures that reduce the discharge of pollutants through treatment or runoff reduction. An extended dry detention basin (EDB) is a basin designed to provide sedimentation by detaining and slowly releasing stormwater. An EDB is similar to a detention basin used for flood control but is designed with a much smaller outlet that extends the emptying time of the more frequently occurring runoff events to facilitate pollutant removal, primarily through sedimentation. An EDB is called "dry" because it is designed not to have a significant permanent pool of water remaining between storm runoff events. It can be used for regional or on-site treatment or as follow-up treatment in series with other SCMs. These basins can be inside the storm water detention basin. An EDB should typically be designed and maintained to pool water for no more than the design draw-down time of 24 to 48 hours.

Two methods can be used to calculate the water quality volume (WQV) for water quality - the Short Cut Method and the Small Storm Hydrology Method. According to Claytor and Schueler (1996), these methods are more accurate than other methods for calculating runoff volumes from small storms on urban sites. The designer may choose to calculate the WQV using either method. Both methods compute a volumetric runoff coefficient (Rv) and multiply this by

the 1 inch water quality storm and the site area. The volumetric runoff coefficient represents the amount of rainfall volume that becomes runoff volume on a site.

Short Cut Method - The Short Cut Method (Claytor and Schueler, 1996) computes Rv based on percent impervious cover. This method is recommended where the site consists of predominately one type of land surface. The Short Cut Method uses the following equation to calculate the WQV.

$$WQV\ (ft3) = (P/12)(Rv)(A*43{,}560)$$

Where: P = rainfall depth = 1 inch
Rv = volumetric runoff coefficient = 0.05 + 0.009I
I = percent impervious cover (in percent, e.g. 80% = 80)
A = total site area in acres

Small Storm Hydrology Method - The Small Storm Hydrology Method (Claytor and Schueler, 1996)
computes Rv based on the specific characteristics of the pervious and impervious surfaces of the drainage area. The Rv to be used for each cover type is provided in Table 2. The Small Storm Hydrology Method uses the following equation to calculate the WQV.

WQV (ft3) = (P/12)(weighted Rv)(A*43,560)

Where: P = rainfall depth = 1 inch
Weighted Rv = [(Rv1*A1)+(Rv2*A2)+...(Rvi*Ai)]/A
Rvi = volumetric runoff coefficient for cover type i
Ai = area of cover type i in acres
A = total site area in acres

Table 1. Volumetric runoff coefficients for urban runoff from directly connected impervious areas for a 1 inch rainfall (Claytor and Schueler, 1996; Hirschman, et al., 2008)

Flat roofs and large unpaved parking lots	Pitched roofs and large impervious areas (large parking lots)	Small impervious areas and narrow streets	**Urban pervious areas** Hydrologic Soil Group B	**Urban pervious areas** Hydrologic Soil Groups C & D	**Forest cover** Hydrologic Soil Group B	**Forest cover** Hydrologic Soil Group C	**Forest cover** Hydrologic Soil Group D
0.84	0.97	0.7	0.11	0.21	0.03	0.04	0.05

The following steps outline the design procedure and criteria:

1. Calculate the design volume based on the water quality volume for the drainage area.

2. The basin length to width ratio (L:W) should be between 2:1 and 4:1 and the inlets should be as far as possible from the outlet. Maximizing the distance between the inlet and the outlet and shaping the pond with a gradual expansion from the inlet and a gradual contraction toward the outlet.

3. Basin side slopes should be a maximum of 4H:1V and the use of flatter slopes is encouraged to facilitate maintenance, access, and safety. If steeper side slopes are necessary, 3H:1V is the maximum allowed and must incorporate a flatter upper zone and/or a "safety bench."

4. Determine the preliminary basin geometry necessary to provide the design volume. Select the preferred depth of the basin, then solve for the basin bottom width that will provide adequate storage of the design volume. Assume a trapezoidal pond with the selected L:W ratio, side slopes and basin depth. The EDB design spreadsheet will assist with this calculation. This information is not necessary if detailed stage-area-volume relationships are available for the EDB.

5. Design the outlet structure to release the design WQV over a 24- to 48-hour period. The outlet structure shall consist of a perforated plate with a stainless steel well screen trash rack. (Details are in the table below for a perforated plate.) Use the fewest number of columns possible to maximize the perforation hole diameter. This helps to reduce clogging problems. If persistent clogging of well screen occurs, making it difficult to establish grass growth, the well screen may be temporarily removed until vegetation is established. Well screen must be reinstalled prior to final termination of the Land Disturbance Permit. The design spreadsheet should be used to complete the design.

Requirements for Water Quality Outlet Structures

Parameter	Perforated Plate Requirement
Minimum Perforation Diameter	1/2 inch
Maximum Perforation Diameter	2 inches
Minimum Number of Holes Per Row	1
Maximum Number of Holes Per Row	3
Minimum Row Spacing	4 inches
Maximum Row Spacing	12 inches

6. For perforated plates, provide a trash rack of sufficient size to prevent clogging of the primary water quality outlet. Size the rack so as not to interfere with the hydraulic capacity of the outlet. Using the total outlet area (calculated by multiplying the perforation area per row by the number of rows) and the selected perforation diameter, the Trashrack Sizing Diagram at the end of this section will help to determine the minimum open area required for the trash rack. Use one-half of the total outlet area to calculate the trash rack's size. This accounts for the variable

inundation of the outlet orifices. The EDB design spreadsheet should be used to complete the design.

7. A freeboard of at least 12 inches, or 1 foot shall be provided above the 100-year water surface elevation for all EDBs (including facilities that are solely for water quality purposes and allow larger flows to "pass through") detention areas.

8. A low flow channel should be provided when groundwater or base flow exists in the basin.

9. Consideration should be given to naturalized basin design and incorporating trees in the bottom of the detention basin in addition to the use of native grasses and plants for pond bottoms, berms, and side slopes.

10. Access to the facility shall be provided for maintenance. Grades of the access should not exceed 10 percent, and a stabilized, all-weather driving surface must be provided.

11. Energy dissipation and erosion control should be provided at inlets.

12. A forebay should be considered when the design volume exceeds 20,000 cubic feet or a large sediment, trash or debris load is anticipated due to upstream land use. A forebay provides an opportunity for larger particles to settle out in the inlet area, which has a solid surface bottom to facilitate mechanical sediment removal. The forebay volume for the extended dry detention basin should be between 3 and 5 percent of the design volume. Outflow from the forebay to the basin shall be through a gravel filter designed to be stable under maximum design flow conditions. The top of the gravel filter shall be set equal to the stage of the design volume. The floor of the forebay should be concrete and contain a low flow channel to define sediment removal limits.

13. Combining the water quality facility with a flood control facility is acceptable. Design of the flood control volume may assume the extended dry detention basin is dry at the beginning of the storm.

Detention Basin storage includes dry detention, extended detention, and wet detention ponds. The following maintenance measures shall be implemented on all detention basins:

- Storage volume in basins must be preserved through regular maintenance and removal of sediment. Sediment should be removed and the basin returned to design grades when either a sediment depth of 6 inches exists or more than 10 percent of the design volume has been lost.

- The storage area and outlet structure shall be inspected to ensure that they are functional, free from debris and have no structural deficiencies in need of repair.

- Erosion of riprap, vegetation or soil, particularly near discharge pipes into the basin, shall be repaired and restored to the original design.

- Vegetation and aesthetic features including fences, shrubs, trees, native grasses, and water quality vegetation shall be maintained to function and provide safety to the public.

- Basins should be inspected on an annual basis. Additional periodic inspections should be made, particularly after rainfall events, to ensure the basin meets the requirements of this chapter and is functional.

- Seed and mulch, sod, or other necessary erosion and sediment control best management practices (BMPs) shall be placed immediately after any excavation or grading is complete to minimize erosion and discharge of sediment to the drainage system.

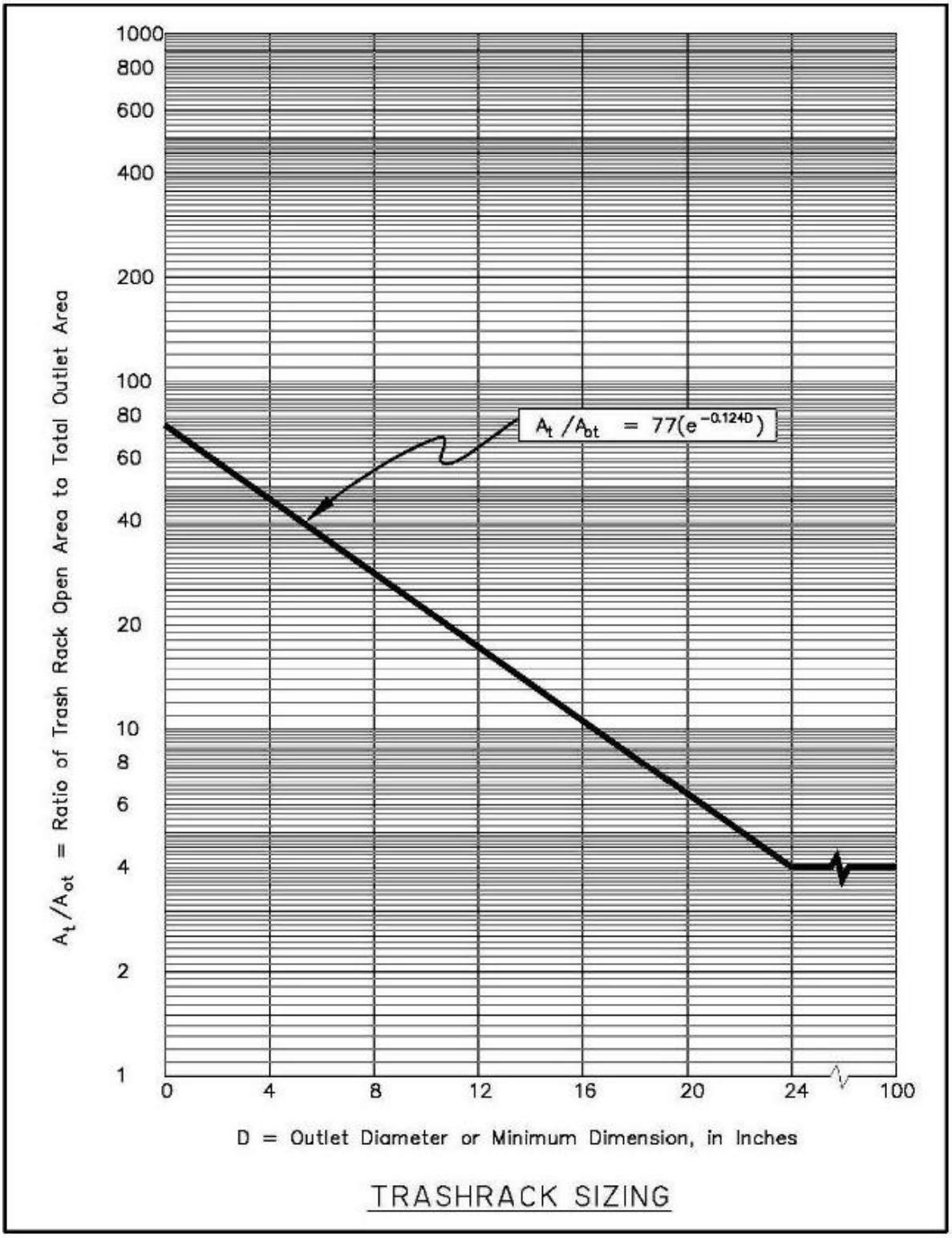
- Routine maintenance to return a facility to its intended designed condition may be conducted without specific permission by the City. Modified designs shall be submitted to the Department of Public Works/Engineering for approval.

Maintenance Responsibility

- Maintenance of drainage facilities is generally the responsibility of the entity owning the facility. Maintenance responsibilities may be further clarified in other legally binding documents such as recorded final plats, recorded paper easements and subdivision covenants.

- Property within the City is required to be mowed and maintained to meet the Branson City Code, 58-294 Section D weeds and vegetation that states grass heights cannot exceed 7 inches. Facilities that incorporate vegetation with heights greater than 12 inches for water quality or other beneficial purposes are allowed, provided that the vegetation does not cause a nuisance or threat to the public health, safety, or welfare.

Trash Rack Sizing Diagram



SECTION VIII. DESIGN CRITERIA FOR SANITARY SEWER LIFT STATIONS

GENERAL: The intent of these criteria is to provide guidance to design engineers regarding minimum requirements of equipment and appurtenances for new construction or upgrades of existing sanitary sewer lift stations **owned and operated by the City of Branson.** Other conditions and requirements for construction will apply including the City of Branson Technical Specifications For Public Works Improvements, National Electrical Code, (latest edition), and City of Branson Planning and Development Department requirements. Design plans and specifications for lift stations must be approved by all applicable City of Branson departments prior to issuance of continuing authority by the Missouri Department of Natural Resources.

All requirements in this document must be described in full detail on the plans and specifications of the lift station. The plans shall include a plan and profile view of all wetwells, drywells, valve vaults, piping and appurtenances. Electrical drawings shall include line diagrams that show all electrical components such as electrical service, motor control center, standby generator, transfer switch, PLC, radio, etc. Also included in the drawings shall be a method of operation for the lift station.

The following requirements are intended to establish a baseline minimum for a standard sanitary sewer lift station owned, operated, and maintained by the City of Branson. Individual lift stations may require site-specific special conditions and/or equipment for proper performance and operation. In such cases design engineers shall coordinate with the required city departments to guarantee proper construction and operation.

A. SITE IMPROVEMENTS - STATION COMPOUND AND ACCESS ROAD

Minimum requirements include the following:

1. Compound fencing including 6-foot high chain link fence with 3-strand barbwire top and a 16-foot wide vehicle gate (2 - 8 ft panels). Vehicle gate shall be located at the access road entrance to the compound providing access to station wet well and dry well. Provide a 3-foot wide man gate next to the vehicle gate.
2. A 12-foot wide (minimum) service road with 6 inches of 0 to 6-inch crushed limestone material for road base and 3 inches of 1-inch limestone base material for road surface. (3-inch thick asphaltic concrete pavement is required on roads having a grade greater exceeding 7 percent.) Roadbeds are to be crowned with necessary ditch lines sloping to storm water crossings for proper storm water drainage.
3. Culverts of appropriate size and length at large water crossings and/or low water concrete crossings at smaller water crossings.
4. Turn around area at front of lift station large enough to turn pump trucks around. Surfacing shall be the same as for the service road.
5. The ground shall slope away from the wet and dry wells at a slope of 3% in all directions, toward the boundaries of the lift station compound. Interceptor ditches shall be installed, as required, to convey surface drainage away from the lift station compound.

6. Ground cover consisting of 3 inches of 1-inch clean gravel for inside lift station compound.
7. Dusk to dawn area lighting to illuminate entire compound (to be operated and maintained by City of Branson). Lighting to be shielded to minimize light spill onto adjacent properties.
8. Potable water to frost-free hydrant within lift station compound (if water is accessible within immediate vicinity).

B. MECHANICAL - PUMPS AND RELATED EQUIPMENT

Minimum requirements include the following:

1. Submersible duplex pumping system manufactured by Flygt, or approved equal. Pumps shall be non-clog type impeller capable of passing 3-inch solids. Mounting and installation shall be per manufacturer's specifications. Any variance to this pump specification must be approved by city staff. Grinder pumps will not be acceptable.
2. Dual rail stainless steel pump slide rail system.
3. Aluminum hatch covers and necessary handrails. Covers to be rated for 300 pounds per square foot live load. Spring cylinders to be provided to prevent accidental hatch cover closing.
4. Stainless steel pump lifting chains.
5. Swing arm jib crane and hoist at stations where access is not possible with existing city-owned truck mounted hoist equipment.
6. Concrete wet well with capacity for 2-hour storage during peak flow. (Stations without standby generator)
7. A 4-inch diameter emergency suction pipe (PVC) to extend from 16 inches above top of wet well to within 24 inches of bottom of wet well with male quick coupler (mounted in a horizontal position with cap) at top to match existing City pump truck hoses.
8. 6 inch diameter coupling, pipe and gate valve to be installed downstream of all forcemain valves for connection of discharge end of portable emergency bypass pump.
9. Separate concrete dry well valve vault for necessary check and isolation valves. Drywell structure to be an 8-foot minimum diameter, round reinforced concrete structure. Minimum height of structure shall be 60 inches. Actual diameter and height may be greater to accommodate minimum clearances from piping. (No confined space applications.)
10. Sump pump installed in 24” x 24” x 6” sump in valve vault floor with float control and alarm circuit signal back to control panel. Discharge line to wet well to be equipped with check valve and isolation gate valve located inside valve vault. (No gravity drains between lift station dry well and wet well allowed.)
11. All valve vaults to be equipped with an electrically powered exhaust fan.
12. Standard swing check valve with spring control exterior lever on each wet well pump discharge line with a gate type valve upstream and downstream of each check valve. Check valve to operate with spring controlled exterior levers. Where the

pump station design includes a flow control valve, the check valve shall be installed downstream of the flow control valve.

13. Force main isolation valve to be located at point just before force main exits valve vault.
14. Emergency portable pump force main connection located in force main between force main isolation valve and the point where pump discharge lines combine to the force main. Connection to consist of isolation gate valve connected to tee in force main, horizontal mounted swing check valve with spring control exterior lever, and 6 inch male quick coupler mounted in vertical position with access from hatch in top of valve vault.
15. All discharge piping, valves, and fittings in valve vault to have minimum 24 inch clearance from walls and 12 inches from floor for removal and maintenance.
16. Wet well and dry well to be equipped with hot dipped galvanized vent pipe, with exterior end screened, located as not to cause trip hazards. Vents shall be installed horizontally through the wall as high in the well as possible. Location of these pipes shall be coordinated with the city. Vent discharge to be directed away from all electrical and mechanical equipment.
17. All pump discharge piping in dry well and wet well to be class 53 ductile iron pipe and fittings with stainless steel bolts.

C. ELECTRICAL CONTROLS AND RELATED EQUIPMENT

Minimum requirements include the following:

1. Variable frequency drives are required for pumps in excess of 1,000 gpm. (if applicable under hydraulic design conditions).
2. Cost comparisons of VFD and soft start equipment should be performed on smaller stations to determine the best options. If VFD is not applicable, soft start or reduced voltage starters may be required depending on horsepower and head conditions. (Coordination with city electrical department is required.)
3. Individual conduit shall be provided for each of the following: submersible motor lead power/control cable, level transducer cable, and backup float switch cables, with entrance into wet well that provides accessibility without wet well entry for cable removal.
4. Power/control cable hangers and strain relief cable grips shall be stainless steel.
5. No splices or plug connections in motor lead power/control cables, level transducer cable, or backup float switch cables, between internal unit connections and control panel. In locations where the wetwell is unusually deep or distant from the control panel, a junction box may be required within the conduit run. This junction box shall be stainless steel, located just outside of the wet well and installed with proper conduit seals as described in the NEC for hazardous locations. Wire connections shall be made on terminal block style connectors with a corrosion-retarding compound applied.
6. A lift station exterior control panel shall be provided consisting of a NEMA 4X stainless steel enclosure with gasketed hinged outer door having a single handle operator and a door within door configuration for the mounting of all controls.

7. Control panel shall have interior steel mounting panel.
8. Items to be mounted on interior control panel door to prevent weather damage include the following: hand-off-auto switches for operation and control of each pump, pump alternator selector switch labeled Pump 1 – Alternate – Pump 2, hour meters, reset buttons, indication lamps, digital display of wet well level, etc.
9. The control panel interior must be sized to house individual pump disconnect switches, motor starters, relays, pump alternator, DC power supply, PLC, level sensor equipment, UPS, radio transmitter, and all other necessary control equipment.
10. The control panel must be mounted on a heavy-duty rigid mounting rack in a manner not to allow movement in any direction. The rigid mounting rack must be sized to adequately hold the control panel, main disconnect switches and any additional electrical equipment required for a complete control system.
11. All connections to the control panel must have watertight fittings entering the enclosure.
12. The control panel shall be furnished with a Chromalox 150 watt type S strip heater and a Chromalox WR-90 thermostat wired to a power supply terminal block through a 5A-cartridge fuse.
13. The control panel shall be provided with 120-volt single-phase service receptacle minimum 20-amp capacity mounted on exterior with weatherproof box cover. (GFI not required.)
14. The control panel shall be equipped with a UPS system of sufficient size and capacity to operate the PLC, radio transmitter, level sensor, and local alarm strobe and buzzer for a minimum of 2 hours in the event of a power outage. (10 min UPS required for stations with standby generator.)
15. Valve vault to be equipped with exhaust fan where applicable, incandescent light (on separate switches) and weatherproof ground fault protected outlet for sump pump.
16. Valve vault to be equipped with float to indicate to local and radio alarm of high water level should sump pump fail.
17. Wet well pump control shall be accomplished through the use of an Allen Bradley Micro 1100 processor, or approved equal that is compatible with software currently used by the City of Branson (RS LINX & RS LOGICS), both of which are Rockwell software.
18. Electrical contractor shall provide no less than 2 hard copies including labels and descriptions in loose-leaf binder and 2 electronic copies including labels and descriptions of the lift station PLC programming.
19. The PLC shall control pump operations and alarm functions by receiving a signal supplied from a level sensor installed in the station's wet well.
20. The wet well level sensor shall be a submerged pressure transducer (KPSI Transducer series 750 with digital display model 3019 or approved equal) suitable for the environment that it is located in and shall deliver an analog type signal to the PLC. (Installation to be in standpipe per manufacturer's specifications)
21. Pumps shall normally operate in lead/lag configuration.

22. Minimum pump controls of the PLC shall include the following: lead pump on, lag pump on, high wet well alarm, pump off, and analog speed signal with level set points (stations with VFD controls).
23. The PLC shall at a minimum monitor and indicate to the computer radio monitoring system and control panel: pump off, pump run, utility power, run on battery, generator run, force main pressure normal, force main pressure low, pump run hours (indicate and store), wet well level, pump seal failure (when pumps are so equipped).
24. The PLC shall at a minimum indicate alarms for these conditions: low wet well level, high wet well level, wet well level clear, pump fail to run, force main low pressure, power out, power restored, generator fail to start (stations with standby generator only), low battery level, transducer fail.
25. 2 float switches, independent of the pressure transducer, shall be installed in the stations wet well as backup to the pressure transducer. One at low level set 1 foot below normal pump shut off elevation by pressure transducer, to shut off pumps and indicate computer and local alarm should pressure transducer fail to function. One set at high level 1 foot above normal high level elevation of pressure transducer, to indicate computer and local alarms if transducer fails to function.
26. All operator interfaces shall be processed through the PLC with exception of the redundant high wet well float switch and low wet well level cutout float switch.
27. All operator annunciations shall be processed through the PLC except the redundant high wet well level float switch and the low wet well level cutout float switch.
28. Redundant float switches shall deliver alarms both locally and to the PLC. The low level redundant float switch shall be wired into the control and alarm circuit as required so that the pumps will shut down regardless of the status of the PLC during a wetwell low level situation. The High-level redundant float will deliver a signal to PLC and also deliver a signal directly to the local alarm and activate the local alarm regardless of PLC output.
29. High wet well alarm indication from the level transducer shall be annunciated by means of a PLC output and the use of a local flashing strobe (red in color) and a horn or buzzer that delivers a minimum of 90 db at a radius of 15 feet from the control panel. Computer alarm status and station monitoring shall be transmitted via wireless radios as specified in City of Branson Radio Path Study by Micro-Comm (project # 04-159, November 2005). The system shall include the following components: Line of sight remote radio, one radio relay, if necessary, to accomplish communication with existing City radio system, battery backup, up to two directional antennas as necessary, antenna support masts as necessary, antenna coax cable and antenna lightning arrestors.
30. 95% data reliability of radio communications is required. Line of sight radios are preferred however UHF radios may be allowed at the discretion of the City if line of sight communications cannot be obtained.
31. The contractor shall obtain site identification from the City of Branson for programming of radio communications. The radio system shall be programmed and placed into service by the contractor at a mutually agreed upon time with the Branson Public Works Department.

32. Force main pressure sensing shall be incorporated on the force main down line of the pump discharge isolation valves and prior to the force main isolation valve to monitor line pressure. The switch shall be non-intrusive pressure type with an adjustable pressure point setting. Isolation valves shall be installed to provide the ability to flush, exorcise and check proper operation.
33. Low force main pressure that exists longer than one minute shall cause the PLC to shut down pumps while in automatic mode should a force main break occur. A time delay relay shall be provided to latch all pumps off and require a manual reset in order to restart the pumps. A push button reset shall be installed on the control panel interior door to allow reset of the low-pressure alarm and time delay relay.
34. Hour meters for each pump shall be wired to an output of the PLC in conjunction with the hour counters within the program of the PLC for each respective pump. Hour meters displaying tenths of hours will be sufficient.
35. Incoming electrical power shall be equipped with lightening surge protection device with field replaceable modules, integral disconnect switch, redundant receptacle modules, red and green LED indicator lights for power and protection status, audible alarm with silence switch to indicate when protection has failed and one set of dry contacts rated at 5A, 250VAC, for remote monitoring of protection status. Peak surge current rating shall be 160ka per phase. Surge protection shall be installed immediately after main service disconnect.
36. All electrical equipment to be mounted a minimum 30 inches above finished grade.
37. All lights, switches, buzzers etc. used in the assembly of lift station shall be labeled and identified as to its purpose with minimum ¾ inch lettering.
38. All electrical wiring shall be identified on each end where terminated with suitable identification making each wire unique among all other wires.
39. All electrical equipment used in the construction of lift station shall be properly marked and identified with equipment name, voltage applied and current or fuse size for that piece of equipment and/or circuit number where applicable. Lettering shall be 2 inches, of reflective material and visible on outside of panel.
40. Standby generator with automatic transfer switch is required at higher flow stations (to be determined by city staff) and stations which receive flow from another lift station. Generator to be sized to start and run all lift station pumps and equipment at a maximum starting current for each pump no higher than 350% of nameplate for a duration of no more than 2 seconds. Generator to be equipped with manual gages displaying oil pressure, volts, amps, temperature, and run hours.
41. Stations without standby generation will be equipped with manual double throw transfer switch and quick coupler connections for portable generator operation.
42. The quick coupler connection equipment shall be Meltric Corp brand type DS2/ metal Cat #37-28043 with additional boot cover to match existing city equipment.
43. Indication lamps shall be mounted in exterior of transfer switch to indicate utility power is available to each incoming phase.

D. ADDITIONAL ELECTRICAL REQUIREMENTS

Minimum requirements include the following:

1. All electrical work shall comply with the 2002 N.E.C.
2. All wiring shall be in conduit. Exterior conduit shall be (IMC) Intermediate Metallic Conduit or (RGS) Rigid Metallic Conduit. Size all conduits per N.E.C.
3. Contractor shall arrange for all permits required. Contractor is responsible for coordination with electric supplier for proper installation of meter loop, buried service conduits, and service connections. Coordinate the exact requirements with the control provider. Verify location of all existing utilities prior to excavation. Contractor shall field determine exact routing of conduit etc.
4. The grounding electrode conductor shall be continuous with connections and/or splices being made at equipment ground bar or with irreversible splices or exothermic welds acceptable by N.E.C. Buried metallic force mains shall be bonded to the station grounding system per NEC requirements.
5. All conductors shall be copper. Branch circuit wiring shall be minimum #12 stranded copper, 600V THHN/THWN insulation. Feeder conductors shall be copper, stranded, 600V THHN/THWN insulation.
6. When contractor chooses to pull more than three current-carrying conductors in a single raceway, the conductor allowable amp capacities shall be reduced, in accordance with N.E.C.
7. Contractor shall increase the size of the branch circuit conductors for loads that are greater than 75 feet from the panel at least one size and shall increase the grounding conductor size proportionally.
8. Contractor shall provide typed circuit directory for all panels.
9. All devices shall be equal to the following:

Duplex Receptacle	'Hubble' CR5362 Series or approved equal
GFCI Duplex Receptacle	'Hubble' GF5352 Series or approved equal

10. An equipment-grounding conductor shall be installed in the same conduit as all circuit conductors. The equipment-grounding conductor shall have green insulation and be sized per N.E.C. Table 250.66.
11. Product Manufacturers

Panelboards, Transfer Switches, and Disconnects:

Square D, Seimens, Cutler Hammer, or approved equal

Devices:

Hubble, Leviton, Pass & Seymour, or approved equal

Soft Starter:

Square D, Cutler Hammer, Allen Bradley, or approved equal

Variable Frequency Drives:

Yaskawa, or approved equal

12. Electrical contractor shall provide a minimum of three as-built drawings and documents listing all parts, specs and electrical schematics in the construction of the lift station to be presented to the city in the form of a loose-leaf binder.
13. The wet well shall be treated as Hazardous Class 1, Division 2. Devices mounted inside the wet well shall be explosion proof. Conduits containing power or control wiring that are routed between the wet well and the control power panel shall be RMC. All entries into wet well or into valve vault by conduits and/or cables shall comply with N.E.C. 501.5 and be sealed by means of a sealing fitting located near the control panel or as noted earlier with junction box by wet well in order to prevent the migration of sewer gases beyond the boundaries of the wet well or valve vault. An approved duct sealant shall be used and installed firmly in seal fitting to provide a gas tight seal.
14. Electrical service transformer shall be located outside of the lift station compound per electrical company requirements.

E. WARRANTY

The General Contractor shall provide a two (2) year warranty on all parts and labor.

SECTION IX. DESIGN CRITERIA FOR EROSION AND SEDIMENT CONTROL MEASURES

A. DEFINITION OF TERMS.

Aggregate: Sand, gravel, crushed stone, or slag usually having a known range of particle sizes. Used with a cementing medium to form concrete or alone as in a roadway bed or railroad ballast.

Berm:

1. A ridge of earth constructed to direct the flow of surface water.
2. A shelf that breaks the continuity of a slope.
3. The embankment of a pit or pond which may be wide and solid enough for vehicular traffic.

Binder: (Emulsion, Tackifier) Natural or synthetic additive that causes an otherwise noncohesive material to become bound into a cohesive matrix.

Blanket: Rolled erosion control materials consisting of coir, jute, straw, wood fiber, or various synthetic materials used to prevent erosion, trap sediment, protect seed, and promote the growth of vegetation. They can be either degradable or permanent.

BMP: Best Management Practice. Structural or nonstructural practices, procedures, or activities which minimize and control the movement of sediment and other pollutants from disturbed areas to protect the quality of surface and ground water from the potential adverse effects of land disturbing.

Catch Basin: A receptacle for diverting surface water to a sewer or subdrain, and having at its base a sediment bowl to prevent the admission of coarse material into a sewer or stream.

Channel: A natural stream or excavated ditch that conveys water.

Channel Stabilization: Protection of the sides and bed of a channel from erosion by controlling flow velocities and directions or by lining the channel with vegetation, rip-rap, concrete, or other material.

Check Dam: Small dam constructed in a gully or other small channel to decrease the flow velocity, minimize channel scour, and promote deposition of sediment.

Coir: Organic fiber from the outer shell of the coconut used as mulch and in the manufacture of erosion control blankets, geotextiles, and tubes.

Compost: Organic residue or a mixture of organic residues and soil that has undergone biological decomposition until it has become relatively stable humus.

Concentrated Flow Path: Depressed areas where overland stormwater flows toward and concentrates thereby increasing volume and velocity as it moves down slope.

Detention: Managing stormwater runoff or sewer flows through temporary holding and controlled release.

Dike: A structure designed either to reduce the water velocity as stream flow passes through so that sediment deposition occurs instead of erosion, or to deflect erosive currents away from the stream bank.

Diversion: A channel and adjacent ridge of earth constructed to redirect surface runoff water from one area to another for disposal at a non-erosive velocity.

Erosion: The process by which soil particles are detached, transported, and deposited by wind, water, ice, or gravity. The following terms are used to describe different types of erosion:

1. Accelerated Erosion: Erosion much more rapid than natural or geologic erosion, primarily as a result of human activities.
2. Channel Erosion: The erosion process whereby a concentrated flow wears away the bed and banks of a well-defined channel.
3. Geological Erosion: The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of floodplains, coastal plans, etc.
4. Gully Erosion: The process whereby runoff water accumulates in narrow channels and over relatively short time periods removes the soil to considerable depths.
5. Natural Erosion: Wearing away of the earth's surface by water, ice, or other natural agents under natural environmental conditions of climate and vegetation. Erosion not caused by human activity.
6. Rill Erosion: The process whereby numerous small channels only several inches deep are formed. Commonly occurs on recently disturbed and exposed soils.

Erosion Control: The prevention or minimization of soil particle movement. Erosion control reduces soil detachment, transport, and deposition.

Filter: Layer of fabric, sand, gravel, straw, or graded rock placed between the bank revetment or channel lining and soil for one or more of three purposes:

1. To prevent the soil from moving through the revetment.
2. To prevent the revetment from sinking into the soil.
3. To permit natural seepage from the stream bank preventing buildup of excessive ground water pressure.

Filter Strip: A long, narrow vegetative planting used to retard or collect sediment for the protection of watercourses, diversions, drainage basins, or adjacent properties.

Geotextile: A woven or non-woven water permeable material either natural or synthetic used to filter liquids, prevent the movement of sediment, and separate reinforce, or strengthen different materials.

Gravel: Rock particles ranging from 1/5 inch to 3 inches in diameter.

Infiltration: The portion of rainfall or surface runoff that moves downward into the subsurface rock and soil.

Land-Disturbing Activities: Activities that destroy or remove the vegetation that covers the soil at a construction site. These activities include clearing, grubbing, and grading.

Landscaping: The placement of sod, seed, trees, and other vegetation after final grading is complete.

Moisture Content: The percentage by weight of water contained in the pore space of a solid material with respect to the total weight of the material.

Mulch: A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, reduces erosion, and aids in the establishment of plant cover.

Open Channel: A drainage course which has no restrictive top; it is open to the atmosphere and may or may not permit surface flow to pass over its edge and into another channel in an unrestricted manner.

Outlet: The point of water disposal from a stream, river, lake, or artificial drain.

Permanent Seeding: The establishment of perennial vegetation on disturbed areas for periods longer than 12 months.

Riprap: A layer, facing, or protective mound of stones strategically placed in erosion prone areas to minimize the displacement of loose sediment and other pollutants.

Runoff: That portion of precipitation that is not lost to infiltration or evapotranspiration and flows on the land surface, in open channels, or in stormwater conveyance systems. Runoff is greatly increased with the addition of impervious surfaces.

Sand: Soil particles ranging from 0.05 to 2.0 mm in diameter; individual particles are visible to the unaided human eye.

Scour: The clearing and digging action of flowing air or water; especially the downward erosion caused by water in sweeping away mud and silt from the outside bank of a curved channel or during a flood.

Sediment: Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity or ice and has come to rest on the earth's surface either above or below sea level.

Sediment Basin: Depressions, formed from the construction of a barrier or dam, created to retain runoff long enough to allow excess sediment to settle out.

Sediment Fence: Temporary sediment barrier consisting of filter fabric, sometimes backed with wire mesh, attached to supporting posts and partially buried.

Silt: Soil particles ranging from 0.05 and 0.002 mm in equivalent diameter.

Straw Bales: Temporary barriers made of straw bales sometimes installed across a slope or around the perimeter of a construction site to intercept, detain, and filter sediment transported by runoff.

Subsurface Drain: Underdrain; a perforated pipe used for subsurface drainage, usually surrounded by aggregate or wrapped in a geotextile filter fabric to prevent the migration of soil particles.

Swale: An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water.

Tackifiers: Material sprayed onto a soil surface to bind soil particles and prevent erosion.

Terrace: An embankment or combination of embankments and channels across a slope to control erosion by diverting, slowing, or storing surface runoff instead of permitting it to flow uninterrupted down the slope.

Topsoil: Surface soil usually containing organic matter; the soil most capable of growing vegetation and crops.

Turf Reinforcement Mat (TRM): Permanent synthetic erosion control blanket that resists erosion and reinforces the root zone of vegetation. TRM's increase the ability of vegetation to resist the erosive force of flowing water.

B. DESIGN GUIDANCE. Design guidance aids the designer with choosing the best management practices to use for erosion and sediment control. A series of questions lead the designer to specific erosion and sediment control practices.

1. ***General Criteria 1.*** Diversion of Upland Water: Is there any upland area? If yes, use diversions as much as practicable to divert stormwater runoff from above the construction site around the disturbed area to decrease volume of runoff treated.

2. ***General Criteria 2.*** Concentrated Flow Paths: Are dikes, swales and diversions planned for the site? If yes, those areas must be seeded and mulched or sodded within 24 hours of construction.

3. ***General Criteria 3***. Minimization of Area and Time of Exposure via Phasing: If utility construction or the grading operation can be phased, the plan should indicate the

anticipated schedule. When natural vegetation is removed and soil disturbances occur, the extent and duration of exposure should be minimized. Plan the phases or stages of development so that only the areas that are actively being developed are exposed. All other areas should have a good cover of temporary or permanent vegetation or mulch. Grading should be completed as soon as possible after it is initiated. As slopes are cut and as fill slopes are brought to grade, the areas should be revegetated as the work progresses.

4. ***General Criteria 4***. Surface Stabilization for Slopes: Are there slopes of 0-6% that are longer than 200 feet? Are there slopes 6-12% and longer than 100 feet? Are there slopes >12% and longer than 50 feet? If yes, use surface stabilization best management practices such as mulch with tackifier, rolled erosion control products, and sodding along with measures to reduce slope length to reduce the potential for surface runoff that produces rills and gullies.
   *Note: all slopes that are 3H:1V or steeper must be fully and permanently stabilized within 2 weeks of final grading.

   Are concentrated stormwater flows expected over cut and fill slopes? If yes, divert stormwater around cut and fill slopes as much as practicable until the slopes are fully stabilized with vegetation.

5. ***General Criteria 5***. Perimeter Control: Is the drainage area less than 2 acres, sheet flow anticipated, or the slope length less than 150 feet? If yes, use perimeter controls such as sediment fence and triangular silt dike, along those perimeter areas where surface runoff leaves the site.

   Is the drainage area less than 5 acres? If yes, use a temporary sediment trap or similar sediment control.
   *Note: if the drainage area is greater than 10 acres, use a temporary sediment basin. Construction sites draining between 5 & 10 acres must have a temporary storm detention structure designed for the appropriate runoff from the site.

6. ***General Criteria 6***. Runoff Control and Conveyance: Does runoff concentrate in a swale or channel? If yes, the channel must be fully stabilized with sod or seed and erosion control blankets within 48 hours after channel is constructed.

   Does the channel velocity range from 10-20 feet per second or the shear stress range from 6-10 pounds per square foot? If yes, use Turf Reinforcement Mats (TRMs).

   Is the channel velocity more than 20 feet per second or the shear stress greater than 10 pounds per square foot? If yes, use riprap, bioengineering or concrete.
   *Note: to reduce velocity in channel and provide sediment control, install check dams.

7. ***General Criteria 7***. Sediment Controls: Does the design include concentrated stormwater flow through pipes? If yes, use inlet and outlet protection for the pipes.

8. ***General Criteria 8***. Other Related Practices. Whenever a construction entrance intersects a paved public road, provisions must be made to minimize the transport of sediment by runoff or vehicle tracking onto the paved surface. Where sediment is transported onto a public road surface, the road should be cleaned thoroughly at the end of each day. Sediment should be removed from roads by shoveling or sweeping and be transported to a controlled sediment disposal area. Street washing should be allowed only after sediment is removed in this manner. The plan must show on a detailed drawing where the construction entrance(s) will be located. Any stormwater inlet receiving polluted flow a construction entrance should have inlet protection.

C. DESIGN PRINCIPLES AND PRACTICES

1. Planning. . To be successful, the construction plan must include a detailed plan for the scheduling, design, installation, and maintenance of erosion and sediment control practices. Stormwater management facilities should be utilized to reduce the impact of stormwater runoff, both during and after construction. Land disturbing activities normally will result in an increase in runoff from the site. Stormwater management structures will reduce the impact of increased runoff on downstream facilities. Permanent stormwater management controls are found in the Design Criteria manual.

2. Suitability of Development to Existing Site Conditions. Review and evaluate all existing conditions in the initial site selection for the project. Choose a site that is suitable rather than force the terrain to conform to development's needs. Ensure that the development's features follow natural contours. Steep slopes, areas subject to flooding, and highly erodible soils severely limit a site's use, while level, well-drained areas offer few restrictions. Any modification of a site's drainage features or topography requires protection from erosion and sedimentation.

3. Final Design. Final designs should be based on detailed engineering surveys, field investigations, sound conservation, professional erosion and sediment control assessment, and engineering principles. Any stormwater runoff generated by the development must be controlled or treated.

4. Diversion of Clean Water. Runoff from the area upland of the development should be diverted around the construction site. This can be accomplished by using perimeter controls or diversions. This will limit the quantity of stormwater to be controlled and treated on the disturbed construction site.

5. Stabilization of Concentrated Flows Before Disturbance Occurs. Runoff from the development should be safely conveyed to a stable outlet using storm drains, diversions, stable waterways, or similar sediment control measures. Temporary facilities for conveyance of stormwater should be designed to withstand the velocities of projected peak discharges. These facilities should be operational as soon as possible

after the start of construction and, if possible, before the disturbance of the surrounding areas.

6. Application of Erosion Control as a First Line of Defense Against On-Site Damage. Implementing practices that prevent or minimize erosion on a construction site is called erosion control. Erosion control strategies attempt to prevent or minimize the problem of erosion on development sites.

   The following guidelines apply to erosion control strategies:

   a. Clear only what is required for construction. Where possible, large projects should be cleared and graded as construction progresses, and mass clearing and grading should be avoided.

   b. Reestablish with vegetation within seven days after construction is completed. Certain sections of large construction projects may be completed before others and be ready for stabilization before the total project is completed. Waiting until the end of the project to commence all site stabilization may leave areas exposed for an unnecessarily long duration.

   c. For areas where soil disturbing activities have ceased and are no planned to resume for more than 14 days, interim stabilization must be initiated within 7 calendar days upon knowing of the 14-day cessation and must be completed with 14 days of ceased operation. Areas having slopes greater than 3:1 (1V:3H), or greater than 3% and longer than 150 ft. must be stabilized within 7 days of ceased operations. The preferred method of stabilization is seed and mulch, but can include other BMP options as well.

   d. Extraneous runoff should be diverted from critical areas, such as highly erodible soils and steep slopes, and conveyed to stable areas.

   e. The formation of a large drainage area and the concentrating of surface runoff flow patterns should be avoided where possible.

7. Sediment Retention on Construction Sites. Even with careful planning, some erosion is unavoidable. Minimize the amount of sediment leaving the site by using proper Best Management Practices (BMPs). Plan the location where sediment deposition will occur, and maintain access for clean out. Protect low points below disturbed areas by building barriers to reduce sediment loss. Whenever possible, plan and construct sediment traps and basins before other land-disturbing activities.

8. Encroachment on Watercourses. Permanent buildings should not be subjected to flooding, sediment damages, or erosion hazards. Earth fills that adversely obstruct water flows or increase downstream velocity of water flows should not be constructed in flood-prone areas. When necessary to span a flood-prone area or watercourse, bridge

and culvert openings should be sized to permit passage of peak discharges without causing undue restrictions in water flows and without creating excessive damages from flooding, scour, and sediment. Temporary bridges or culverts should be employed when it is necessary for construction equipment to cross natural or constructed channels.

9. Inspection and Maintenance of Control Measures. Inspection and maintenance is vital to the performance of erosion and sediment control measures. If not properly maintained, some practices may cause more damage than they prevent. Always evaluate the consequences of a control measure failing when considering which control measure to use since failure of a practice may be hazardous to both people and property. For example, a large sediment basin failure can have disastrous results, and low points in dikes can cause major gullies to form on a fill slope. It is essential to inspect all practices to determine that they are working properly and to ensure that problems are corrected as soon as they develop.

10. Installation of Construction Entrances. Before construction begins on a project, a construction entrance must be built for equipment and materials to enter and exit the site from a public road. A temporary entrance will help reduce the sediment that could potentially leave the site.

D. SITE PREPARATION

1. Temporary Construction Entrance. A temporary construction entrance is a stabilized layer of large aggregate that is located at any point where traffic leaves a construction site and move directly onto a public road or other paved area.

   a. Application. A temporary construction entrance is a stone base pad designed to provide a buffer area where construction vehicles can drop their mud to avoid transporting it onto public roads.

   b. Planning Considerations. Areas that are graded for construction vehicle transport and parking purposes are especially susceptible to erosion. The exposed soil surface is continually disturbed, leaving no opportunity for vegetative stabilization. During wet weather, they often become muddy quagmires that generate significant quantities of sediment which may pollute nearby streams or be transported off site on the wheels of construction vehicles. Dirt on roads can become so unstable during wet weather that they are virtually unusable and unsafe.

   c. Design Criteria.

      Stone: 3 to 6 inch crushed aggregate or recycled concrete equivalent shall be placed at least 6 inches deep on top of geotextile material for the entire length of the entrance (50 ft. min.). Rock should be added or occasionally fluffed to ensure a 6-inch depth and overall effectiveness in sediment

removal. A section of corrugated steel panel has been used to increase the removal of mud, rock, and debris from vehicles, but is not required.

Location: A stabilized construction entrance shall be located at every point where construction traffic enters or leaves a construction site. Vehicles leaving the site must travel over the entire length of the stabilized construction entrance.

2. Slope Breaks. Slope breaks consist of reshaping the ground surface to provide suitable topography for buildings, facilities, and other land uses. Measures such as slope breaks can be installed during land grading to control surface runoff and to minimize soil erosion and sedimentation both during and after construction.

   a. Application. Slope break can be applied to sites where the existing topography must be modified to prepare for another land use or where adapting proposed development to the existing landscape can reduce the erosion potential of the site and the cost of installing erosion and sediment control measures.

   b. Planning Considerations. Prior to start of construction, the site grading plan should be designed by a qualified design professional. The grading plan should show disturbed areas, cuts, fills and finished elevations for graded areas. Plans and specifications should be referred to by field personnel throughout the construction process.

   c. Design Criteria.

      1) Scheduling Construction Activities. Schedule construction activities in such a way that the least area is disturbed at one time.

      2) Slope Breaks. Use slope breaks, such as diversions, sediment fence, compost berms, or other devices as appropriate to reduce the length of cut and fill slope to limit sheet and rill erosion and prevent gullying.

      3) Surface Runoff. Avoid disturbing natural drainage ways, if possible. At each slope break, intercept runoff and channel to storm drains or stabilized watercourses. If runoff is laden with sediment, protect drain inlets with a filter or divert water to a sediment trap or basin according to the site grading plan.

      4) Erosion Control. Disturbed areas should be stabilized with mulch, vegetation, crushed stone, riprap or other measures, as soon as the project is completed, or if work will be ceased for more than 14 days.

5) Slopes to be Vegetated. Vegetation shall be placed on slopes of 2H:1V or flatter especially where it is to be maintained by tractor or other equipment. Slopes should be roughened during grading operations to retain water, increase infiltration, and promote vegetative growth. Slopes should be protected from surface runoff while vegetation is being established.

6) Borrow and Disposal Areas. Borrow and disposal areas shall be shown on the grading plan and no closer than 50 feet to a stream bank. Sediment control devices must be used on the down slope side of these areas.

7) Outlet. Stable channels and waterways should be provided for runoff from the disturbed area to retain sediment on site.

3. Surface Roughening. This practice provides a rough soil surface with horizontal depressions to aid in the establishment of vegetation, reduce runoff, increase infiltration, reduce erosion and provide for sediment trapping.

a. Application. Surface roughening is appropriate for all slopes but works especially well on slopes steeper than 3H:1V and in areas with highly erodible soil. Stair-step grading, grooving, harrowing or tracking accomplishes this if the slopes are to be stabilized with vegetation. If the slope is designed for a rolled erosion control product, it should be fine graded. Areas with grades of 3H:1V or flatter should have the soil surface lightly roughened and loosened to a depth of 2 to 4 inches prior to seeding. Areas that have been graded and will not be stabilized immediately may be roughened to reduce runoff velocity until seeding takes place. Slopes with a stable rock face do not require roughening or stabilization.

b. Planning Considerations. There are different methods for achieving a roughened soil surface on a slope, and the selection of an appropriate method depends upon the type of slope. Roughening methods include stair-step grading, grooving, and tracking. Factors to be considered in choosing a method are slope steepness, mowing requirements, and whether the slope is formed by cutting or filling. Disturbed area that will not require mowing may be stair-step graded, grooved, or left rough after filling. Stair-step grading is particularly appropriate in soils containing large amounts of soft rock. Each “step” catches material that sloughs from above, and provides a level site where vegetation can become established. Areas flatter than 3H:1V that will be mowed may have small furrows left by discing, harrowing, raking or seed-planting machinery operated on the contour. It is important to avoid excessive compacting of the soil surface when scarifying. Tracking with bulldozer treads is preferable to not roughening at all but is not as effective as other forms of roughening because the soil surface is severely compacted and runoff is increased.

c. Design Criteria. No formal design is required.

4. Topsoiling. This is a method of preserving and using the surface layer of undisturbed soil, often enriched in organic matter, to obtain a more desirable planting and growth medium.

a. Application. Conditions where topsoiling is applicable.

1) Where the preservation or importation of topsoil is determined to be the most effective method of providing a suitable growth medium.

2) Where the subsoil or existing soil presents the following problems:

A) Texture, pH, or nutrient balance of available soil cannot be modified by reasonable means to provide adequate growth medium.
B) The soil is too shallow to provide an adequate root zone and to supply necessary moisture and nutrients for plant growth.
C) The soil contains substances potentially toxic to plant growth.

3) Where high quality turf is desirable to withstand intense use or meet aesthetic requirements.

4) Where ornamental plants will be established.

5) Only on slopes that are 2H:1V or flatter, unless other measures are taken to prevent erosion and sloughing.

b. Planning Considerations. Measure whether an adequate volume of topsoil exists on the site. Topsoil will be spread at a compacted depth of 4 to 6 inches. Locate the topsoil stockpile so that it does not interfere with work on the site and stabilize it. Allow sufficient time in scheduling for topsoil to be spread and bonded prior to seeding, sodding or planting. Care must be taken not to apply topsoil to subsoil if the two have contrasting textures. Clay topsoil over sandy subsoil or vice versa is a particularly poor combination. Water may creep along the junction between the soil layers, causing the topsoil to slough. If topsoil and subsoil are not properly bonded, water will not infiltrate the soil profile evenly and it will be difficult to establish vegetation. Topsoiling of steep slopes should be discouraged unless good bonding of soils can be achieved.

c. Design Criteria. No formal design is required.

5. Vegetative Buffers (Filter Strips). These are wide strips of undisturbed existing vegetation or constructed vegetation areas consisting of grass, woody vegetation, or other erosion resistant plants surrounding the disturbed site. They provide infiltration, intercept sediment and other pollutants, and reduce stormwater flow and velocity. They can also act as a screen for visual pollution and reduce construction noise.

   a. Application. Vegetative Buffers can be used as perimeter control for sites less than 5 acres on ground with slopes less than 15 percent or in conjunction with other sufficient BMPs.

   b. Planning Considerations. Natural wooded strips or grass strips should be fenced off prior to construction. Avoid storing debris from clearing and grubbing and other construction waste material on these strips during construction. Wooded or grass strips should be constructed along the perimeter of a site immediately after the area for the filter strip is graded. This area should be fenced off and remain undisturbed for the entirety of the project. The constructed vegetative buffer should be planted with trees, shrubs or grasses with a more fibrous or seed-forming root system. Avoid using trees or shrubs with top roots or clump forming grasses.

   c. Design Criteria. The minimum length of strip must be at least as long as the contributing runoff area but no less than 50 feet plus 4 feet for each one percent increase in slope.

6. Vegetated Stream Buffers. Buffers bordering streams are critical due to the invaluable protection of streams from sediment. Stream buffers are also useful in cooling rivers and streams and providing food and cover for wildlife.

   a. Application. This practice is intended to protect the banks of a natural stream from damage due to development, lessen the risk of flooding in developed areas, and provide a buffer between the developed area and the stream. A properly maintained stream bank buffer will help maintain channel capacity and stability, reduce sediment load in the channel, and reduce movement of pollutants into the stream.

   b. Planning Considerations. A vegetated stream buffer of 50 feet or greater can protect water from excess sedimentation. The buffer should be increased to 2 feet in width for every one percent slope. Ensure the channel is stable before determining the width of stream bank setback.

   c. Design Criteria. The buffer shall either extend beyond the 100-year built-out floodplain or a minimum of 50 feet from the top of the stream bank. Larger buffers will be needed where channels are downcutting, where hydrology is shifting, and in large drainage areas.

E. SURFACE STABILIZATION (EROSION CONTROLS)

1. Temporary Seeding. Temporary seeding is the establishment of fast-growing annual vegetation to provide economical erosion control for up to 12 months and reduce the amount of sediment moving off the site. Annual plants which sprout rapidly and survive for only one growing season are suitable for establishing temporary vegetative cover.

    a. Application. This practice applies where short-lived vegetation can be established before final grading or in a season not suitable for permanent seeding. It helps prevent costly maintenance operations on other erosion control systems such as sediment basin clean-out. Temporary or permanent seeding is necessary to protect earthen structures as dikes, diversions, and the banks and dams of sediment basins.

    b. Planning Considerations. Prior to the start of construction, plant materials, seeding rates, and times should be specified by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. To ensure emergence, vigorous growth of seedlings, and continued plant growth, prepare seedbed, add lime and fertilizer according to soil tests, mulch all but the most ideal sites and follow seeding dates.

2. Permanent Seeding. Permanent seeding is the establishment of perennial vegetation on disturbed areas for periods longer than 12 months. Permanent vegetation provides economical, long-term erosion control and helps prevent sediment from leaving the site.

    a. Application. This practice is used when vegetation is designed to permanently stabilize the soil. It is necessary to protect earthen structures such as dikes, channels, and embankments. Particular care is required to establish a thick cover of permanent grass.

    b. Planning Considerations. Prior to the start of construction, plant materials, seeding rates, and times should be specified by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. To ensure germination and growth, prepare seedbed, add lime and fertilizer according to soil tests, mulch all but the most ideal sites, and follow seeding dates.

3. Sodding. A mat of vigorous turf, about an inch in thickness and free from disease, insects, and weeds. Sod prevents rain drops from disrupting the soil, slows runoff, and acts as a filter when sediment laden water flows across the sodded area.

a. Application. Sodding is well suited for stabilizing erodible areas such as grass-lined channels, stormwater detention basins, diversions, swales, slopes, and filter strips because it provides an instant vegetative cover with an established root system.

b. Planning Considerations. Prior to installation, plant materials and amendments should be specified by a qualified professional. Plans and specifications should be referred to by field personnel throughout the installation process. Installation of sod must occur immediately after finish grading.

4. Mulching and Hydro Mulch. Mulching and hydro mulch are the application of plant residues such as straw or other suitable materials to the soil surface. Mulch protects the soil surface from the erosive force of raindrop impact and reduces the velocity of overland flow. It helps seedlings germinate and grow by conserving moisture, protecting against temperature extremes, and controlling weeds. Mulch also maintains the infiltration capacity of the soil.

a. Application. Mulch can be applied to seeded areas to help establish plant cover. It can also be used as temporary cover in unseeded areas to protect against erosion over the winter or until final grading and shaping can be accomplished.

b. Planning Considerations. Prior to the construction, mulch requirements should be designed by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process.

5. Tackifiers, Soil Binders, and Bonded Fiber Matrix. Tackifiers, binders and bonded fiber matrix (BFM) can increase the performance of mulch material.

a. Polyacrylamide (PAM). The land application of a product containing anionic polyacrylamide as a temporary soil binding agent to reduce soil erosion.

b. Tackifiers and Binders. Substances used to anchor straw, hay, paper or wood mulch by causing the organic material to bind together.

c. Bonded Fiber Matrix (BFM). A classification of erosion control products that are designed to stay in place on steep slopes. A BFM is a continuous layer of elongated fiber strands held together by a binding agent that is water-resistant. Once dry, the BFM forms a water absorbent protective cover that is porous and breathable and secures soil and seed while enhancing establishment of vegetation.

d. Application. Due to many different types of products available on the market, it is best to consult with the manufacturer for proper application rates and procedures.

e. Planning Considerations. Tackifiers and binders must be applied to organic mulch to reduce the potential of mulch movement by water or wind and increase the performance of the material. Binders and BFM can be directly applied to the bare soil to provide binding of the soil particles and reduce the erosion potential of the bare soil.

6. Rolled Erosion Control Products. Rolled erosion control products (RECP), sometimes referred to as simply Erosion Control Blankets (ECB), are protective blankets of plastic fibers, straw or other plant matter, which are installed on a steep slope, channel or shoreline, to protect soil from overland flow, erosion from precipitation, and retain moisture to facilitate plant growth.

a. Application. Myriad factors, such as soil type, steepness of slope, length of slope, soil conditions, runoff volume and velocities, and time required to establish adequate vegetation influence the choice of rolled product. Some RECPs are temporary and will usually degrade naturally; some RECPs are permanent and remain in place. Follow the manufacturer's recommendations and specifications during the installation process.

b. Planning Considerations. RECPs are used in many applications where a structural lining would previously have been required and care must be taken to choose the blanket or matting which is most appropriate for the specific needs of a project. Generally, RECPs should be installed immediately following the completion of a phase of grading or the installation of vegetation.

7. Turf Reinforcement Mats. Turf Reinforcement Mats (TRMs) are used to raise the maximum permissible velocity and shear stress of turf grass stands areas by enabling the turf to resist the forces of erosion during storm events in channelized areas and critical slopes.

a. Application. TRMs are typically installed permanently on seeded areas, in grass-lined channels with increased runoff velocities, and on steep slopes. The installation of TRMs should follow the recommendations and specifications of the manufacturer.

b. Planning Considerations. Myriad factors, such as soil type, steepness of slope, length of slope, soil conditions, runoff volume and velocities, and time required to establish adequate vegetation influence the choice product. Typically, TRMs should be installed immediately following the completion of a phase of grading or the installation of vegetation.

F. SEDIMENT CONTROL

1. Straw Bale Barrier. A straw bale barrier is a temporary sediment barrier consisting of a row of entrenched and anchored straw bales.

   a. Application.

      1) To intercept and detain small amounts of sediment from disturbed areas of less than one acre in order to prevent sediment from leaving the construction site.

      2) To decrease the velocity of sheet flows.

   b. Planning Considerations. Bales of straw are not generally recommended due to the tedious installation and maintenance requirements and are mostly used in concert with other sediment control methods. Prior to the start of construction, straw bale sediment barriers should be designed by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. The straw bale sediment barriers should be built according to planned grades and dimensions.

   b. Design Criteria. Straw bale barriers shall be used for sheet flow only with less than ¼ acre drainage area per 100 linear feet of barrier. An effort should be made to locate the straw bale barrier as well as other perimeter controls at least 5 to 7 feet from the base of disturbed slopes with grades steeper than 7 percent. This will help prevent the measure from being rendered useless following the initial movement of soil. Straw bale barriers should be installed on the contour to be most effective. Straw bales must be entrenched, staked, and replaced regularly; the typical life span for a straw bale is 3 months.

2. Compost Berm or Tubes. Compost berm and tubes consist of organic mulch or composted material blown in place and used as erosion and sediment control devices.

   a. Application. These berms can be designed as perimeter controls for surface runoff where sheet flow or small concentrated flow is present. The drainage area should not exceed 0.25 acres per 100-foot sock length. They can also be designed as diversions above the disturbed area to bypass stormwater around the site that does not need to be treated with Best Management Practices.

   b. Planning Considerations. Berms should be placed on the contour prior to the start of construction, in intervals along a slope, and for inlet protection.

These berms are very effective if used in combination with vegetation buffers or filter strips.

3. Sediment Fence. Sediment fence is a temporary sediment barrier consisting of synthetic fabric stretched across and attached to supporting posts and entrenched or sliced in place for the purpose of removing suspended particles from the water passing through the fence.

   a. Application.

      1) To intercept and detain small amounts of sediment from disturbed areas of limited extent in order to prevent sediment from leaving the construction site.

      2) To decrease the velocity of sheet flows.

   b. Planning Considerations. Prior to start of construction, sediment fence placement should be designed by a qualified professional. Plans and specifications should be referred to by field personnel throughout the construction process. Fences with wire, sometimes chain-link, backing are especially effective at the bottom of steep slopes.

   c. Design Criteria.

      1) Drainage Area: Limited to ¼ acre per 100 feet of fence. Area may be further restricted by slope steepness.

      2) Location: Fence should be built on a nearly level grade and at least 10 feet from the toe of the slope to provide a broad shallow sediment pool. Install on the contour where fence can intercept runoff as a sheet flow, not in channels, waterways or other concentrated flow paths and not attached to existing trees.

      3) Length: Maximum of 600 feet. Flare ends of fence uphill to temporarily impound water.

      4) Spacing of Support Posts: 10 feet maximum for fence supported by wire; 5 feet maximum for high strength fabric without supportive wire backing.

      5) Trench: Bottom 1 foot of fence must be buried minimum of 6 inches deep or slice into place.

      6) Impounded Water Depth: Not to exceed 1.5 feet at any point along the fence.

7) Support Posts:

4-inch diameter wood or 1.33 lb./linear foot steel, buried or driven to a depth of 24 inches with support wire;
2-inch square wood or 1.0 lb/linear foot steel without support wire.
Steel posts should have projections for fastening fabric.

8) Synthetic Geotextile Fabric: Containing ultraviolet light inhibitors and stabilizers. Minimum design life of 6 months.

4. Log or Wattle Products. Log or wattle products are tubes of open weave containment material filled with straw, rice or wheat straw, excelsior, coir, or compost material. They come in a variety of diameters and lengths and can be used to control sheet or concentrated flows.

a. Application. Logs or wattles can be used as perimeter control for disturbed area and stockpiles, along contours as slope breaks, for inlet protection, and for stream bank protection. With the exception of straw wattles, they can also be used for ditch checks.

b. Planning Considerations. Wattle products should be installed immediately after rough grading and prior to seeding or mulching. They should be installed along the contour of a slope with the ends turned upslope to prevent runoff from flowing around the wattle. For larger areas and/or steeper slopes, several rows of wattles should be added to slow the flow of water and reduce erosion. The vertical spacing should be determined based on the slope gradient and soil type. A good rule of thumb is: 1:1 slopes=10 feet apart, 2:1 slopes=20 feet apart, 3:1 slopes=30 feet apart, 4:1 slopes=40 feet apart. Follow the manufacturers recommendations and specifications when installing wattle prooducts.

5. Check Dams. Check dams are small temporary dams constructed across a swale or drainage ditch. These can be constructed of rock, Triangular Silt Dike™, Geo-Ridge® (In combo with ECB or TRM), sand bags, fiber rolls, compost filter socks, EnviroBerm® Porous Sediment Control System (In combo with ECB or TRM).

a. Application. Check dams reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. They also trap sediment generated from adjacent areas or the ditch itself, mainly by ponding the stormwater runoff.

b. Planning Considerations. Check dams are effective in reducing flow velocity and the potential for channel erosion. It is usually better to establish a protective vegetative lining before flow is confined or to install channel lining in addition to installing check dams. Check dams installed in grass-lined channels may kill the vegetative lining if submergence after

rain is too long or sedimentation is excessive. If check dams are used in grass-lined channels which will be moved, care should be taken to remove all the stone when the dam is removed, including any stone which has washed downstream. A geotextile fabric may be used under the rock for easier removal.

6. Drop or Curb Inlet Protection. Inlet protection consists of a sediment barrier or an excavated impounding area with free-draining material such as gravel around a storm drain drop inlet or curb inlet. Inlet protection controls include but are not limited to the use of sand bags, rock socks, wattles/fiber logs, and various filter devices provided that they are maintenance at least once per week.

   a. Application. Inlet protection prevents sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area.

   b. Planning Considerations. Prior to the start of construction, inlet protection structures should be designed by a qualified design professional. Plans and specifications should be referred to be field personnel throughout the construction process.

      1) Storm sewers which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainage ways. In case of extreme sediment loading, the storm sewer itself may clog and lose its capacity. To avoid these problems it is necessary to prevent sediment from entering the system at the inlets.

      2) There are several types of inlet protection and traps which have different applications depending on site conditions and type of inlet. Other innovative techniques for accomplishing the same purpose are encouraged, but only after specific plans and details are submitted to and approved by the appropriate authority.

      3) Care should be taken when choosing a specific type of inlet protection. Inlet protection which causes excessive ponding in an area of high construction activity may become so inconvenient that it is removed or bypassed, thus transmitting sediment-laden flows unchecked. In such situations, a structure with an adequate overflow mechanism should be utilized.

7. Triangular Silt Dike™. Triangular Silt Dike™ is triangular shaped having a height of at least eight to ten inches. The triangular shaped inner material shall be urethane foam. The outer cover shall be a woven geotextile fabric placed around the inner material and allowed to extend beyond both sides of the triangle by two to three feet.

a. Application. Triangular Silt Dike™ should be used to contain sediment along the contoured terraces, at the perimeter of a site, or as a ditch check to minimize erosion and contain sediment.

b. Planning Considerations. The dike shall be used either as a continuous line barrier just off the toe of slope or right-of-way line to contain sediment or as a ditch check placed perpendicular to the flow of water in a defined drainage ditch to minimize erosion and contain sediment.

8. Grass-Lined Channels with Sod or Seed and TRM. Grass-lined channels are constructed for the purpose of handling concentrated surface runoff in such a way as to prevent damage from erosion and sedimentation.

a. Application. This practice applies to sites where:

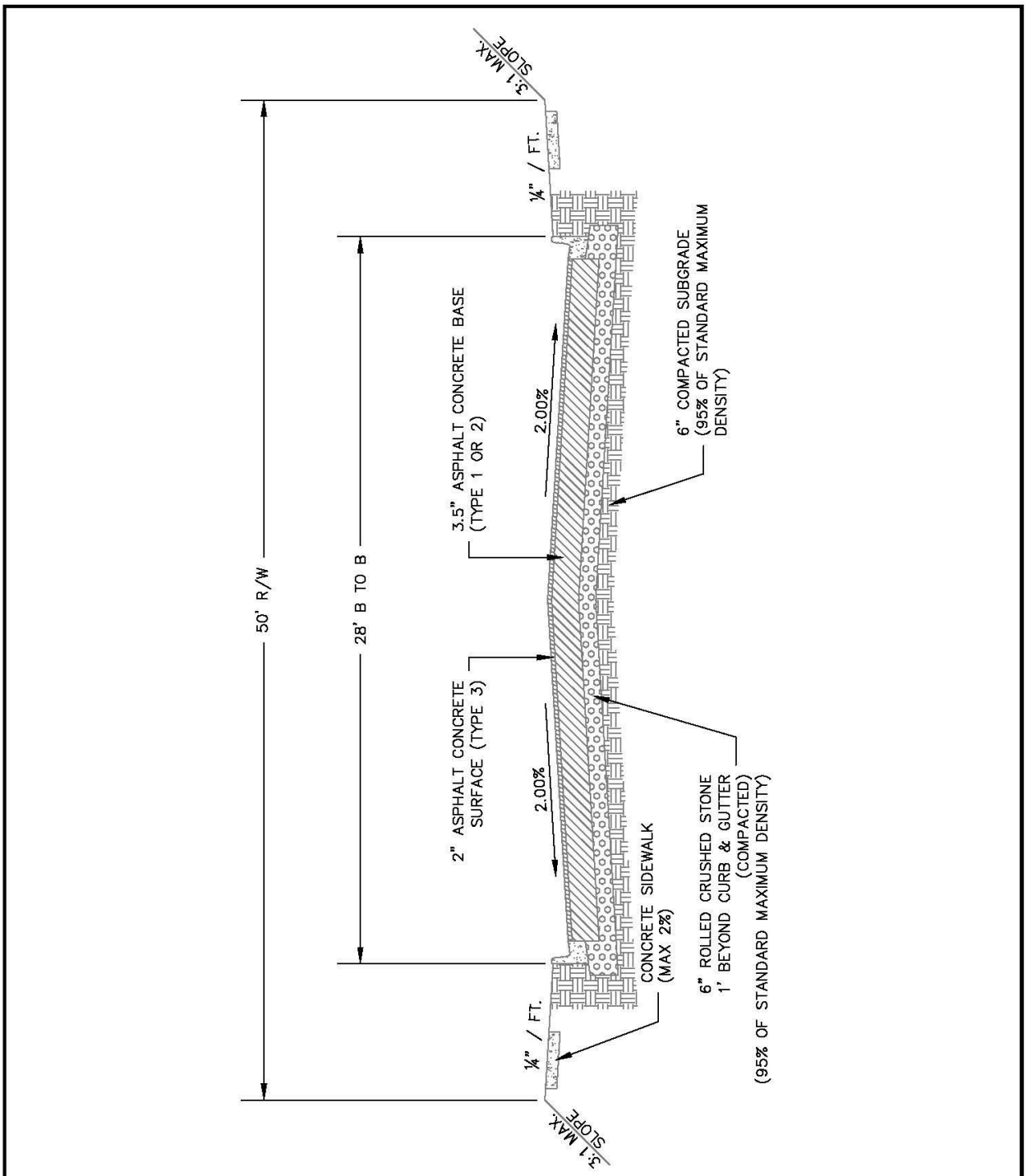
1) Concentrated runoff will cause erosion damage
2) A vegetative lining provides sufficient stability for the channel as designated
3) Channel grades are less than 5 percent
4) Space is available for a relatively large cross section.

Typical uses include roadside ditches, channels at property boundaries, outlets for diversion and other areas requiring stabilization of concentrated flow.

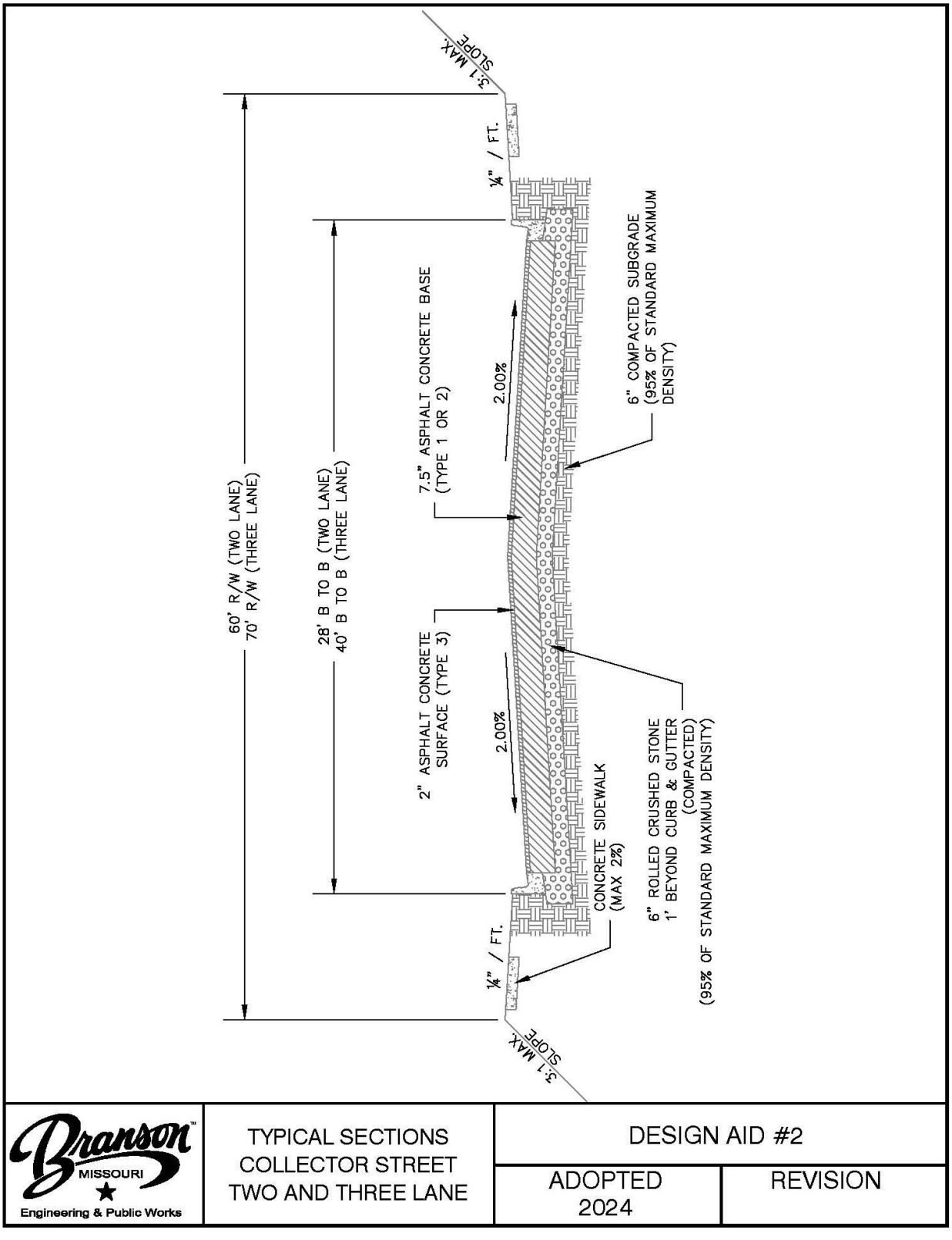
b. Planning Considerations. Prior to the start of construction, grass-lined channels should be designed by a qualified design professional. Plans and specifications should be referred to by field personnel throughout the construction process. The channel should be built according to planned alignment, grade, and cross section. Vegetation in the channels should be established as soon as practicable, this may include regular watering if there has not been sufficient rainfall for root growth.

c. Design Criteria.

1) Cross Section: Trapezoidal or parabolic.
2) Side Slopes: 3H:1V or flatter for trapezoidal channels.
3) Channel Stabilization: Use mulch, erosion control blankets, turf reinforcement mats or other appropriate practices as specified in the design plan.
4) Outlet: Channels should empty into sediment traps, detention or retention basins or stable outlets.
5) Subsurface Drain: Use in areas with seasonally high water tables or seepage problems.



Branson MISSOURI ★ Engineering & Public Works	TYPICAL SECTIONS LOCAL STREET TWO LANE	DESIGN AID #1
		ADOPTED 2024 / REVISION


3:1 MAX. SLOPE
¼" / FT.
6" COMPACTED SUBGRADE
(95% OF STANDARD MAXIMUM
DENSITY)
2.00%
7.5" ASPHALT CONCRETE BASE
(TYPE 1 OR 2)
60' R/W (TWO LANE)
70' R/W (THREE LANE)
28' B TO B (TWO LANE)
40' B TO B (THREE LANE)
2" ASPHALT CONCRETE
SURFACE (TYPE 3)
2.00%
CONCRETE SIDEWALK
(MAX 2%)
6" ROLLED CRUSHED STONE
1' BEYOND CURB & GUTTER
(COMPACTED)
(95% OF STANDARD MAXIMUM DENSITY)
¼" / FT.
3:1 MAX. SLOPE
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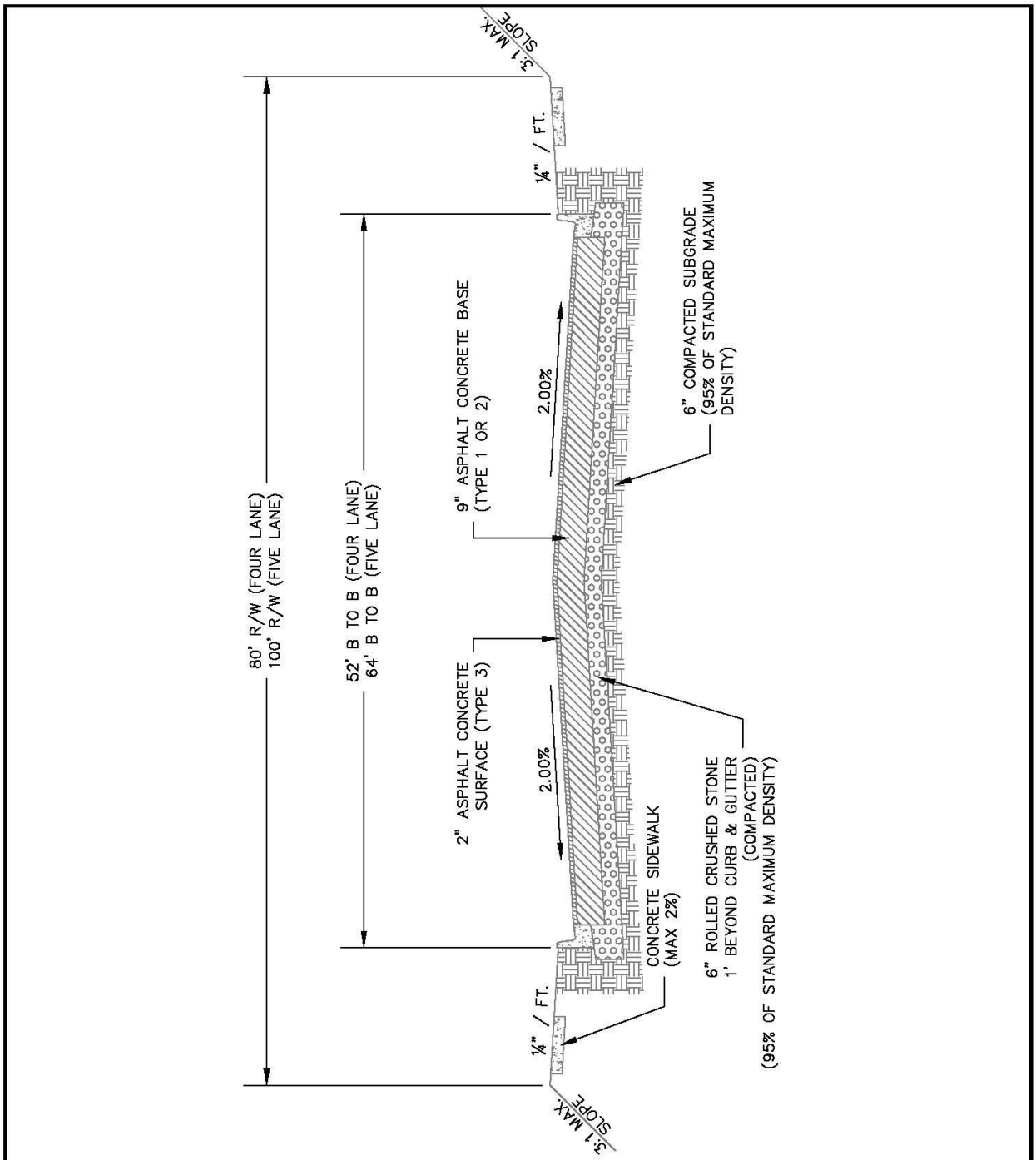
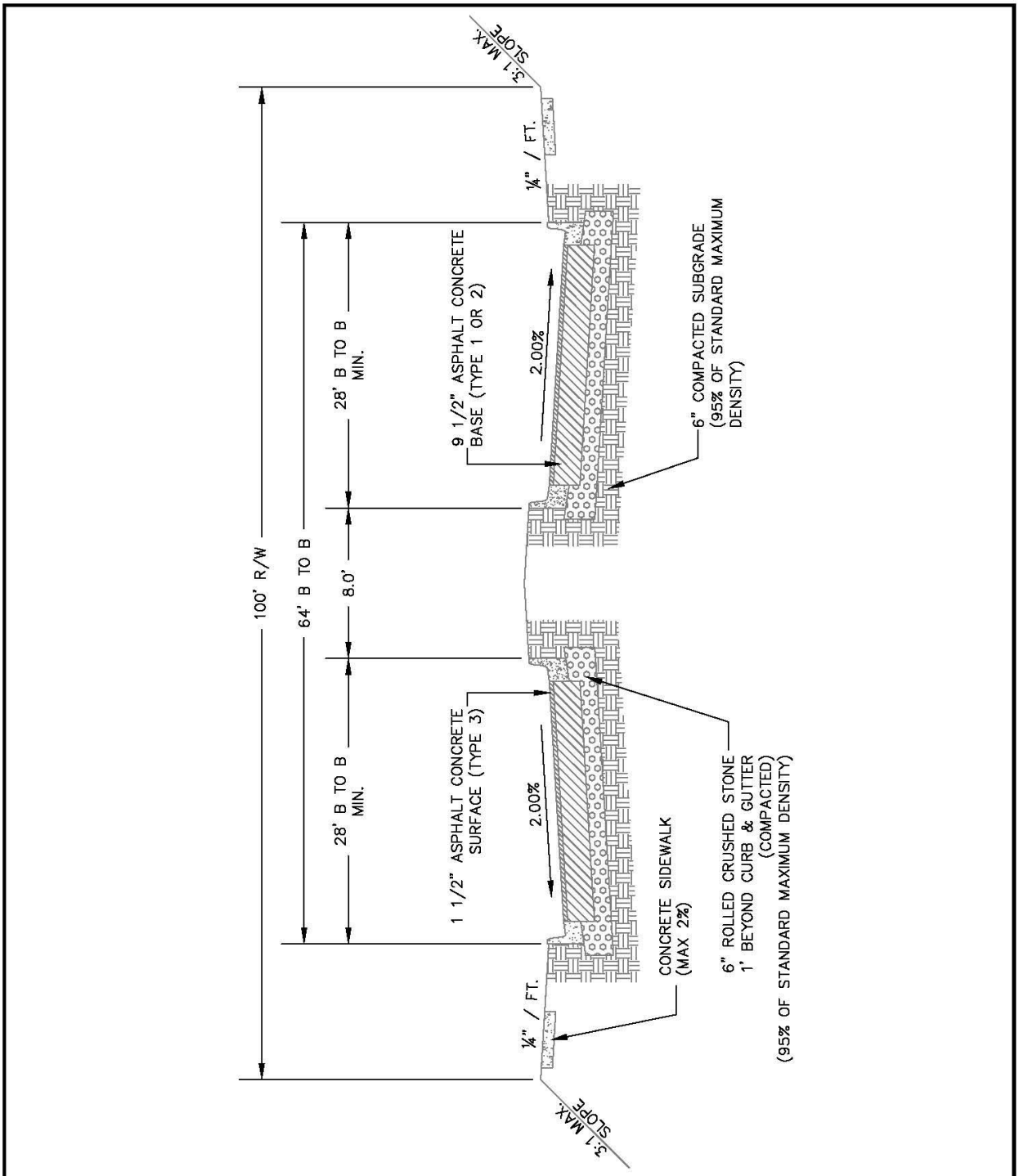
MISSOURI
Engineering & Public Works
TYPICAL SECTIONS
COLLECTOR STREET
TWO AND THREE LANE
DESIGN AID #2
ADOPTED
2024
REVISION



Branson MISSOURI ★ Engineering & Public Works	TYPICAL SECTIONS ARTERIAL STREET FOUR AND FIVE LANE	DESIGN AID #3
		ADOPTED 2024 / REVISION



Branson MISSOURI ★ Engineering & Public Works	TYPICAL SECTIONS ARTERIAL STREET WITH MEDIAN	DESIGN AID #4
		ADOPTED 2024 / REVISION

STREET CLASSIFICATION	PAVEMENT TYPES: OPTION #1	PAVEMENT TYPES: OPTION #2
LOCAL	2" TYPE 3 ASPHATIC CONCRETE SURFACE 3.5" MIN. ASPHALTIC CONCRETE BASE COURSE (TYPE 1 OR 2) 6" ROLLED CRUSHED STONE BASE 6" MIN. COMPACTED SUB. GRADE 95% OF STANDARD MAX. DENSITY	6" MIN. PORTLAND CEMENT CONCRETE PAVEMENT 6" MIN. COMPACTED SUBGRADE 95% OF STANDARD MAX. DENSITY
COLLECTOR	2" TYPE 3 ASPHATIC CONCRETE SURFACE 7.5" MIN. ASPHALTIC CONCRETE BASE COURSE (TYPE 1 OR 2) 6" ROLLED CRUSHED STONE BASE 6" MIN. COMPACTED SUB. GRADE 95% OF STANDARD MAX. DENSITY	7" MIN. PORTLAND CEMENT CONCRETE PAVEMENT 6" MIN. COMPACTED SUBGRADE 95% OF STANDARD MAX. DENSITY
ARTERIAL	2" TYPE 3 ASPHATIC CONCRETE SURFACE 9" MIN. ASPHALTIC CONCRETE BASE COURSE (TYPE 1 OR 2) 6" ROLLED CRUSHED STONE BASE 6" MIN. COMPACTED SUB. GRADE 95% OF STANDARD MAX. DENSITY	9" MIN. PORTLAND CEMENT CONCRETE PAVEMENT 6" MIN. COMPACTED SUBGRADE 95% OF STANDARD MAX. DENSITY

NOTE: Pavement type options to be considered shall be submitted to the City Engineer for approval.

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STREET PAVEMENT TYPES

DESIGN AID #5

ADOPTED 2024

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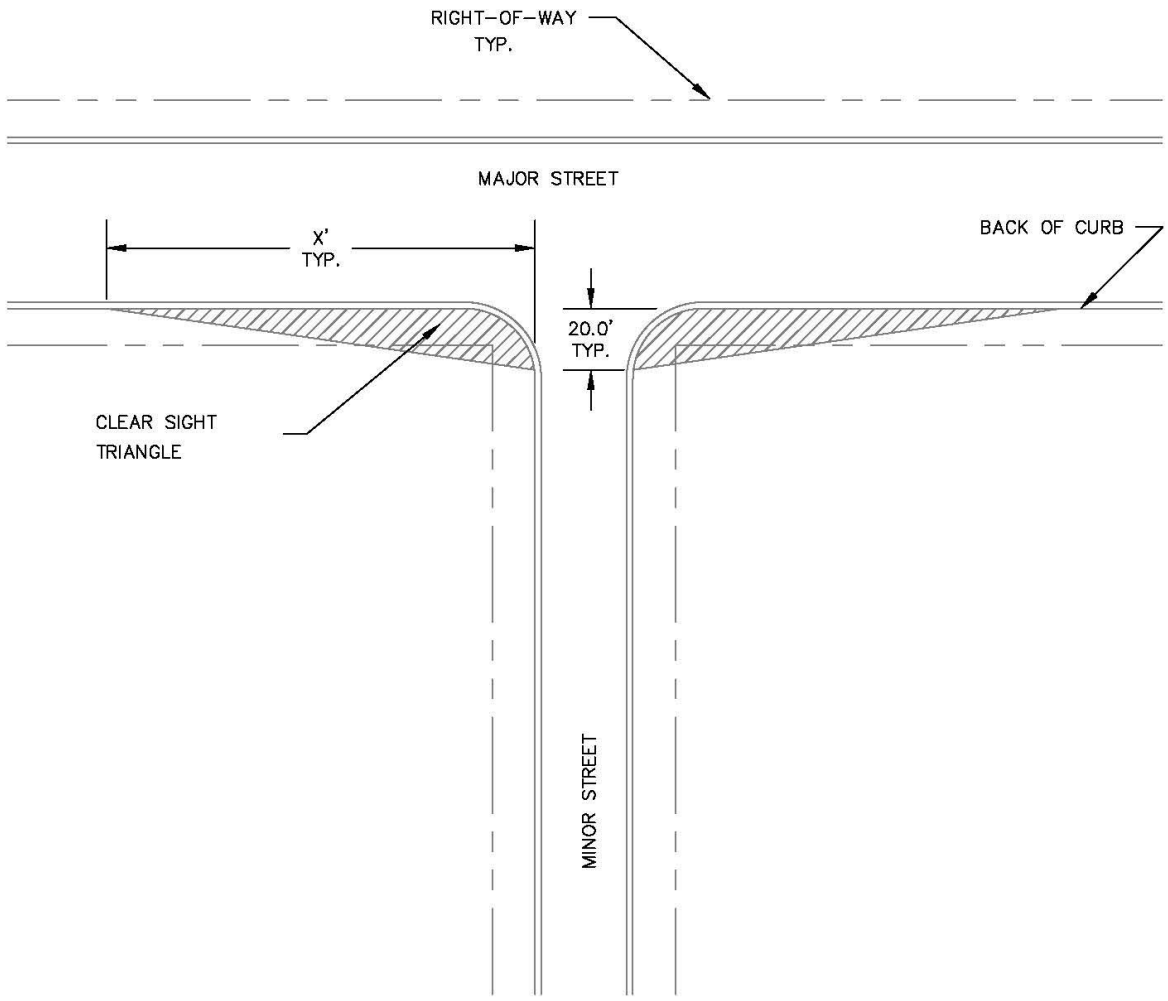
DESIGN CONTROLS FOR STOPPING SIGHT DISTANCE FOR CREST AND SAG VERTICAL CURVES

DESIGN SPEED (mph)	US CUSTOMARY DESIGN STOPPING SITE DISTANCE (ft.)	RATE OF VERTICAL CURVATURE, K (FT./%)	
		Crest	Sag
15	80	3	10
20	115	7	17
25	155	12	26
30	200	19	37
35	250	29	49
40	305	44	64
45	360	61	79
50	425	84	96
55	495	114	115

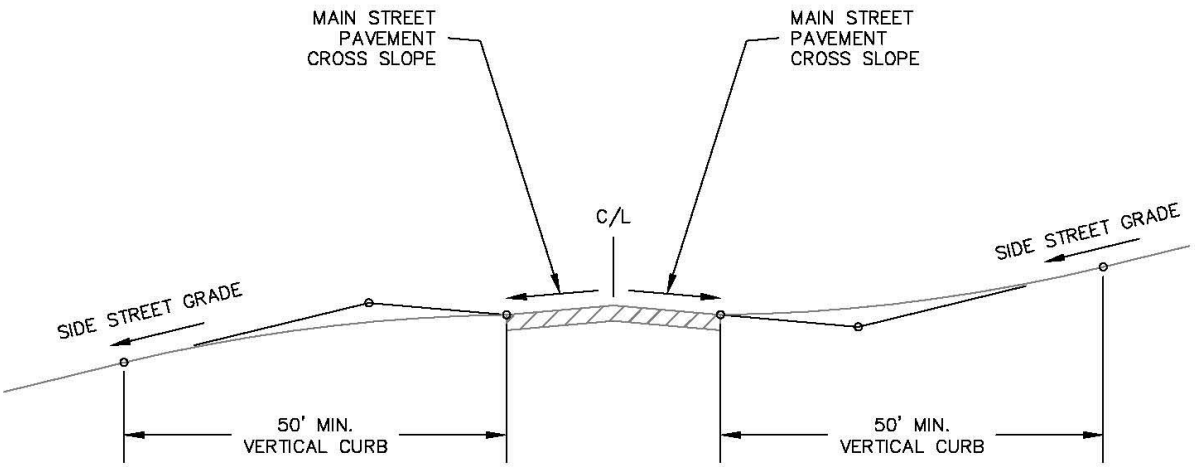
Source: AASHTO

Branson MISSOURI Engineering & Public Works	MINIMUM STOPPING DISTANCE FOR CREST AND SAG VERTICAL CURVES	DESIGN AID #6	
		ADOPTED 2024	REVISION

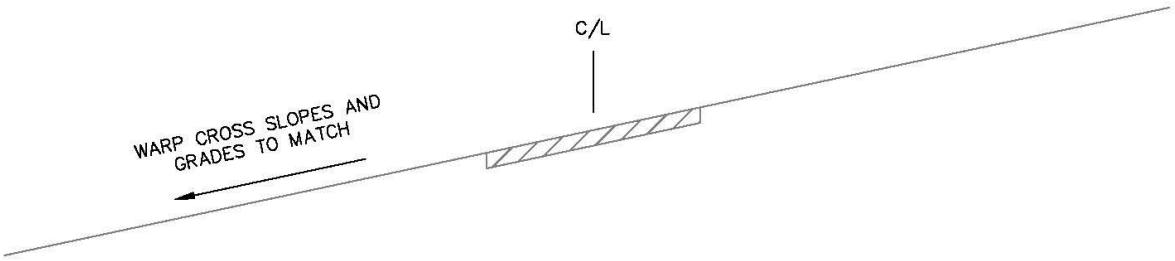
SPEED (MPH)	DISTANCE "X" (FT)
≤30	140
35	165
40	195
45	220
50	245
55	285



Branson MISSOURI ★ Engineering & Public Works	INTERSECTION CLEAR SIGHT TRIANGLE	DESIGN AID #7A
		ADOPTED 2024 / REVISION



MAIN STREET SECTION & SIDE STREET PROFILE INTERSECTION OF LESSER WITH A GREATER FUNCTION STREET



THRU STREET AND PERPENDICULAR STREET PROFILE INTERSECTION OF EQUAL FUNCTION STREETS

Branson MISSOURI ★ Engineering & Public Works	INTERSECTION VERTICAL ALIGNMENT	DESIGN AID #7B	
		ADOPTED 2024	REVISION

Manning's Roughness Coefficient n	
Closed Conduits	N
Reinforced Concrete Pipe	0.013
Reinforced Concrete Elliptical Pipe	0.013
Corrugated Metal Pipe	0.022
Clay Pipe	0.013
Open Channel	N
Gabions	0.025
Concrete	
Trowel Finish	0.013
Float Finish	0.015
Unfinished	0.017
Concrete Bottom Finished Sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble	0.025
Riprap	0.030
Gravel Bottom Finished Sides of	
Random Stone	0.023
Riprap	0.033
Grass	0.030
Riprap	0.035
Channel of Weeds and Brush	0.090
Natural Stream	
Clean and Straight	0.030
Winding and Sluggish	0.100
Flood Plain	
Grass, no brush	0.030
Some brush	0.090
Street Curbing	0.014

Branson MISSOURI Engineering & Public Works	MANNING'S ROUGHNESS COEFFICIENT n	DESIGN AID #12	
		ADOPTED 2024	REVISION

Minor losses shall be calculated by: $h = k\left(\frac{V^2}{2g}\right)$

Where: h= Head loss in feet
V= Velocity of flow in ft per second at point of interest
2g= 64.4 feet per second per second
K= coefficient from table below

HEAD LOSS COEFFICIENT k	
Condition	k
Manhole, Junction Boxes and Inlets with shaped inverts:	
Thru flow	0.15
Junction	0.4
Contraction Transition	0.1
Expansion Transition	0.2
90° Bend	0.4
45° and less bends	0.3
Culvert Outlet	1
Culvert Inlets:	
Pipe, Concrete	
Projecting from fill, socket and (groove end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove end)	0.2
Square edge	0.5
Rounded	0.2
Mitered to conform to fill slope	0.7
Standard end section	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side-or-slope-tapered inlet	0.2
Pipe or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and singwalls square edge	0.5
Mitered to conform to fill slope, paved or unpaved	0.7
Standard end section	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side-or-slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall Parallel to embankment (no wingwall)	
Square edge 3 edges	0.5
Rounded on 3 edges of 1/12 barrel dimension	0.2
Wingwalls at 30° or 75° to barrel	
Square edge at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension	
or beveled top edge	0.2
Wingwalls at 10° or 25° to barrel	
Square edge at crown	0.5
Wingwalls parallel (extension of sides)	
Square edge at crown	0.7
Side-or-slope-tapered inlet	0.2

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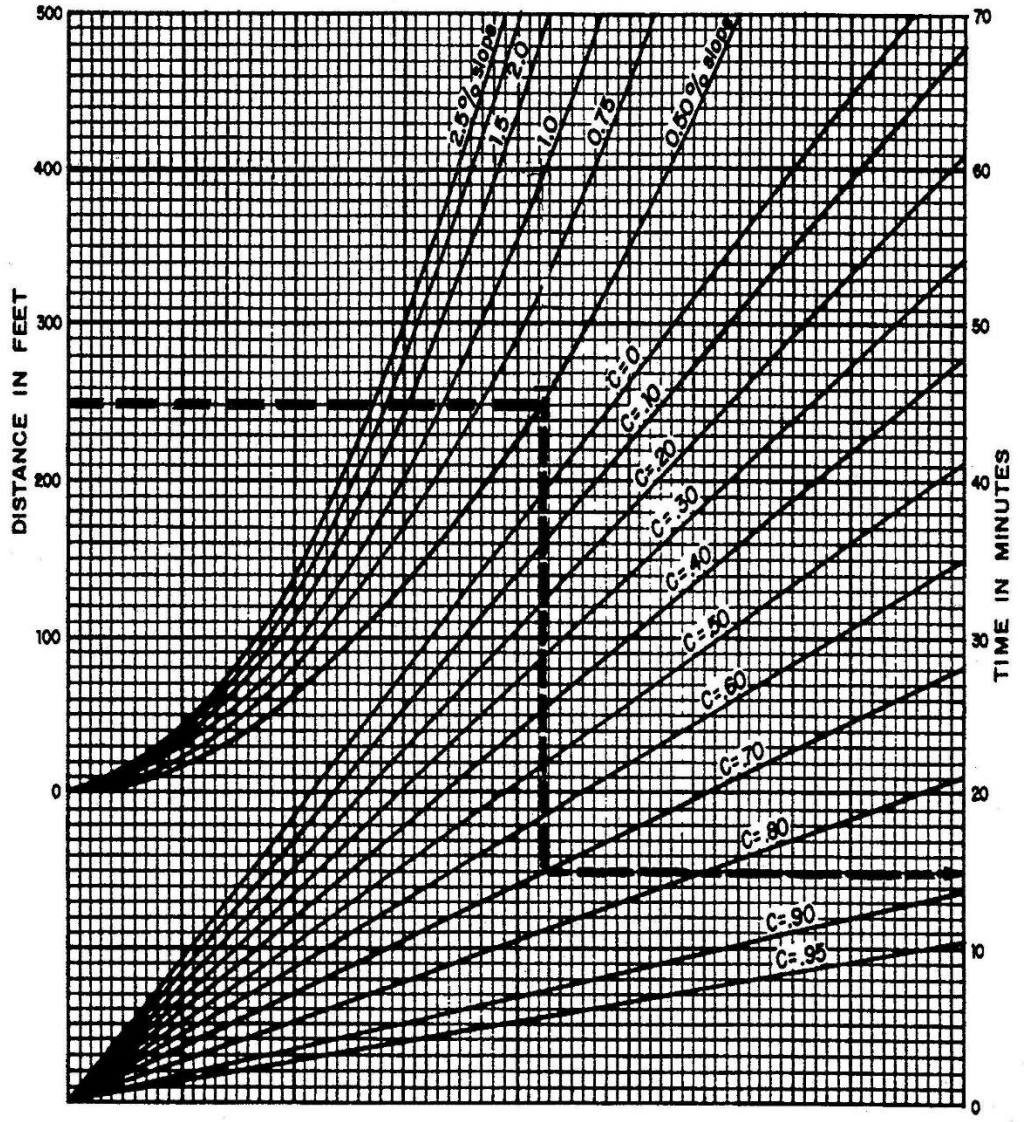
HEAD LOSS COEFFICIENT k

DESIGN AID #13

ADOPTED 2024

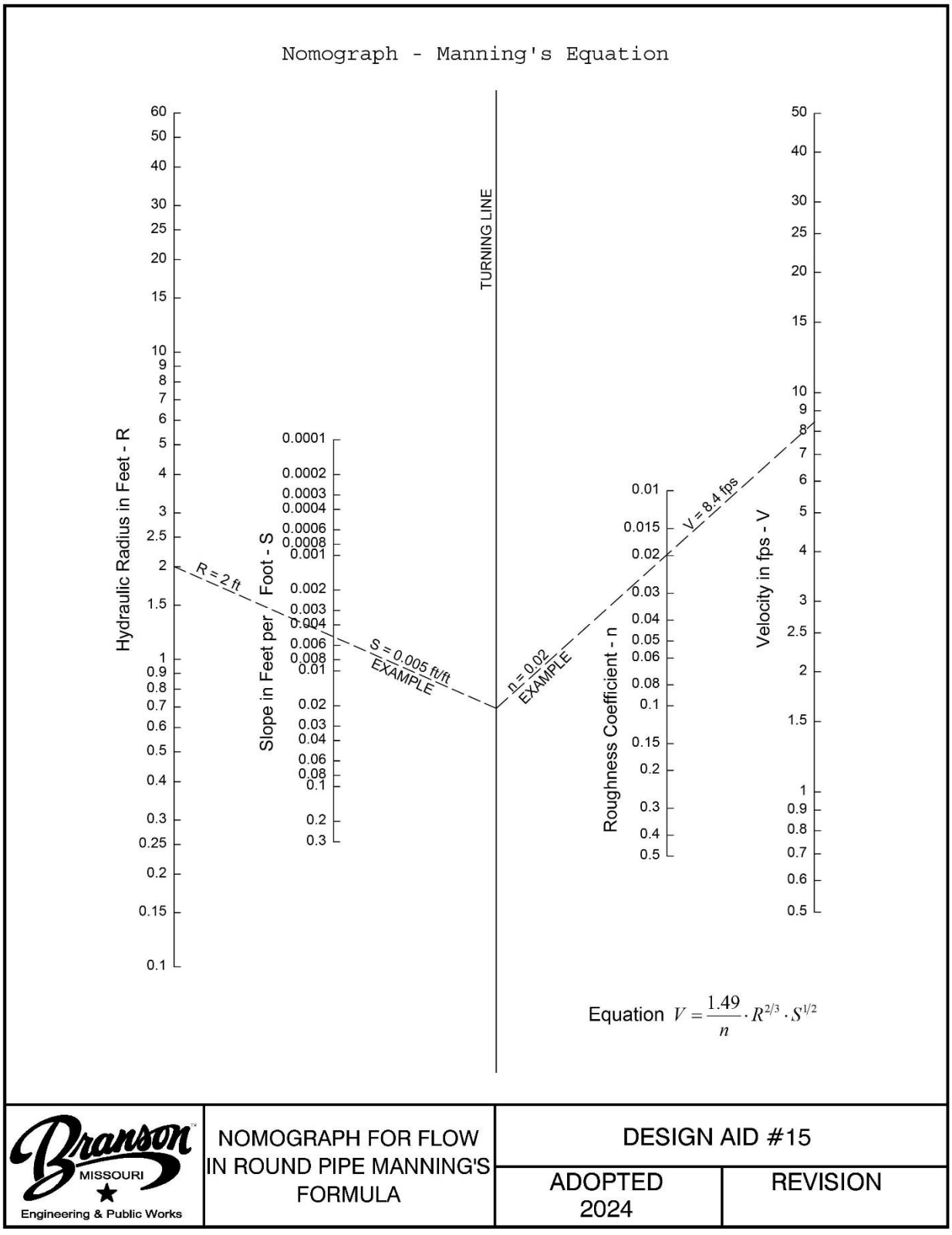
REVISION



(Source: Airport Drainage, Federal Aviation Administration, 1965)

Relation of overland time of travel to overland travel distance, average slope, and coefficient C, for use in Rational Method

Branson MISSOURI ★ Engineering & Public Works	RAINFALL TIME OF CONCENTRATION NOMOGRAPH	DESIGN AID #14	
		ADOPTED 2024	REVISION


Nomograph - Manning's Equation
Hydraulic Radius in Feet - R
Slope in Feet per Foot - S
TURNING LINE
Roughness Coefficient - n
Velocity in fps - V
R = 2 ft
S = 0.005 ft/ft
EXAMPLE
n = 0.02
EXAMPLE
V = 8.4 fps
Equation $V = \frac{1.49}{n} \cdot R^{2/3} \cdot S^{1/2}$
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MISSOURI
Engineering & Public Works
NOMOGRAPH FOR FLOW IN ROUND PIPE MANNING'S FORMULA
DESIGN AID #15
ADOPTED 2024
REVISION

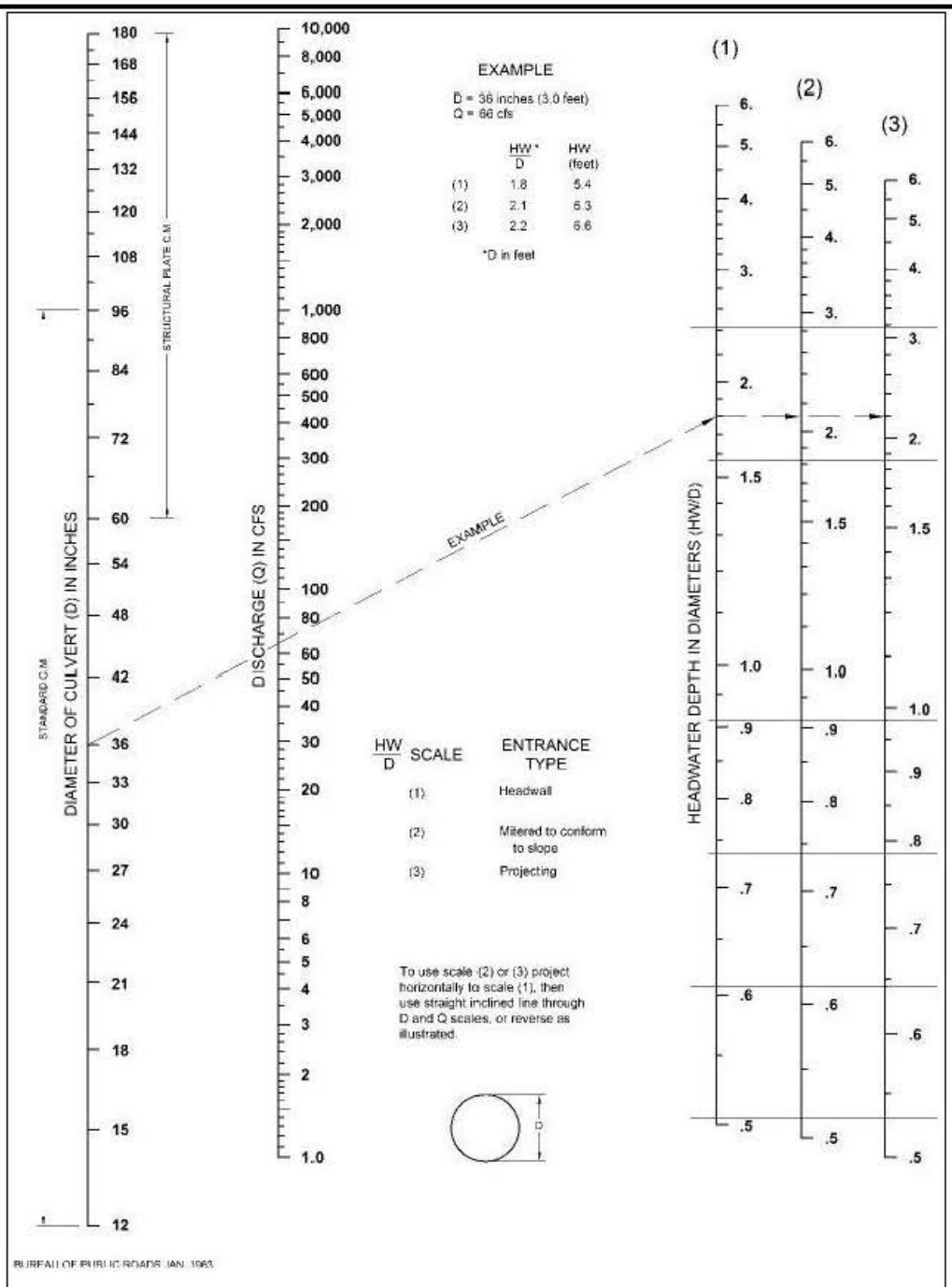


Figure 5603-5: Headwater Depth for Corrugated Metal Pipe Culverts with Inlet Control

Branson MISSOURI ★ Engineering & Public Works	HEADWATER DEPTH FOR C.M. PIPE CULVERTS WITH INLET CONTROL	DESIGN AID #16
		ADOPTED 2024 / REVISION

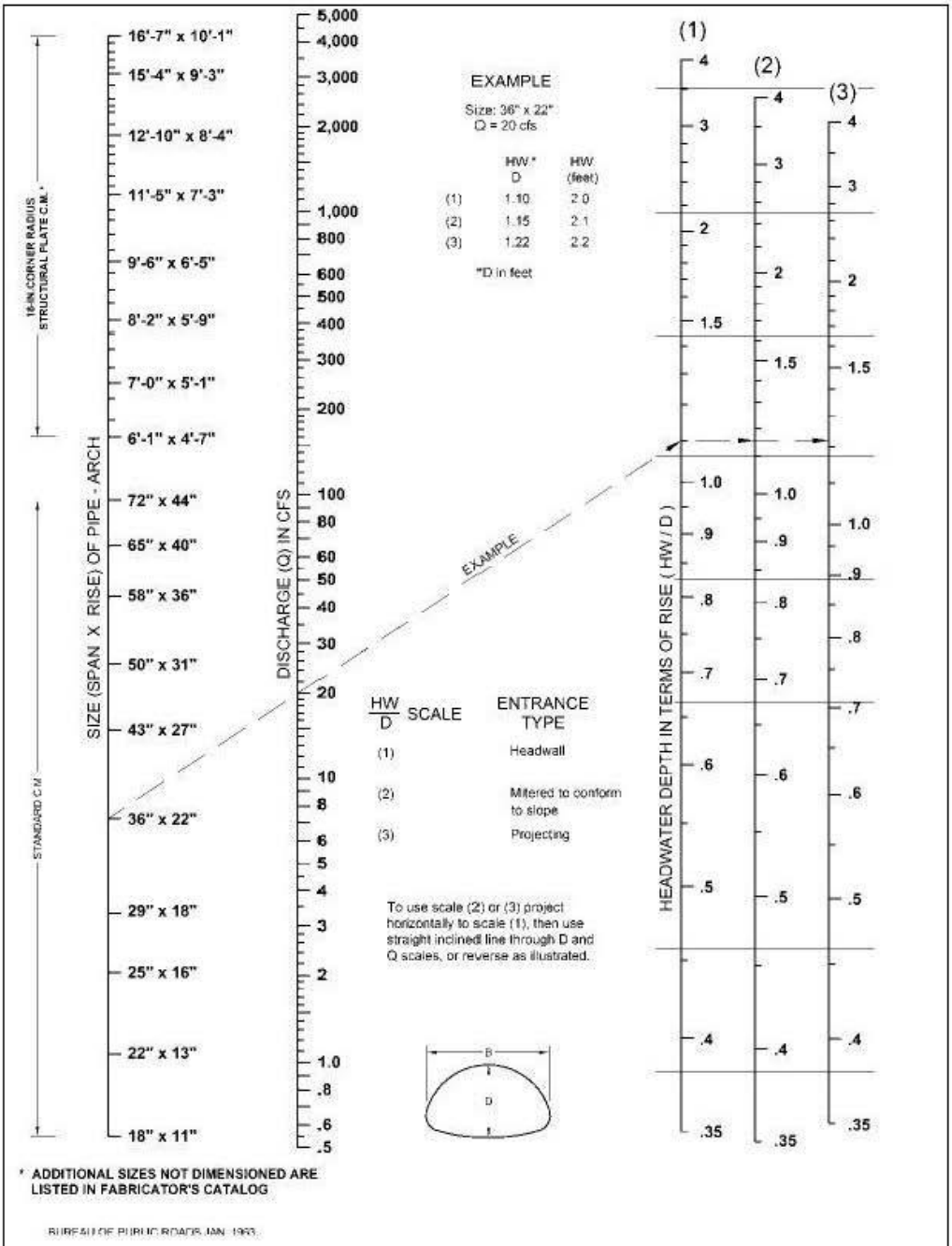


Figure 5603-6: Headwater Depth for Corrugate Metal Pipe – Arch Culvert with Inlet Control

Branson MISSOURI Engineering & Public Works	HEADWATER DEPTH FOR C.M. PIPE-ARCH CULVERTS WITH INLET CONTROL	DESIGN AID #17
		ADOPTED 2024 / REVISION

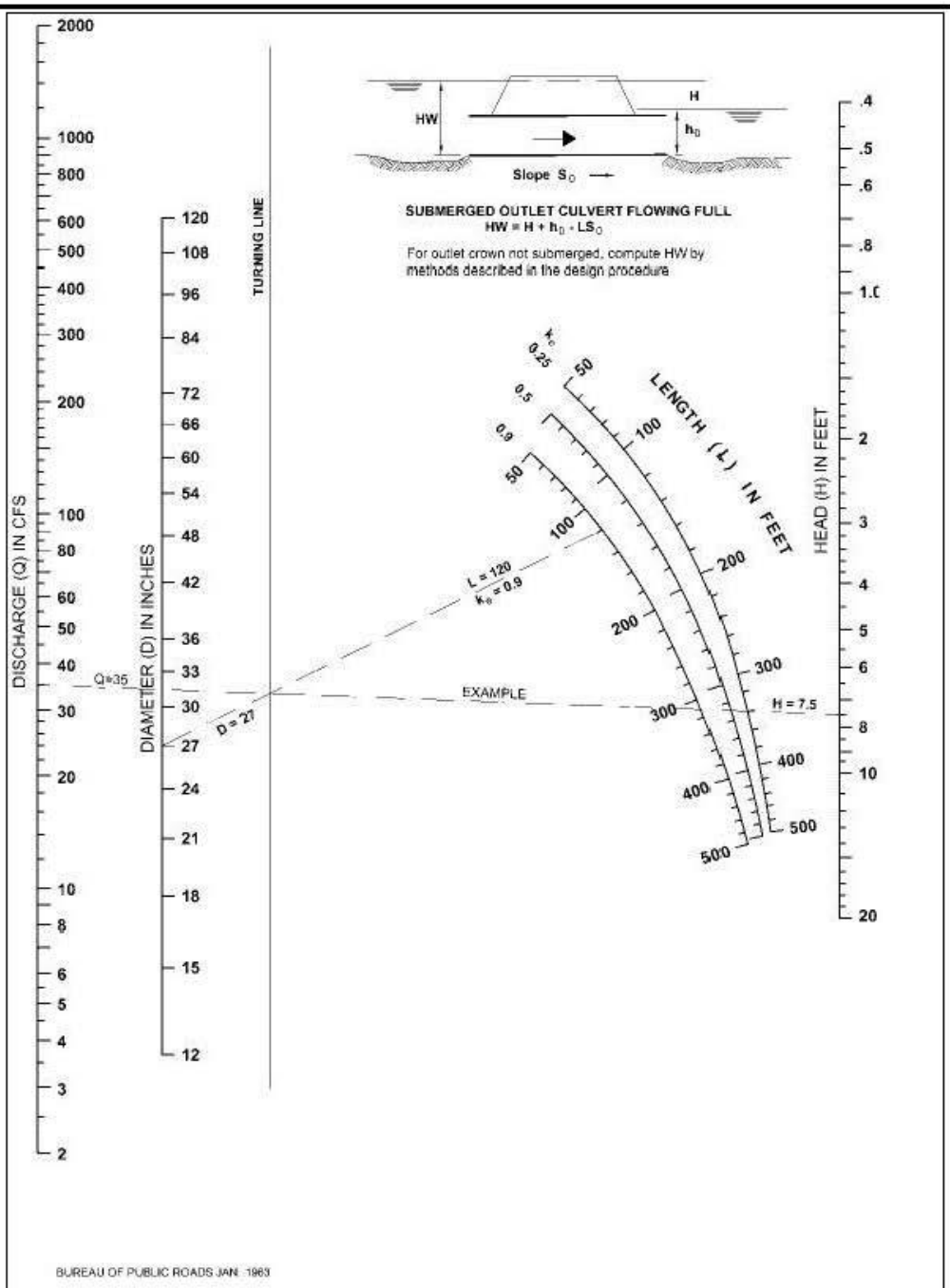


Figure 5603-11: Head for Standard Corrugate Metal Pipe Culverts Flowing Full (n=0.024)

Branson MISSOURI Engineering & Public Works	HEAD FOR STAND C.M. PIPE CULVERTS FLOWING FULL n=0.024	DESIGN AID #18
		ADOPTED 2024 / REVISION

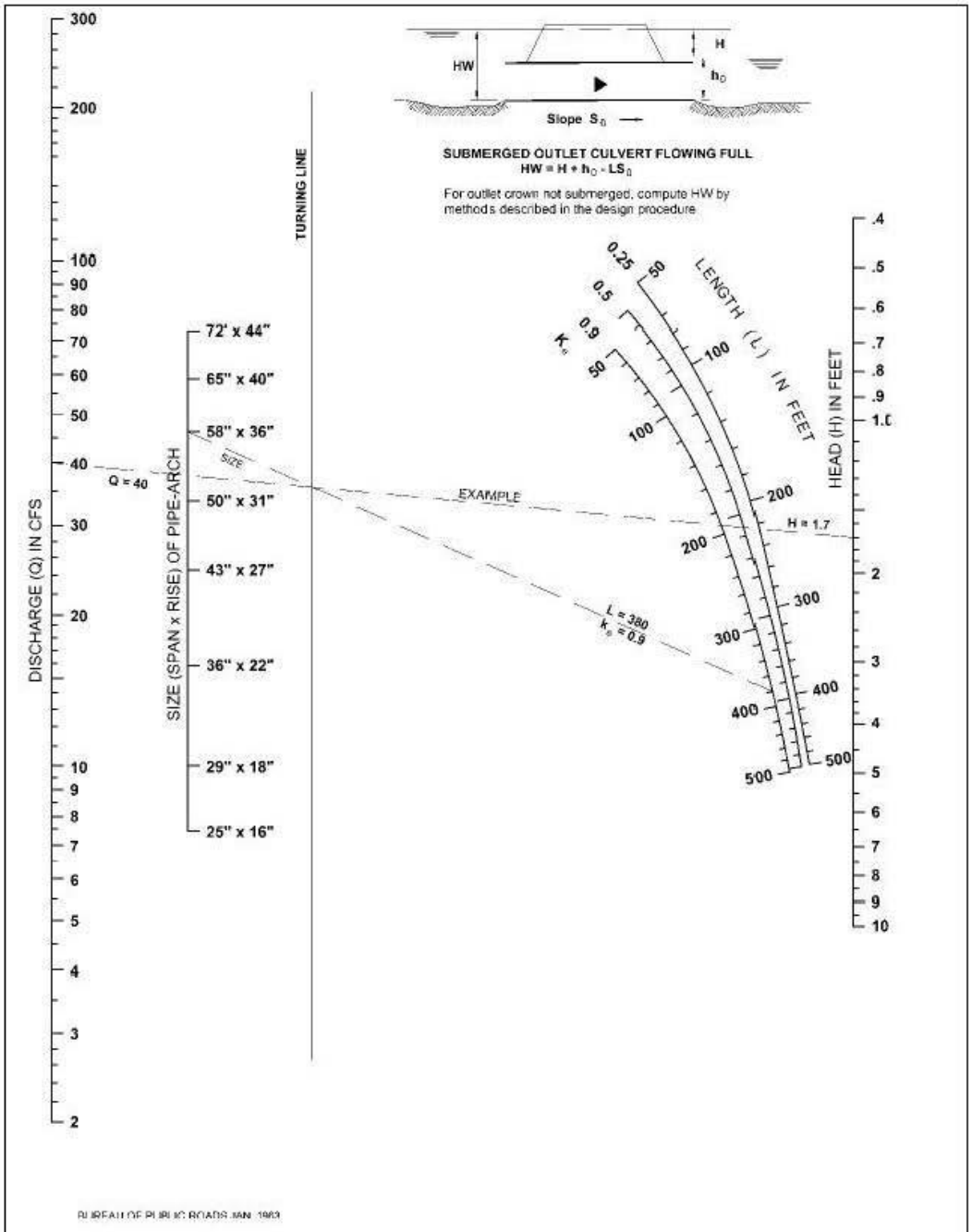


Figure 5603-12: Head for Standard Corrugated Metal Pipe-Arch Culverts Flowing Full (n=0.024)

Branson MISSOURI Engineering & Public Works	HEAD FOR STAND C.M. PIPE-ARCH CULVERTS FLOWING FULL n=0.024	DESIGN AID #19
		ADOPTED 2024 / REVISION

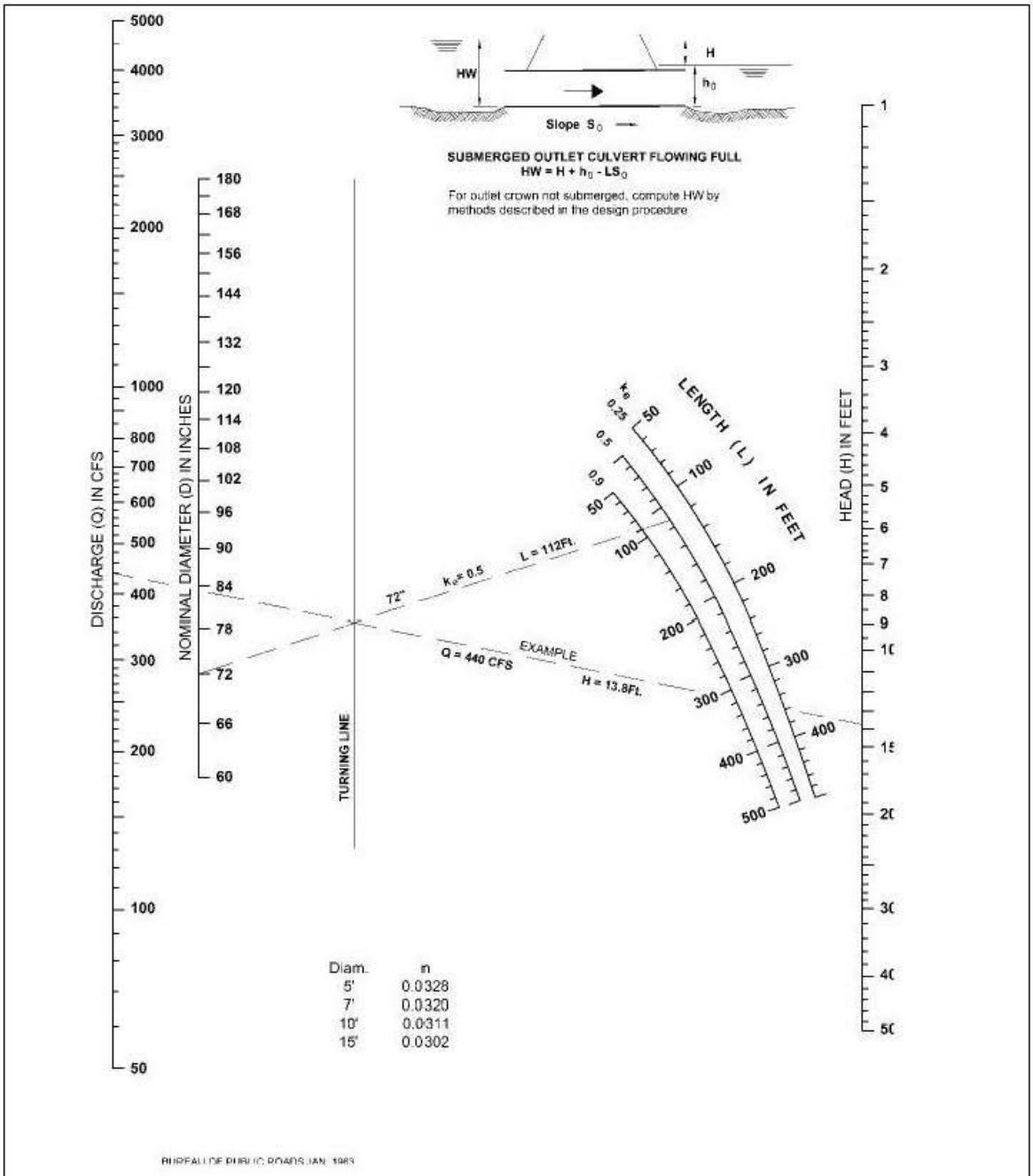
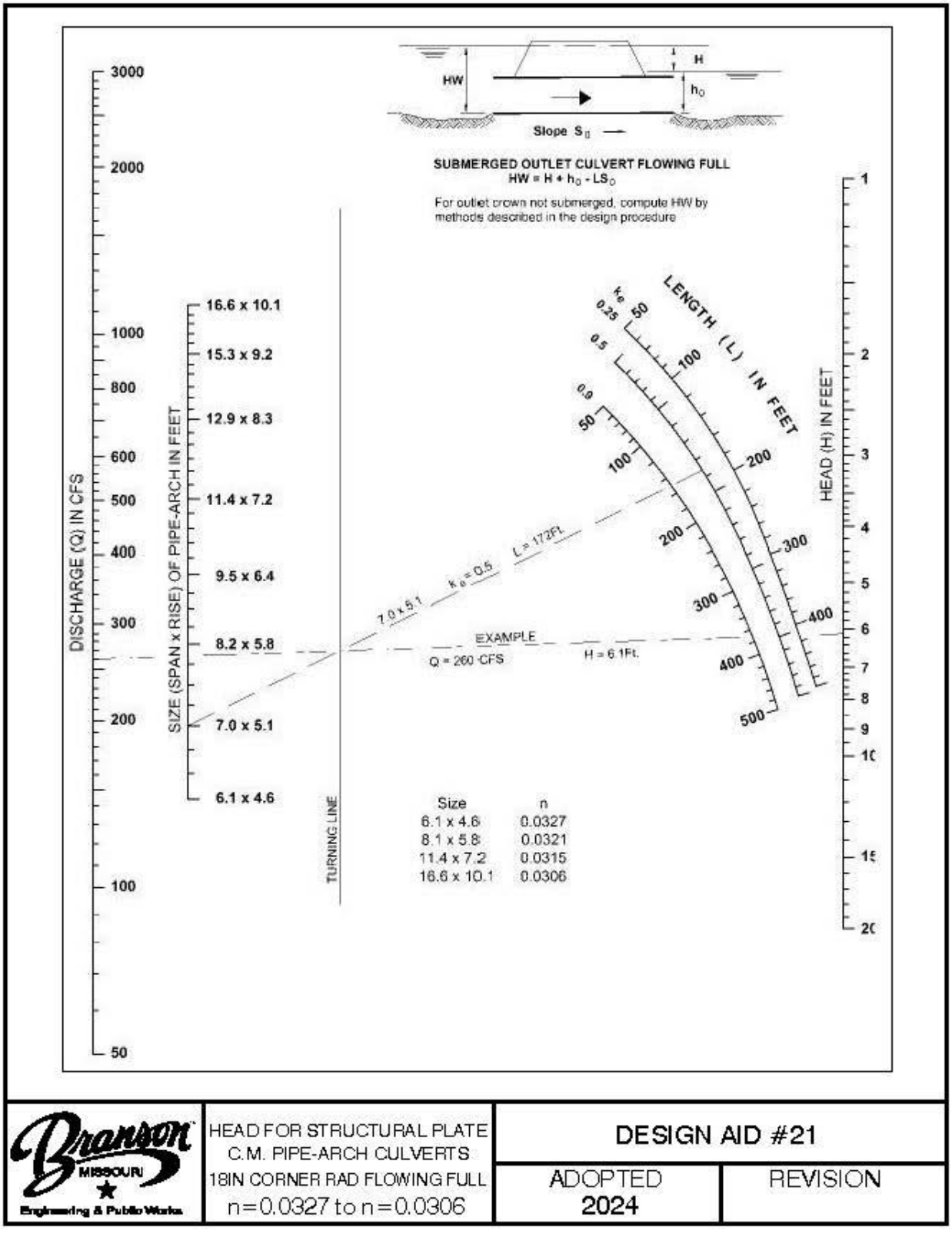


Figure 5603-13: Head for Structural Plate Corrugated Metal Pipe Culverts Flowing Full (n=0.0328 to 0.0302)

Branson MISSOURI Engineering & Public Works	HEAD FOR STRUCTURAL PLATE CORR. METAL PIPE CULVERTS FLOWING FULL n= 0.0328 to n=0.0302	DESIGN AID #20
		ADOPTED 2024 / REVISION



Branson MISSOURI Engineering & Public Works	HEAD FOR STRUCTURAL PLATE C.M. PIPE-ARCH CULVERTS 18IN CORNER RAD FLOWING FULL n=0.0327 to n=0.0306	DESIGN AID #21
		ADOPTED 2024 / REVISION

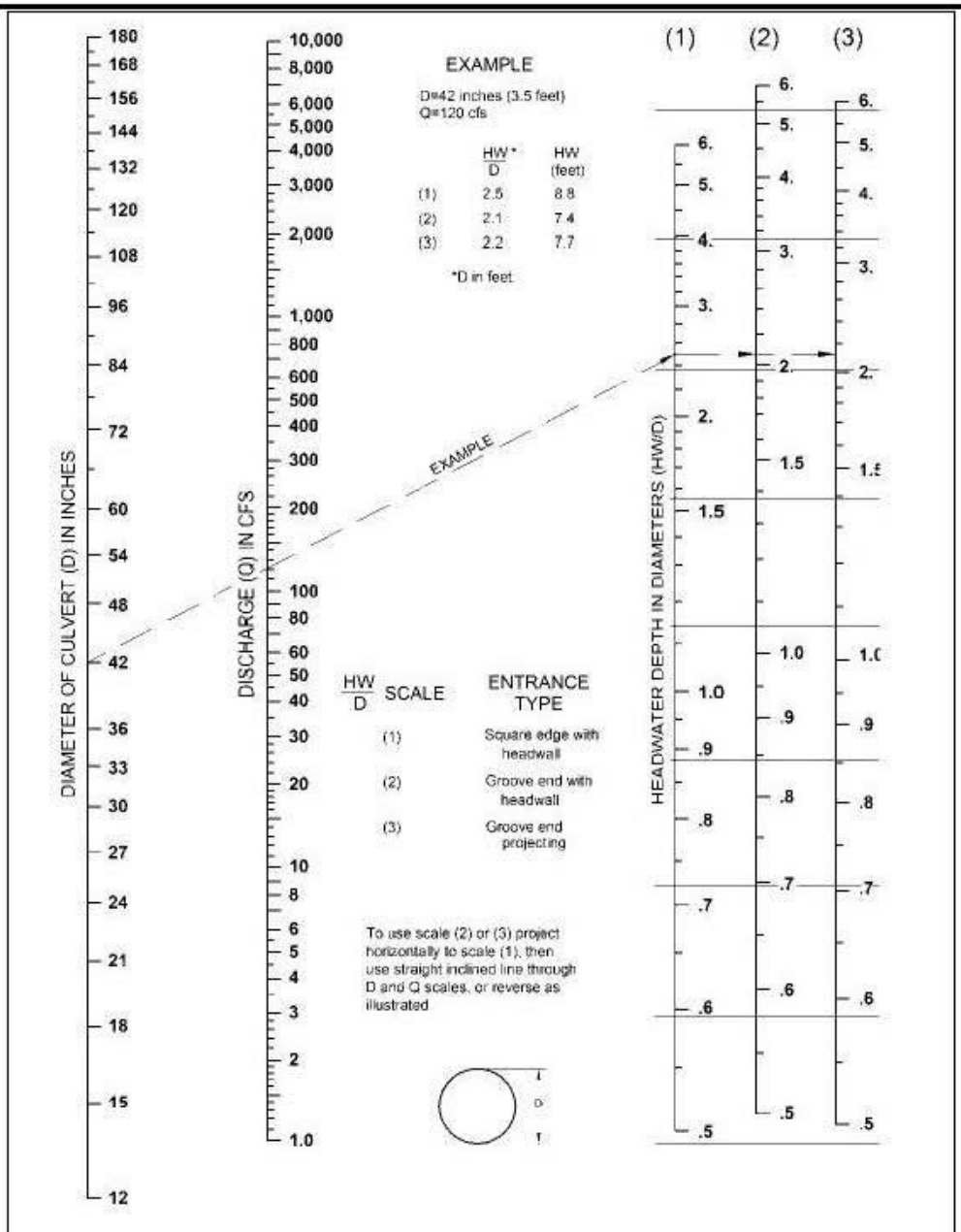


Figure 5603-2: Headwater Depth for Concrete Pipe Culverts with Inlet Control

Branson Missouri Engineering & Public Works	HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL	DESIGN AID #22
		ADOPTED 2024 / REVISION

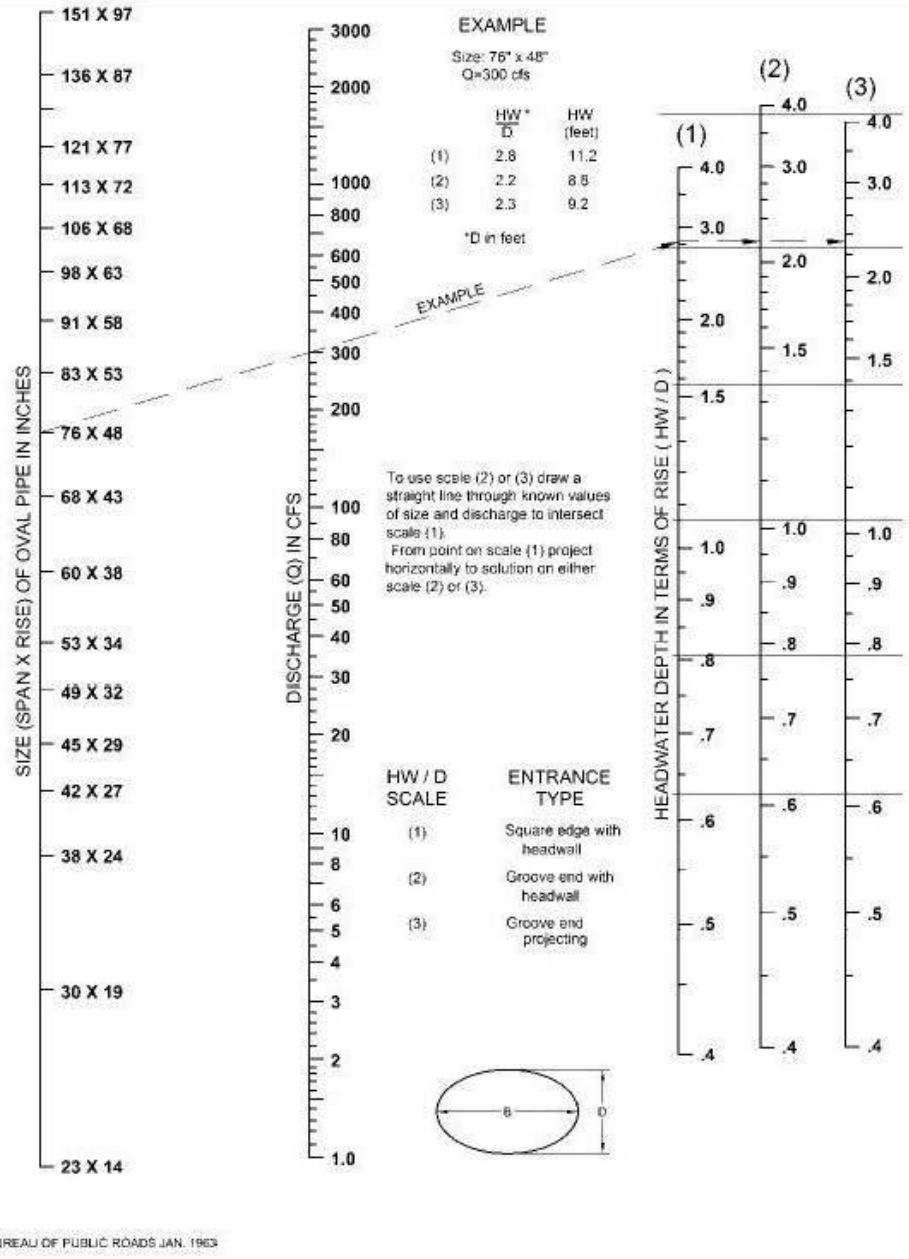


Figure 5603-3: Headwater Depth for Oval Concrete Pipe Culverts, Long Axis Horizontal with Inlet Control

Branson MISSOURI Engineering & Public Works	HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL WITH INLET CONTROL	DESIGN AID #23
		ADOPTED 2024 / REVISION

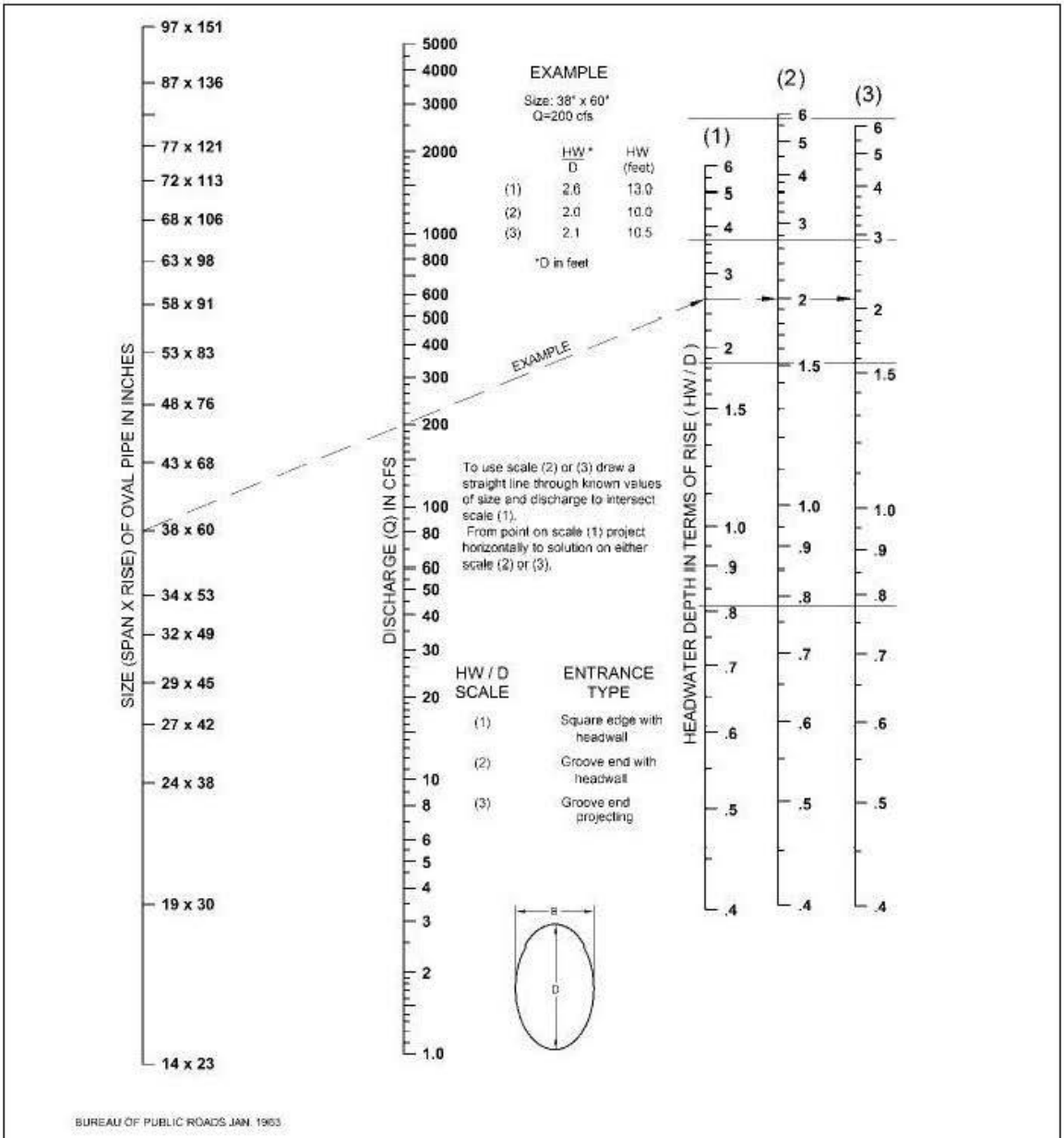


Figure 5603-4: Headwater Depth for Oval Concrete Pipe Culverts, Long Axis Vertical with Inlet Control

Branson MISSOURI Engineering & Public Works	HEADWATER DEPTH FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS VERTICAL WITH INLET CONTROL	DESIGN AID #24
		ADOPTED 2024 / REVISION

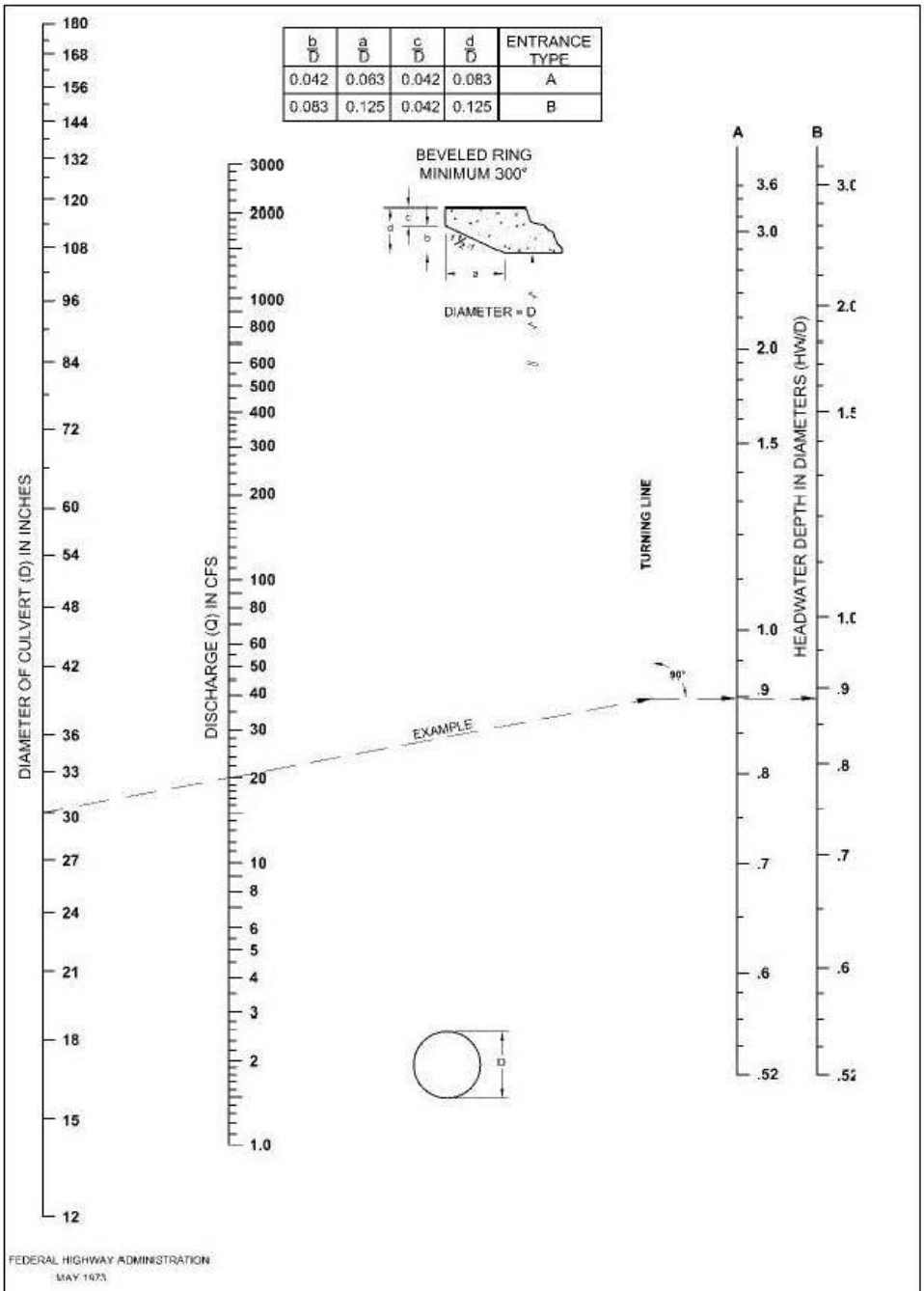
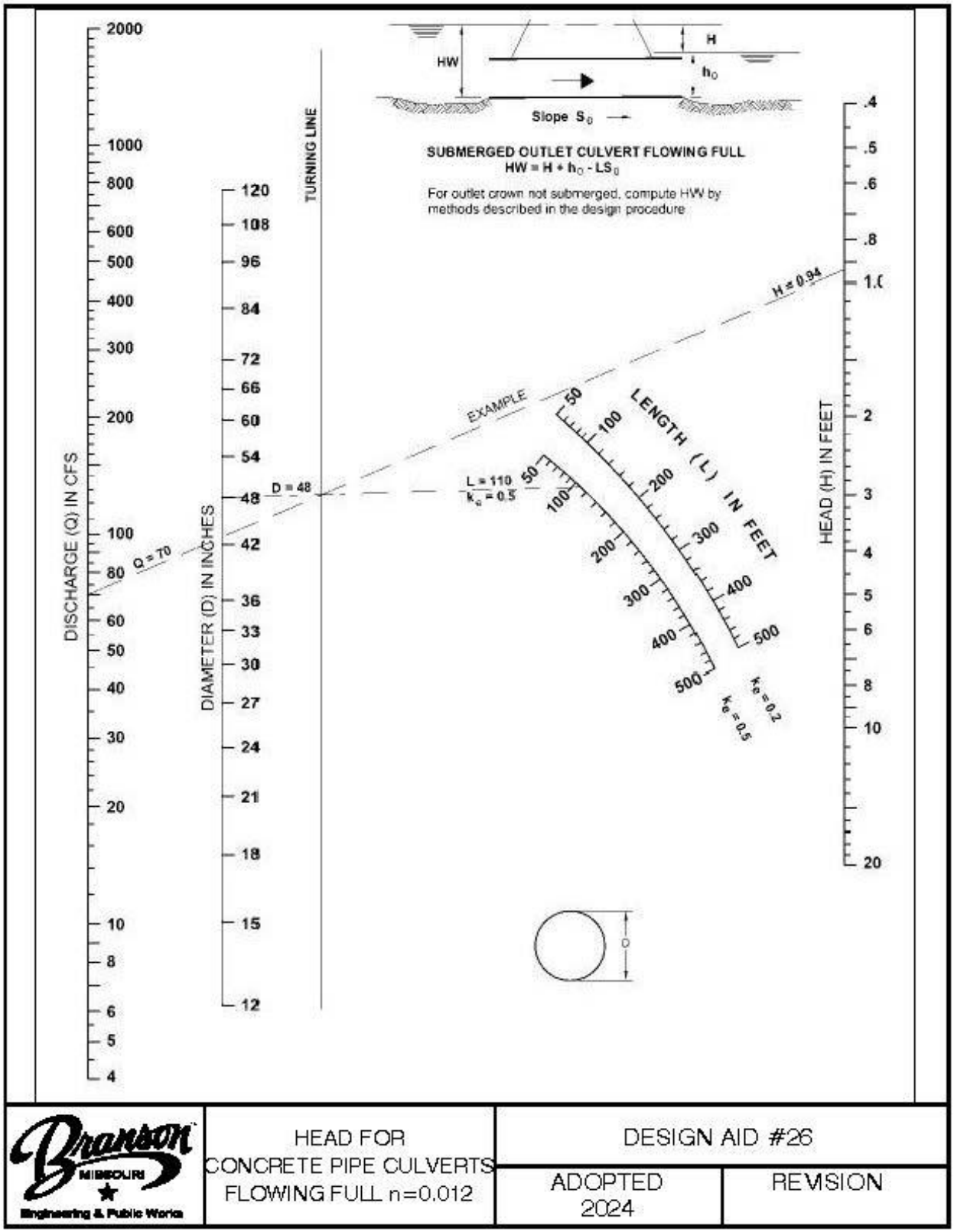
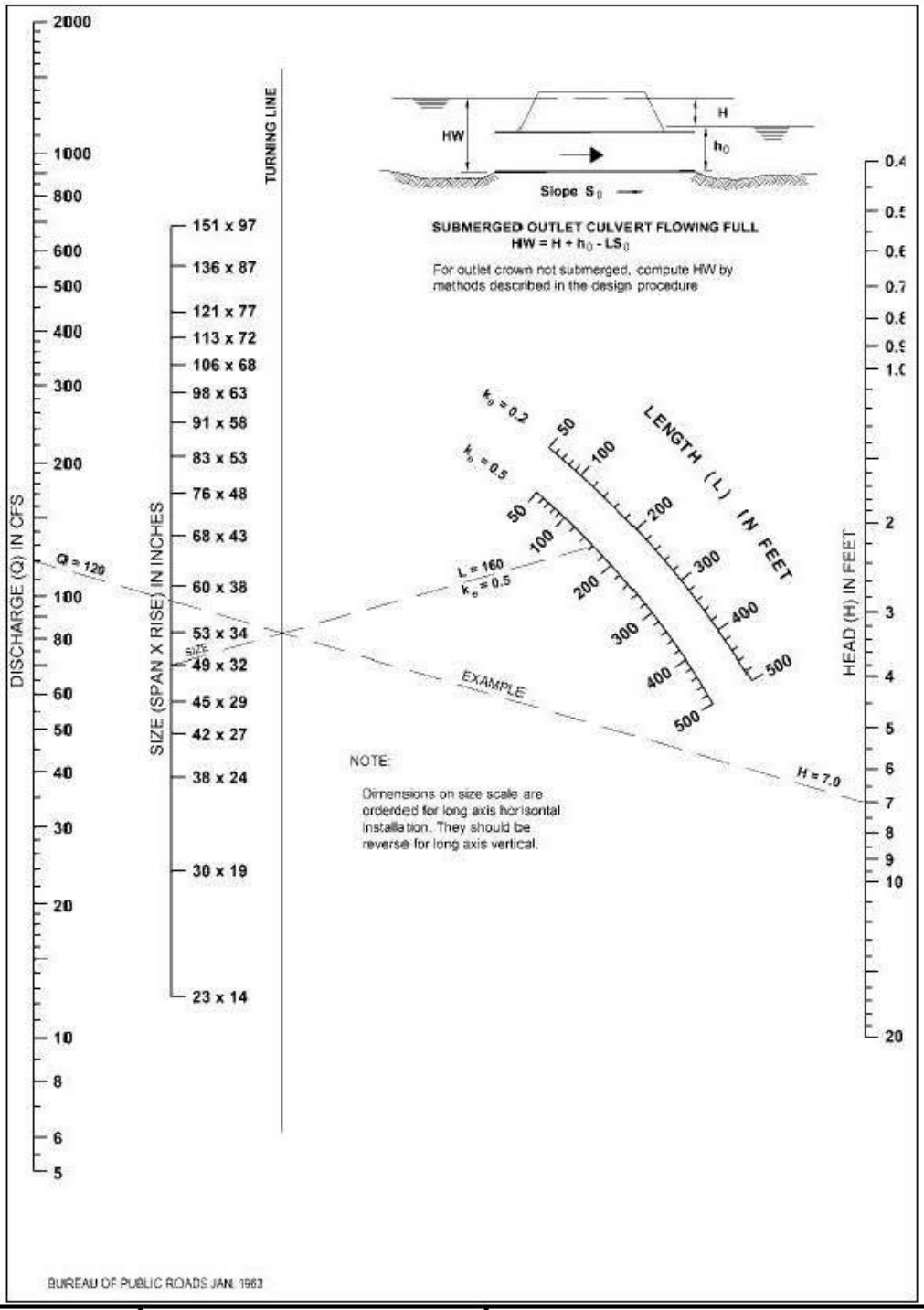


Figure 5603-7: Headwater Depth for Circular Pipe Culverts with Beveled Ring Inlet Control

Branson MISSOURI Engineering & Public Works	HEADWATER DEPTH FOR CIRCULAR PIPE CULVERTS WITH BEVELED RING INLET CONTROL	DESIGN AID #25
		ADOPTED 2024 / REVISION



Branson MISSOURI Engineering & Public Works	HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n=0.012	DESIGN AID #26	
		ADOPTED 2024	REVISION



Branson MISSOURI Engineering & Public Works	HEAD FOR OVAL CONCRETE PIPE CULVERTS LONG AXIS HORIZONTAL OR VERTICAL FLOWING FULL n=0.012	DESIGN AID #27
		ADOPTED 2024 / REVISION

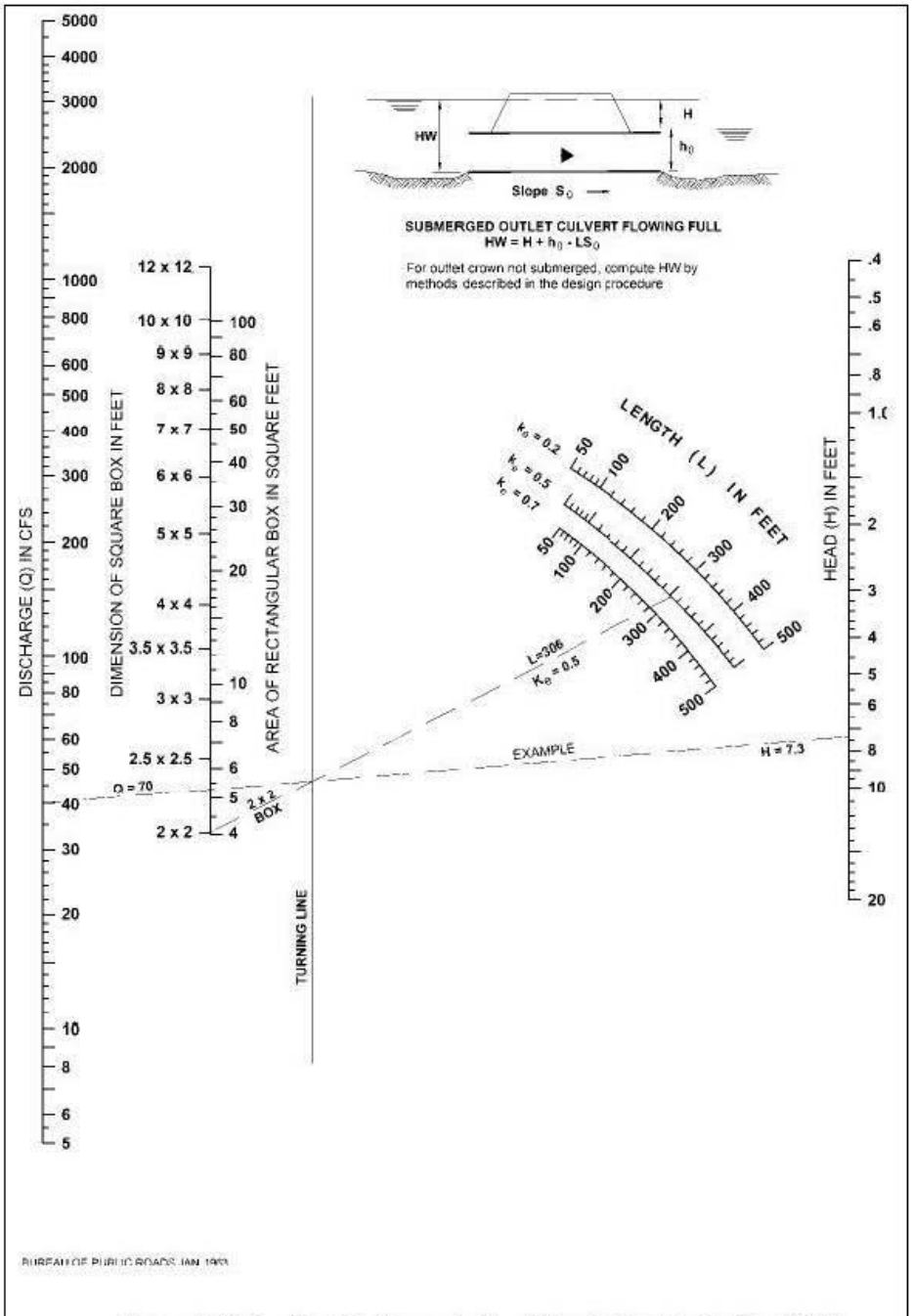


Figure 5603-9: Head for Concrete Box Culverts Flowing Full (n=0.012)

Branson MISSOURI Engineering & Public Works	HEAD FOR CONCRETE BOX CULVERTS FLOWING FULL n=0.012	DESIGN AID #28
		ADOPTED 2024 / REVISION

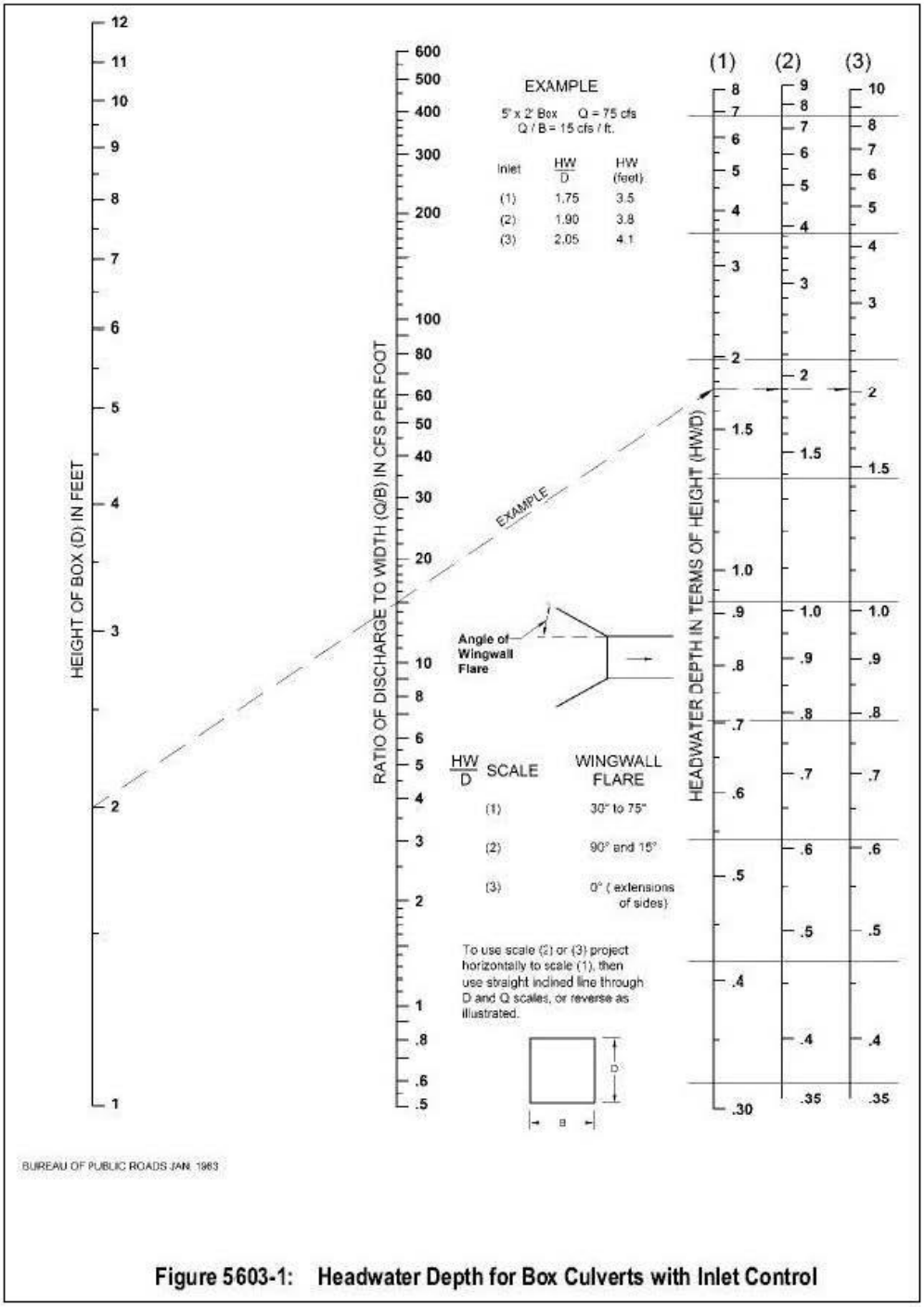
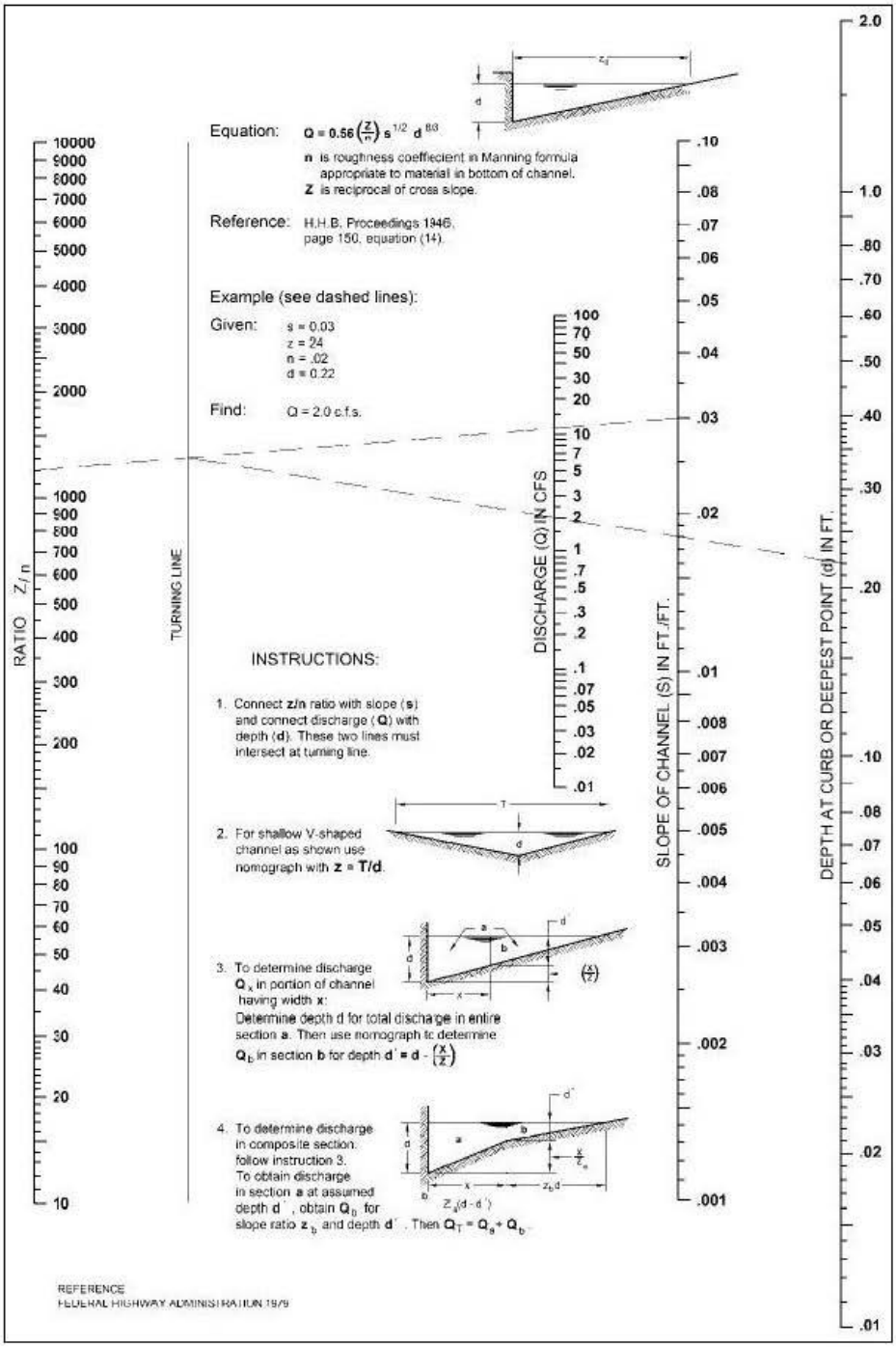
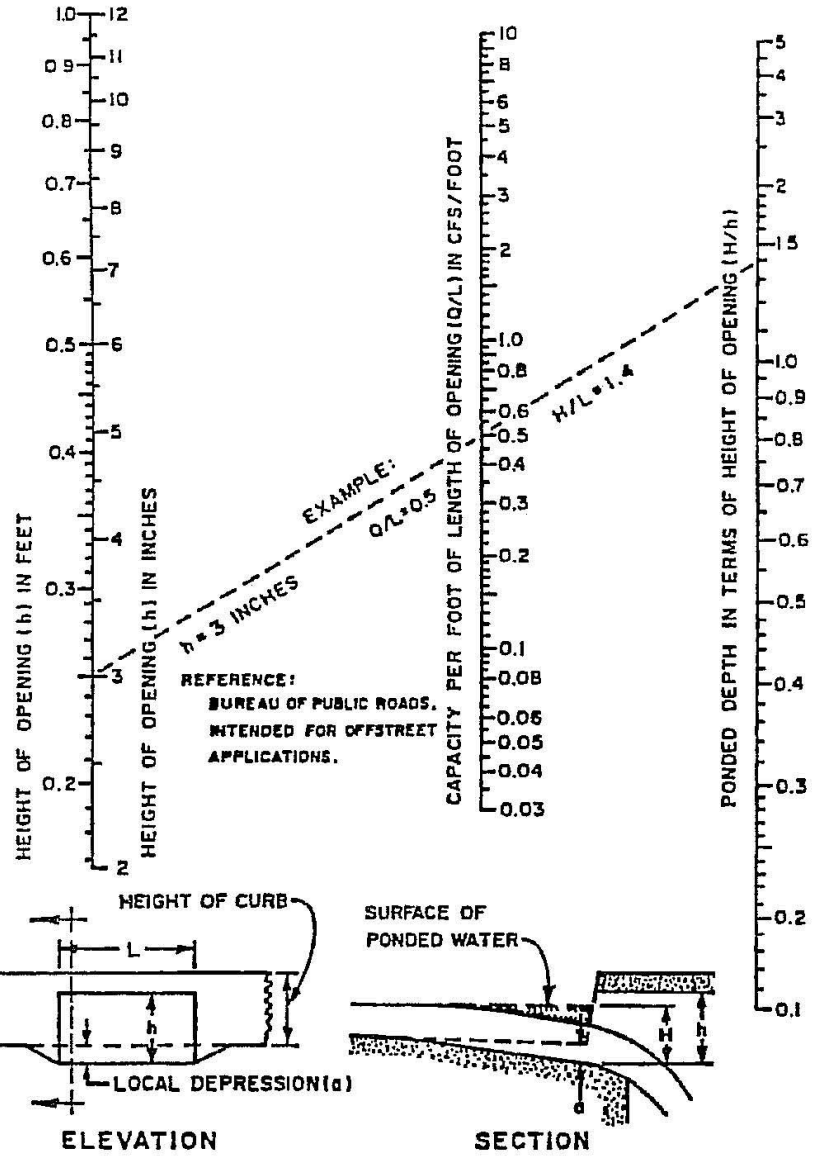


Figure 5603-1: Headwater Depth for Box Culverts with Inlet Control

Branson MISSOURI Engineering & Public Works	HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL	DESIGN AID #29
		ADOPTED 2024 / REVISION

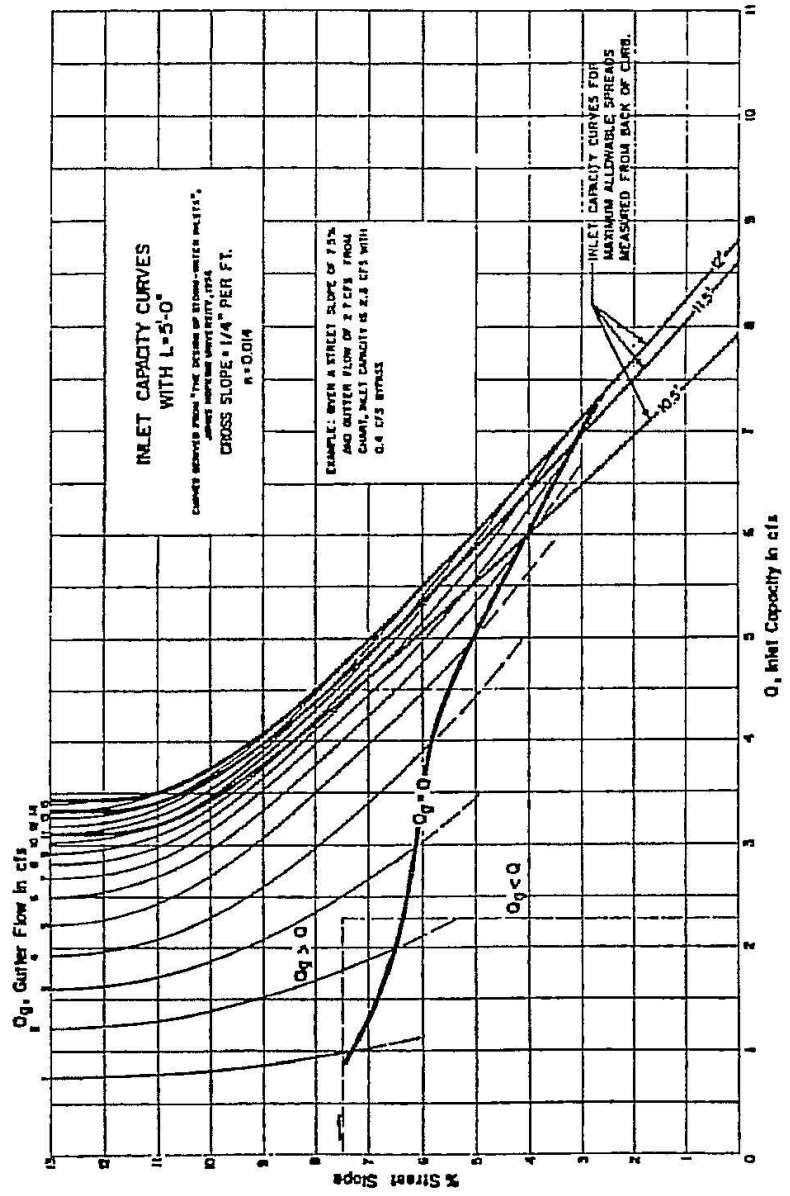


Branson MISSOURI Engineering & Public Works	NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS	DESIGN AID #30
		ADOPTED 2024 / REVISION

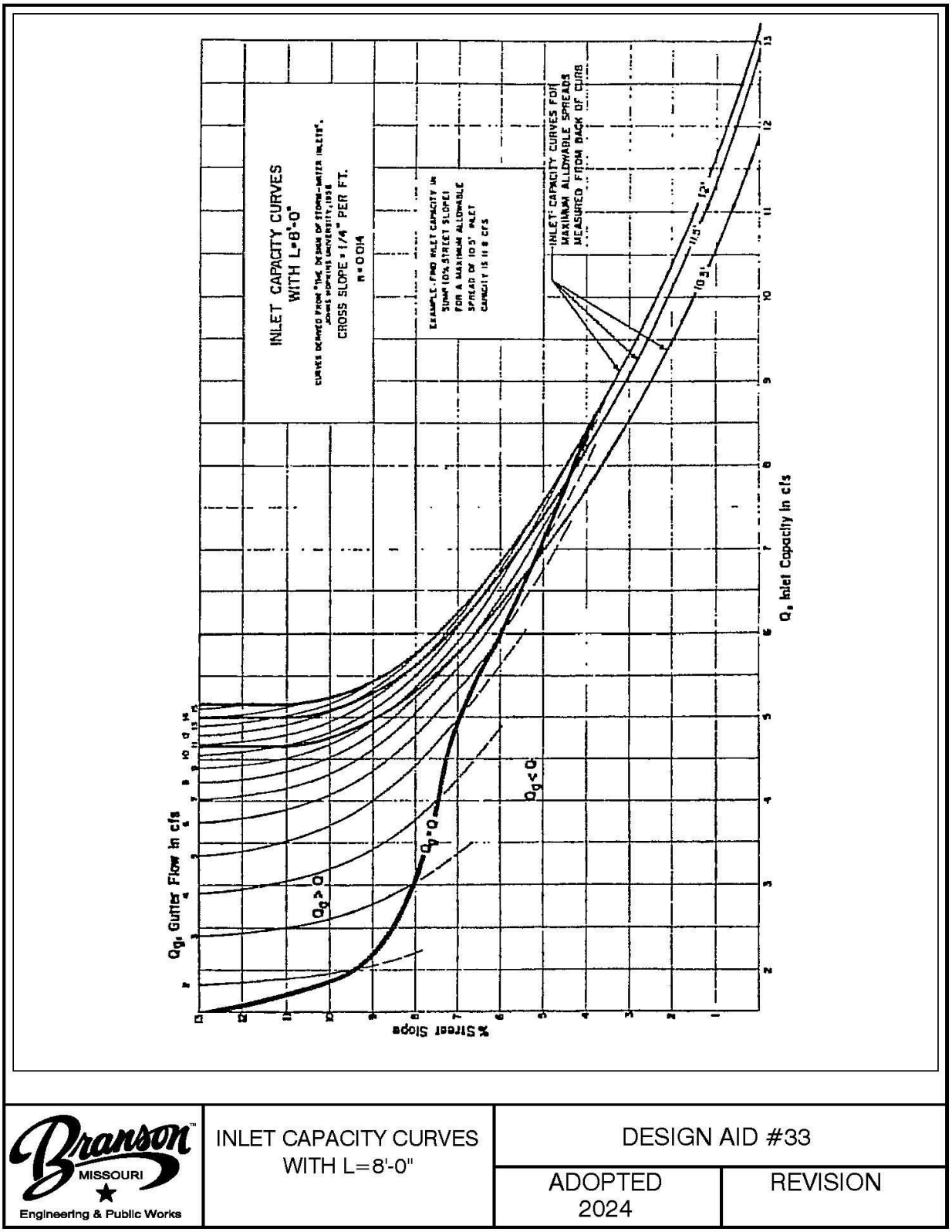


CAPACITY OF CURB OPENING INLET
AT LOW POINT IN GRADE.

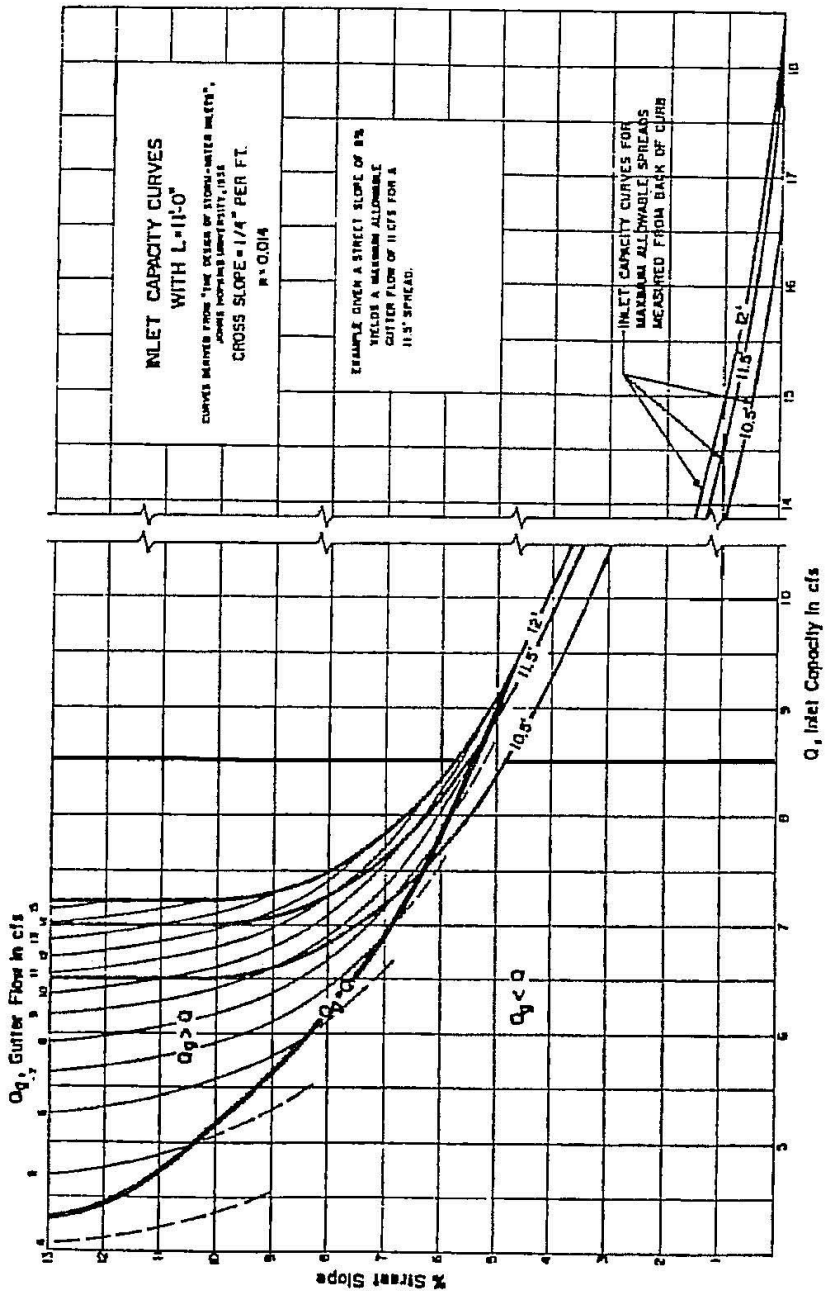
Branson MISSOURI ★ Engineering & Public Works	CAPACITY OF CURB OPENING INLET AT LOW POINT IN GRADE	DESIGN AID #31
		ADOPTED 2024 / REVISION



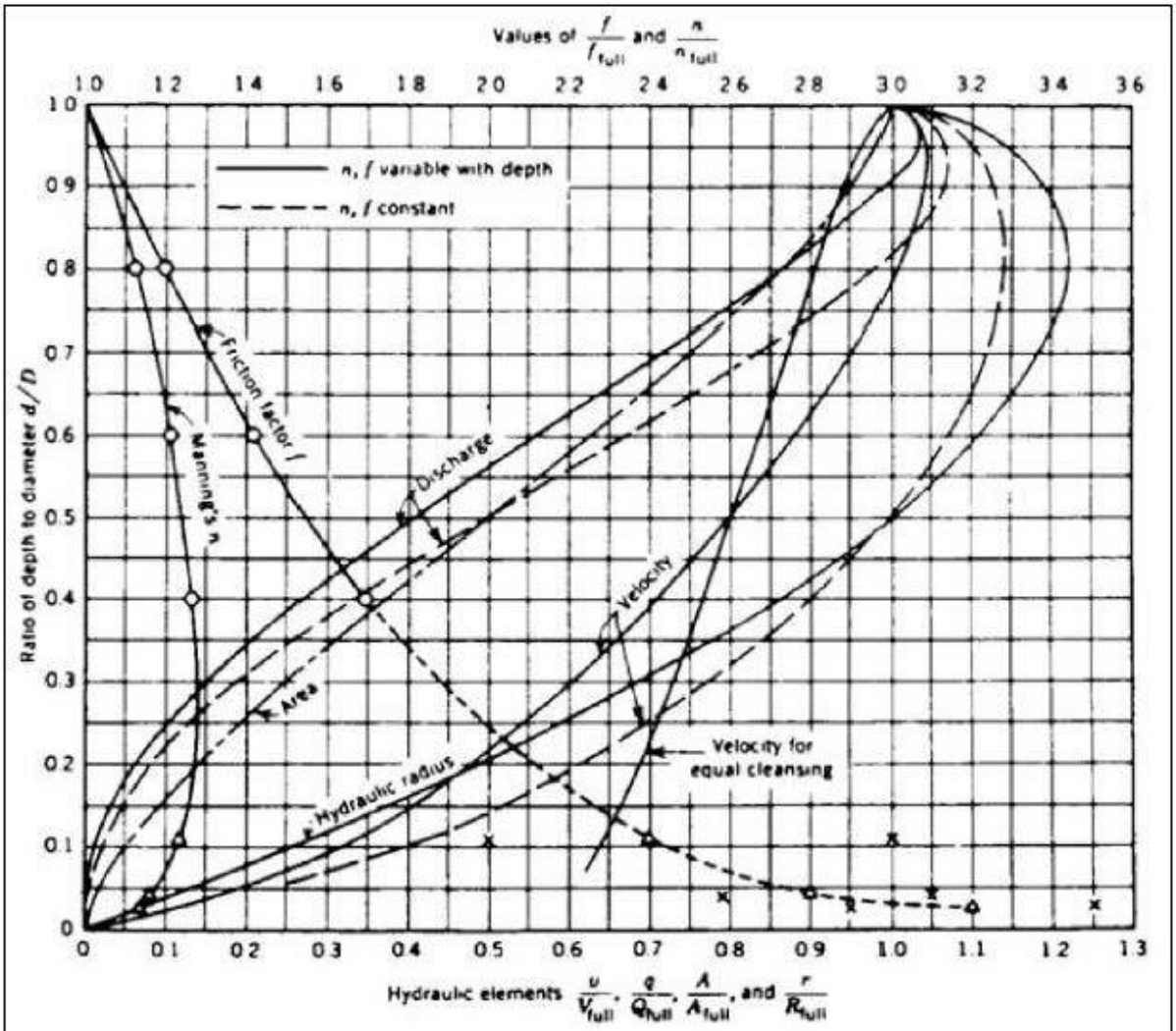
Branson MISSOURI ★ Engineering & Public Works	INLET CAPACITY CURVES WITH L=5'-0"	DESIGN AID #32	
		ADOPTED 2024	REVISION



Branson MISSOURI ★ Engineering & Public Works	INLET CAPACITY CURVES WITH L=8'-0"	DESIGN AID #33
		ADOPTED 2024 / REVISION



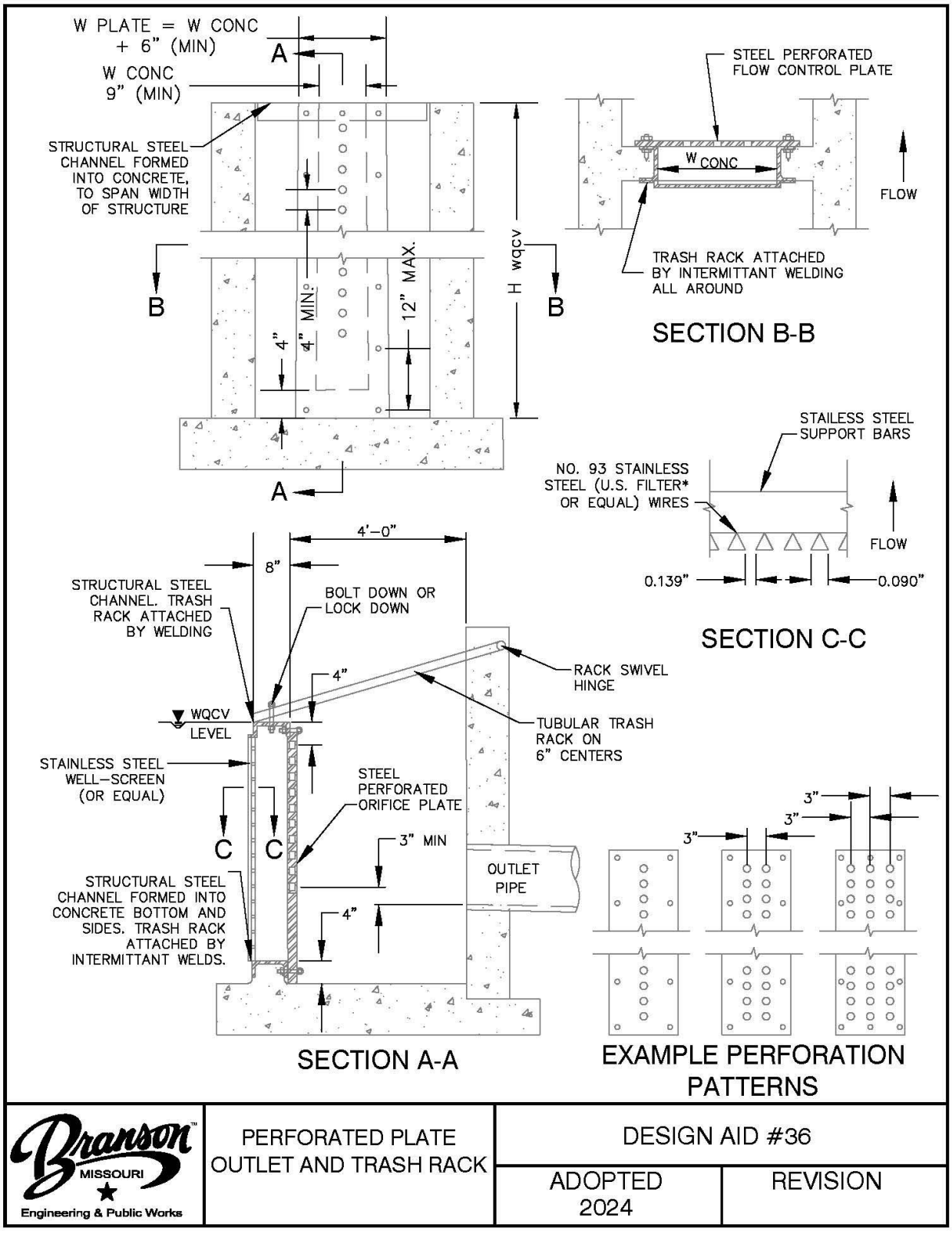
Branson MISSOURI ★ Engineering & Public Works	INLET CAPACITY CURVES WITH L=11'-0"	DESIGN AID #34
		ADOPTED 2024 / REVISION



v = Actual velocity of flow (fps)		A = Area occupied by flow (ft^2)	
V_{full} = Velocity flowing full (fps)		A_{full} = Area of pipe (ft^2)	
q = Actual quantity of flow (cfs)		r = Actual hydraulic radius (ft.)	
Q_{full} = Capacity flowing full (cfs)		R_{full} = Hydraulic radius of full pipe (ft.)	

Figure 5606-1: Hydraulic Elements of Circular Conduits

Branson Missouri Engineering & Public Works	HYDRAULIC ELEMENTS OF CIRCULAR CONDUITS	DESIGN AID #35
		ADOPTED 2024 / REVISION


W PLATE = W CONC + 6" (MIN)
W CONC 9" (MIN)
A
STRUCTURAL STEEL CHANNEL FORMED INTO CONCRETE, TO SPAN WIDTH OF STRUCTURE
B
B
4" MIN.
4"
12" MAX.
H WQCV
A
STEEL PERFORATED FLOW CONTROL PLATE
W CONC
FLOW
TRASH RACK ATTACHED BY INTERMITTANT WELDING ALL AROUND
SECTION B-B
STAILESS STEEL SUPPORT BARS
NO. 93 STAINLESS STEEL (U.S. FILTER* OR EQUAL) WIRES
FLOW
0.139"
0.090"
SECTION C-C
4'-0"
8"
STRUCTURAL STEEL CHANNEL. TRASH RACK ATTACHED BY WELDING
BOLT DOWN OR LOCK DOWN
4"
RACK SWIVEL HINGE
WQCV LEVEL
TUBULAR TRASH RACK ON 6" CENTERS
STAINLESS STEEL WELL-SCREEN (OR EQUAL)
STEEL PERFORATED ORIFICE PLATE
C
C
3" MIN
OUTLET PIPE
STRUCTURAL STEEL CHANNEL FORMED INTO CONCRETE BOTTOM AND SIDES. TRASH RACK ATTACHED BY INTERMITTANT WELDS.
4"
SECTION A-A
3"
3"
3"
EXAMPLE PERFORATION PATTERNS
Branson MISSOURI
Engineering & Public Works
PERFORATED PLATE OUTLET AND TRASH RACK
DESIGN AID #36
ADOPTED 2024
REVISION